Enhancement of Concrete Strength by Partial Replacement of Sand as Coir Pith and Treatment for Mitigation of Fluoride in Water

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ABSTRACT: Most of the materials which are being used in concrete are getting depleted or scarcity day by day due to over consumption in the construction field. So in this research, it is planned to find an alternative material for sand (fine aggregate) and also to improve the standard of water, since it act as a major role in helping the concrete to attain the desired strength. Fine aggregate is one of the finest filler material used in concrete ,which is getting depleted due to more usage, so we are in need to find an alternative material as in the form of utilizing any waste product (agricultural waste) as an partial replacement. Fluoride is one of the major constituents in water, at the same time if it exceeds the limit; it directly affects the reinforcement and results in corrosion which in turn reduces the strength of the concrete. The fluoride reduction process is carried out by "Nalgonda" technique in such way that the cost effective, less foot print & easy to operate and maintain in long period of time with locally available chemicals.

KEYWORDS: *Concrete, Coir pith, Filler material, Water treatment, Fluoride, Nalgonda techniqu*.

I. INTRODUCTION

Major problem faced by most of the countries including India is about allocating space for dumping various kind of waste like Agricultural waste, Municipal waste, etc. Here we used one of the agricultural waste by-product coir pith obtained from coconut industries as a replacement material. Curing is one of the major factors which enhance the strength property of concrete. When coir pith is incorporated in concrete as a partial replacement of sand, it minimizes the period of curing as this material can absorb more amount of water. Coir pith is an eco friendly material and it can also be used as a light weight concrete.

Similarly fluoride are formed as cryolite (Na_3AlF_6), fluorspar (CaF_2), fluorapatite [$3Ca_3(PO_4)_2$ $Ca(F,Cl_2)$]and sellaite (MgF_2). From sedimentary rocks fluorspar is present and from igneous rocks cryolite is present. The minerals found in fluoride are insolvable in water. Hence due to this property of minerals, they are found in ground water

II. Experiment materials

2.1 Materials:

2.1.1 Ordinary Portland Cement:OPC is one of the most predominantly and habitually used cement throughout the world since long duration of time.OPC cement was first processed in a powdery form by blending raw materials which mostly includes argillaceous,gypsum and calcareous as constituent materials. OPC is used in places which requires faster construction.

2.1.2 Aggregate: Aggregate is a granular material used to construct concrete or mortar. The sizes of these granular materials differ and can be classified into:

*i)**Fine Aggregate**:* In concrete, fine aggregate is the most essential material. The standard of fine aggregate strongly impact in the hardened properties of the concrete. To make the concrete more stronger and durable, the fine aggregate which is less than 4.75mm should be choosed by depending on itszone, shape and surface texture.

*ii)**Coarse aggregate**:* Coarse-grained aggregates are those which are retained on 4.75 mm sieve. To make the concrete mix more economical, coarser aggregate are used. Large sized aggregate fills the major part of concrete and thus it increases the strength and stability.

2.1.3 Water: For concrete water is one of the important constituent.A desired property of concrete is achieved when hydration process takes part (chemical reaction between cement and water). Strength and durability of concrete was controlled to a majorlimit by its W/C ratio place an important role in determining the strength and also the durability of concrete.

2.1.4Coir pith: Coir pith is a by-product agricultural waste material which is obtained from coconut after extracting oil from them. Coconut shells after being washed properly is sun dried for 5days under closed temperature and later stratified. With the help of sharp scissors and maintaining a fixed length the fibers are driven out (shredded). These shredded fibers were then oven dried for 5hours at 800°C and is then cooled using desiccators.

Figure 1: Coir Pith

III. Experimentmethods and discussion:

3.1.1 Compressive Strength: Compressive strength of concrete is an experiment which is done to determine the compression strength of the concrete at various ages using the test specimens like 7,14 and 28 days. A minimum of three specimens shall be casted and tested for each selected age.The specimens after being casted are kept in water and have been tested quicklyafter removing it from water. Then the casted cubes are inserted in between these surfaces and load is being applied.

Table 1: Compressive Strength of Cubes

Days	% Replacement of fine aggregatewith coir pith			
	3%	5%	10%	15%
7th day	22.07	20.44	20.30	15.63
14th day	24.07	22.22	24.07	16.59
21st day	27.63	26.89	25.11	17.85
28th day	31.41	30.67	26.96	19.78

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3.1.2 Split tensile strength: Generally concrete and structures made of concrete are extremely liable to tensile cracking. Hence it is very important to do this test. Reinforcement needs to be provided in concrete as the concrete is sturdy in the compression force and weak in tension force. Hence they are provided in concrete at the top of the structure to arrest the formation of tensile crack.

Table 2: Split Tensile Strength of Cylinder

Sl.No	Replacement % of untreated coir pith as fine aggregate	Split tensile strength at 28th day (in N/mm^2)
1	3%	4.38
2	5%	3.96
3	10%	3.53
4	15%	2.26

3.1.3 Flexural strength: Flexural strength of concrete prism indirectly determines the lastingness of a concrete.These tests evaluate the power of a concrete beam or slab which is not reinforced to face up to the failure when bending.

Table 3: Flexural Strength of Prism

Sl.No	Replacement % of untreated coir pith as fine aggregate	Flexural strength at 28th day (in N/mm^2)
1	3%	4.75
2	5%	4.00
3	10%	3.25
4	15%	1.20

3.1.4 Brief of fluoride removal methods and performance:

Table:4 Abstract &Performance on Different Technique

S.No	**Methods**	**Domestic + Low costs**	**Community + Low cost**	**Domestic + High F Removal**	**Community + High F Removal**	**Domestic + Brackish water**	**Community + Brackish Water**
1	**Sorption process**						
1.1	Activated Alumina						
1.2	Bone Charcoal						

1.3	Clay						
2	Precipitation process						
3	Nano filtration						
4	Membrane process						
5	Ion Exchange						
6	Electrodialysis						
7	Electro Coagulation						
8	Distillation						
9	Nalgonda Process						

Legend

	This method is optimistically suitable for given situation
	It is suitable for averagely
	This method can be used in case of there is no alternate method

3.1.5Fluoride removal methods

In laboratory, the above mentioned methods were tested and recorded its performance. In table 4, the removal of fluoride achieved by different process is indicated in the form of comparative analysis. On the whole, clay and bone charcoal methods in Nalgonda technique werelow cost methods in removing fluoride for domestic purpose and it is portable. The remaining methods in Nalgonda technique were carried out in the case of removal of high fluoride.

3.1.6Design Data For Nalgonda Process

a. Inlet water Specification and Quantity

1. Inlet water maximum flow rate: 5000 Cum./hr (120 Million Liters per day)
2. Water consumption: 70 LPCD
3. Population considered: 16.42 Lakhs
4. Method of Treatment: Various process technique and "**Nalgonda**"
5. Treatment scheme: stilling chamber, chemical dosing, coagulationprecipitation, flocculation, Agglomeration, Clarification, Filtration, Pre and Post Disinfection and sludge treatment unit is consisting of Gravity Thickening and Mechanical dewatering
6. Inlet water contains fluoride: up to 4 mg/l (Test report is attached)
7. Colour of inlet water: Colour less
8. Design guide: CPHEEO, Metcalf and eddy & Literature references
9. Backwash water consumption in day: 3500 to 5000 Cum per day
10. Duration of cleaning: 30 minutes

b. Treated water Quantity & Quality

1. Treated water flow rate in day: 4750 Cum./day to 4850 Cum./day
2. Loss: 3% to 5%
3. Treated water contains fluoride: less than 1.0 mg/l
4. Colour in treated water: Colourless

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5. Method for use: Portable

3.1.7DESIGN CONSIDERATION:

1. Scheme have been designed for 5000 Cum./hr flow and 5% extra water quantity to provide for sedimentation bleed losses and filter back wash requirements.
2. Optimistic chemical dosing is used based on the jar test analysis & specific water quality day to day operation
3. The inclined plate settler is clarification device made to convert a large conventional clarifier into a smaller form.
4. High rate dual media filtration with nozzle under drain system
5. Backwashing of the High rate dual media sand filter would be carried out by using raw water from the Overhead tank
6. Mechanical dewatering will be used for minimizing the system waste & decrees the volume of solid waste land filling
7. Pre and post disinfection are used for avoid contamination of alga growth, E-Coli and Pathogens in drinking water
8. The Product water quality form treatment plant to meet the potable standard IS 10500 and CPHEEO.
9. Power shut- down is frequent and rarely more than two hours' supply is available in the morning and evening. Accordingly, raw water pumping hours assumed to be 2 hrs in the morning and in evening. During these four hours pumping period, total daily requirements of water are to be pumped to elevated tank to draw water by gravity flow to the treatment unit.
10. The capacity of Overhead tank and sump shall be one-day storage in each at the rate of 130 LPCD.

3.1.8 Methods of Nalgonda technique:

This technique shall be adopted in four purpose based in the state of affairs

1. Domestic de fluoridation
2. Fill and Draw de fluoridation (Small community)
3. Fill and Draw de fluoridation (Rural community)
4. Community de fluoridation – (Continuous operation)

Fig :2 Different Method of Nalgonda Technique

3.1.9 COMMUNITY DE FLUORIDATION - CONTINUOUS OPERATION:

The Nalgonda Technique includes the addition of lime, bleaching powder and aluminium salts continued by the process such as rapid mixing, flocculation, sedimentation, filtration and disinfection.

Schematic diagram is as shown in below:

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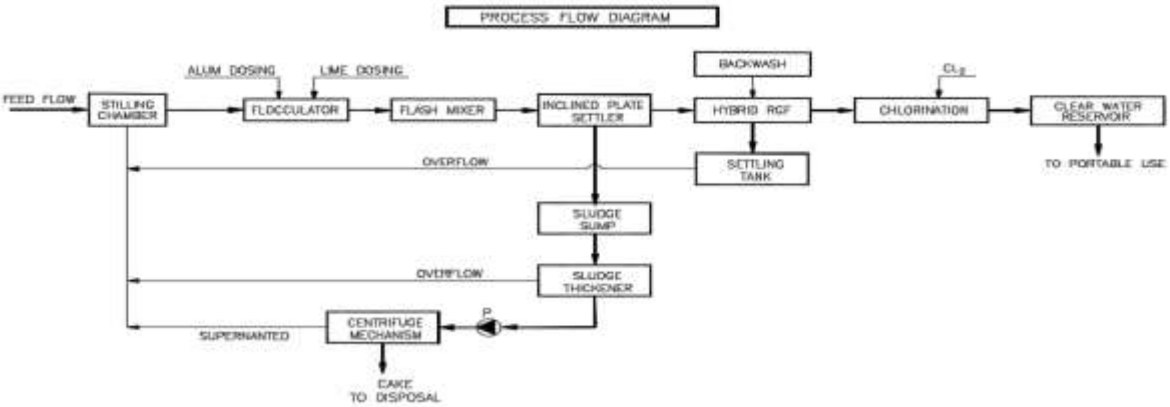

Fig: 3 Process Flow Diagram – Continuous Process

The reaction occurs through the following equations:

$2Al_2(SO_4)_3.\ 18H_2O + NaF + 9Na_2CO_3 \longrightarrow \qquad + 9Na_2SO_4$

$5Al(OH)_3.Al(OH)2F \ + NaHCO_3 + 8CO_2 + \ 45H_2O$

$3Al_2(SO_4)_3.\ 18H_2O + NaF + 17Na\ HCO_3 \longrightarrow$

$5Al\ (OH)_3.Al(OH)2F + 9Na_2SO_4 + 17CO_2 + 18H_2O$

JAR test analysis decides the alum dosage with respect to fluoride concentration and thus it was shown in the below figure.

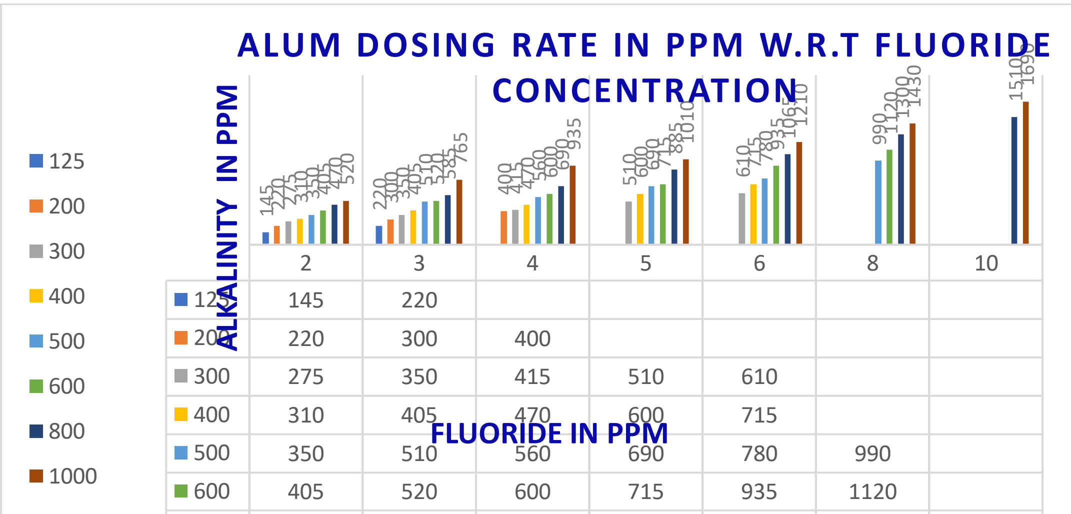

Fig : 4 Alum Dosing Rate in ppm W.R.T Fluoride Concentration

3.1.10Process design calculation

Treated water output from WTP : 120 MLD

: 120000 Cum./day

: 5000 Cum/hr

Feed flow Required as per Water balance : 5119 Cum/hr

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Add for wastages 3.0% : 3600 Cum./day

: 150 Cum/hr

For design purpose considered the feed flow for process units 5000 + 150
: 5150 Cum/hr

Hours of operation per day : 24 hours

<u>Flocculator:</u>

No of units considered : 2.0 Nos

Design rate of flow : 5150 Cum/hr

Detention Time : 40 Minutes

(As per CPHEEO Manual: 10 to 40 Minutes, P-213)

Volume of tank : ((5150 / 60) x 40)/2 = 1717 Cum.

Depth considered : 3.0m

Surface area of Each Flocculator : (1717/3) = 572.5 sq.m

Size of the tank : 24.0 Sq.m

Size of tank provided : 5.0m x 5.0 x 3.0m H +0.5m FB

3.1.11Design of inclined plate separator:

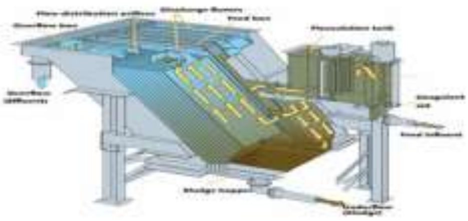

Fig 5 : Typical Plan &Cross Section View of IPS

Inclined Plate Settler (IPS)

No of units considered : 2.0 Nos

Design rate of flow : 5150 Cum/hr

Flow in each units : 2575 Cum/hr

Calculate total quantity of plates for each IPS

Length of the plate considered : 1.20 m

Breadth of the plate : 1.20 m

Thickness of the plate : 0.004m (4mm)

Angle of inclination : 55 Deg

Plate spacing : 50 mm

Flow area : 1.2m x 0.05 = 0.06Sq.m

Perimeter : 1.2+1.2 = 2.40m

Viscosity : 0.0010090

Density : 1.01 Kg/m3

Horizontal projected area : 1.2 x 1.2x Cos 55 = 0.826

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Effective rise rate

Vertical Height : 1.2 sin (55) = 0.983 m

No of plates required : (2575 / 1.5)/0.825 = 2081 Nos

at 90% plate area for clarification : 2081 /90% = 2312 Nos

Total projected surface area : 0.83 x 2312 = 1919 Nos

Inclined plate settler velocity : 2575 / 1919 =1.34 m/s

Vertical gap between plates : 0.08717 m

Specific Surface Area : 6.58

Horizontal Projection : 0.0714 m

Horizontal Distance Between Plates centers : 65.04 m

Reynolds Number. Re= ρvL/n

Consider Plate spacing : 50 mm

Plate width : 1.20 m

Velocity : 0.00488 m/sec

Re : 241.660

Less than Re 800 : Hence OK

Surface area of each unit with 2312 plates with the size of 1.2mW and 1.2 m long plate of 5 mm thick would be 24.0 x 24.0 x 3.0m SWD + 0.5 m F.B – 2 Nos

Surface area of IPS

Surface area of each IPS : 24.0- Cos (Radians (55))* 1.2*7 : 196.782 Sq.m

Total Surface area of each IPS : 196.782 x 2 = 393.6 Sq.m

Total flow : 123600 Cum./day

Surface Loading : 123600/24/393.6 = 13.08 $m^3/m^2/h$

3.1.12UNDER DRAIN DESIGNS:

The set up consist of a PVC nozzle which are placed into RC (reinforced concrete) with a minimum space below.

Fig 6 : PVC Nozzle

Instead, an emphasis is made in the careful selection of nozzles with slot sizes ranging from of 0.3 to 0.5 mm to prevent sand leakage through the nozzles. The density of the nozzle is based on the type of nozzles and as a standard as adopts a design basis of about 40 nozzles (of Polypropylene) per m² of bed area.

3.1.13Design of filter beds

Design flow of each filter bed : 515.0 Cum

Rate of filtration : 135 lpm/ Sq.m

Aera of filter bed required : 515/(135x 60)/1000 = 63.6 sq,m

Length to width ratio

As per CPHEEO manual P-245(1.11 to 1.66) : 1.3

Width of the filter bed : (63.6 /1.3)^ 0.5 = 7.0 m

Length of filter unit : 63.6/7.0 = 9.1 m

Provided 10 Nos of filter bed of each size is 9.1m L x 7.0 m

Filter underdrain system for Filter bed (Nozzles) - Based on inlet flow & backwash flow:

Rate of flow/inlet : 515.0 Cum/hr

Rate of pumping for back wash – : 36 Cum/Sq.m/hr

As per CPHEEO page No: 251 24 - 36 m3/m2/hr

Backwash water flow per bed : 9.1 x 7 x 36 = 2293.2 Cum.hr

As the backwash flow is higher than the inlet flow, the nozzle are designed for backwash flow

Capacity of each filter nozzle (considering) : 2.25 Cum/hr

No of Nozzle required : 2294 / 2.25 = 1019.5 or 1020

Total number of Nozzle : 1020 x 10 = 10200 Nos

Filter underdrain system for Twin Bed Filter (Nozzles) - Based on surface area

Area provided per Filter : 63.7 Sq.m

The No of nozzles per Cum. : 40 Nos /Sq.m

No of Nozzle per filter : 2548 Nos

No of Nozzle required for total Filter bed : 25480 Nos

Table: 5ComparisonsBetween the Conventional Treatment and Mitigation of FluorideTreatment Using Hybrid RGF

Description	Hybrid fluoride mitigation treatment	Conventional treatment
Process	Pre treatment ---- Inclined plate separator – Hybrid rapid gravity filter ------ Chlorination	Pretreatment - conventional Clarifier - RGF – Chlorination
Area requirement	3.16 Acre	25 to 30% additionally required (4.0 Acre)
Turbidity	Up to 1000 NTU	Up to 100 NTU
Filtration rate	6 to 10 Cum/sq.m/day	4.5 to 7 Cum/sq.m/day
Surface overloading	Surface loading rates upto for IPS is 10 to 15 m3/m2 of basin area/ h.	Effective surface loading rates for clarifier upto 3 m3/m2 of basin area / h.

Power consumption	Less	High
Water quality	It is fulfill the CPHEEO and IS 10500 portable drinking water quality	It is full fill the IS 10500.and some time will attain the CPHEEO
Capital cost	20% of cost is high	Economical
Land cost	20% less	It is more
Power consumption	10 to 15% is less	It is high
Maintenance	Maintenance activities are can be done with unskilled manpower	highly skilled manpower is required
Automation	Minimal automation is required	Highly technology shall be used for automation purpose
Sludge settling efficiency	Good due to surface area is high	Poor, due to surface area is low

Table 6: Water Analysis Report

Parameters	Unit	Before treatment	After treatment	As per IS 10500
pH		6.8	7.9	6.5 to 8.5
Fluoride	mg/l	3.9	0.84	1.0
Turbidity	NTU	26	< 1	10
Total Alkalinity (CaCo3)	mg/l	270	120	200
Total Hardness	mg/l	407	40	300
Residual chlorine	mg/l	Nil	0.17	0.2
Total Dissolved solid	mg/l	113	121	500

IV. Conclusion

Based on the research carried out it is concluded that coir pith as a partial replacement of sand gives relatively acceptable values for the test conducted such as compressive strength, split tensilestrength and flexural test upto 10% replacement. After 15% replacement, it shows the gradual decrease in strength of the concrete. Then under specified conditions each of the above discussed techniques was found very much effective in reducing fluoride content in water and itsreducing effectdiffersbased on many factors like geographical, economic conditions and site-specific chemical.Thecomparison statement contains all the aspects for conventional and Hybrid fluoride mitigation treatment.Overall results presented that the mitigation of fluoride become safe drinking water using Nalgonda treatment process with inclined plate separator & hybrid rapid gravity filter is suitable treatment method for domestic, Portable & community scale. So this fluoride content reduced water helps to avoid corrosion formation in reinforcement concrete.

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