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Effect Of Partial Replacement Of Cement With Ceramics Waste And Discarded Tyre As Coarse Aggregate On The Properties Of Concrete

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Abstract
Concrete is an artificial stone-like mass, it is a composite material that is created by mixing binding material (cement or lime) along with the aggregate (Sand, gravel, stone, brick chips, etc.), water, admixtures, e.t.c in specific proportions. The strength and quality are dependent on the mixing proportions. Concrete has been in existence for over 200year and over the Years efforts has been made to improve certain of its properties ranging from strength, appearance, ductility and corrosion resistance. This journal tries to determine the effect of partial replacement of cement with ceramics waste and coarse aggregate with discarded tyre on the properties of concrete. A controlled mix was done and then different sets of cubes were casted with the percentage of ceramics waste and discarded tyre added ranging from 5% to 20%. The cubes were crushed at 7days, 14days, 21days and 28days and the strength of the concrete was tabulated commensurate with the age of the concrete. Regression analysis was carried out on the ultimate strength in order to obtained a mathematical relationship between the percentage of ceramics waste at a given percentage of discarded tyre and the strength obtained. It was discovered from the equations of the line obtained from the plot that the strength of concrete keeps decreasing as the percentage of either the ceramics waste or discarded tyre keeps increasing.
Keywords: *Ceramics waste; Discarded Tyre; Concrete.*

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I. Introduction

Concrete is a composite material consist of mainly water, aggregate, and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mixture [1]. The strength and quality are dependent on the mixing proportions. The formula for producing concrete from its ingredients can be presented in the following equation: **Concrete** = Binding Material + Fine & Coarse Aggregate + Water + Admixture (optional) [2,3]. A solid mass that can be easily moulded into desired shape can be formed by mixing these ingredients in certain proportions. Over the time, a hard matrix formed by cement binds the rest of the ingredients together into a single hard (rigid) durable material with many uses such as buildings, pavements etc., The technology of using concrete was adopted earlier on large-scale by the ancient Romans, and the major part of concrete technology was highly used in the Roman Empire [1]. The colosseum in Rome was built largely of concrete and the dome of the pantheon is the World's largest unreinforced concrete structure [1-3]. After the collapse of Roman Empire in the mid-18th century, the technology was re-pioneered as the usage of concrete has become rare. Today, the widely used man made material is concrete in terms of tonnage [1]. Because of the wide use of concrete, a lot of experiments has been carried out to determine the effect of fully or partially replacement of its constituents. One of these experiments is the Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete. The use of Silica Fume (SF) in short period of time had one of the most dramatic impacts on the industry's ability to routinely and commercially produce SF modified concrete of flowable in nature but yet remain cohesive, which in turn would develop both high early and high later-age strengths including resistant to aggressive environments [4]. Another researched carried out tries to determine the Impact of Partial Replacement of Cement with Polymethyl Methacrylate on the Compressive Strength of Concrete in that research, it was determined that at 4% of cement gives a higher strength of cube [5]. For the purpose of this research, we intend to determine the effect of partial replacement of cement with ceramics waste and discarded tyre as coarse aggregate on the properties of concrete.

II. Materials And Methods

Different Sets of cubes were casted varying the proportion of the ceramics waste in the cement and also varying the proportion of the shredded tyre in the coarse aggregate trying to capture all possible combinations of the effects of their partial replacements as shown in the table below.

Fig 3.1 Mixture of Cement + ceramics, fine Aggregates and Coarse Aggregate + tyre

Fig 3.2 Compacting Factor Test

Fig 3.4 Concrete Cubes Before Demoulding

Fig 3.5 Curing of cubes

Fig 3.6 Crushing of cubes

Fig 3.1 Table of percentage of mix of ceramics and discarded tyre added

EFFECT OF PARTIAL REPLACEMENT OF CEMENT WITH CERAMICS WASTE AND DISCARDED							
SPECIMEN ID	CERAMICS+ CEMENT			FINE AGGREGATE	CRUSH ROCK + TYRE CONTENT(%)		
	CERAMICS (%)	CEMENT (%)	TOTAL (%)		ROCK (%)	TYRE (%)	TOTAL (%)
0% DT , 0% CW	0	100	100	100	0	100	100
0% DT , 5% CW	5	95	100	100	0	100	100
0% DT , 10% CW	10	90	100	100	0	100	100
0% DT , 15% CW	15	85	100	100	0	100	100
0% DT , 20% CW	20	80	100	100	0	100	100
5% DT , 0% CW	0	100	100	100	5	95	100
5% DT , 5% CW	5	95	100	100	5	95	100
5% DT , 10% CW	10	90	100	100	5	95	100
5% DT , 15% CW	15	85	100	100	5	95	100
5% DT , 20% CW	20	80	100	100	5	95	100
10% DT , 0% CW	0	100	100	100	10	90	100
10% DT , 5% CW	5	95	100	100	10	90	100
10% DT , 10% CW	10	90	100	100	10	90	100
10% DT , 15% CW	15	85	100	100	10	90	100
10% DT , 20% CW	20	80	100	100	10	90	100
15% DT , 0% CW	0	100	100	100	15	85	100
15% DT , 5% CW	5	95	100	100	15	85	100
15% DT , 10% CW	10	90	100	100	15	85	100
15% DT , 15% CW	15	85	100	100	15	85	100
15% DT , 20% CW	20	80	100	100	15	85	100
20% DT , 0% CW	0	100	100	100	20	80	100
20% DT , 5% CW	5	95	100	100	20	80	100
20% DT , 10% CW	10	90	100	100	20	80	100
20% DT , 15% CW	15	85	100	100	20	80	100

From each set of the 12 cubes, 3 numbers were crushed at 7 days, another 3 were crushed at 14days, 3 again at 21 days and finally another 3 at 28 days. The results obtained were tabulated appropriately. 2 cubes were taken from each set for fire resistance test and 2 were kept for ductility test. All results obtained were tabulated appropriately.

Table 4.1 Oxide Composition of Ceramics waste

S/N	Elemental Oxides	% Composition Ceramic Waste
1	CaO	12.18
2	SiO_2	56.04
3	AL_2O_3	16.38
4	Fe_2o_3	4.88
5	MgO	3.73
6	SO_3	2.08
7	Na_2O	1.37
8	K_20	3.09
9	P_2O_5	0.18
10	TiO_2	0.58
11	MnO	0.15
12	*LOSS OF IGNITION*	0.00

Sieve Analysis of fine Aggregate

The table below shows the result of the particle size analysis of the fine aggregate.

Table 4.2 Particle size analysis of fine Aggregate

Sieve Sizes (mm)	Weight Retained	% Weight Passing through	Cumulative % weight Retained	% Passing
4.77	0.00	0.00	0.00	100.00
2.35	0.00	0.00	0.00	100.00
1.18	0.00	0.00	0.00	100.00
0.6	1.71	0.34	0.34	99.65
0.425	1.60	0.32	0.66	99.34
0.3	9.20	1.84	2.50	97.30
0.212	92.60	18.52	21.02	79.98
0.15	332.70	66.54	87.56	12.44
0.075	36.60	7.32	94.88	5.14
Pan	5.60	1.12	96.00	4.00

Percentage passing No. 200 BS = $\frac{499-480}{499} = \frac{19}{499} = 0.03$

0.03 x 100 = 3%

Percentage (%) retained on size number 200 BS sieve = 100 – 3 = 97 %

Sand moisture Content (fine aggregate)

The table below show the result of the moisture content carried out on the fine aggregate

Table 4.3 Fine Aggregate Moisture Content

Container No.	KC	MB	UF
Mass of Container (M1)	20.63	20.14	23.01
Mass of Container + wet Sand (M2)	35.23	20.14	23.01
Mass of Container + Dry Sand (M3)	34.35	29.89	29.08
Mass of dry sand (M3 – M1) = M5	13.72	9.75	6.07
Mw = Mass of sand (M2 – M3)	0.87	0.85	0.76
Moisture Content = W (Ww/Ws)*100	6.34	8.71	12.52

Average W = 10.04

Moisture Content of Sand = 10.04

Specific gravity of fine aggregate
M1 = 21g
M2 = 53g
M3 = 82g
M3 = 63g

$$\mathrm{Gs} = \frac{(M2 - M1)}{(M4 - M1) - (M3 - M4)}$$

$$Gs = \frac{(53 - 21)}{(63 - 21) - (82 - 53)}$$

= 2.67

Sieve Analysis of Coarse Aggregate
The table below shows the result of the particle size analysis of the coarse aggregate.

Table 4.4 Particle size Analysis of Coarse Aggregate

Sieve Sizes (mm)	Weight Retained	% Weight Passing through	Percentage Passing Through
19	0	500	100
13.5	112	388	77.7
9.5	235	154	30.5
4.75	67	87	17.3
2.56	43	43	8.6
1.18	10	33	6.6
0.6	6	26	5.3
0.3	7	20	4
0.15	9	12	2.2
0.075	1.1	9.8	1.97

Specific gravity of Coarse aggregate
M1 = 206g
M2 = 69.9g
M3 = 1065g
M3 = 754g

$$\mathrm{Gs} = \frac{(M2 - M1)}{(M4 - M1) - (M3 - M4)}$$

$$Gs = \frac{(697 - 206)}{(754 - 206) - (1065 - 677)}$$

= 2.72

Stone moisture Content (Coarse aggregate)
The Table below shows the moisture content of the coarse aggregate.

Table 4.4 Moisture Content of Coarse Aggregate

Container No.	AC	B2	QM
Mass of Container (M1)	25.75	30.46	30.34
Mass of Container + wet Sand (M2)	49.30	52.58	55.48
Mass of Container + Dry Sand (M3)	48.35	51.60	54.49
Mass of dry sand (M3 – M1) = M5	22.00	21.05	24.18
Mw = Mass of sand (M2 – M3)	0.95	0.98	0.99
Moisture Content = W (Ww/Ws)*100	4.31	4.65	4.09

Average W = 13.15
Moisture Content of Sand = 13.15

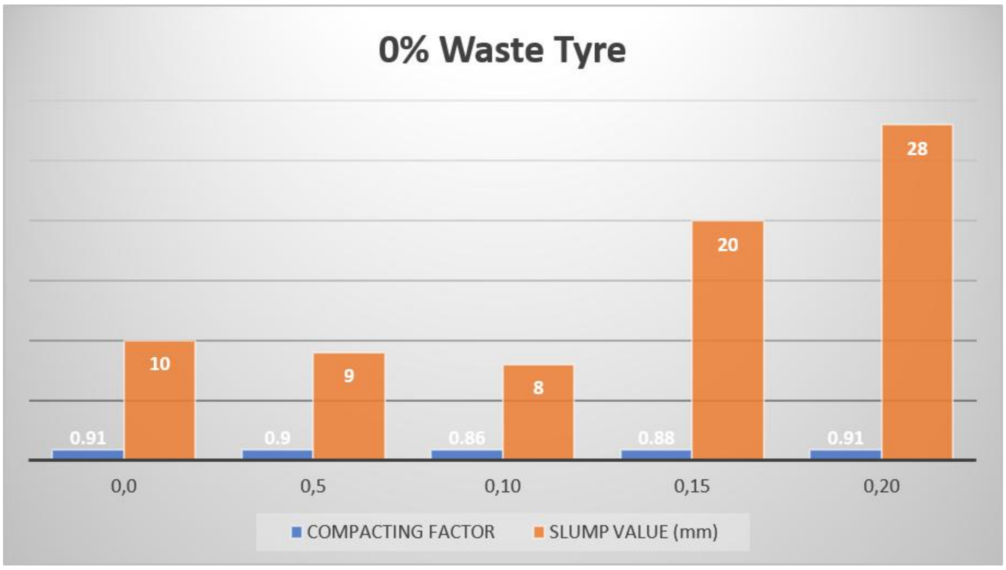
CONCRETE ANALYSIS
Fresh Concrete Analysis

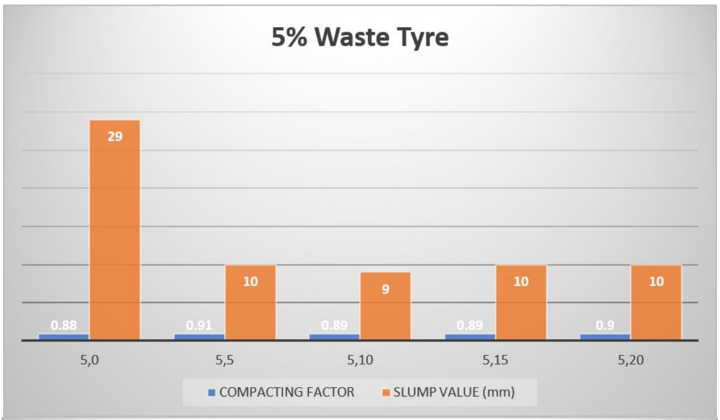
The table below shows the results obtained from the slump test and the compaction factor test carried out on the samples.

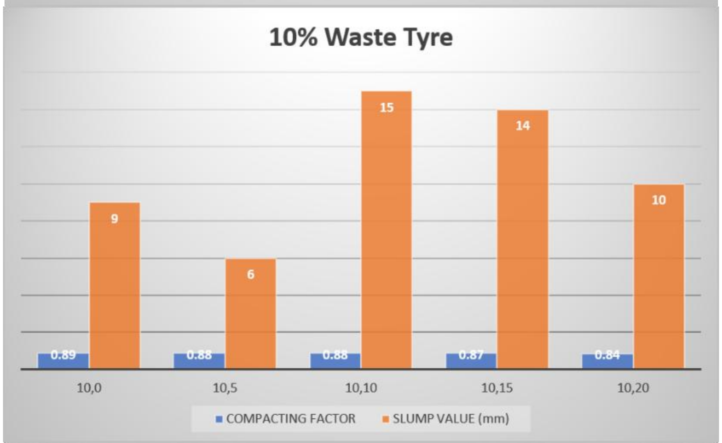
Table 4.5 The Table Slump and Compacting factor of the Fresh

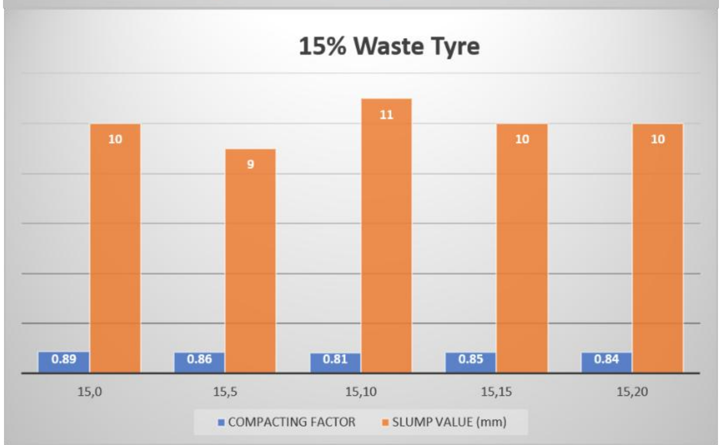
% Replacement (Dt & Cw)	Weight Of Partially Compacted Concrete	Weight Of Fully Compacted Concrete	Compactin G Factor	Slump Value (Mm)	Stamp Type
0,0	15535	17163	0.91	10	Zero
0,5	15428	17072	0.9	9	Zero
0,10	14620	17046	0.86	8	Zero
0,15	15042	17072	0.88	20	Zero
0,20	15532	17022	0.91	28	Zero
5,0	15046	17056	0.88	29	Zero
5,5	15038	16547	0.91	10	Zero
5,10	14857	16717	0.89	9	Zero
5,15	14846	16720	0.89	10	Zero
5,20	14856	16578	0.9	10	Zero
10,0	14845	16648	0.89	9	Zero
10,5	14398	16385	0.88	6	Zero
10,10	14308	16345	0.88	15	Zero
10,15	14208	16340	0.87	14	Zero
10,20	13659	16343	0.84	10	Zero
15,0	14533	16382	0.89	10	Zero
15,5	13876	16068	0.86	9	Zero
15,10	13826	17085	0.81	11	Zero
15,15	13829	16306	0.85	10	Zero
15,20	13566	16095	0.84	10	Zero
20,0	14140	16130	0.88	9	Zero
20,5	14600	15848	0.92	10	Zero
20,10	14055	15662	0.9	10	Zero
20,15	14340	16062	0.89	10	Zero
20,20	15190	16010	0.95	14	Zero

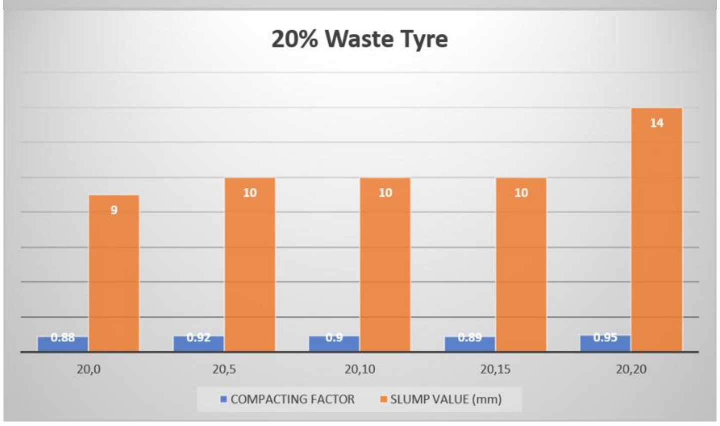
Below are the bar charts representing the slump and the compacting factor of each of the samples.











Hardened Concrete Analysis

The table below shows the analysis of results of the crushing strength of the various sets of concrete cubes at the standard ages of 7days, 14days, 21 days and 28 days.

Table 4.5 Strength of the various grades of Concrete.

SPECIMEN ID		DATE CASTED	DATE TESTED	AGE AT TESTING (Days)	MASS OF SPECIMEN (g)	AVE. MASS OF SPECEMEN (g)	DENSITY OF SPECIMEN	LOAD AT FAILURE (KN)	AVE. LOAD AT FAILURE	STRENGTH (N/mm²)
	1	14-11-23	21-11-23	7	2586			230		
	2	14-11-23	21-11-23	7	2515	2540.0	25.4	235	235	23.50
	3	14-11-23	21-11-23	7	2519			240		
	4	14-11-23	28-11-23	14	2536			328		
	5	14-11-23	28-11-23	14	2470	2515.7	25.2	329	329	32.87
	6	14-11-23	28-11-23	14	2541			329		
0% DT , 0% CW	7	14-11-23	5-12-23	21	2573			340		
	8	14-11-23	5-12-23	21	2587	2569.7	25.7	340	340	34.00
	9	14-11-23	5-12-23	21	2549			340		
	10	14-11-23	12-12-23	28	2598			361		
	11	14-11-23	12-12-23	28	2569	2580.7	25.8	360	360	36.03
	12	14-11-23	12-12-23	28	2575			360		
	13	14-11-23	21-11-23	7	2652			235		
	14	14-11-23	21-11-23	7	2687	2668.0	26.7	231	233	23.33
	15	14-11-23	21-11-23	7	2665			234		
	16	14-11-23	28-11-23	14	2587			346		
	17	14-11-23	28-11-23	14	2589	2579.0	25.8	352	348	34.83
	18	14-11-23	28-11-23	14	2561			347		
0% DT , 5% CW	19	14-11-23	5-12-23	21	2490			360		
	20	14-11-23	5-12-23	21	2419	2469.7	24.7	359	360	35.97
	21	14-11-23	5-12-23	21	2500			360		
	22	14-11-23	12-12-23	28	2505			360		
	23	14-11-23	12-12-23	28	2552	2551.7	25.5	361	361	36.10
	24	14-11-23	12-12-23	28	2598			362		
	25	14-11-23	21-11-23	7	2626			236		
	26	14-11-23	21-11-23	7	2519	2560.7	25.6	234	234	23.37
	27	14-11-23	21-11-23	7	2537			231		
	28	14-11-23	28-11-23	14	2569			338		
10% CW	29	14-11-23	28-11-23	14	2526	2553.7	25.5	340	340	33.97
	30	14-11-23	28-11-23	14	2566			341		

0% DT ,	31	14-11-23	5-12-23	21	2510			351		
	32	14-11-23	5-12-23	21	2520	2511.7	25.1	351	351	35.10
	33	14-11-23	5-12-23	21	2505			351		
	34	14-11-23	12-12-23	28	2538			349		
	35	14-11-23	12-12-23	28	2552	2560.0	25.6	349	349	34.93
	36	14-11-23	12-12-23	28	2590			350		
0% DT , 15% CW	37	14-11-23	21-11-23	7	2616			233		
	38	14-11-23	21-11-23	7	2595	2591.3	25.9	232	233	23.30
	39	14-11-23	21-11-23	7	2563			234		
	40	14-11-23	28-11-23	14	2536			341		
	41	14-11-23	28-11-23	14	2515	2542.3	25.4	340	337	33.67
	42	14-11-23	28-11-23	14	2576			329		
	43	14-11-23	5-12-23	21	2526			347		
	44	14-11-23	5-12-23	21	2409	2455.3	24.6	348	348	34.77
	45	14-11-23	5-12-23	21	2431			348		
	46	14-11-23	12-12-23	28	2490			348		
	47	14-11-23	12-12-23	28	2510	2501.7	25.0	348	348	34.83
	48	14-11-23	12-12-23	28	2505			349		
0% DT , 20% CW	49	15-11-23	22-11-23	7	2450			231		
	50	15-11-23	22-11-23	7	2446	2457.0	24.6	232	231	23.13
	51	15-11-23	22-11-23	7	2475			231		
	52	15-11-23	29-11-23	14	2495			323		
	53	15-11-23	29-11-23	14	2668	2616.3	26.2	304	311	31.10
	54	15-11-23	29-11-23	14	2686			306		
	55	15-11-23	6-12-23	21	2526			320		
	56	15-11-23	6-12-23	21	2425	2478.7	24.8	320	318	31.77
	57	15-11-23	6-12-23	21	2485			313		
	58	15-11-23	13-12-23	28	2575			319		
	59	15-11-23	13-12-23	28	2522	2537.3	25.4	319	319	31.87
	60	15-11-23	13-12-23	28	2515			318		
	61	15-11-23	22-11-23	7	2504			199		
	62	15-11-23	22-11-23	7	2507	2472.7	24.7	198	198	19.83
	63	15-11-23	22-11-23	7	2407			198		
	64	15-11-23	29-11-23	14	2465			282		

5% DT , 0% CW	65	15-11-23	29-11-23	14	2496	2498.7	25.0	283	283	28.30
	66	15-11-23	29-11-23	14	2535			284		
	67	15-11-23	6-12-23	21	2434	2443.7	24.4	292	292	29.17
	68	15-11-23	6-12-23	21	2451			292		
	69	15-11-23	6-12-23	21	2446			291		
	70	15-11-23	13-12-23	28	2465	2461.7	24.6	310	311	31.07
	71	15-11-23	13-12-23	28	2447			311		
	72	15-11-23	13-12-23	28	2473			311		
5% DT , 5% CW	73	15-11-23	22-11-23	7	2456	2400.0	24.0	207	208	20.77
	74	15-11-23	22-11-23	7	2356			208		
	75	15-11-23	22-11-23	7	2388			208		
	76	15-11-23	29-11-23	14	2461	2484.0	24.8	292	291	29.13
	77	15-11-23	29-11-23	14	2469			291		
	78	15-11-23	29-11-23	14	2522			291		
	79	15-11-23	6-12-23	21	2446	2437.7	24.4	300	301	30.07
	80	15-11-23	6-12-23	21	2435			300		
	81	15-11-23	6-12-23	21	2432			302		
	82	15-11-23	13-12-23	28	2469	2455.3	24.6	321	320	32.03
	83	15-11-23	13-12-23	28	2461			320		
	84	15-11-23	13-12-23	28	2436			320		
5% DT , 10% CW	85	15-11-23	22-11-23	7	2465	2454.7	24.5	205	205	20.53
	86	15-11-23	22-11-23	7	2423			206		
	87	15-11-23	22-11-23	7	2476			205		
	88	15-11-23	29-11-23	14	2463	2441.0	24.4	289	288	28.80
	89	15-11-23	29-11-23	14	2427			288		
	90	15-11-23	29-11-23	14	2433			287		
	91	15-11-23	6-12-23	21	2466	2446.3	24.5	300	299	29.93
	92	15-11-23	6-12-23	21	2467			299		
	93	15-11-23	6-12-23	21	2406			299		
	94	15-11-23	13-12-23	28	2447	2459.3	24.6	318	319	31.87
	95	15-11-23	13-12-23	28	2465			319		
	96	15-11-23	13-12-23	28	2466			319		
	97	16-11-23	23-11-23	7	2466	2474.7	24.7	168	168	16.80
	98	16-11-23	23-11-23	7	2492			168		

5% DT , 15% CW	99	16-11-23	23-11-23	7	2466			168		
	100	16-11-23	30-11-23	14	2459			234		
	101	16-11-23	30-11-23	14	2449	2451.3	24.5	234	234	23.40
	102	16-11-23	30-11-23	14	2446			234		
	103	16-11-23	7-12-23	21	2426			243		
	104	16-11-23	7-12-23	21	2446	2482.3	24.8	244	244	24.37
	105	16-11-23	7-12-23	21	2575			244		
	106	16-11-23	14-12-23	28	2482			259		
	107	16-11-23	14-12-23	28	2343	2431.3	24.3	259	259	25.87
	108	16-11-23	14-12-23	28	2469			258		
5% DT , 20% CW	109	16-11-23	23-11-23	7	2426			186		
	110	16-11-23	23-11-23	7	2426	2456.7	24.6	188	187	18.73
	111	16-11-23	23-11-23	7	2518			188		
	112	16-11-23	30-11-23	14	2466			261		
	113	16-11-23	30-11-23	14	2483	2470.3	24.7	262	262	26.17
	114	16-11-23	30-11-23	14	2462			262		
	115	16-11-23	7-12-23	21	2432			269		
	116	16-11-23	7-12-23	21	2426	2434.3	24.3	269	269	26.90
	117	16-11-23	7-12-23	21	2445			269		
	118	16-11-23	14-12-23	28	2467			285		
	119	16-11-23	14-12-23	28	2499	2497.3	25.0	285	285	28.50
	120	16-11-23	14-12-23	28	2526			285		
10% DT , 0% CW	121	16-11-23	23-11-23	7	2345			144		
	122	16-11-23	23-11-23	7	2317	2345.7	23.5	145	145	14.47
	123	16-11-23	23-11-23	7	2375			145		
	124	16-11-23	30-11-23	14	2453			219		
	125	16-11-23	30-11-23	14	2316	2378.3	23.8	220	220	21.97
	126	16-11-23	30-11-23	14	2366			220		
	127	16-11-23	7-12-23	21	2446			234		
	128	16-11-23	7-12-23	21	2327	2387.3	23.9	235	235	23.47
	129	16-11-23	7-12-23	21	2389			235		
	130	16-11-23	14-12-23	28	2456			241		
	131	16-11-23	14-12-23	28	2499	2478.0	24.8	241	241	24.10
	132	16-11-23	14-12-23	28	2479			241		

10% DT , 5% CW	133	16-11-23	23-11-23	7	2275			157		
	134	16-11-23	23-11-23	7	2282	2317.7	23.2	157	157	15.70
	135	16-11-23	23-11-23	7	2396			157		
	136	16-11-23	30-11-23	14	2367			209		
	137	16-11-23	30-11-23	14	2465	2384.7	23.8	209	209	20.93
	138	16-11-23	30-11-23	14	2322			210		
	139	16-11-23	7-12-23	21	2432			211		
	140	16-11-23	7-12-23	21	2447	2441.7	24.4	211	211	21.13
	141	16-11-23	7-12-23	21	2446			212		
	142	16-11-23	14-12-23	28	2496			225		
	143	16-11-23	14-12-23	28	2422	2457.0	24.6	225	225	22.47
	144	16-11-23	14-12-23	28	2453			224		
10% DT , 10% CW	145	17-11-23	24-11-23	7	2342			156		
	146	17-11-23	24-11-23	7	2306	2340.0	23.4	157	157	15.67
	147	17-11-23	24-11-23	7	2372			157		
	148	17-11-23	1-12-23	14	2350			206		
	149	17-11-23	1-12-23	14	2391	2361.0	23.6	205	205	20.50
	150	17-11-23	1-12-23	14	2342			204		
	151	17-11-23	8-12-23	21	2334			211		
	152	17-11-23	8-12-23	21	2496	2445.3	24.5	212	212	21.20
	153	17-11-23	8-12-23	21	2506			213		
	154	17-11-23	15-12-23	28	2420			224		
	155	17-11-23	15-12-23	28	2402	2376.7	23.8	225	225	22.47
	156	17-11-23	15-12-23	28	2308			225		
10% DT , 15% CW	157	17-11-23	24-11-23	7	2343			150		
	158	17-11-23	24-11-23	7	2316	2347.0	23.5	151	152	15.17
	159	17-11-23	24-11-23	7	2382			154		
	160	17-11-23	1-12-23	14	2306			192		
	161	17-11-23	1-12-23	14	2286	2352.7	23.5	193	193	19.30
	162	17-11-23	1-12-23	14	2466			194		
	163	17-11-23	8-12-23	21	2416			199		
	164	17-11-23	8-12-23	21	2356	2406.0	24.1	199	200	20.00
	165	17-11-23	8-12-23	21	2446			202		
	166	17-11-23	15-12-23	28	2446			212		

	167	17-11-23	15-12-23	28	2428	2404.0	24.0	212	213	21.27
	168	17-11-23	15-12-23	28	2338			214		
10% DT , 20% CW	169	17-11-23	24-11-23	7	2324	2322.0	23.2	135	135	13.53
	170	17-11-23	24-11-23	7	2306			136		
	171	17-11-23	24-11-23	7	2336			135		
	172	17-11-23	1-12-23	14	2342	2344.3	23.4	178	178	17.77
	173	17-11-23	1-12-23	14	2346			178		
	174	17-11-23	1-12-23	14	2345			177		
	175	17-11-23	8-12-23	21	2313	2292.3	22.9	185	186	18.60
	176	17-11-23	8-12-23	21	2268			186		
	177	17-11-23	8-12-23	21	2296			187		
	178	17-11-23	15-12-23	28	2448	2419.3	24.2	192	193	19.30
	179	17-11-23	15-12-23	28	2482			193		
	180	17-11-23	15-12-23	28	2328			194		
15% DT , 0% CW	181	17-11-23	24-11-23	7	2320	2366.3	23.7	131	132	13.17
	182	17-11-23	24-11-23	7	2390			132		
	183	17-11-23	24-11-23	7	2389			132		
	184	17-11-23	1-12-23	14	2349	2387.7	23.9	181	182	18.17
	185	17-11-23	1-12-23	14	2458			182		
	186	17-11-23	1-12-23	14	2356			182		
	187	17-11-23	8-12-23	21	2353	2294.7	22.9	192	192	19.17
	188	17-11-23	8-12-23	21	2282			191		
	189	17-11-23	8-12-23	21	2249			192		
	190	17-11-23	15-12-23	28	2316	2313.3	23.1	195	195	19.50
	191	17-11-23	15-12-23	28	2342			195		
	192	17-11-23	15-12-23	28	2282			195		
.5% DT , 5% CW	193	18-11-23	25-11-23	7	2399	2381.0	23.8	101	101	10.13
	194	18-11-23	25-11-23	7	2378			102		
	195	18-11-23	25-11-23	7	2366			101		
	196	18-11-23	2-12-23	14	2358	2388.3	23.9	141	141	14.13
	197	18-11-23	2-12-23	14	2348			141		
	198	18-11-23	2-12-23	14	2459			142		
	199	18-11-23	9-12-23	21	2379	2431.0	24.3	147	147	14.67
	200	18-11-23	9-12-23	21	2486			146		

1	201	18-11-23	9-12-23	21	2428			147		
	202	18-11-23	16-12-23	28	2338			155		
	203	18-11-23	16-12-23	28	2382	2391.3	23.9	155	156	15.63
	204	18-11-23	16-12-23	28	2454			159		
15% DT , 10% CW	205	18-11-23	25-11-23	7	2238			107		
	206	18-11-23	25-11-23	7	2339	2277.7	22.8	107	108	10.77
	207	18-11-23	25-11-23	7	2256			109		
	208	18-11-23	2-12-23	14	2328			150		
	209	18-11-23	2-12-23	14	2316	2346.7	23.5	152	151	15.13
	210	18-11-23	2-12-23	14	2396			152		
	211	18-11-23	9-12-23	21	2338			155		
	212	18-11-23	9-12-23	21	2246	2293.3	22.9	155	156	15.60
	213	18-11-23	9-12-23	21	2296			158		
	214	18-11-23	16-12-23	28	2239			165		
	215	18-11-23	16-12-23	28	2356	2271.7	22.7	164	165	16.53
	216	18-11-23	16-12-23	28	2220			167		
15% DT , 15% CW	217	18-11-23	25-11-23	7	2316			106		
	218	18-11-23	25-11-23	7	2269	2310.3	23.1	109	108	10.77
	219	18-11-23	25-11-23	7	2346			108		
	220	18-11-23	2-12-23	14	2386			148		
	221	18-11-23	2-12-23	14	2259	2344.7	23.4	147	147	14.70
	222	18-11-23	2-12-23	14	2389			146		
	223	18-11-23	9-12-23	21	2266			153		
	224	18-11-23	9-12-23	21	2276	2266.0	22.7	155	154	15.40
	225	18-11-23	9-12-23	21	2256			154		
	226	18-11-23	16-12-23	28	2296			164		
	227	18-11-23	16-12-23	28	2218	2308.0	23.1	165	165	16.53
	228	18-11-23	16-12-23	28	2410			167		
20% CW	229	18-11-23	25-11-23	7	2359			112		
	230	18-11-23	25-11-23	7	2340	2345.7	23.5	114	112	11.20
	231	18-11-23	25-11-23	7	2338			110		
	232	18-11-23	2-12-23	14	2480			153		
	233	18-11-23	2-12-23	14	2408	2432.3	24.3	158	156	15.60
	234	18-11-23	2-12-23	14	2409			157		

Below is the output of the regression analysis of the results obtained.

Output for the Regression analysis at 0% Addition of Tyre Waste

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.920450721
R Square	0.847229529
Adjusted R Square	0.770844294
Standard Error	0.866121623
Observation	4

ANOVA

	df	SS	MS	F	Significance F
Regression	1	8.3205	8.3205	11.09154	0.079549279
Residual	2	1.500333333	0.750167		
Total	3	9.820833333			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	ower 95.0%	Jpper 95.0%
Intercept	37.66666667	1.060778016	35.50853	0.000792	33.10250724	42.23083	33.10251	42.23083
0% DT	-0.258	0.077468273	-3.3304	0.079549	-0.591319077	0.075319	-0.59132	0.075319

RESIDUAL OUTPUT

Observation	Predicted 28days	Residuals
1	36.37666667	-0.276666667
2	35.08666667	-0.086666667
3	33.79666667	1.003333333
4	32.50666667	-0.64

Output for the Regression analysis at 5% Addition of Tyre Waste is as below

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.670976858
R Square	0.450209943
Adjusted R Square	0.266946591
Standard Error	2.232786003
Observations	5

ANOVA

	df	SS	MS	F	ignificance F
Regression	1	12.24711111	12.24711	2.456628	0.215022
Residual	3	14.956	4.985333		
Total	4	27.20311111			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	ower 95.0%	Jpper 95.0%
Intercept	32.08666667	1.729508601	18.55248	0.000342	26.5826	37.59073	26.5826	37.59073
5% DT	-0.221333333	0.141213786	-1.56736	0.215022	-0.67074	0.228072	-0.67074	0.228072

RESIDUAL OUTPUT

Observation	Predicted 28days	Residuals
1	32.08666667	-0.986666667
2	30.98	1.02
3	29.87333333	1.893333333
4	28.76666667	-2.9
5	27.66	0.973333333

Output for the Regression analysis at 10% Addition of Tyre Waste is as below

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.963704
R Square	0.928725
Adjusted R Square	0.904966
Standard Error	0.554677
Observations	5

ANOVA

	df	SS	MS	F	ignificance F
Regression	1	12.02678	12.02678	39.09029	0.008256
Residual	3	0.923	0.307667		
Total	4	12.94978			

	Coefficients	andard Err	t Stat	P-value	Lower 95%	Upper 95%	ower 95.0%	Jpper 95.0%
Intercept	24.1	0.429651	56.09203	1.25E-05	22.73266	25.46734	22.73266	25.46734
10% DT	-0.21933	0.035081	-6.25222	0.008256	-0.33098	-0.10769	-0.33098	-0.10769

RESIDUAL OUTPUT

Observation	dicted 28d	Residuals
1	24.1	0.1
2	23.00333	-0.60333
3	21.90667	0.526667
4	20.81	0.356667
5	19.71333	-0.38

Output for the Regression analysis at 15% Addition of Tyre Waste is as below

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.401655886
R Square	0.161327451
Adjusted R Square	-0.118230066
Standard Error	1.609600825
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.495111	1.495111	0.577081	0.502700014
Residual	3	7.772444	2.590815		
Total	4	9.267556			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Upper 95.0%*
Intercept	17.76666667	1.246791	14.24991	0.000749	13.79881986	21.73451	13.79882	21.73451
15% DT	-0.077333333	0.1018	-0.75966	0.5027	-0.401306668	0.24664	-0.40131	0.24664

RESIDUAL OUTPUT

Observation	*Predicted 28days*	*Residuals*
1	17.76666667	1.733333
2	17.38	-1.88
3	16.99333333	-0.49333
4	16.60666667	-0.30667
5	16.22	0.946667

Output for the Regression analysis at 20% Addition of Tyre Waste is as below

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.777817459
R Square	0.605
Adjusted R Square	0.473333333
Standard Error	0.540918286
Observations	5

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1.34444444	1.34444444	4.594936709	0.121441582
Residual	3	0.87777778	0.29259259		
Total	4	2.22222222			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	17.23333333	0.4189935	41.1303116	3.16272E-05	15.89990901	18.5667577	15.899909	18.5667577
20% DT	-0.073333333	0.03421068	-2.1435803	0.121441582	-0.182206974	0.03554031	-0.182207	0.03554031

RESIDUAL OUTPUT

Observation	*Predicted 28days*	*Residuals*
1	17.23333333	-0.4
2	16.86666667	0.63333333
3	16.5	-0.3333333
4	16.13333333	0.36666667
5	15.76666667	-0.2666667

Graphical Results of Analysis

The Result for the 0% tyre waste is given below

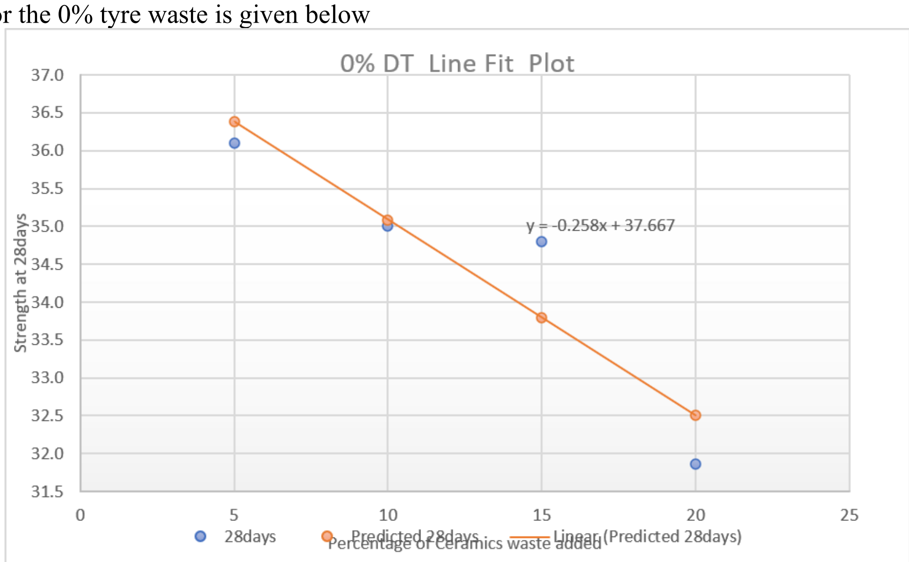


Fig 4.1 A graph of Percentage ceramics waste added against strength at 0% discarded Tyre

The Result for the 5% tyre waste is given below

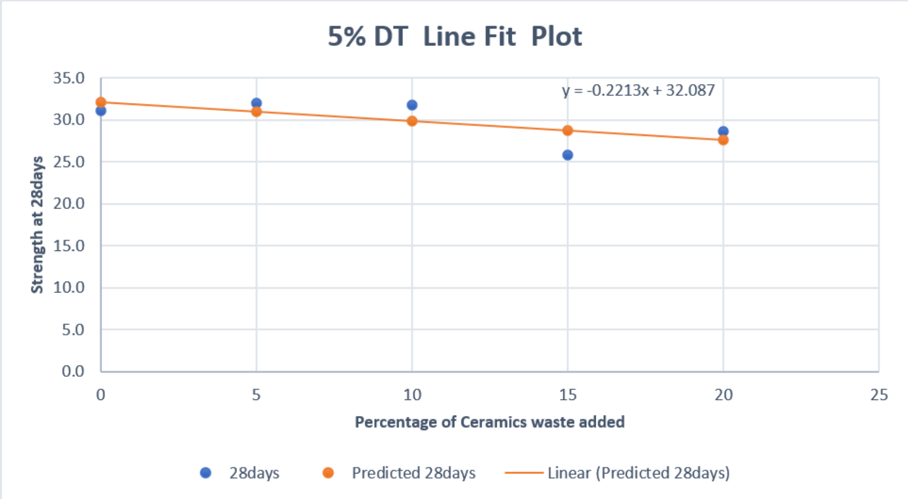


Fig 4.2 A graph of Percentage ceramics waste added against strength at 5% discarded Tyre

The Result for the 10% tyre waste is given below

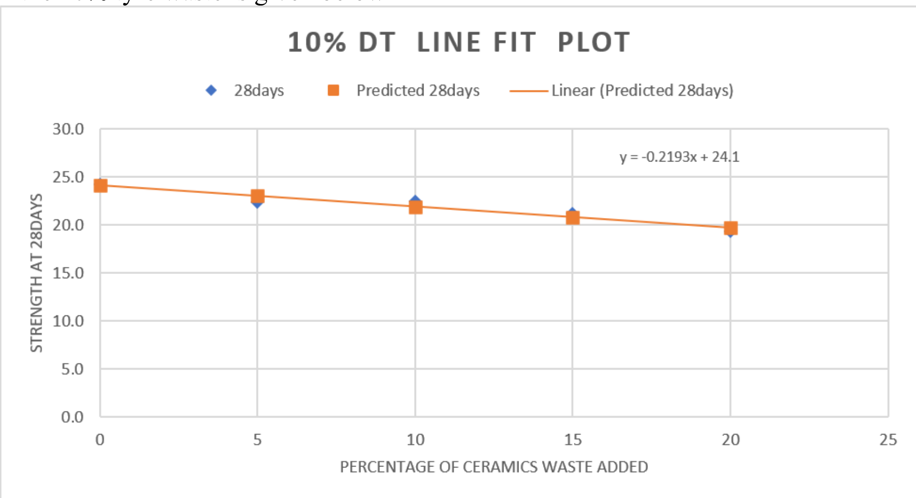


Fig 4.3 A graph of Percentage ceramics waste added against strength at 10% discarded Tyre

The Result for the 15% tyre waste is given below

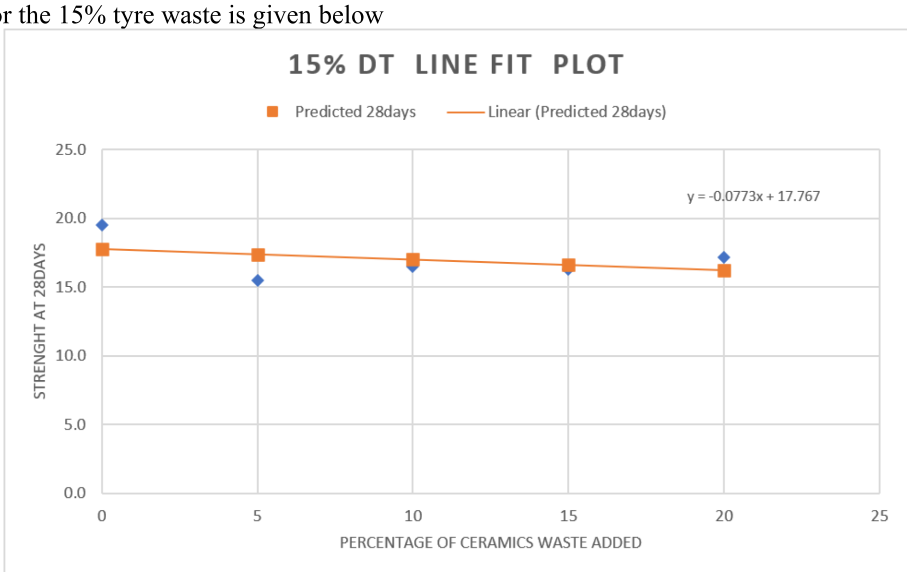


Fig 4.4 A graph of Percentage ceramics waste added against strength at 15% discarded Tyre

The Result for the 20% tyre waste is given below

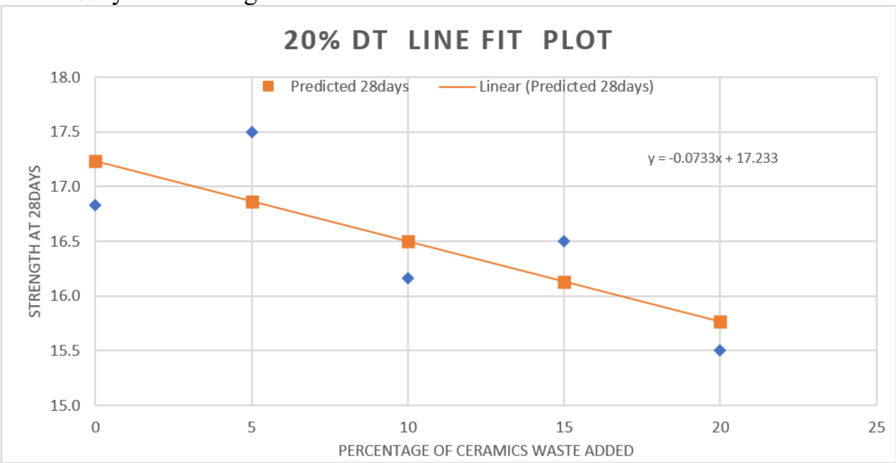


Fig 4.5 A graph of Percentage ceramics waste added against strength at 20% discarded Tyre

Strength gain trend of the Concrete

0% DT	7days	14days	21days	28days
0	65	91	94	100
5	65	96	100	100
10	67	97	100	100
15	67	97	100	100
20	73	98	100	100

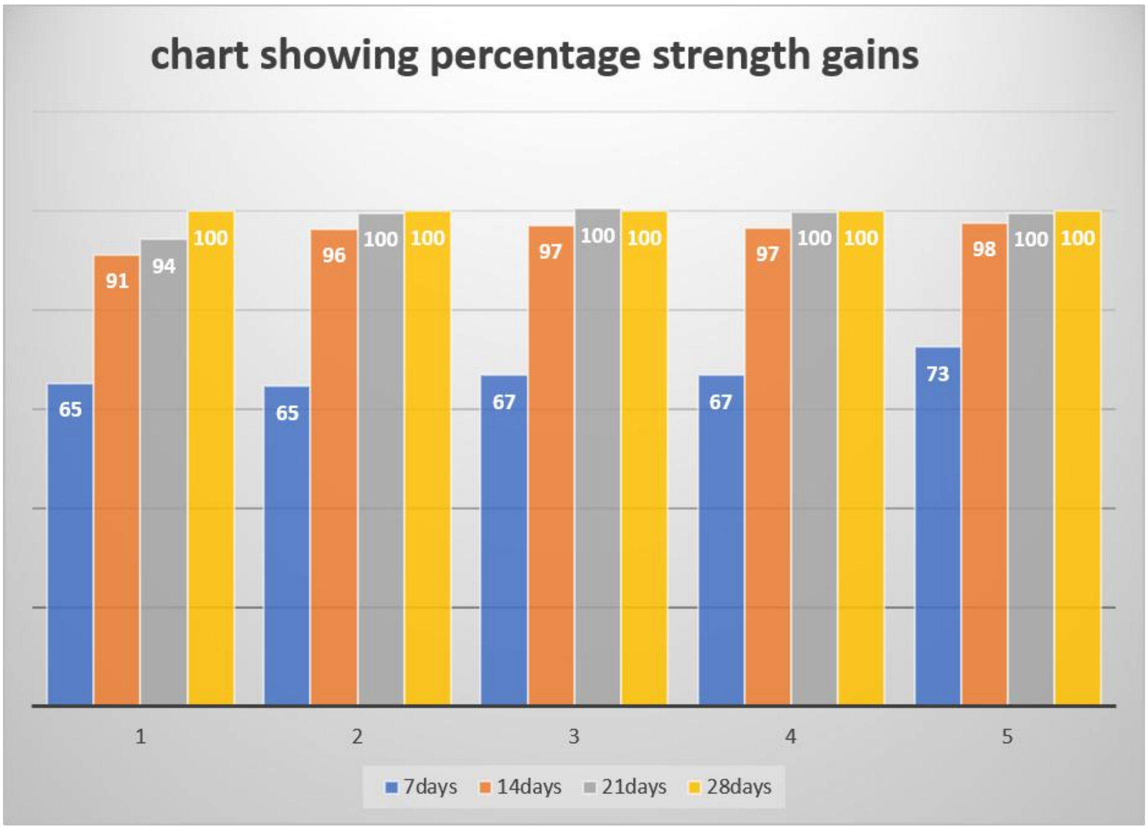


Fig 4.6 A graph showing the rate of strength gain of concrete with respect to age

Density Trend Of Concrete With Increase In Percentage Of Discarded Tyre

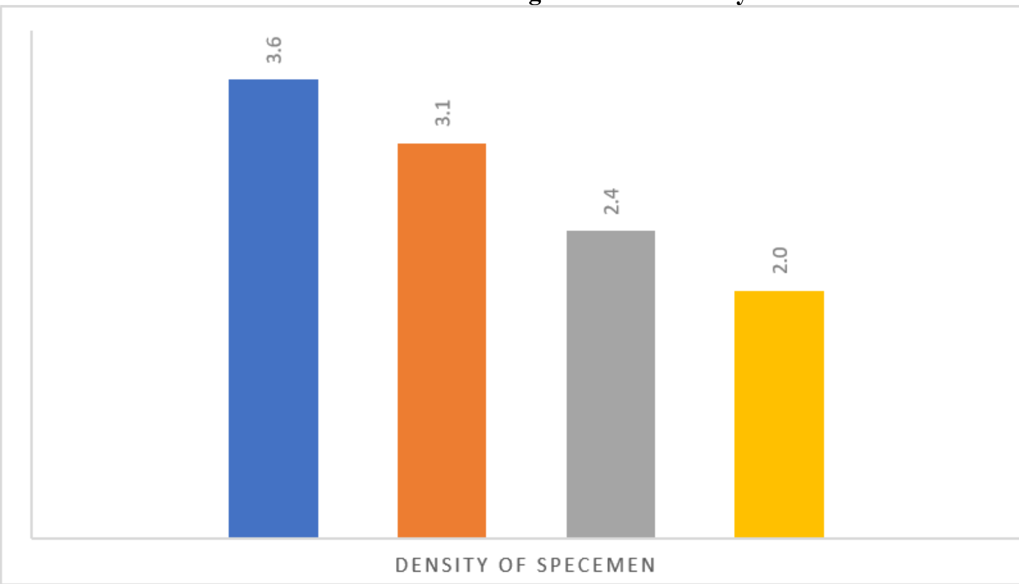


Fig 4.6 A graph showing the density trend of the cube with increase in the percentage of discarded tyre.

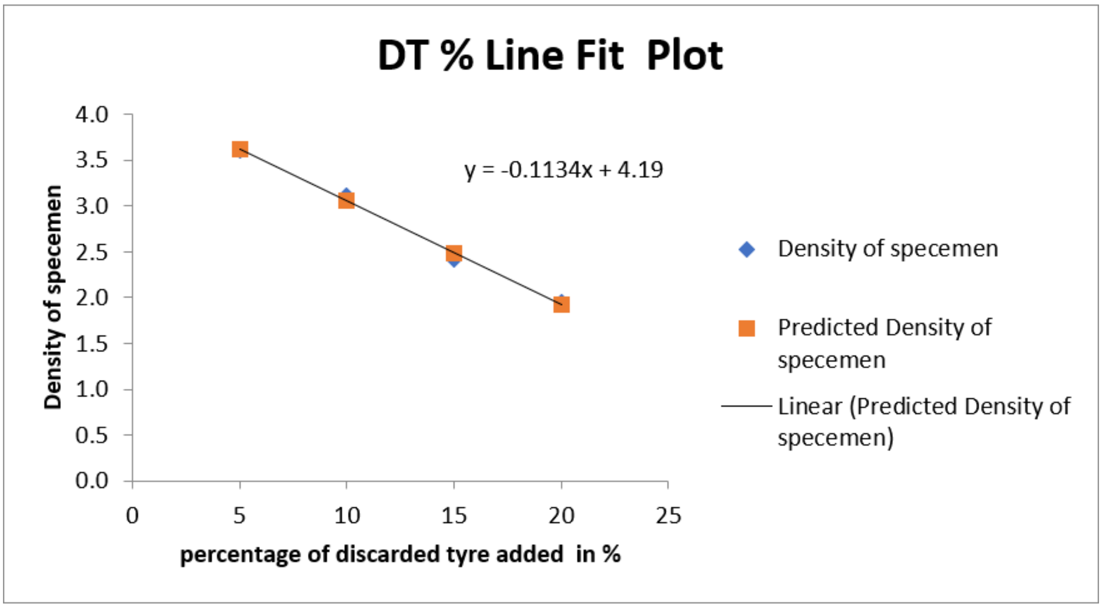


Fig 4.7 A graphical representation of the relationship between the density of the cubes and the percentage of discarded tyre added.

III. Conclusion

The effect of partial replacement of cement with ceramics waste and coarse aggregate with discarded tyre was evaluated by casting different sets of cubes with varying percentages of ceramics waste added to the tyre and also varying the percentage of the discarded tyre added to the coarse aggregate. The strength of the cubes was determined at 7days, 14day, 21days and 28days by carrying out destructive test on the cubes. Regression analysis was then carried on the ultimate strengths of the different sets of cubes based on the percentage of ceramics was added to the cement or discarded tyre added to the coarse aggregate. The following observations were made:

i) For concretes made with no discarded tyre added but with partial addition of ceramics waste, the relationship between the percentage of ceramics waste added to the strength obtained can be expressed in a mathematical equation as Y = - 0.258x + 37.667 were Y is the strength at 28days and x is the percentage of Ceramics Waste added.
ii) For concretes made with 5% discarded tyre added and with partial addition of ceramics waste ranging from 5% - 20%, the relationship between the percentage of ceramics waste added to the strength obtained can be expressed in a mathematical equation as Y = - 0.2213x + 32.087 where Y is the strength at 28days and x is the percentage of Ceramics Waste added.

iii) For concretes made with 10% discarded tyre added and with partial addition of ceramics waste ranging from 5% - 20%, the relationship between the percentage of ceramics waste added to the strength obtained can be expressed in a mathematical equation as $Y = -0.2193x + 24.1$ where Y is the strength at 28days and x is the percentage of Ceramics Waste added
iv) For concretes made with 15% discarded tyre added and with partial addition of ceramics waste ranging from 5% - 20%, the relationship between the percentage of ceramics waste added to the strength obtained can be expressed in a mathematical equation as $Y = -0.0773x + 17.767$ where Y is the strength at 28days and x is the percentage of Ceramics Waste added
v) For concretes made with 20% discarded tyre added and with partial addition of ceramics waste ranging from 5% - 20%, the relationship between the percentage of ceramics waste added to the strength obtained can be expressed in a mathematical equation as $Y = -0.0733x + 17.233$ where Y is the strength at 28days and x is the percentage of Ceramics Waste added
vi) For cubes with only ceramics waste added to them but no discarded tyre, the time at which the sets of cubes reached ultimate strength tends to be faster than those of normal concrete.
vii) For concretes made with no ceramics waste added but with partial addition of discarded tyre, the relationship between the percentage of density of the concrete obtained and density of the cubes can be expressed in a mathematical equation as $Y = -0.1134x + 4.19$ where Y is the density of the concrete and x is the percentage of discarded tyre added.

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