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An Influence of Recycled Concrete Aggregate and Treated Waste Water Containing 50% GGBS Content in Light weight Concrete Mixes

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ABSTRACT

Extraction of natural aggregates is expensive and has a huge impact on the environment. The main issues in sand and gravel mining are the large areas that are affected, ground water level changes, illegal mining, unsuitability of desert and marine sand, and costs of transport. Metallurgical waste can be used as a substitute for natural aggregates, the waste is recycled and the use of natural aggregates is reduced. Environmental sources are diminishing every day and hence, usage of available sources become even more important..The novelty of this research reports the experimental examination of applying Recycled Aggregate (RA), Treated wastewater (TW) and GGBS in concrete. Four groups of mixes were developed (Groups NW, TW, NWG, and TWG) with each group consisting of four mixes, providing a total of 16 mixes. Group NW: 100% Natural Water (NW) with different percent ratio of RA contents Group TW: 100% Treated waste water (TW) with different percent ratio of RA contents Group NWG: 100% Natural Water (NW) and 50% GGBS (replacement with Portland cement [PC]) with different percent ratio of RA content Group TWG: 100% TW and 50% GGBS (replacement with PC) with different percent ratio of RA contents The test result are compressive strength tests after 1,7,15, and 28 days. The statistical analysis results showed that the effect on concrete compressive strength was only significant when 20% RA was used in concrete exposed to TWW with 50% replacement of GGBS.

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1. INTRODUCTION

The cement industry produces approximately 1.4 billion tons CO2 , which equals to almost 7%of the global CO2, which is equals to almost 7% of the global CO2production [4]. Concrete industry utilizes one billion tons of mixing water every year. Also, to clean truck mixers, concrete pumps, equipment, aggregate, curing concrete and ready mix an enormous amout of fresh water is consumed. Because of increasing use of cement in various types of construction activities that use fresh water, instead of fresh water reuse of treated wastewater is studied at the researches. The research into the reuse of treated wastewater as an alternative to fresh water is justified by the increasing use of cement in various types of construction activities that use fresh water. Recycled concrete aggregate (RCA) is a shredded waste generated during the demolition of concrete and reinforced concrete structures. The resulting aggregates are the subject of research to reduce the need for natural aggregates for concrete applications. The use of RCA increases the demand for water and decreases the consistency of the concrete mix with the same effective water-cement ratio According to Big Market Research (BMR), Aggregates Market Development by 2026 report [4] and Grand View Research (GVR), Aggregates Market Size, Share and Trends Analysis Report [1] the global aggregates market was worth about 430 B USD in 2018, and is still raising. It is predicted to be worth about 600 B USD in 2026. The GVR's report showed that about 60% of aggregates excavated worldwide was used for concrete production and about 20% for road substructures [1]. It was estimated that only about 100 M tonnes of concrete were recycled into aggregate in 2004 [5]. In 2017 only in Great Britain 72 M tonnes of recycled and secondary sources aggregates were used, which is quite a large amount in comparison to 176 M tonnes of primary aggregates [6]. Nowadays, limiting the use of natural aggregates to concrete is doubly justified.

Concrete is the most widely used material worldwide, it is not surprising for the concrete industry to be among the most significant contributors to air pollution. It is the environmental and societal responsibility of concrete industries to contribute to sustainable development. It is important to note that the said industry consumes vast quantities of water, alongside other natural materials. One ton of CO2 and various green-house gases (which are among the contributors of global warming) are released into the atmosphere with each ton of cement that is produced. Global production of aggregates was 21 B tonnes in 2007 and 40 B tonnes in 2014 [1,2]. The most recent data presents value of 50 B tonnes of sand and gravel yearly consumption [3]. This applies to mixtures containing 50% and 100% RCA [5]. Similar results are presented in [24]. The studies described in [8] have shown that mixes containing 50% and 100% RCA and modified with a superplasticizer have reached the same consistency as the reference mix-therefore it is possible to control the consistency of mixes containing even large amounts of RCA The use of fine RCA causes a decrease of the durability properties of concrete—an increase of absorbability and permeability, increase of carbonation depth and chloride migration rate 9]. However, it is possible to shape and improve these properties using chemical admixtures—mainly superplasticizers. No significant decrease in durability properties of concrete using up to 30% RCA was found [10,11]. Above this amount a faster corrosion of reinforcing steel was observed. Chloride diffusion coefficient increased in concretes containing RCA [12].

The main objectives of this project is to compare the compressive strength of conventional concrete cubes with concrete cubes made by using recycle aggregate, treated waste water and 50%GGBS. Investigate the physical properties of previous concrete made with replacement levels of construction and demolition waste as recycle coare aggregate. The ground granulated blast furnace slag (GGBS) is a waste from the iron assembling industry, which is utilized as partial substitution of concrete because of its natural cementing properties. In the nation like India, where the improvement of the infrastructure projects is high, such employments of waste material in concrete won't just decrease the outflow of greenhouse gases yet in addition will be the reasonable method for the management of waste [13]. Models for anticipating compressive strength, split tensile strength and flexural strength were developed dependent on various mix of materials. The R2 of 0.9996 was obtained for compressive strength and Mean Square Error as obtained as 0.9365 [14]. Kalaivani included fly ash and GGBS in the form of powder in the proportion of 60% and 40%. As the result the load carrying capacity of the beam increased by 28.33% when compared to standard specimen. On comparison with standard specimen the stiffness characteristics of beam also increased about 38.77% [14,15]. Shreyas attempted to strength characteristic study of sustainable concrete mix with GGBS incorporation as a partial replacement of cement. He made a conclusion that GGBS imparted filler effect within the concrete without detrimental to the overall strength. He also found that 28 days of compressive strength increased adding GGBS up to of 20%. The workability of concrete with GGBS addition up to 30% cement replacement in M35 grade concrete was found to be within a safer limit [14]. The main objective of this project is to compare the compressive strength of conventional concrete cubes with concrete cubes made by using recycle aggregate, treated waste water and 50% GGBS. Investigate the properties of demolished waste of coarse aggregates and To study the behaviour of fresh Properties of concrete with recycled coarse aggregate concrete and compare its properties to those of conventional concrete

2. RESEARCH METHOD

In this experimental work Ordinary Portland cement (OPC) 43 grade cement confirming to IS: 8112- 1989 is used. GGBS is categorized as CEM III in accordance to the TS EN 197-1 standards. Recycled aggregate is an alternative to using natural aggregate (NA) in concrete. Recycled concrete aggregate (RCA) are aggregates obtained by recycling clean concrete waste where content of other building waste must be very low – below few percent. Locally available crushed angular recycled aggregates of 20mm down size confirming to IS2386- 1963 (Part 1, 2 & 3) was used for the work.

Table 2.1

Mix No.	Description
NW1 (Natural Water)	100% Natural Water
NW2	100% Natural Water + 50% RA
NW3	100% Natural Water + 40% RA
NW4	100% Natural Water + 30% RA
TW1 (Treated Water)	100% Treated Water
TW2	100% Treated Water + 50% RA
TW3	100% Treated Water + 40% RA
TW4	100% Treated Water + 30% RA
NWG1(GGBS with Natural Water Content)	100% Natural Water + 50% GGBS
NWG2	100% Natural Water + 50% GGBS + 50% RA
NWG3	100% Natural Water +50% GGBS + 40% RA
NWG4	100% Natural Water + 50% GGBS +30% RA
TWG1 (GGBS with Treated Waste Water Content)	100% Treated Water + 50% GGBS
TWG2	100% Treated Water + 50% GGBS +50% RA
TWG3	100% Treated Water + 50% GGBS +40% RA
TWG4	100% Treated Water +50% GGBS +30% RA

Fine Aggregate Locally available M sand belonging to Zone I of 383-1970 was used for the project work. In the present work, treated wastewater is used for both mixing of concrete. Tap water is fully replaced by tertiary treated wastewater and secondary treated wastewater for casting of concrete. Sample of treated wastewater collected in Chikkamagaluru. Various stages of experimental work is explained using the flow chart

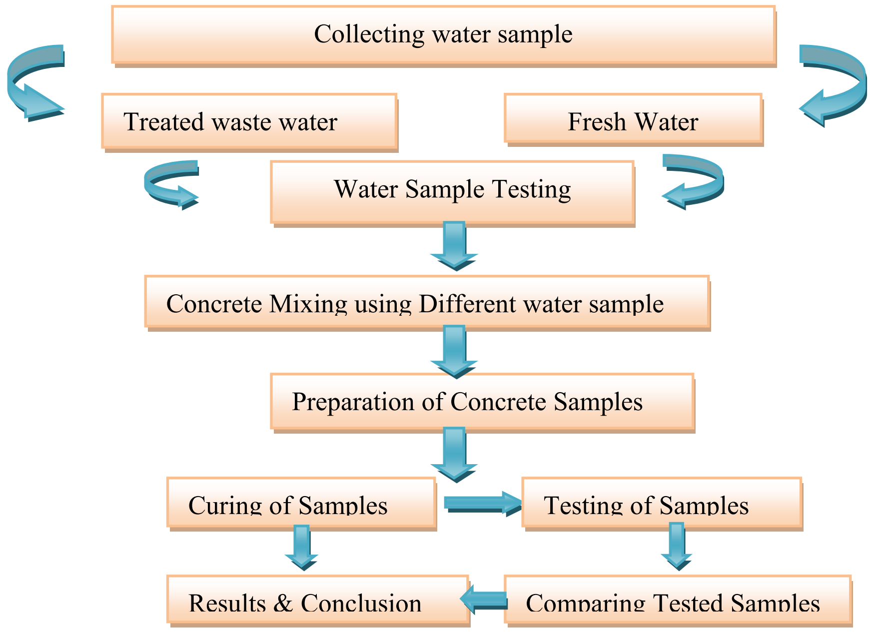

Table 2. 2

The properties of natural coarse aggregates and recycled coarse aggregates

Aggregates	Particle Size (mm)	Apparent Density (kg/m3)	Bulk Density (kg/m3)	Water Absorption (%)	Crushing Index (%)
Natural aggregates	–20	677	318	.9	.7
Recycled aggregates	–20	270	400	.0	1.0

Table 2.3

Mix No.	NFA	RP	NCA	GGBS	PC	NW	TW	WC
W1	03		100		56	28		.45
W2	02	02	100		56	28		.45
W3	62	42	100		56	28		.45
W4	22	81	100		56	28		.45
W1	03		100		56		28	.45
W2	02	02	100		56		28	.45
W3	62	42	100		56		28	.45
W4	22	81	100		56		28	.45
WG1	03		100	28	28	28		.45
WG2	02	02	100	28	28	28		.45
WG3	62	42	100	28	28	28		.45
WG4	22	81	100	28	28	28		.45
WG1	03		100	28	28		28	.45
WG2	02	02	100	28	28		28	.45
WG3	62	42	100	28	28		28	.45
WG4	22	81	100	28	28		28	.45

able 2. 4 Chemical **Physical properties of Portland cement (PC).**

Composition (%)	PC	Property	PC
CaO	64.7	Surface Area	300-450 m2/kg
SiO2	21.2	Setting time initial	80-200 min
Al2O3	5.1	Apparent particle density	3080-3180 kg/m3
MgO	0.9	Bulk Density Aerated	1000-1300 kg/m3

Fe2O3	2.5	Settled	1300-1450 kg/m3
K2O	0.2	Specific Gravity	3.15
SO3	1.5		

Table 2. 5 Chemical **Physical properties of Ground Granulated Blast furnace Slag (GGBS).**

Composition (%)	GBS	Property	GGBS
CaO	0	Fineness (m2/kg)	425
SiO2	5	Bulk Density (kg/m3)	1000-1100 (loose)
Al2O3	2	Specific Gravity	2.9
MgO	0		
Fe2O3	.2		

Table 2.6 Water quality analysis of Treated wastewater (TW) and natural water (NW).

PARAMETER	The Value of the Quality Standars	Normal Water	TWW
PH	7.5-8.5	7	7
BOD	6 PPM	<2	2.8
TSS	400PPM	<2	10.5
CL	250PPM	<2	293
COD	50PPM	<5	48

3. RESULTS AND DISCUSSIONS

In order to evaluate the feasibility of the mixes created using varying replacement percentage of surface modified recycled coarse aggregates (RCA) a slump test was conducted according to the guidelines of IS 1199-1959. The comparative result of slump and compacting factor values for concrete were obtained with natural water, treated water, plastic and using GGBS content. A slump of 50-100mm and 0.92-0.98 range of compaction factor form a concrete. The values are tabulated and all slump values are within the slump range. The replacement of different percentage of recycled aggregate with fine aggregates ie. Natural water with 30, 40 and 50% RA in NW mixes reduces the slump value with increasing the compacting factor.

Mix No.	Slump (mm)	Compacting Factor
NWG1	155	0.96
NWG2	66	0.95
NWG3	75	0.97
NWG4	80	0.98
TWG1	143	0.94
TWG2	63	0.95
TWG3	68	0.97
TWG4	77	0.96

Table 3.1: Slump and Compaction Factor Value

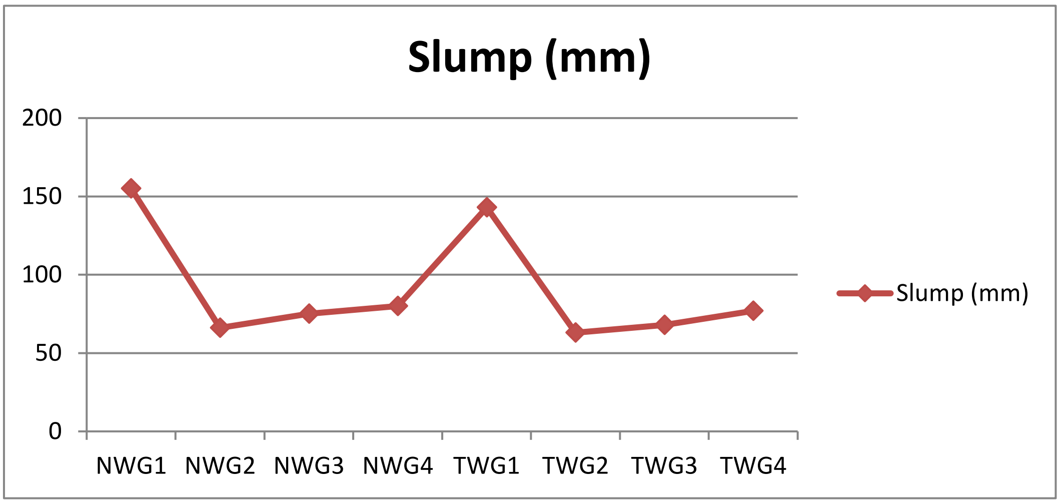

Fig 3.1: Slump (NW and TW) Values with 50% GGBS

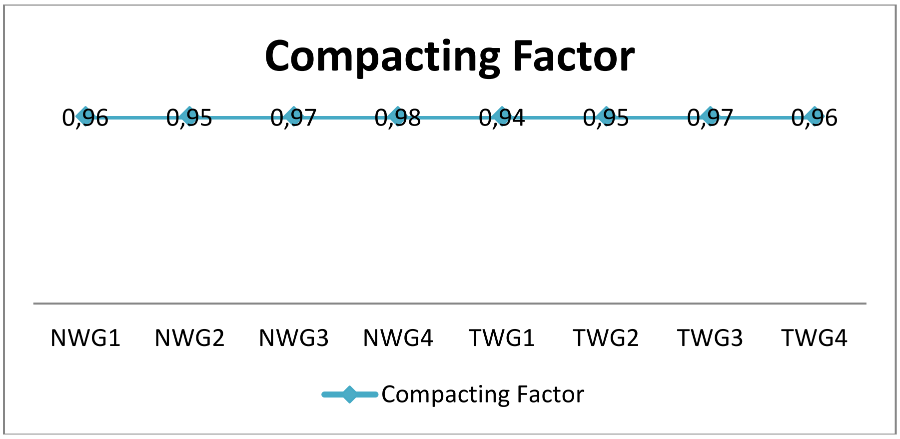

Fig 3.1: Compaction Factor NW and TW Values with 50% GGBS

The slump decreases by seeing the results. The NW2, NW3 and NW4 the reductions of slump are 58.2%, 50.40%, and 45.0% comparing with NW1 mix respectively. Because of non uniform shape there is reduction in slump. And also it can be observed that using waste water instead of potable water in fresh concrete increase the sludge content, creating a greater water absorption it results decrease in workability, However if the waste water is used before chlorination , only the setting time was increased without having any effect on slump values. Addition of of GGBS takes small amount of water by cement particles makes smooth and dense concrete that in turn decreases the slump values. The percentage of recycled aggregate along with GGBS marginal decrease in slump value is noticed for all the mixes. TWW with RA & GGBS decreased the slump value of the concrete mix except TWG3 mix is greater value of slump than TW3 concrete mix.

Mix No.	Slump (mm)	Compacting Factor
NW1	170	0.94
NW2	70	0.96
NW3	85	0.94
NW4	95	0.97
TW1	165	0.96
TW2	60	0.94
TW3	78	0.93
TW4	88	0.97

Table 3.2: Slump and Compaction Values of NW &TW

Compressive strength of the concrete mixes was cured in water tank. For each mixes three samples are made and tested. Three concrete cubes 150X150X150mm from each mix were analyzed and compressive strength of each mixes were applied on 1 day , 7 days , 14 days and 28 days.

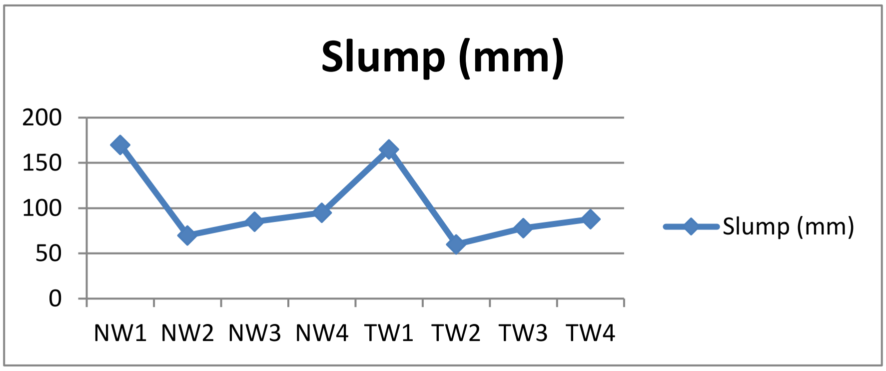

Fig3.2: Slump values of Treated wastewater (TW) and natural water (NW).

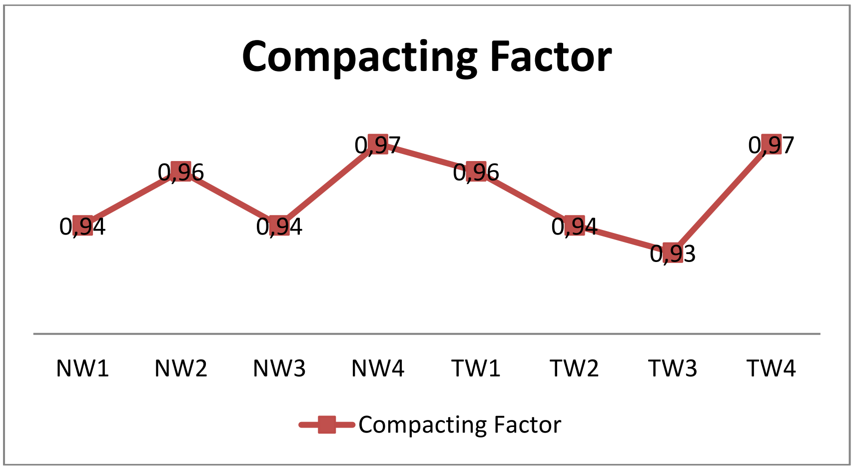

Fig3.3: Compaction Factor values of Treated wastewater (TW) and natural water (NW).

Results indicates that use of recycled aggregates mixes variations in that NW1 mix has higher compressive strength is 35 MPa. According to the results, confirm that 100% treated waste water gives similar compressive strength with 100% natural water content mixes at 28 day in curing age. It was seen that the compressive strength of concrete is reduced as 100% of treated wastewater is used. TW1 mix has higher compressive strength value in Group TW mixes, while mean of the compressive strength 37 N/mm2 with a coefficient of varia- tion is 33%. The strength mean and coefficient variation values are slightly similar with NW1 mix. On the other hand, TW2 mix has the lowest compressive strength from TW and NW groups having a mean strength of 13 N/mm2 with a coeffi- cient of variation 41%. However, TW3 and TW4 mixes have similar compressive strength values; 16 N/mm2 and 17.1 N/mm2 respectively with corresponding coefficient of variation fig- ures resulted as 35.7% (for TW3) and 33.33% (for TW4)

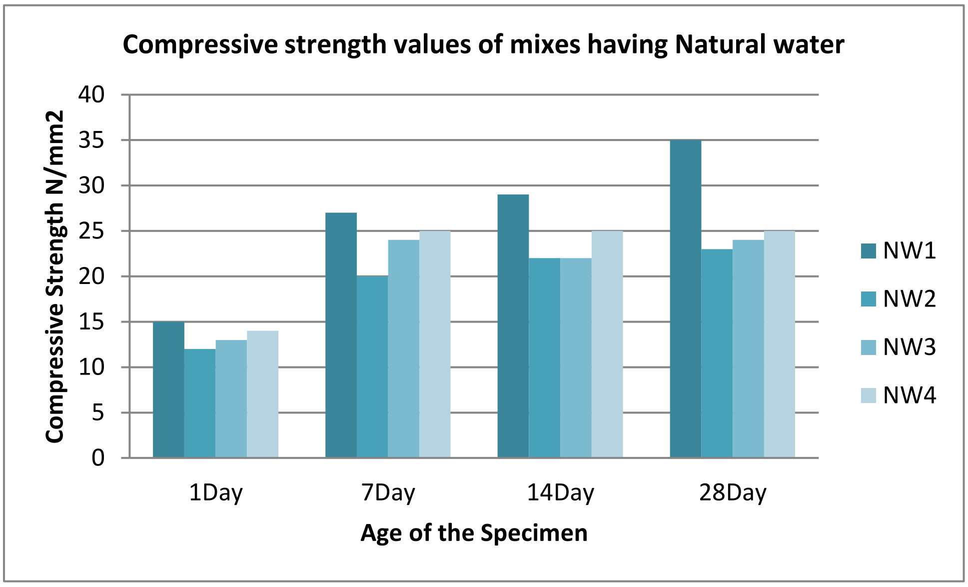

Fig 3.4 : Compressive strength values of mixes having Natural water

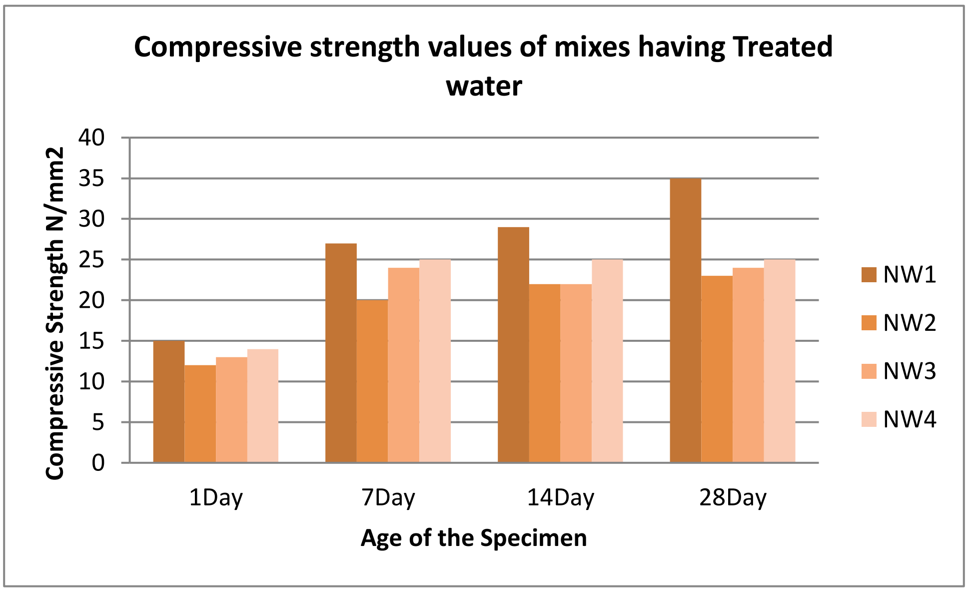

Fig3.5: Compressive strength values of mixes having Treated water

Mix No	Compressive Strength MPa			
	1Day	7D ay	14Day	28Day
NW1	15	27	29	35
NW2	12	20	22	23
NW3	13	24	22	24
NW4	14	25	25	25
TW1	15	28	30	37
TW2	8	15	14`	20
TW3	10	16	17	21
TW4	10	17	21	23
NWG1	7	21	27	31
NWG2	8	14	18	22
NWG3	6	15	20	24
NWG4	6	15	21	25
TWG1	7	18	24	31
TWG2	5	15	19	20
TWG3	5	13	15	22
TWG4	5	14	15	23

Table 3.3: Compressive Strength Values

Consequently, the compressive strength, Wu et al. [68] explained that this is particularly caused by the chemical features of treated waste water. Otherwise, compressive strength of GGBS is better after 28 days. This strength devel- opment depends on the usage percentage of GGBS replace- ment and concrete age. And also, Kumar Tiwari et al. [29] mentioned that the glassy compounds in GGBS react slowly with water and it takes time to obtain hydroxyl ions, except the hydration product of Portland cement to crack the glassy slag parcels at early age. However, when GGBS hydration and pozzolanic reaction is completed, compressive strength of GGBS concrete becomes more than traditional ordinary Port- land cement concrete (OPC)

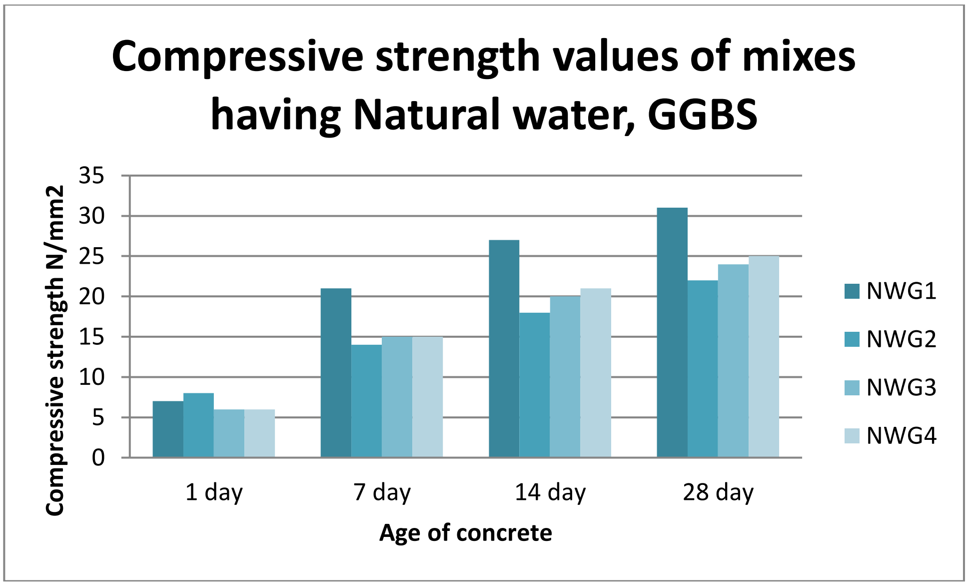

Fig3.6: Compressive strength values of mixes having NW&GGBS

The results of the compressive strength for using treated waste water with 50% GGBS and recycled aggregate mixes. It was found that the treated wastewater with GGBS and recycled aggregate concretes decrease the compressive strength more than any other type of concrete mix in 28 days at curing time.

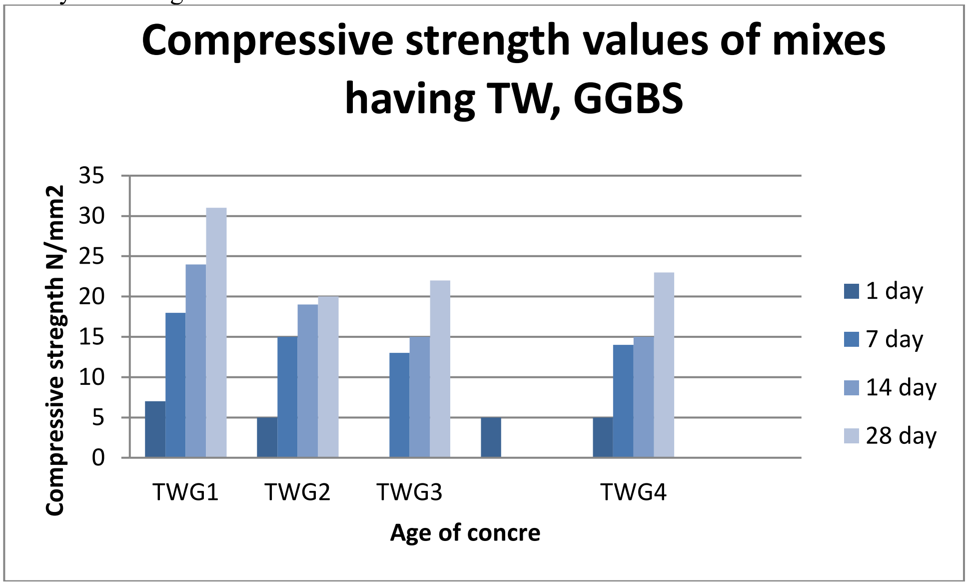

Fig3.7: Compressive strength values of mixes having TW&GGBS

TWG1 mix has higher compressive strength value in Group TWG mixes, while mean of the compressive strength is 27.5 MPa with a coefficient of variation is 31.97%. The strength mean and coefficient variation values are slightly similar with NW1 mix. On the other hand, TWG2 mix has the lowest reduces as the treated wastewater with GGBS and recycled plastic concretes are used, according to the other type of concrete mix (NW and NWG mixes) in 28 days at curing time. The compressive strength from TWG and NWG groups having a mean strength of 12 MPa with a coefficient of variation 48.11%. However, TWG3 and TWG4 mixes have similar compressive strength values; 15.25 MPa and 16.76 MPa respectively with corresponding coefficient of variation

CONCLUSION (10 PT)

- Recycled concrete aggregate can produce uniform quality products to meet the specification of quality recycled aggregate and consistent supply. There is also a significant argument that the laboratory test result showed that the compressive strength of recycled concrete can meet the requirements of high strength concrete standard.
- The result also indicated that the cost of recycled concrete were 10 percent less than those for natural concrete per m2, as well as saving the budget for disposal. This study has shown that recycled concrete aggregate with 50%GGBS is a useful resource and can be used in the production of high strength or high performance structural concrete subjected to the strength and durability testes, and had been shown to perform satisfactorily and in a comparable manner to concrete containing virgin aggregate.
- It is expected that this study could lead to a greater use of recycled concrete aggregate materials and its diversion from landfills. The consistency, initial and final setting time of cement by mixing treated waste water is within thr IS limit. The compressive strength of the concrete is increased by mixing treated waste water at the end of 7 days. The preliminary research findings suggested that significant difference do not exist between concrete cubes made of both treated waste water & portable water.

- Treated waste water can be used in the preparation of concrete for both casting & curing purpose without affecting the target mean strength of the concrete at the age of 28 days curing foe M-30 grade concrete. Workability of concrete is good. With the comparison of concrete prepared with treated waste water and portable water gives similar results. Low cost and environmental friendly concrete cab be produced by using treated waste water in concrete. Concrete cost can be reduced by using treated waste water in concrete.

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