

Equations for Predicting Flexural Strength and Compressive Strength of Plastic Concrete Pavement Blocks

Eric Ababio Ohemeng*, Kofi Owusu Adjei & Anita Asamoah-Duodu

Kumasi Polytechnic, Faculty of Built and Natural Environment, Department of Building Technology, P. O. Box 854, Kumasi - Ashanti, Ghana.

* E-mail of the corresponding author: ohemengababioeric@yahoo.com

Abstract

The influence of plastic content within the range of 0% - 60% as replacement for sand volume, water cement (w/c) ratio of 0.30 – 0.50 and curing age of 7 days – 28 days on flexural strength and compressive strength of plastic concrete pavement blocks (PCPBs) was investigated. All the mixtures were proportioned with a fixed aggregate / cement ratio of 4.5. Based on the experimental results, the flexural strength and the compressive strength of the PCPBs were calculated by considering the predictor variables (water cement ratio, curing age and plastic content). Equations derived based on the results from the experimental work are proposed to predict the flexural strength and the compressive strength of the developed PCPBs. The effect of water cement ratio, curing age and plastic content on flexural strength and compressive strength of PCPBs was found to be statistically significant ($P < 0.0001$). The equations are only capable of predicting the flexural strength and the compressive strength of plastic concrete products, if the w/c ratio, the curing age and the aggregate cement ratio used are within the tested range.

Keywords: water cement ratio, plastics, curing age, flexural strength, compressive strength.

1. Introduction

The management of waste plastics has become an indispensable issue in the globe by virtue of its non-decomposable nature. Various researchers have made significant attempt to utilize waste plastics in concrete products (Bayasi and Zeng, 1993; Rebeiz, 1996; Al-Manaseer and Dalal, 1997; Choi et al., 2005; Jo et al., 2006; Marzouk et al., 2007; Suganthy et al., 2013, Ohemeng et al., 2014). Due to the low specific gravity of plastic, the reduction in density of plastic concrete is expected to increase as the percentage of the plastic aggregate increases. Research conducted by Suganthy et al. (2013) demonstrated that the weight of plastic concrete decreased as the plastic content increased. The weight of the plastic concrete was reduced by about 9% when 50% of the sand was substituted with plastic. Similarly, Baboo et al. (2012) reported a reduction in fresh density of plastic concrete when the plastic aggregate increased. The fresh density was lowered by about 9% when 10% plastic was used. Al-Manaseer and Dalal (1997) mentioned that the bulk density of plastic concrete decreased as the plastic aggregate went up. The density was declined by approximately 6% when plastic content of 30% was applied. Experimental work carried out by Choi et al. (2005) showed that waste plastic could reduce the weight of normal concrete by about 2 – 6%.

The inclusion of plastic aggregate in concrete is anticipated to reduce the mechanical properties of concrete due to the poor bond between the plastic and the cement paste. Batayneh et al. (2007) reported that the compressive strength of plastic concrete was lowered by approximately 50% when 15% of the fine aggregate was substituted with plastic. Likewise, Choi et al. (2005) observed a decrease in compressive strength when part of the aggregate was replaced by plastic. The compressive strength was decreased by about 35% when compared to that of normal concrete. Baboo et al. (2012) further reported that the compressive strength values of waste plastic concrete mixtures decreased at each curing age when plastic ratio increased. However, the compressive strength tends to increase by 5% when super-plasticizer was added to the plastic concrete mix. Suganthy et al. (2013) noticed an increase in compressive strength of plastic concrete when the curing age moved from 7 days to 28 days irrespective of the batch used. Batayneh et al. (2007) also observed reductions in flexural strength and splitting tensile strength of concrete mix when the plastic content increased. The flexural strength was lowered by about 40% when 15% of the aggregate was replaced by plastic whilst the splitting tensile strength was decreased by about 50% when 20% of the aggregate was substituted with plastic. Ohemeng and Yalley (2013) observed the influence of water cement (w/c) ratio on density and compressive strength of rubberized concrete pavement blocks. It is apparent that strengths of plastic concrete products hinge on the relative amount of plastic aggregate, w/c ratio, and curing age applied. Therefore, the objective of this study is to develop equations to predict flexural strength and compressive strength of plastic concrete pavement blocks based on plastic content, curing age and w/c ratio used.

2. Experimental studies

2.1 Materials

Ordinary Portland cement (OPC), fine aggregate (sand), coarse aggregate (stones), ground plastic (GP) and water were the materials used to develop the plastic concrete pavement blocks (PCPBs). Samples of the cement, sand, stones, and ground plastic used are shown in Figure 1.

Figure 1: Samples of the materials used to develop the PCPBs

2.1.1 Cement

Ordinary Portland cement (CEM I 42.5 N) produced by Ghana cement works (Ghacem) that conformed to EN 197-1 and labelled OPC was used. The mean particle size (μm) and specific gravity of the OPC were 4 and 3.14 respectively. Table 1 displays the chemical composition of the OPC.

Table 1: Chemical composition of ordinary Portland cement

Chemical composition	Content (%)
Silicon dioxide (SiO_2)	19.70
Aluminium oxide (Al_2O_3)	5.00
Ferric oxide (Fe_2O_3)	3.16
Calcium oxide (CaO)	63.03
Magnesium oxide (MgO)	1.75
Potassium oxide (K_2O)	0.16
Sodium oxide (Na_2O)	0.20
Sulphur oxide (SO_3)	2.80
Loss on ignition (LOI)	2.58

2.1.2 Sand, coarse aggregate, ground plastic and water

Natural river sand from Jacobu in the Ashanti Region of Ghana was used for the preparation of the PCPBs. The sand was dried in an opened place to remove the moisture. The sand conformed to zone II as per IS: 383 – 1970. The ground plastic used also conformed to zone II as per IS: 383 – 1970. The coarse aggregate used in this study were 10 mm nominal size, and were tested as per IS: 383 – 1970. Tables 2 and 3 show the physical properties and the sieve analysis of the sand, stones, and plastic respectively. Potable water was used for the preparation and curing of the PCPBs.

Table 2: Physical properties of sand, stones and ground plastic

Material	Specific gravity	Compacted bulk density (kg/m^3)	Fineness modulus	Moisture content (%)
Sand	2.60	1695.00	2.53	2.04
Stones	2.63	1723.00	1.97	1.39

Ground plastic	1.10	813.60	3.51	-

Table 3: Sieve analysis of sand, stones and ground plastic

IS sieve size (mm)	Weight retained			% retained			% passing		
	sand	stones	plastic	sand	stones	plastic	sand	stones	plastic
12.50	0.0	0.00	0.0	0.00	0.00	0.00	100.00	100.00	100.00
10.00	0.0	105.98	0.0	0.00	8.58	0.00	100.00	91.42	100.00
4.75	0.0	990.20	0.0	0.00	80.16	0.00	100.00	11.26	100.00
2.36	25.6	137.89	39.30	4.35	11.16	4.44	95.65	0.10	95.56
1.18	127.0	-	191.30	21.56	-	21.60	74.09	-	73.96
0.60	164.5	-	245.88	27.94	-	27.76	46.15	-	46.20
0.30	135.4	-	204.02	23.00	-	23.04	23.15	-	23.16
0.15	89.2	-	134.69	15.15	-	15.20	8.00	-	7.96
pan	47.1	1.20	70.47	8.00	0.10	7.96			

2.1.3 Preparation of the ground plastic

Waste water sachets were collected and cleaned. They were cut into pieces. The plastics were put on fire until they got melted. The plastics in the liquid form were poured on roofing sheets and were allowed to solidify. With the help of metallic mortar and pestle, the solidified plastics were ground into small particles. Figure 2 displays the preparation process of the plastic.

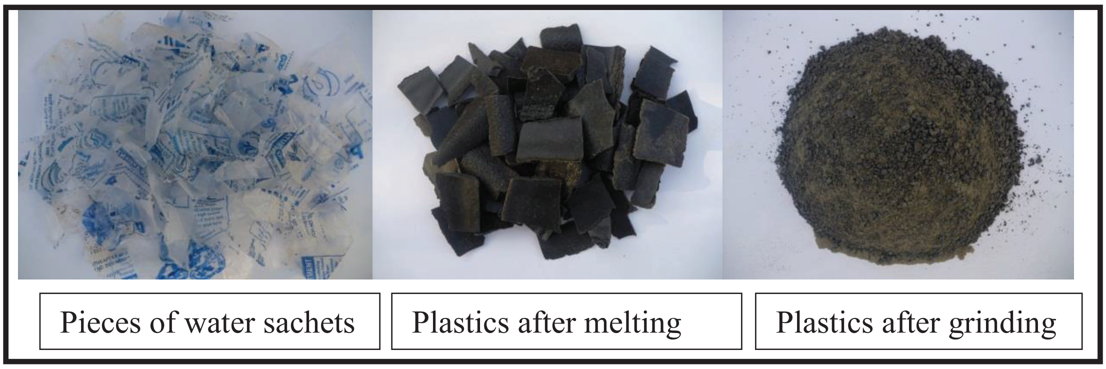

Figure 2: Preparation of the plastic

2.2 Methods

2.2.1 Proportion of the mix

The mix proportion was 1: 1.5: 3 (cement: sand: coarse aggregate). The percentage weight of the ground plastic was 0%, 10%, 20%, 30%, 40%, 50%, and 60% by volume of sand. Different water cement ratios (0.30, 0.35, 0.40, 0.45 and 0.50) were used for the experiment. The plain concrete was used as a control test and denoted as Ay, where y is the water cement ratio. The rest of the batches with ground plastic were denoted as Bx/y. Where B is the batch with certain % of plastic, x is the volume percentage of ground plastic and y is the w/c ratio. Table 4 exhibits the mix proportion of the aggregates used for the PCPBs.

Table 4: Mix proportion

Batch	Constituents of PCPBs (weight in kg)				
	Water	Cement	Coarse aggregate	Sand	Ground plastic
A0.30	1.350	4.500	13.500	6.750	0.000
A0.35	1.575	4.500	13.500	6.750	0.000
A0.40	1.800	4.500	13.500	6.750	0.000
A0.45	2.025	4.500	13.500	6.750	0.000
A0.50	2.250	4.500	13.500	6.750	0.000
B10/0.30	1.350	4.500	13.500	6.075	0.320
B10/0.35	1.575	4.500	13.500	6.075	0.320
B10/0.40	1.800	4.500	13.500	6.075	0.320
B10/0.45	2.025	4.500	13.500	6.075	0.320
B10/0.50	2.250	4.500	13.500	6.075	0.320
B20/0.30	1.350	4.500	13.500	5.400	0.640
B20/0.35	1.575	4.500	13.500	5.400	0.640
B20/0.40	1.800	4.500	13.500	5.400	0.640
B20/0.45	2.025	4.500	13.500	5.400	0.640
B20/0.50	2.250	4.500	13.500	5.400	0.640
B30/0.30	1.350	4.500	13.500	4.725	0.960
B30/0.35	1.575	4.500	13.500	4.725	0.960
B30/0.40	1.800	4.500	13.500	4.725	0.960
B30/0.45	2.025	4.500	13.500	4.725	0.960
B30/0.50	2.250	4.500	13.500	4.725	0.960
B40/0.30	1.350	4.500	13.500	4.050	1.280
B40/0.35	1.575	4.500	13.500	4.050	1.280
B40/0.40	1.800	4.500	13.500	4.050	1.280
B40/0.45	2.025	4.500	13.500	4.050	1.280
B40/0.50	2.250	4.500	13.500	4.050	1.280
B50/0.30	1.350	4.500	13.500	3.375	1.600
B50/0.35	1.575	4.500	13.500	3.375	1.600
B50/0.40	1.800	4.500	13.500	3.375	1.600
B50/0.45	2.025	4.500	13.500	3.375	1.600
B50/0.50	2.250	4.500	13.500	3.375	1.600
B60/0.30	1.350	4.500	13.500	2.700	1.920
B60/0.35	1.575	4.500	13.500	2.700	1.920
B60/0.40	1.800	4.500	13.500	2.700	1.920
B60/0.45	2.025	4.500	13.500	2.700	1.920
B60/0.50	2.250	4.500	13.500	2.700	1.920

*Note: Density of sand = 1695.0 Kg/m^3 and density of GP = 813.6 Kg/m^3. Therefore, weight of GP for an equivalent volume of sand (conversion factor) = 813.6/1695.0 =0.48

2.2.2 Preparation and curing of PCPBs

Mixing of concrete and compaction of blocks were done mechanically. Steel mould with internal dimensions of 200mm in length, 100mm in width and 60mm in depth was used to mould the PCPBs. The prepared PCPBs were packed on boards and covered with polythene sheets for 24 hours before curing started. The specimens were then placed in curing tank for specified number of days (i.e. 7 days, 14 days and 28 days).

2.2.3 Testing of specimens

The compressive strength was tested in conformity with BS 6717 – Part 1 (1986). To test the flexural strength, a centre line was marked at the top of the specimen perpendicular to its length. The PCPBs were tested under the centre line load while simply supported over supporting span of 150 mm. The flexural strength was then calculated from the formula; $\sigma = 3/2\ (LF / BD^2)$, where σ is the flexural strength (N/mm^2), L is the span length (mm), F is the maximum applied load (N), B is the average width of the specimen (mm), and D is the average thickness (mm).

3. Results and discussion

3.1 Effect of w/c ratio, plastic content and curing age on strengths of PCPBs

The results of the strengths of PCPBs for various w/c ratios, plastic content and curing periods are summarized in Table 5. It is observable that several strengths were obtained when different w/c ratios were used. Water cement ratio of 0.45 was found to be the optimum. By comparing the optimum w/c ratio to the other w/c ratios, the flexural strength was decreased by about 16%, 10%, 6% and 3% when w/c ratios of 0.30, 0.35, 0.40 and 0.50 were applied irrespective of the percentage of plastic aggregates and curing age employed. For the compressive strength, a reduction of approximately 21%, 14%, 8% and 5% were experienced when w/c ratios of 0.30, 0.35, 0.40 and 0.50 were used regardless of the plastic content applied. The differences in strengths may be due to the different quantities of water used for the preparation of the PCPBs. Mixes produced from w/c ratios of 0.30, 0.35 and 0.40 may be little dry causing insufficient compaction and hence leading to decrease in strengths. Mixes made from w/c ratio of 0.50 may be quite wet and this might have created voids in the concrete as the results of the evaporation of excess water from the PCPBs after hydration reaction. The findings are in agreement with Ohemeng and Yalley (2013), who observed the effect of w/c ratios on compressive strength of rubberized concrete pavement blocks.

It can also be noticed that the strengths of PCPBs reduced as the plastic content increased (Table 5). The decrease pattern of the strengths is similar for the five different w/c ratios. The flexural strength lowered from 4.97N/mm^2 to 2.58 N/mm^2, 5.28 N/mm^2 to 2.83 N/mm^2, 5.57 N/mm^2 to 2.98 N/mm^2, 5.84 N/mm^2 to 3.04 N/mm^2 and 5.61 N/mm^2 to 3.00 N/mm^2 at 0.30, 0.35, 0.40, 0.45 and 0.50 w/c ratios respectively. Similarly, the compressive strength lessened from 38.12 N/mm^2 to 14.70 N/mm^2, 41.66 N/mm^2 to 16.10 N/mm^2, 44.50 N/mm^2 to 17.30 N/mm^2, 47.29 N/mm^2 to 18.81 N/mm^2 and 45.20 N/mm^2 to 18.12 N/mm^2 at 0.30, 0.35, 0.40, 0.45 and 0.50 w/c ratios in order. These suggest that the flexural strength and the compressive strength were declined by approximately 46% and 62% respectively when 60% of the total sand was replaced by plastic aggregates irrespective of the w/c ratio used. The reason for the reduction in strengths could be attributed to the smooth surface of the plastic aggregates which might have weakened the adhesion between the boundaries of the plastic particles and the cement paste. The findings are supported by Choi et al. (2005), Batayneh et al. (2007) and Marzouk et al. (2007), who noticed a slump in flexural strength and compressive strength of plastic concrete as the plastic content increased.

The impact of curing age on the strengths of PCPBs is also demonstrated in Table 5. It is obvious that the flexural strength and the compressive strength rise as the curing age increases regardless of the plastic content deployed. Critical examination of the table shows that the flexural strength and the compressive strength were increased by about 25% and 27% respectively when the curing period moved for 7days to 28 days. This upsurge may be due to the hydration reaction of the cement paste which increases the strengths of concrete as curing age increases. The findings are in consonance with Suganthy et al. (2013), who experienced an increase in strengths of plastic concrete when the curing age moved from 7 days to 28 days.

3.2 Development of equations for predicting the flexural strength and the compressive strength of the developed PCPBs

The equations were developed based on the experimental results presented in Table 5. Multiple regression analysis was used to develop the predictive equations with the help of Statistical Analysis System (SAS). Multiple regressions give the opportunity to establish the evidence that one or more independent variables cause another dependent variable to change (Blakie, 2003). In so doing, the analysis establishes the relative magnitude of the contribution of each predictor variable. It also offers the opportunity to examine what proportion of the variance in the outcome variable is explained by each predictor variable and or / their combined effect (Brace et al., 2003). In this case the predictor variables (independent variables) were represented by water cement ratio, curing age and plastic content while the criterion variable (dependent variable) was flexural strength or compressive strength of PCPBs.

Table 5: Experimental testing results of flexural strength and compressive strength

W/C ratio	Plastic content (%)	Flexural strength (N/mm^2)			Compressive strength (N/mm^2)		
		7 days	14 days	28 days	7 days	14 days	28 days
0.30	0	3.65	4.49	4.97	28.02	34.50	38.12
	10	3.46	4.26	4.70	25.96	31.95	35.23
	20	3.16	3.89	4.31	22.83	28.12	31.14
	30	2.84	3.49	3.84	19.33	23.78	26.16
	40	2.55	3.14	3.49	16.46	20.29	22.52
	50	2.14	2.63	2.89	13.00	15.98	17.55
	60	1.88	2.32	2.58	10.72	13.21	14.70
0.35	0	3.91	4.80	5.28	30.83	37.91	41.66
	10	3.63	4.46	4.89	27.56	33.87	37.14
	20	3.29	4.05	4.46	24.66	30.34	33.41
	30	3.10	3.81	4.17	20.73	25.46	27.86
	40	2.59	3.19	3.52	17.74	21.84	24.11
	50	2.47	3.04	3.32	14.81	18.18	19.85
	60	2.08	2.56	2.83	11.81	14.55	16.10
0.40	0	4.07	4.96	5.57	32.49	39.61	44.50
	10	3.86	4.71	5.28	30.33	36.96	41.44
	20	3.56	4.31	4.85	28.45	34.42	38.76
	30	3.14	3.85	4.31	21.33	26.19	29.30
	40	2.69	3.24	3.66	18.62	22.42	25.30
	50	2.42	2.98	3.33	15.12	18.66	20.83
	60	2.16	2.63	2.98	12.52	15.29	17.30
0.45	0	4.38	5.28	5.84	36.10	42.56	47.29
	10	4.12	4.81	5.43	34.07	38.79	43.58
	20	3.75	4.46	4.98	29.20	35.05	39.83
	30	3.50	4.06	4.58	23.41	27.96	31.95
	40	2.99	3.44	3.91	20.89	24.33	27.18
	50	2.65	3.14	3.53	15.99	19.37	21.89
	60	2.24	2.74	3.04	13.73	16.90	18.81
0.50	0	4.29	5.12	5.61	33.93	40.22	45.20
	10	3.96	4.73	5.32	32.37	37.04	42.31
	20	3.67	4.32	4.87	28.96	34.98	39.05
	30	3.36	3.93	4.39	22.34	26.75	30.57
	40	2.87	3.33	3.83	19.63	23.02	26.74
	50	2.54	3.04	3.38	15.35	18.89	21.09
	60	2.19	2.65	3.00	13.11	16.22	18.12

3.2.1 Predicting the flexural strength of the developed PCPBs

With the application of SAS, the necessary outputs needed for predicting the flexural strength are shown in Tables 6, 7 and 8. Table 6 presents the model summary of the results for the regression analysis. The R-square ($R^2 = 0.953$) which is the coefficient of determination shows that there is strong correlation between the criterion variable (flexural strength) and the predictor variables (water cement ratio, curing age and plastic content). The table also demonstrates that the adjusted $R^2 = 0.951$. Using the analysis of variance (Table 7) and the adjusted R^2, the following conventional statistical report was extracted (adjusted $R^2 = 0.951$, $F_{3,\ 101} = 677.294$, $P < 0.0001$). As $P < 0.0001$, it implies that the equation is statistically significant. The parameter estimate column (Table 8), gives the coefficients of the predictor variables in the regression equation. Subsequently, the following equation for predicting the flexural strength was derived:

Flexural Strength of PCPBs = 3.057 + 2.558 w/c ratio + 0.048 curing age – 0.039 plastic content (Adjusted R^2 = 0.951).

The 3.057 is a constant value for predicting the flexural strength of the developed PCPBs. The 2.558 means if water cement ratio is increased by one unit, flexural strength of the developed PCPBs will on average increase by 2.558. The 0.048 indicates that if curing age is increased by one unit, flexural strength of the PCPBs will on average increase by 0.048. The – 0.039 suggests that if plastic content is increased by one unit flexural strength of the developed PCPBs will on average decrease by 0.039. The adjusted R^2 = 0.951 indicates that 95.1% of the variation in flexural strength can be explained by water cement ratio, curing age and plastic content. The t-values and the respective P – values reported in Table 8 indicate the significant contribution of w/c ratio, curing age and plastic content in predicting the flexural strength of PCPBs. The t-values measure how strongly each variable influence the prediction of the flexural strength. Table 8 also demonstrates that the contribution of water cement ratio, curing age and plastic content in determining the flexural strength of PCPBs is statistically significant ($P < 0.0001$).

3.2.1.1 Test of goodness of fit

The adjusted R^2 of 95.1% is very high and this suggests that the equation is relatively good. Analysis of variance (ANOVA) (Table 7) also indicates that the regression equation is statistically significant ($P < 0.0001$). These parameters are indications of the goodness of fit of the equation.

Table 6: Model summary of the regression analysis

Root MSE	Dependent mean	Coefficient of variance	R-square	Adjusted R-square
0.20675	3.6949	0.2534	0.953	0.951

Table 7: Analysis of variance table showing the significance of the regression model

Analysis of Variance					
Source	DF	Sum of squares	Mean square	F-value	Pr > F
Model	3	86.851	28.950	677.294	<.0001
Error	101	4.317	0.043		
Corrected Total	104	91.169			

Table 8: Parameter estimates table showing the coefficients of the independent variables in the regression equation

Parameter Estimates					
Variable	DF	Parameter Estimates	Standard Error	t-value	Pr > │t│
Intercept	1	3.057	0.126	24.339	<.0001
Water cement ratio	1	2.558	0.285	8.965	<.0001
Curing age	1	0.048	0.002	20.967	<.0001
Plastic content	1	- 0.039	0.001	- 38.883	<.0001

3.2.2 Predicting the compressive strength of the developed PCPBs

With the employment of SAS, the outputs required for determining the compressive strength of the PCPBs are given in Tables 9, 10, and 11. Table 9 gives the model summary of the results for the regression analysis. The adjusted R^2 = 0.952 exhibits that there is strong correlation between the dependent variable (compressive strength) and the independent variables (water cement ratio, curing age and plastic content). Using the adjusted R^2 and the analysis of variance (Table 10), the following conventional statistical report was extracted (adjusted $R^2 = 0.952$, $F_{3, 101} = 695.787$, $P < 0.0001$). As $P < 0.0001$, it indicates that the equation is statistically significant. The parameter estimate column (Table 11) gives the coefficients of the independent variables in the regression equation. Subsequently, the following equation for predicting the compressive strength was derived:

Compressive strength of PCPBs = 22.739 + 25.819 w/c ratio + 0.352 curing age – 0.410 plastic content (Adjusted R^2 = 0.952).

The 22.739 is a constant value for predicting the compressive strength of the developed PCPBs. The 25.819 means if water cement ratio is increased by one unit, compressive strength of the PCPBs will on average increase by 25.819. The 0.352 suggests that if curing age is increased by one unit, compressive strength of the PCPBs will on average increase by 0.352. The – 0.410 indicates that if plastic content is increased by one unit, compressive strength of the developed PCPBs will on average decrease by 0.410. The adjusted R^2 = 0.952 shows that 95.2%

of the variation in compressive strength can be explained by water cement ratio, curing age and plastic content. The t-value in Table 11 demonstrates that water cement ratio and curing age have positive influence on the determination of the compressive strength while plastic content has a negative influence. Table 11 also shows that the contribution of water cement ratio, curing age and plastic content in predicting the compressive strength of PCPBs is statistically significant ($P < 0.0001$).

3.2.2.1 Test of goodness of fit.

The adjusted R^2 of 95.2% is very high and this suggests that the equation is relatively good. Analysis of variance (ANOVA) (Table 10) also indicates that the regression equation is statistically significant ($P < 0.0001$). These parameters are indications of the goodness of fit of the equation.

Table 9: Model summary of the regression analysis

Root MSE	Dependent mean	Coefficient of variance	R-square	Adjusted R-square
9.20220	26.5200	0.3470	0.954	0.952

Table 10: Analysis of variance table showing the significance of the regression model

Analysis of Variance					
Source	DF	Sum of squares	Mean square	F-value	Pr > F
Model	3	8400.315	2800.105	695.787	<.0001
Error	101	406.462	4.024		
Corrected Total	104	8806.776			

Table 11: Parameter estimates table showing the coefficients of the independent variables in the regression equation

Parameter Estimates					
Variable	DF	Parameter Estimates	Standard Error	t-value	Pr > |t|
Intercept	1	22.739	1.219	18.659	<.0001
Water cement ratio	1	25.819	2.769	9.325	<.0001
Curing age	1	0.352	0.022	15.702	<.0001
Plastic content	1	- 0.410	0.010	- 41.879	<.0001

4. Conclusions

Based on the experimental results of this study, the following conclusions can be drawn.

1. The flexural strength and compressive strength of the developed PCPBs are affected differently depending on the water cement ratio, the curing age and the plastic content used.
2. The effect of water cement ratio, curing age and plastic content on flexural strength and compressive strength of PCPBs was found to be statistically significant ($P < 0.0001$). The equations are only capable of predicting flexural strength and compressive strength of PCPBs if the w/c ratio, the curing age and the aggregate cement ratio used are within the tested ranged.
3. The equations show that increase in w/c ratio results in increase in flexural and compressive strengths. This does not mean that whenever w/c ratio is increased, flexural and compressive strengths of PCPBs would be increased. This is happening as a result of the range of w/c ratios used. From the experiment, it was realized that after the optimum w/c ratio (0.45) was used, the strengths started declining when w/c ratio of 0.50 was employed. This presupposes that if a different range of w/c ratios of say 0.45 to 0.80 is used, the effect of w/c ratio on the prediction of flexural and compressive strengths may probably be the reverse. Hence, the equations should not be applied outside the range of w/c ratios used in this study.

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