$$\sum yx = a_0 \sum x + a_1 \sum x^2$$
$$2467 = 60a_0 + 1400a_1 \quad \text{(B)}$$

Solving equations A and B simultaneously, $a_0 = 41.77$ and $a_1 = -0.028$

Hence, the equation of the regression line of compressive strength (*y*) on mix designation (*x*) is

$$y = 41.77 - 0.028x$$

Discussion: The linear regression analysis revealed that the compressive strength of the green concrete will decrease if more rice husk ash along with fly ash is used to replace cement. This analysis also makes it possible to predict the compressive strength of the green concrete at 28 days curing duration for any percentage replacement of cement with rice husk ash along with flyash, as it yielded 40.79MPa at 35% replacement of cement with rice husk ash along with fly ash.

Using least square regression line method for non-linear relationship, a trial plot of the data on a graph will show that the trend line is quadratic (like the polynomial trendline in Figure 3). So

$$y = -\theta_0 x^2 + \theta_1 x + \theta_2$$

Let the mix designation be *x* and the compressive strength at 28 days be *y*.

Table 3.1e gives the detail values of the parameters in the equation

Table 3.1e: Detail values of parameters

Assume θ_0, θ_1 and θ_2 = 0.025, 0.60 and 40.0 respectively as trial values				
x	*y* (from Experiment)	$y_c = -\theta_0 x^2 + \theta_1 x + \theta_2$	$e = y - y_c$	e^2
0	40.1	40.0	0.1	0.01
10	42.3	43.5	-1.2	1.44
20	44.6	42	2.6	6.76
30	38.4	35.5	2.9	8.41
			$\sum =$	16.62

Table 3.1f: Detail values of parameters

Assume θ_0, θ_1 and θ_2 = 0.020, 0.60 and 39.7 respectively as trial values				
x	*y* (from Experiment)	$y_c = -\theta_0 x^2 + \theta_1 x + \theta_2$	$e = y - y_c$	e^2
0	40.1	39.7	0.4	0.16
10	42.3	43.7	-1.4	1.96
20	44.6	43.7	0.9	0.81
30	38.4	39.7	-1.3	1.69
			$\sum =$	4.62

Since Table 3.1f gives the least of the sum of square of error (that is $\sum e^2 = 4.62$), θ_0 = 0.020, θ_1 = 0.60 and θ_2 = 39.7.

Hence, the equation of the regression line of compressive strength (*y*) on mix designation (*x*) is

$$y = -0.020x^2 + 0.60x + 39.7$$

Discussion: The non-linear regression analysis also revealed that the compressive strength of the green concrete will decrease if more rice husk ash along with fly ash is used to replace cement. It was confirmed by using the equation to predict the green concrete compressive strength for 35% replacement of cement with rice husk ash along with fly ash which yielded 36.20MPa. It is also noted that least square regression line method for linear relationship can be used for all non-linear relationship with polynomial and power trendline since the powers only apply to the independent variable *x* and not the θs.

3.2 Water Absorption of Combined Fly ash and Alccofine Concrete

Table 3.2a presents [15] result of water absorption of green concrete produced using 30% fly ash with 0%, 4%, 8% and 12% alccofine 1203 to replace cement.

Table 3.2a: Water absorption of combined fly ash and alccofine concrete

Mix	Oven dried weight (kg)	Weight of specimen (kg)	% Water absorption
CM	24.6	8.9	0.56
R10FA10	26.5	8.581	0.256
R10FA20	8.551	8.752	0.244
R10FA30	9	8.829	0.23

Correlation Analysis

Using Pearson's product-moment formula,

$$r = \frac{\sum \mathrm{XY}}{\sqrt{[(\sum \mathrm{X}^2)(\sum \mathrm{Y}^2)]}}$$

Let the mix be *x* and the water absorption be *y*.

Table 3.3b gives the detail values of the parameters in the equation

Table 3.2b: Detail values of parameters

	x	*y*	X=$x - \bar{x}$	Y=$y - \bar{y}$	XY	X^2	Y^2
	0	0.56	–15	0.24	-3.6	225	0.058
	10	0.256	–5	–0.064	0.32	25	0.0041
	20	0.244	5	–0.076	–0.38	25	0.0058
	30	0.23	15	–0.09	–1.35	225	0.0081
$\sum$ =	60	1.29			-5.01	500	0.076

$$\bar{x} = \frac{\sum x}{n} = \frac{60}{4} = 15$$

$$\bar{y} = \frac{\sum y}{n} = \frac{1.29}{4} = 0.32$$

Hence,

$$r = \frac{-5.01}{\sqrt{(500)(0.076)}} = -0.81$$

Discussion: The value of Pearson's correlation coefficient "r" revealed a fairly inverse relationship between the green concrete water absorpton and the percentage replacement of cement with combined fly ash and alccofine. This means that the water absorption of the green concrete will decrease with increase in percentage replacement of cement with combined fly ash and alccofine.

Regression Analysis

Using least square regression line method for non-linear relationship, a trial plot of the data on a graph will show that the trend line is exponential (like the exponential trendline in Figure 4). So

$$y = \theta_0 e^{-\theta_1 x}$$

Let the mix be *x* and the water absorption be *y*.

Table 3.3c gives the detail values of the parameters in the equation

Table 3.2c: Detail values of parameters

Assume θ_0, and θ_1 = 0.47 and 0.02 respectively as trial values				
x	*y* (from Experiment)	$y_c = \theta_0 e^{-\theta_1 x}$	$e = y - y_c$	e^2
0	0.56	0.47	0.09	0.0081
10	0.256	0.385	-0.129	0.0166
20	0.244	0.315	-0.071	0.00504
30	0.23	0.258	-0.028	0.000784
			$\sum =$	0.0305

Table 3.2d: Detail values of parameters

Assume θ_0, and θ_1 = 0.44 and 0.02 respectively as trial values				
x	*y* (from Experiment)	$y_c = \theta_0 e^{-\theta_1 x}$	$e = y - y_c$	e^2
0	0.56	0.44	0.12	0.0144
10	0.256	0.36	-0.104	0.0108
20	0.244	0.295	-0.051	0.0026
30	0.23	0.241	-0.011	0.000121
			$\sum =$	0.0279

Since Table 3.2d gives the least of the sum of square of error, θ_0 = 0.44 and θ_1 = 0.02.

Hence, the equation of the regression line of water absorption (*y*) on mix (*x*) is

$$y = 0.44e^{-0.02x}$$

Discussion: The non-linear regression analysis has revealed that the water absorption of the green concrete will decrease if more combined fly ash and alccofine is used to replace cement. For instance, using the regression equation to predict the water absorption of the green concrete when cement is replaced with 35% combined fly ash and alccofine yields 0.218 % water absorption.

CONCLUSION

Correlation and regression were used as statistical tools to analyse the mechanical and durability properties of green concrete. The use of these analytical tools showed that the degree of relationship that exists between a green concrete property (for example compressive strength or water absorption or resistance to sulphate attack) and percentage replacement of cement with a civil engineering material can be established using correlation; the nature and extent of the relationship can be known using regression; and the green concrete property analysed using regression can be predicted with the regression equation.

The results of regression analysis in section 3.1 has also shown that, for data whose trendline is polynomial in shape with the highest power of its assumed equation more than two (that is higher than quadratic equation), it is better to analyse such data using least square regression line method for linear relationship than least square regression line method for non-linear relationship as section 3.1 produced predicted values of 40.79MPa and 36.20MPa for linear and non-linear relationship respectively for 35% replacement of cement with rice husk ash along with fly ash.

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