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THE EFFECTS OF CROWN CORKS ON THE STRENGTH PROPERTIES OF CONCRETE

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ABSTRACT
Crown corks are metal bottle caps used in covering the bottles of drinks. They are the second most littered items after cigarette butts. They are non-biodegradable and highly destructive to the environment. As a way of finding suitable alternative to dumping of this waste in landfills, this paper considered the effects of crown corks on the strength properties of concrete. Slump and Compressive Strength properties of concrete produced with waste crown cork were investigated. Concrete was produced using mix ratio 1:2:4, 0.55 water-cement ratio and replacement of coarse aggregates at 0, 5, 10, 15, 20, 25, 30, 35, and 40% with crown cork. From the experimental analysis carried out, it was found that the workability of the concrete was decreasing as the percentage replacement ratio of the cork crown was increasing. The twenty eight days compressive strength of the concrete which was 28.85N/mm^2 at 0% replacement reduced by 1.77% to 28.34N/mm^2 at 5% replacement, it further reduces by 19.90% to 23.11N/mm^2 at 10% replacement of coarse aggregates with crown corks, and the strength reduced further by 76.12% to 6.89N/mm^2 at 40% replacement. This paper concluded that optimum strength was obtained at five and ten percent replacement of coarse aggregates with crown cork.

Keywords: *Aggregates, Crown cork, Compressive Strength, Environment, Landfill*

INTRODUCTION

In civil engineering or in the construction industry, concrete means a hard and solid material made from mixture of cement, water, and aggregate (Vazirani et al; 2010). According to Bandyopadhyay (2008), ˝mineral admixtures may be added to improve certain properties of concrete˝. The quality of concrete depends on the properties of the material used, method of batching and mixing, and the method of construction (Neville, 1987). Cement and aggregate (river sand and crushed stone) are the most important constituents used in concrete production. The amount of concrete used worldwide per tone is twice that of steel, wood, plastics and aluminum combined (www.crackerbaybnb.co.za>concrete, 2018). Concrete is the second most consumed substance in the world–behind water (www.concretehelper.com, 2018). This inevitably leads to a continuous and increasing demand of natural materials used for concrete production. Parallel to the need for the utilization of the natural resources emerges a growing concern for protecting the environment and a need to preserve natural resources, such as aggregate, by using alternative materials that are either recycled or discarded as a waste. Crown cork also known as metal bottle caps are often used in the bottling companies or industries for the purpose of covering the bottles of drinks. Crown cork as a product, is produced from natural materials which generally is metal. Metals display a considerable number of properties not found in any major group of materials for example, high tensile and compressive strength as well as the ability to deform plastically without damage, this implies that crown cork as aggregate in concrete might increase the compressive and tensile strength of concrete as well as reduce collapse in concrete structures since it deforms plastically. Crown cock (metal bottle caps) of about 1or 2 inches piece of metal can cause serious environmental harm when there are billions of them thrown away every year (www.recyclenation.com/recycle-bottle-caps, 2018). Every single day people drink 1.7 billion of servings of Coca-Cola products (www.recyclenation.com/recycle-bottle-caps, 2018). When you throw in beer, water and other drinks people commonly consume from bottles that is a lot of bottle caps (www.recyclenation.com/recycle-bottle-caps, 2018). Metal bottle caps are one of the top ten items found during marine debris beach clean-ups and are the second most littered item after cigarette butts (Thejaskar et al; 2018). 67 million metal bottle caps are thrown away each day (Thejaskar et al; 2018). They are highly destructive to the environment. From the statistics presented about the number of crown cork used yearly, and its inimical effects on the ecosystem, it clearly shows that the use of cork crown (non-biodegradable waste product) in concrete may assist greatly in solving waste disposal problems associated with it. It could also serve as a suitable alternative to depleting, non- sustainable excavation and blasting of rocks for coarse aggregate in concrete production.

Figure 1: Soft Drink Crown Cork

MATERIALS AND METHODS

The fine aggregate used in this research work is a sharp river sand obtained from river Badeggi in
Bida, Niger state. It is a well graded sharp sand which falls under zone II and has a specific gravity of 2.64. It was air dried for 72 hours in other to drive out the moisture present in it. The coarse aggregate used for this research is a well graded granite coarse aggregate, which has a specific gravity of 2.74. It was obtained from an authorized granite dealer opposite Umaru Sanda general hospital, Bida, Niger state. It has a maximum grain size of 20mm. Dangote Obajana brand of ordinary Portland cement (OPC) was used as a

binder in this research work. It was obtained from an authorized dealer in Bida, Niger state.

The crown cork used in this research was obtained from various hotels and guest houses in Bida and from metal collection depot called Panteka in Minna. Reasonable quantities were also collected from various restaurant dump sites and from the neighbourhoods. Potable water free from impurities, collected from concrete laboratory, The Federal Polytechnic, Bida was used for mixing and curing of concrete.

The crown corks were cleaned in order to remove silts and dirts present in it and on the surfaces since they were majorly sourced from dump site and metal collection depot. The rubber linings inside the crowns were removed, so that the crown cork will be a complete metal. The crown corks were then tightly folded in order to obtain a "solid" like material with different shapes, since the shape of an aggregate determines its interlocking characteristics. Angular crown cork aggregate may interlock better with fine materials in a concrete mix. In casting the concrete cubes, mix ratio 1:2:4 was used with constant water-cement ratio of 0.55; the physical properties of the constituents had earlier been determined in accordance to BS 812: 2: 1995. The moulds were cleaned and oiled to ensure easy stripping, and were securely tightened together with bolts and knots. Mixing was done manually; the aggregate (fine, crown cork and coarse) was first spread in a uniform layer. Cement was then spread over the aggregate and the dry materials were mixed by turning it over severally with shovel until a uniform mix was achieved. The dry material were then spread in a uniform layer and the required quantity of water was added and mixed again thoroughly to homogeneity. The freshly mixed concrete was scooped into the mould of dimensions (150 x 150 x 150) mm, in three layers; each layer was tamped 35 times with tamping rod. Eight cubes were moulded at each replacement ratio (0, 5, 10, 15, 20, 25, 30, 35 and 40%) of coarse aggregate with crown cork, making seventy cubes altogether. 82.8kg of cement, 165.6kg of fine aggregate, 66.24kg of crown cork aggregate, 265kg of granite aggregate and 45.54kg of water were used in casting all the cubes. The moulded cubes were kept in the laboratory for 24 hours to allow setting of the concrete, after 24 hours they were remolded and immersed in a curing tank for period of 7, 14, 21 and 28 days to enable curing to take place. This was carried out in accordance with

BS1881: part108: 1983. The strength of the concrete cubes was determined in a compressive machine in accordance with BS 1881: Part116: 1983 and recorded as shown in Tables (1 to 9)

DISCUSSION OF RESULT

The fine aggregates used in this research work falls within zone II in the sieve analysis table, this shows that the fine aggregate was well graded (BS EN 12620: 2002). The coarse aggregate used was a well graded aggregate. The replacement of coarse aggregate with crown cork reduced the compressive strength of the concrete as shown in Tables (1 to 9). Figure 2 shows the variation of mean compressive strength against percentage replacement. From the figure, it can be deduced that compressive strength of crown cork concrete was reducing as percentage replacement was increasing. There was decrease in compressive strength by 1.77% at 5% replacement of coarse aggregate with crown cork as shown in Table 10. Further increase in the percentage replacement of crown cork by 10, 15, 20, 25, 30, 35 and 40% decreases the strength of the concrete by 19.90, 40.70, 54.94, 70, 71.1, 75.74 and 76.12% respectively as shown in the table. Workability of the concrete was also reducing as percentage replacement was increasing. However, compressive strength was increasing as curing days (age) of the concrete were increasing as shown in figure 3.

Table 1: Compressive Strength of Concrete Cubes At 0% Replacement of Coarse Aggregate with Crown Cork

Mass of cubes (kg)	Density of cubes (kg/m3)	Mean Density of cubes (kg/m3)	Age (days)	Load (KN)	Strength (N/mm2)	Mean Strength (N/mm2)
8.27	2450		7	490	21.78	
8.12	2406	2428	7	400	17.78	19.78
8.21	2433		14	510	22.67	
8.07	2391	2412	14	620	27.56	25.12
8.37	2480		21	545	24.22	
8.27	2450	2465	21	670	29.78	27.0
8.22	2436		28	620	27.56	
8.13	2409	2423	28	678	30.13	28.85

Table 2: Compressive Strength of Concrete Cubes At 5% Replacement of Coarse Aggregate with Crown Cork

Mass of cubes (kg)	Density of cubes (kg/m3)	Mean Density of cubes (kg/m3)	Age (days)	Load (KN)	Strength (N/mm2)	Mean Strength (N/mm2)
7.15	2119		7	380	16.89	
8.12	2406	2263	7	500	22.22	19.56
8.47	2510		14	495	22.00	
7.94	2353	2432	14	505	22.44	22.22
8.30	2459		21	510	22.67	
8.24	2441	2450	21	515	22.89	22.78
8.20	2430		28	675	30.00	
8.06	2388	2409	28	600	26.67	28.34

Table 3: Compressive Strength of Concrete Cubes At 10% Replacement of Coarse Aggregate with Crown Cork

Mass of cubes (kg)	Density of cubes (kg/m3)	Mean Density of cubes (kg/m3)	Age (days)	Load (KN)	Strength (N/mm2)	Mean Strength (N/mm2)
7.78	2305		7	380	16.89	
8.19	2427	2366	7	415	18.44	17.67
7.65	226		14	460	20.44	
8.52	2524	2396	14	420	18.67	19.55
7.74	2293		21	495	22.00	
7.85	2326	2310	21	460	20.44	21.22
8.03	2379		28	540	24.00	
7.61	2255	2317	28	500	22.22	23.11

Table 4: Compressive Strength of Concrete Cubes At 15% Replacement of Coarse Aggregate with Crown Cork

Mass of cubes (kg)	Density of cubes (kg/m3)	Mean Density of cubes (kg/m3)	Age (days)	Load (KN)	Strength (N/mm2)	Mean Strength (N/mm2)
7.26	2151		7	180	8.00	
7.73	2290	2221	7	255	11.33	9.67
7.72	2287		14	245	10.89	
7.67	2273	2280	14	285	12.67	11.78
7.90	2341		21	380	16.89	

7.96	2359	2350	21	310	13.78	15.34
7.58	2246		28	410	18.22	
7.71	2284	2265	28	360	16.00	17.11

Table 5: Compressive Strength of Concrete Cubes At 20% Replacement of Coarse Aggregate with Crown Cork

Mass of cubes (kg)	Density of cubes (kg/m3)	Mean Density of cubes (kg/m3)	Age (days)	Load (KN)	Strength (N/mm2)	Mean Strength (N/mm2)
7.59	2249		7	190	4.22	
7.91	2344	2297	7	210	4.67	4.45
8.06	2388		14	230	10.22	
7.68	2276	2332	14	245	10.89	10.56
8.33	2468		21	250	11.11	
8.04	2382	2425	21	295	13.11	12.11
7.86	2329		28	285	12.67	
7.69	2279	2304	28	300	13.33	13.00

Table 6: Compressive Strength of Concrete Cubes At 25% Replacement of Coarse Aggregate with Crown Cork

Mass of cubes (kg)	Density of cubes (kg/m3)	Mean Density of cubes (kg/m3)	Age (days)	Load (KN)	Strength (N/mm2)	Mean Strength (N/mm2)
6.86	2033		7	100	4.44	
6.80	2015	2024	7	155	6.89	5.65
7.61	2255		14	140	6.22	
7.22	2139	2197	14	160	7.11	6.67
7.16	2121		21	150	6.67	
7.21	2136	2129	21	180	8.00	7.34
7.17	2124		28	190	8.44	
7.37	2184	2154	28	200	8.89	8.67

Table 7: Compressive Strength of Concrete Cubes At 30% Replacement of Coarse Aggregate with Crown Cork

Mass of cubes (kg)	Density of cubes (kg/m3)	Mean Density of cubes (kg/m3)	Age (days)	Load (KN)	Strength (N/mm2)	Mean Strength (N/mm2)
7.04	2086		7	125	5.56	
7.28	2157	2122	7	125	5.56	5.56
6.81	2018		14	155	6.89	

6.98	2068	2043	14	140	6.22	6.56
7.34	2175		21	195	8.67	
7.13	2113	2144	21	150	6.67	7.67
7.31	2166		28	200	8.89	
7.14	2116	2141	28	175	7.78	8.34

Table 8: Compressive Strength of Concrete Cubes At 35% Replacement of Coarse Aggregate with Crown Cork

Mass of cubes **(**kg**)**	Density of cubes (kg/m3)	Mean Density of cubes (kg/m3)	Age (days)	Load (KN)	Strength (N/mm2)	Mean Strength (N/mm2)
7.04	2139		7	125	5.56	
7.28	2184	2162	7	100	4.44	5.00
6.81	2631		14	130	5.78	
6.98	2110	2371	14	115	5.11	5.45
7.34	1896		21	140	6.22	
7.13	2062	1979	21	145	6.44	6.33
7.31	2222		28	155	6.89	
7.14	1953	2088	28	160	7.11	7.00

Table 9: Compressive Strength of Concrete Cubes At 40% Replacement of Coarse Aggregate with Crown Cork

Mass of cubes **(**kg**)**	Density of cubes (kg/m3)	Mean Density of cubes (kg/m3)	Age (days)	Load (KN)	Strength (N/mm2)	Mean Strength (N/mm2)
6.89	2041		7	100	4.44	
6.77	2006	2023	7	115	5.11	4.78
6.42	1902		14	125	5.56	
6.78	2009	1956	14	125	5.56	5.56
6.53	1935		21	130	5.78	
6.84	2027	1981	21	135	6.00	5.89
7.23	2145		28	170	7.56	
6.79	2012	2079	28	140	6.22	6.89

Table 10: Percentage Compressive Strength in Relation to Control Strength

Percentage Replacement (%)	Control Strength (N/mm2)	Cube Strength(N/mm2)	Percentage Reduction in Strength (N/mm2)
5	28.85	28.34	1.77
10	28.85	23.11	19.90
15	28.85	17.11	40.70

20	28.85	13.00	54.94
25	28.85	8.67	70.00
30	28.85	8.34	71.10
35	28.85	7.00	75.74
40	28.85	6.89	76.12

Table 11: Slump of Concrete at Different % Replacement of Coarse Aggregate

Percentage Replacement	Slump (mm)
0%	27
5%	24
10%	22
15%	19
20%	17
25%	15
30%	13
35%	12
40%	10

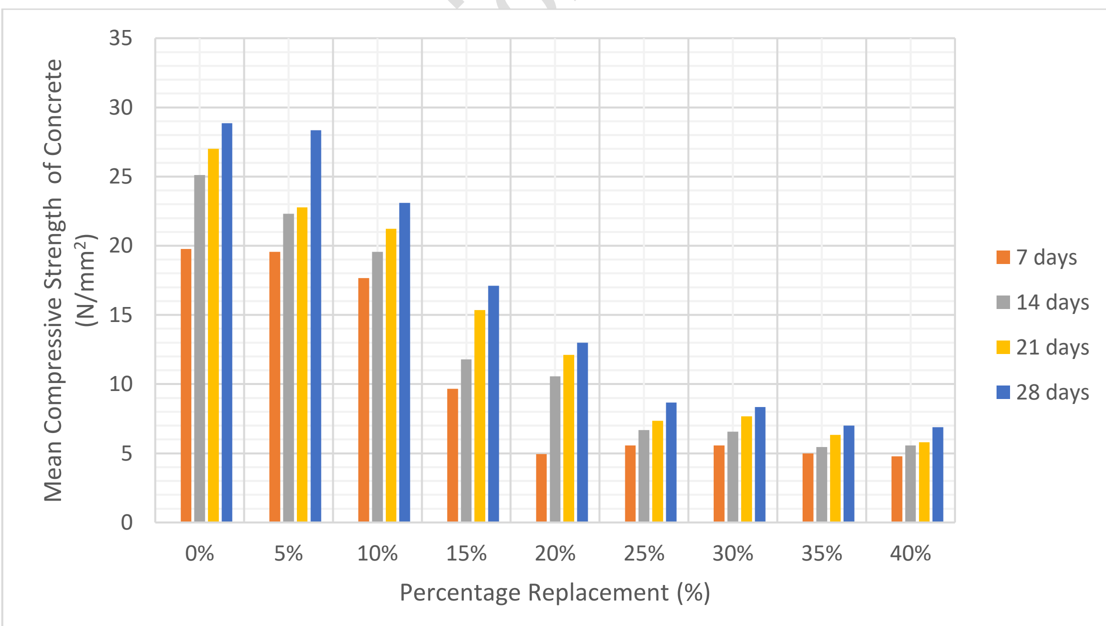

Figure 2: Bar chart showing mean compressive strength against percentage replacement

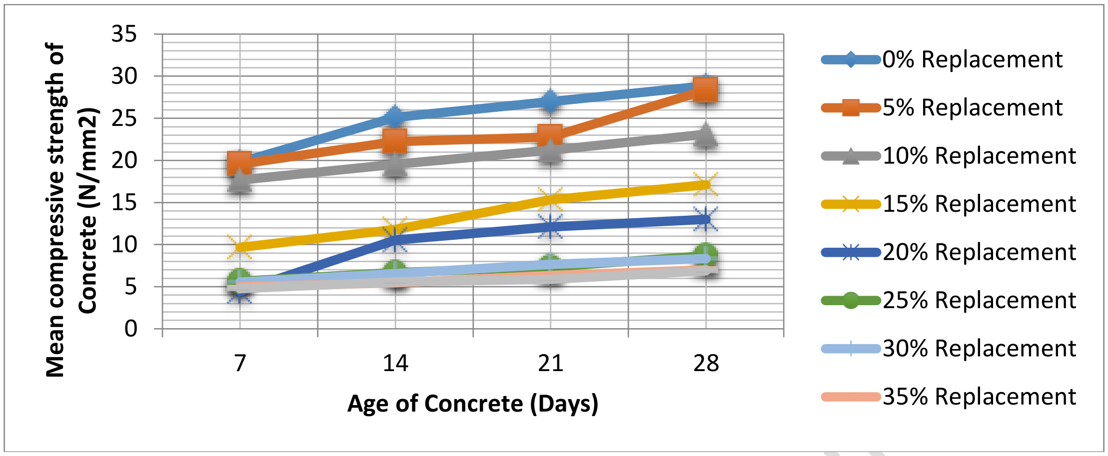

Figure 3: Graph of mean compressive strength against age of concrete

CONCLUSION

Replacing coarse aggregate with crown cork decreases the strength of the concrete below the reference values. This decrease in strength could be as a result of lack of bonding between the crown cork and other concrete constituents. Insufficient force of adhesion between the crown cork, fine aggregate and cement could also be responsible for the reduction in strength. Five and Ten percent replacement gave optimum values of 28.34 and 23.11N/mm^2 respectively at the 28th day.

REFERENCES

Bandyopadhyay J. N. (2008). Design of concrete structures. 1st Edition, PHI Learning Pvt Ltd, Pataparganj Delhi- India

British Standards Institution (1995). BS812-2: Methods for Determination of Physical Properties of Aggregates. BSI, London, United Kingdom.

British Standards Institution (1983). BS1881: Part 108: Methods of making test cubes From Fresh Concrete, BSI, London, United Kingdom

British Standards Institution (1983). BS1881: Part 116: Methods for Determination of Compressive Strength of Concrete Cubes. BSI, London, United Kingdom

British Standards Institution (2002). BS EN 12620: Aggregates for Concrete, BSI, London, United Kingdom

http///www.crackerbaybnb.co.za>concrete, 2018

http///www. concretehelper.com>concrete-facts, 2018

http/// www. reyclenation.com/recycle-bottle-cap, 2018

Neville, A. M, (2003). Properties of Concrete. 4th Edition. Pearson Education (Singapore) Pte Ltd, Patparganj Delhi, India.

Thejaskar, R. T. V., Aruna, K. S. S., Ranjith, B., Pavan, K. M. K.,Govinda, R. J. N. (2018). Reducing Environmental Impact of Metal Bottle Crown Caps By Reusing them as Fiber in Concrete. International of Advances in Science, Engineering, and Technology. Vol. 6, Iss-1

Vazirani, V.N. and Chandola S. P. (2010). Concise Hand Book of Civil Engineering, S.chand and companyLtd 736, RAM Nagar, New Delhi Pp. 370-371