

# A Critical Analysis of Feasibility of Mixing Waste Water in Cement Mortar and Concrete



Suma. Yarlagadda, SS. Asadi, Ch. Nithin Kumar Reddy

**Abstract:** The aim of this paper is to find the probability of using wastewater obtained from water plants situated in private structures. For the purpose of case study water treatment plants are selected in the region of Kankipadu of Krishna District of Andhra Pradesh. Each plant produces about 3600 to 4100 L/day water is being sold to the consumers of the area. Each plant is producing about 67% of wastewater in this process. Hence 91,500 lts/day is generating as waste water in the municipality region. All plants extract ground water for production and then treat them through Reverse Osmosis Process. The waste water so generated is drained off. Physical and chemical investigation were carried out on 14 water treatment plants. Out of which 10 typical plants were selected namely Chaitanya Junior College (CC), Punadipadu (PC) area, Near Shivalayam (SC) and Bank colony (BC), in view of the convergences of constituent's in wastewater investigated by chemical and physical examinations. Performance of these wastewater plants on the properties for example setting times, flexural strength, and compressive strength of OPC were performed in lab and contrasted them with test specimens using Distilled Water as blending water. No noteworthy changes were seen in the initial setting time yet considerable change has seen in the final setting time. Concrete properties like Slump & Density had not influenced by mixing water [2]. No major change has observed in compressive strengths (90 days) in four selected plants contrasted with that of test specimens. The XRD was carried out to observe the main compounds in the hydration process.

**Index Terms:** Water Crisis, Waste water, Chemical analysis. Use of recycled water in OPC.

## I. INTRODUCTION

Water is life that is why it is called "Jeevan" in Sanskrit. Water sustain all life, ecosystems and human activities. Although water seems to be a common commodity, it is scarcely available on earth and has no substitute [1]. Globally, concrete industry consumes 100 crore tons of water every year for blending. Notwithstanding that huge amount of water is used in construction for washing of mixers, curing, for concrete pumps & equipment and for ready mix concrete [4], [5]. In perspective of the

issue looked in tending to the expanded interest the accessibility of usable nature of water is again deteriorating step by step all through the previous years and proceeding. This situation is being watched everywhere throughout the country and furthermore careful the world, for the most part if there should arise an occurrence of creating nations, by virtue of release of waste water from the treatment plants to the earth, which are contaminating both the surface and subsurface water bodies. According to Central Statistical Organization, there are nearly 32 lakhs industries in India (1988-1999 decade) of which 1,35,55 are registered as manufacturing industries, else are the industries, of small scale and other like Automobile parking, food industries and suppliers, Fabric industries etc. As per the latest inventory of Central Pollution Control Board, at about 8432 huge and moderate polluting industries are existing in India. In addition, lot many very small scale industries are established in inadvertent areas in a disorganized manner. Besides, such industries are located in residential areas. Over this most of these industries are unregistered. Endeavors for wastewater recycle have gradually increased overall consideration in both the mechanical and horticultural fields. With every one of these results, reuse of waste-water that is created in the water treatment plants must be drilled broadly to monitor valuable water assets and to get economic advancement. Partially treated water contains dissolved solids that affect the water. Even if the water stored unused causes major pollution [3]. In this connection, the present experimental studies are intended to use of waste-water as blending water in Ordinary Portland Cement. The constraints considered are setting times, normal consistency and compressive strength, flexural strength. Setting times & Normal consistency of OPC evaluated. Compressive and flexural strength of OPC evaluated at different ages (3 days, 7 days, and 28 days, and 90 days).

**Table 1: Adequate Limits of polluting influences for solid blending water (all qualities in mg/L, with the exception of PH)**

S.No	Constituent	Acceptable Limits
1	Inorganic solids	3000
2	Organic solids	200
3	Suspended solids	2000
4	Total solids	4000
5	Total Alkalinity as CaCO <sub>3</sub>	1000

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6	Sulphates	1000
7	pH	6-8
8	Sodium Carbonates & Bicarbonates	2000
9	Dissolved solids	2000
10	Carbonate & Bicarbonates	1000
11	Chlorides for PCC	2000
12	Chlorides RCC	3000

Subsequently, everywhere throughout the nation, numerous obscure small scale water-treatment plants are being running because of it, enormous volume of waste-water is produced. Subsequently the point of the present work is to observe the practical implication of waste-water from small scale water treatment plants located in the residential areas as blending water in cement, which is an ingredient in concrete and other cementations works.

## A. Use of Waste water in Cement Mortar

Since from the invention of concrete, potable water has been used for mixing. The present study revealed that the waste-water from the human consumption can also be used in concrete. Water from the sources like rivers that are not polluted by humans and cattle, and that don't have any saline taste, has been found fit for concrete mix [9]. It's also been found that the local water bodies in the villages, like ponds and lakes have very low concentrations of organic matter, silt or other impurities that has a very little or even no adversative effect on properties exhibited by concrete [10]. Potable water resources are endless. For the developing countries and cities with limited resources paired with vast commercial growth, and increase in construction activities, that need to preserve the potable water becomes more urgent each and every year. Thereby the efforts laid for the recycling of the used/waste water have gained prominence all over the world and concentration in both construction/ Industrial and agricultural sectors. In recent time, more attention has been drawn towards the different parts of waste-water reuse, albeit numerous researches has been conducted on the utilization of rejected water that are created from the treatment plants for creation of concrete. The appositeness of utilizing treated waste-water for blending of concrete was tentatively assessed in Kuwait. Concrete cubes were casted using consumable water, essential treated wastewater, auxiliary treated wastewater and tertiary treated wastewater got from the Raqqa (neighborhood) squander water treatment plant. This sort of water did not influence the concrete properties for example slump and density. Nevertheless, the setting time of concrete were seen to be increment with disintegrating waste-water quality. Preliminary treated wastewater and secondary treated wastewater were observed to have the most impact on retarding setting time and further showed slower strength development for very long time up to 1 year. At initial age of concrete up to 7 days, the strength of concrete with tertiary treated wastewater is more than that of concrete with tap water. There is a probability of corrosion with an increase in the usage of preliminary treated wastewater and secondary treated wastewater, specifically provided with less cover. In abstract, tertiary treated waste-water from waste-

water in Kuwait is observed to be suitable for blending concrete with no unfavorable impacts [2].

## II. OBJECTIVES

1. Collection of waste water data
2. Conducting the physical and chemical analysis of collected waste water samples
3. Examine the feasibility of wastewater mixing water in OPC

## III. METHODOLOGY

The Physio-chemical properties of cement, sand and wastewater used in the investigation and also the standard experimental procedures laid down in IS codes, which were adopted for the determination of initial and final setting times and normal consistency, compressive strength of cement and mortar cubes are presented in this chapter. Compressive strength is the capacity of the material to oppose the load. It is referred as compressive stress at the point where the material fails [6].

### A. Materials

The materials used for the study are:

- I. 53-Grade OPC
- II. Fine Aggregate (sand)
- III. Wastewater from four water treatment plants and Distilled water (DW)

#### a. Sand

The sand, which was used all through the experimental work, was obtained from the Ennore, near Chennai (Ennore sand IS 650:1991). The sand was obtained from Tamilnadu minerals limited, Chennai. It is the only organization in India, approved by Indian Standard Institution to manufacture and supply of sand conforming to IS 650:1991. The sand used in the experimental work has the following particle size distribution.

- a) Passing through 2mm & retained on 1mm
- b) Passing through 1mm & retained on 0.5mm
- c) Passing through 0.5mm & retained on 0.09mm

**Table 2: Ennore Sand Properties**

S.No	Properties	Results
1	Shape of grains	Sub Angular
2	Grading	In Percentage
2a	Retained on 2mm sieve	100%
2b	Passing in 2mm sieve	100%
2c	Particle size less than 500 $\mu$ to 90 $\mu$	33.34%
2c	Particle size 2mm to 1mm	33.32%
2d	Particle size less than 1mm to 500 $\mu$	33.33%
3	Fineness Modulus	2.73

4	Specific Gravity	2.66
5	Absorption	0.80%
6	Bulk density, KN/m <sup>3</sup>	15.89

presented in Table 3. The characteristics of wastewater opted for the present study (CC, PC, SC and BC) is provided in Table 4.

**b. Distilled water and waste water**

The physical properties as well as chemical properties of distilled and Waste-water used as mixing water in OPC are

**Table 4: Characteristics of wastewaters opted for present study**

**Table 3: Physical and Chemical Properties of Distilled & Waste-water Samples**

Name of the plant	pH	Alkalinity CaCO <sub>3</sub> (mg/L)			Acidity CaCO <sub>3</sub> (mg/L)		Solids in mg/L			chloride s in mg/L	Sulphat es in mg/L
		OH <sup>-</sup>	CO <sub>3</sub> <sup>-2</sup>	HCO <sub>3</sub> <sup>-</sup>	Min eral acid ity	CO <sub>2</sub> acidit y	Total solids	Organicsol ids	Inorganic solids		
DW	7	0	0	0	0	0	0	0	0	0	0
CC WW	7.12	0	0	559	0	79.0	501.13	17.3	484	174.5	21.5
SCWW	6.92	0	0	463.5	0	80.0	320.91	16.3	302	139.0	20
PC WW	7.15	0	0	543.5	0	79.0	437.12	17.1	420	158.0	23.5
BC WW	7.05	0	0	519	0	82.1	401.85	17.5	384	144	27.6
CMCWW	6.81	0	0	300.2	0	91.1	219.2	19.7	201	150.7	16.7
RC WW	6.01	0	0	410.4	0	92.2	270.10	20.2	248	130.8	15.8
YCWW	6.59	0	0	425.25	0	90.6	225	32.0	194	160.35	08
MSC WW	6.52	0	0	300.13	0	95.79	228	24	203	170.7	4.5
KYC WW	6.79	0	0	423.15	0	95.1	243	23	219	172.3	10.8
PNC WW	6.43	0	0	416.44	0	97.0	280.5	30	249	144.7	12.7
IBCWW	6.62	0	0	413.44	0	96.86	247.4	27.4	219	140.8	10.5
ASCWW	6.35	0	0	400.29	0	98.5	236	20	216	139.2	9.4
NKCWW	6.34	0	0	355.91	0	54.84	241	19	221	152.1	11.5
KKC WW	6.51	0	0	419.17	0	46.26	170	20	149	148.9	12.2

S. No	Waste Waters	pH	Alkalinity as CaCO <sub>3</sub> (mg/L)			Acidity as CaCO <sub>3</sub> (mg/L)		Solids in mg/L			Chlorides in mg/L	Sulphates in mg/L
			OH <sup>-</sup>	CO <sub>3</sub> <sup>-2</sup>	HCO <sub>3</sub> <sup>-</sup>	Mineral acidity	CO <sub>2</sub> acidity	Total solids	Organic	Inorganic		
1.	DW	7	0	0	0	0	0	0	0	0	0	0
2.	CCWW	7.12	0	0	559	0	79.0	501.13	17.03	484	174.5	21.5
3.	SC WW	6.92	0	0	463.5	0	80.0	320.91	16.93	302	139.60	20
4.	PCWW	7.15	0	0	543.5	0	79.0	437.12	17.11	420	158.90	23.5
5.	BCWW	7.05	0	0	519	0	82.1	401.85	17.05	384	144	27.6

tests and Flexural strengths on OPC were performed. The results are presented and discussed in subsequent sections.

**IV. RESULT AND DISCUSSIONS**

The purpose of the investigation is to examine the applicability of waste-water obtained from the small scale plants in Kankipadu as water in OPC. Hence, in laboratory, setting time, normal consistency & compressive strength

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## A. Normal consistency of Ordinary Portland Cement

Effect of DW, CC, SC, PC and BC on normal consistency of OPC shown in Fig. 1 shows the values of Normal consistency of the selected samples are presented in Table 5.

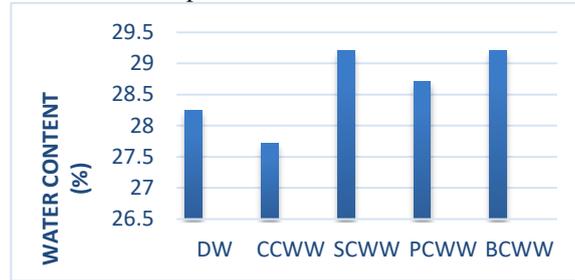


Fig. 1: Waste-water effect on normal consistency of OPC

The effect of DW, CC, SC, PC and BC on normal consistency of OPC differs marginally compared to that of DW. Normal consistency of CC, SC, PC and BC are 28.5, 27.72, 29.21, 28.71, and 29.21% respectively.

Table 5: Effect of waste-water on physical properties of OPC

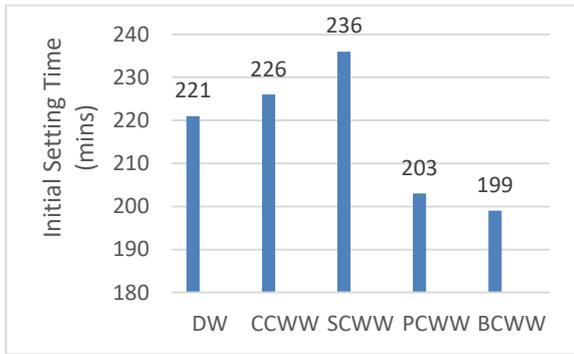
S. No	Sample Name	Normal consistency in %	Setting times in mins		Compressive strength in MPa				Flexural strength in MPa			
			Initial setting time	Final setting time	3 days	7 days	28 days	90 days	3 days	7 days	28 days	90 days
1.	DW	28.25	221	311	33.22	42.17	58.85	61.66	4.06	5.60	6.39	6.54
2.	CCWW	27.72	226	364	34.55	44.71	56.28	59.50	4.11	5.79	6.29	6.48
3.	SC WW	29.21	236	352	32.23	41.78	56.48	60.28	4.04	5.59	6.40	6.44
4.	PCWW	28.71	203	384	33.99	42.27	56.75	59.93	4.08	5.65	6.38	6.43
5.	BCWW	29.21	199	309	33.09	40.97	55.94	59.20	4.08	5.52	6.33	6.29

Table 6: Percentage Change in strengths of OPC

S. No	Waste waters	Percentage change in Compressive strength (MPa)				Percentage change in Flexural strength (MPa)			
		3 Days	7 Days	28 Days	90 Days	3 Days	7 Days	28 Days	90 Days
1	DW	0	0	0	0	0	0	0	0
2	CCWW	+3.98	+5.94	-4.31	-3.46	+1.206	+3.323	-1.53	-0.898
3	SC WW	-2.92	-0.92	-3.98	-2.21	-0.483	-0.175	+0.153	-1.497
4	PCWW	+2.30	+0.227	-3.52	-2.766	+0.483	+0.875	-0.153	-1.796
5	BCWW	-0.346	-2.83	-4.87	-3.94	+0.483	-1.398	-0.92	-3.89

## B. Setting times of OPC

**Initial setting time of concrete:** The below shown table 5 and Fig 2 represents the effect of CC, SC, PC and BC on initial setting time of OPC.



**Fig. 2: Different wastewaters on initial setting time of OPC**

The selected plants does not shows any significant change compared to that of DW. Initial setting time of different plants are shown in table 5 as 221, 226, 236, 203 & 199 minutes respectively. Change of initial setting time of different plants with Distilled Water is +5, +15, -18, -22 mins respectively.

**Final setting time:** Table 5 represents the effect of CC, SC, PC and BC on final setting time of OPC. Final setting time of different plants are shown in table 5 as 311, 364, 352, 384 and 309 minutes respectively. Change of final setting time of different plants with distilled water is +53 mins, +41 mins, +73 mins, and -2 minutes. Subsequently, it is seen that, there is a substantial increase in CC, SC, PC and insignificant decrease in BC when compared to that of DW.

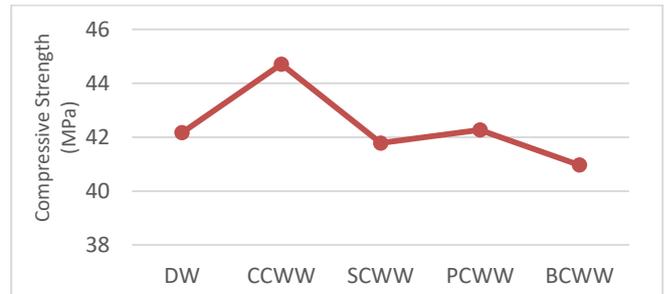
**C. Compression strength of OPC**

Three specimens of 150mm standard cubes are tested for compressive strength as per IS516:1959 [7]. Effect of CC, SC, PC and BC on compressive strength of Ordinary Portland Cement is displayed in Table 5. Percentage change in the Compressive Strength of OPC is mentioned in Table 6. Impact of DW, CC, SC, PC and BC on 3 days compressive strength is shown in Fig. 4.



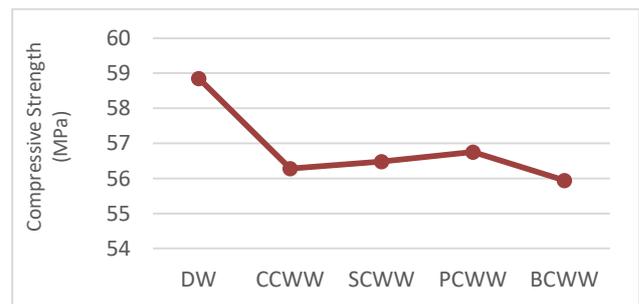
**Fig. 4: Wastewater on 3 days compressive strength of OPC**

Compressive strength obtained for 3 days by using different water plants is shown as 33.22 N/mm<sup>2</sup>, 34.55 N/mm<sup>2</sup>, 32.23 N/mm<sup>2</sup>, 34.99 N/mm<sup>2</sup>, 33.09 N/mm<sup>2</sup> respectively. Difference in compressive strength is minor when contrasted to that of DW. Change in percentage is shown as (+3.98), (-2.92), (+2.30), (-0.346) respectively when contrasted to that of DW.



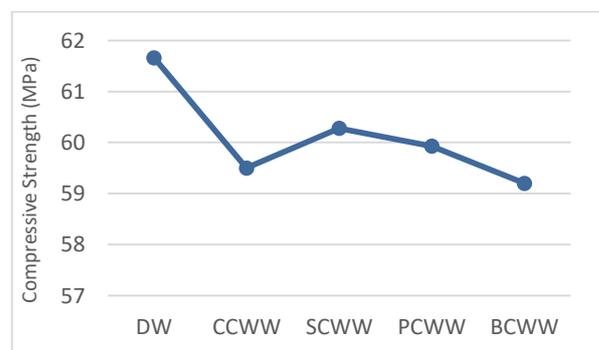
**Fig. 5: Wastewater on 7 days compressive strength of OPC**

Impact of DW, CC, SC, PC and BC on 7 days compressive strength is shown in Fig. 5. Compressive strength obtained for 7 days by using different water plants is shown as 42.17, 44.71, 41.78, 42.27, 40.97 N/mm<sup>2</sup> respectively. Difference in compressive strength is irrelevant compared to that of Distilled Water. Change in percentage is (+5.94), (-0.92), (+0.227), (-2.83) respectively contrasted to that of DW. Impact of DW, CC, SC, PC and BC on 28 days compressive strength of OPC is shown in Fig. 6. Compressive strength obtained for 28 days by using different water plants is shown as 58.85, 56.28, 56.48, 56.75, 55.94 N/mm<sup>2</sup> respectively. Difference in the compressive strength is irrelevant compared to Distilled Water. The change in percentage is (-4.31), (-3.98), (-3.76), (-4.92) respectively contrasted to that of DW.



**Fig. 6: Effect of different wastewaters on 28 days compressive strength of OPC**

Impact of DW, CC, SC, PC and BC on 90 days compressive strength of is shown in Fig. 7.



**Fig. 7: Impact of wastewater on 90 days compressive strength of OPC**

Compressive strength obtained for 90 days by using different water plants is shown as 61.66, 59.50, 60.28, 59.93, 59.20 N/mm<sup>2</sup> respectively.

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Difference in compressive strength is irrelevant contrasted to DW. Change in percentage is (-3.46), (-2.21), (-2.766), (-3.94) respectively contrasted to DW. However, the proportionate change in compressive strength for 3days, 7days, 28 days and 90 days is (+3.98), (+5.94), (-4.31), (-3.46) for SC (-2.92), (-0.92), (-3.98), (-2.21) for PC (+2.30), (+0.227), (-3.52), (-2.766) for BC (-0.346), (-2.83), (-4.87), (-3.94) respectively when compared to DW.

### D. Flexural Strength of OPC

Impact of DW, CC, SC, PC and BC on Flexural strength is presented in Table 5. Percentage change in Flexural Strength is mentioned in Table 6. Fig 8 shows the effect of DW, CC, SC, PC and BC on Flexural strength for 3days. It shows the 3days Flexural strength as 4.06, 4.11, 4.04, 4.08, 4.08 N/mm<sup>2</sup> respectively. Difference in Flexural strength is irrelevant contrasted to DW. The percentage change is (+1.206), (-0.483), (+0.483), (+0.483) respectively contrasted to DW.



**Fig. 8: Effect of different wastewaters on 3days flexural strength**

Impact of DW, CC, SC, PC and BC on 7 days Flexural strength is shown in Fig. 9.



**Fig. 9: Impact of wastewater on 7days flexural strength of OPC**

It shows the 7 days Flexural strength as 5.60, 5.79, 5.59, 5.65, 5.52 N/mm<sup>2</sup> respectively. Difference in the Flexural strength is irrelevant when contrasted to Distilled Water. The percentage change is (+3.323), (-0.175), (+0.875), (-1.398) respectively contrasted to DW.

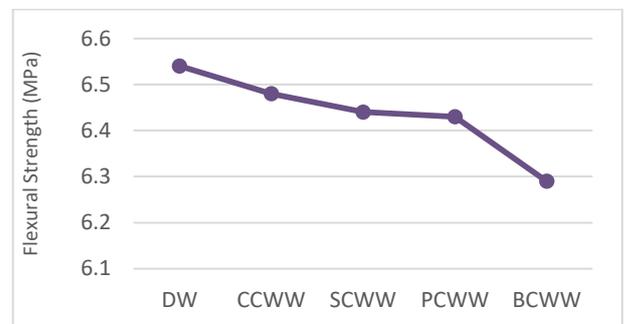
Effect of Distilled Water, CC, SC, PC and BC on 28 days Flexural strength is shown in Fig. 10.



**Fig. 10: Effect of waste waters on 28 days flexural strength of OPC**

It shows the 28days Flexural strength as 6.39, 6.29, 6.40, 6.38, 6.33 N/mm<sup>2</sup> respectively. Difference in the Flexural strength is irrelevant contrasted to DW. Change in percentage is (-1.53), (+0.153), (-0.153), (-0.92) respectively contrasted to DW.

Impact of DW, CC, SC, PC and BC on 90 days Flexural strength is shown in Fig. 11.



**Fig. 11: Impact of wastewater on 90days flexural strength**

It shows the 90 days Flexural strength as 6.54, 6.48, 6.44, 6.43, 6.29 N/mm<sup>2</sup> respectively. Difference in the Flexural strength is irrelevant when contrasted to Distilled Water. Percentage change is (-0.898), (-1.497), (-1.796), (-3.89) respectively compared to DW. However, Compressive & Flexural Strength values of DW, CC, SC, PC and BC are not exceeding 10% of results when compared with Distilled Water.

### E. X-Ray Diffraction ANALYSIS

XRD analysis for 28 days cured reference samples and test samples are shown in Fig. 3.10 and 3.11. It seems that in samples XRD pattern is same. The crystalline compounds found in the reference sample are C<sub>2</sub>S, C<sub>3</sub>S, Calcium Hydroxide {Ca(OH)<sub>2</sub>} at 29.5<sup>0</sup>, 18<sup>0</sup>, (34.2<sup>0</sup> and 47.1<sup>0</sup>) whereas in test sample are C<sub>2</sub>S, C<sub>3</sub>S, Ca(OH)<sub>2</sub>, Calcium Carbonate {CaCO<sub>3</sub>}, Calcium Chloride {CaCl<sub>2</sub>} at 29.5<sup>0</sup>, 18<sup>0</sup>, 34.2<sup>0</sup>, 47.3<sup>0</sup>, 50.9<sup>0</sup>. Due to presence of chlorides and bicarbonates in test sample the new compounds i.e., CaCl<sub>2</sub> & CaCO<sub>3</sub> are reformed.

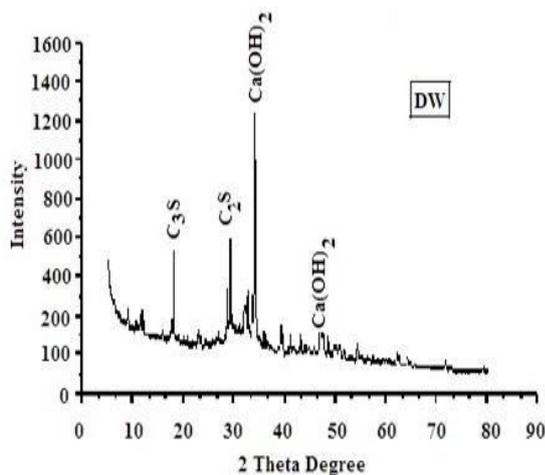


Fig. 12: XRD for 28 days hydrated reference sample

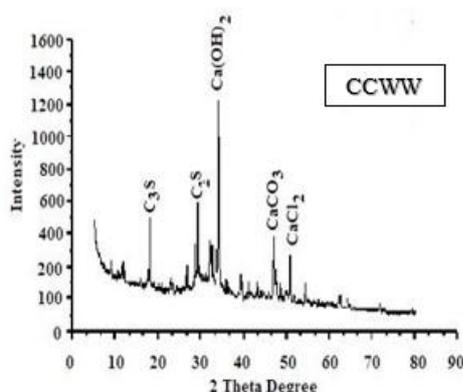


Fig. 13: XRD for 28 days hydrated of test sample

The following are the conclusions drawn from the test results obtained

- 1) Test samples shows less flexural & compressive strength contrasted to the reference samples, but within the permissible limits as per IS: 456-2000, and BS: 3148-1980. However, longterm strength development and durability studies are to be investigated.
- 2) Wastewater from the selected plants may be prescribed in cement mortar.
- 3) In X-ray diffraction analysis,  $\text{CaCO}_3$  and  $\text{CaCl}_2$  are observed in hydrate cement.
- 4) Wastewaters of CC, SC, PC and BC may be used as mixing water in OPC.

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