

Original Research Article A Predictive Model for POP Cement Prices in the Nigerian Construction Industry

ABSTRACT

This study was aimed at formulating a model to predict the price of Plaster of Paris (POP) cement using a multiple linear regression modelling technique. The prices of POP cement were predicted between the fiscal years 2024 and 2030, given the prices between the fiscal years 2017 and 2023. Secondary data were obtained for the Interest Rates, Inflation Rates, Naira exchange rates against the US Dollar, Population growth rates, and Gross Domestic Product (GDP) growth rates between 2017 and 2023. Primary data were obtained to investigate the prices at which POP was sold between the fiscal years 2017 and 2023. Exponential trends forecasting was used to forecast the above decision variables or factors affecting the price of POP cement between 2024 and 2030. A multiple linear regression model was derived for the prediction of the POP cement prices between the said years. The model was found fit, adequate, and of a high predictive attribute with an R^2 value of 0.99. This study will help in the proactive planning of effective cost management for building construction projects in which POP cement was used. It will reduce problems and challenges of cost overrun on construction projects in the Nigerian construction industry.

Keywords: Cost Prediction, Gypsum, Mathematical Modelling, Nigerian Construction Industry, Plaster of Paris.

1. INTRODUCTION

For centuries, Plaster of Paris (POP) has been used by the Egyptians and Romans for construction [1]. POP, a lightweight material, is made out of gypsum [2]. When mixed with water, the material becomes dense, rigid, and solid. Several historical records have been in circulation regarding the origin of POP. However, [1] posit the records that credit King Henry III, when he visited Paris in AD1254. On seeing some walls finished with the white substance, he later ordered similar finishing as he went back to England that year, after which he named the substance 'Plaster of Paris'. The medical profession also uses POP, but for the management of bone fractures. Another name for POP is calcined gypsum [3]. POP is produced by heating gypsum, thereby making it lose some of its moisture content to the atmosphere as described by eq. (1). In Nigeria, POP cement, a white powdered substance, has gained much acceptance and popularity amongst construction practitioners and property developers in the construction industry. They have found several ways to use the material to create aesthetical edifices on walls, ceilings, and various finishes on diverse building structures. POP cement in Nigeria is retailed in 40kg per bag. The material is either manufactured locally in Nigeria or imported from abroad. A recent study [4] on 18 local and 1 foreign gypsum manufacturing sources shows that locally manufactured gypsum is suitable for cement manufacture in Nigeria. During some finishes, especially those on ceilings and walls, a sponge-like material is used to strengthen and reinforce the POP cement. That material is called kenaf filament fibre [5]. Some popular POP cement brands in Nigeria are ABS, Knauf, Dove, and Gyproc.





Fig. 1. Stacked bags of POP cement. Source: [6]

POP cement is packaged in bags and stored in depots across the country as shown in Fig.1, such that it does not get in contact with moisture. Fig. 2 shows a typical suspended ceiling finishing of a room. The finishing was done with POP cement mixed with water and Kenaf filament fibre.



Fig. 2. POP ceiling finishing. Source: [7]

This study aims to formulating a mathematical model to solve the problems of cost overrun and planning of the cost of building projects by arming the project manager with prior information of the behaviour of POP cement prices in the future before the construction stage takes place. The study is however limited to factors bordering on inflation, interests, currency exchange, Population growth, and Gross Domestic Product (GDP). To achieve the aim, the earlier mentioned factors were obtained through secondary and primary data collection processes for the last 7 years. After that, the same factors were forecast for the next 7 years. Finally, a multiple linear regression model was formulated, with which the prices of POP cement were predicted and tested. Tables 1 to 5 show data for the said factors as prepared by respective organizations, and extracted for the purpose of this study.

1.1 The Nigerian Construction Industry

Construction in Nigeria is a major industry. Its major sectors are [8] residential, commercial, infrastructure, industrial, energy and utilities, and institutional construction. In the second quarter of 2021, the Nigerian construction industry expanded by about 3.7% [9] year on year. The industry, according to [8] has a capital base of about \$135.9 billion. The

increase in housing demand, rise in population, and rise in prices of commodities across the country have continually impacted on the industry.

1.2 Factors Affecting POP Cement Price

Economic factors such as inflation, interests, currency exchange, and Gross Domestic Product (GDP) are some of the major reasons for changes in the prices of POP cement in Nigeria. However, other factors such as population, demand & supply, government policies, taxes, customs duties, transportation, corruption, bad roads, and many others constitute a more comprehensive list that affects POP cement prices in Nigeria. These have constantly created problems of cost overrun during the planning and execution of construction and building projects that involve the use of POP cement. A study carried out [10] on cement prices considered Inflation, Population growth, and GDP only. Similarly, [11] conducted a study on currency exchange rates for construction materials such as reinforcement, tiles, and cement. Many others [12]–[16] have conducted extensive research on various construction materials, especially on cement. Some of the major factors they considered were GDP and currency exchange rates. Some also formulated mathematical models. However, none of these studies have been able to completely address the effective prediction of POP cement prices due to the factors and dynamic changes the material has experienced over the years.

Table 1. Inflation Rates of Nigeria

Fiscal Year	Inflation Rates (%)
2003	11.71
2004	20.80
2005	8.56
2006	12.46
2007	9.93
2008	2.41
2009	10.54
2010	11.43
2011	11.39
2012	12.19
2013	9.45
2014	7.22
2015	7.40
2016	10.13
2017	13.50
2018	12.08
2019	10.30
2020	10.09
2021	12.45
2022	14.68
2023	18.03

Source: [17]

Table 2. Interest Rates in Nigeria

Fiscal Year	Average Interest Rates (%)
2023	28.16
2022	27.85
2021	28.06
2020	29.65
2019	30.76
2018	31.10
2017	30.60

2016	27.29
2015	26.71
2014	25.74
2013	24.69
2012	23.79
2011	22.39
2010	22.51
2009	22.62
2008	18.70
2007	18.36
2006	18.37

Source: [18]

Table 3. Official Naira Exchange Rates against the US Dollar

Rate Date	Currency	Rate Year	Rate Month	Buying Rate (₦)	Central Rate (₦)	Selling Rate (₦)
10/25/2023	US DOLLAR	2023	October	802.21	802.71	803.21
12/30/2022	US DOLLAR	2022	December	448.05	448.55	449.05
12/31/2021	US DOLLAR	2021	December	412.49	412.99	413.49
12/31/2020	US DOLLAR	2020	December	379	379.5	380
12/31/2019	US DOLLAR	2019	December	342.5	343	343.5
12/31/2018	US DOLLAR	2018	December	306	306.5	307
12/29/2017	US DOLLAR	2017	December	305	305.5	306
12/30/2016	US DOLLAR	2016	December	304	304.5	305
12/31/2015	US DOLLAR	2015	December	196	196.5	197
12/31/2014	US DOLLAR	2014	December	167	167.5	168
12/31/2013	US DOLLAR	2013	December	154.7	155.2	155.7
12/31/2012	US DOLLAR	2012	December	154.77	155.27	155.77
12/30/2011	US DOLLAR	2011	December	155.7	156.2	156.7
12/31/2010	US DOLLAR	2010	December	148.17	148.67	149.17
12/31/2009	US DOLLAR	2009	December	147.1	147.6	148.1
12/31/2008	US DOLLAR	2008	December	130.25	130.75	131.25
12/31/2007	US DOLLAR	2007	December	115.8	116.3	116.8
12/29/2006	US DOLLAR	2006	December	126	126.5	127
12/30/2005	US DOLLAR	2005	December	128	128.5	129
12/31/2004	US DOLLAR	2004	December	131.85	132.35	132.85
12/31/2003	US DOLLAR	2003	December	136	136.5	137

Source: [19]

Table 3 was extracted from the comprehensive exchange rates as official rates. However, in Nigeria, the official exchange rates are rarely used for any transaction. Rather, the rates from the parallel market are used for business in Nigeria.

Table 4. Population Growth Rates of Nigeria

Fiscal Year	Population Growth Rate (%)
2015	2.54
2016	2.50
2017	2.52
2018	2.50

2019	2.45
2020	2.44
2021	2.41
2022	2.38

Source: [20]

The population growth rates and real GDP rates were also extracted and presented in Tables 4 and 5 respectively.

Table 5. Real GDP Rates of Nigeria

Fiscal Year	Real GDP Growth Rate (%)
2015	2.65
2016	-1.62
2017	0.81
2018	1.92
2019	2.21
2020	-1.79
2021	3.65
2022	3.25

Source: [21]

2. MATERIAL AND METHODS

The study was carried out in all 36 states and the Federal Capital Territory (FCT) of Nigeria. The material in question was Plaster of Paris (POP). Interviews were done with POP cement sellers, Civil Engineers, Builders, Architects, POP cement manufacturers, Construction Managers, building owners, and material suppliers across the country. This aspect of the research lasted for 5 weeks. The aim of the interviews was to gather primary information on the prices of POP cement in the country between the years 2017 and 2023. The interviews also took place in some construction companies, POP cement manufacturing companies, POP sales depots, POP finishing installers, and consultancy firms across the country. The actual average prices of the material are shown in Table 7.

Exponential trend forecasting with a seasonality of 3, using Microsoft Excel, was performed on the secondary data obtained in Tables 1 to 5. These resulted in Figs. 3 to 7.

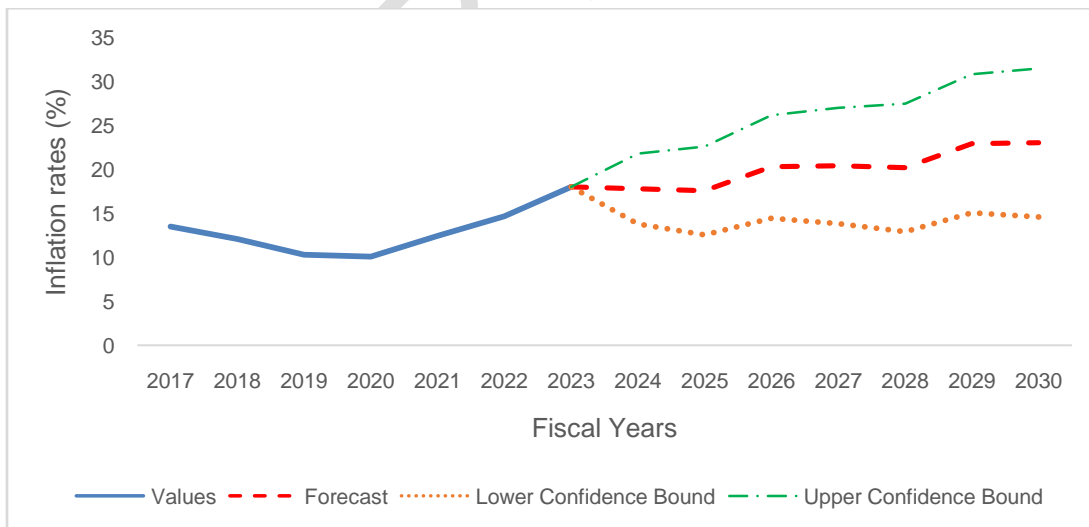


Fig. 3. Exponential Trend Forecast of Inflation Rates

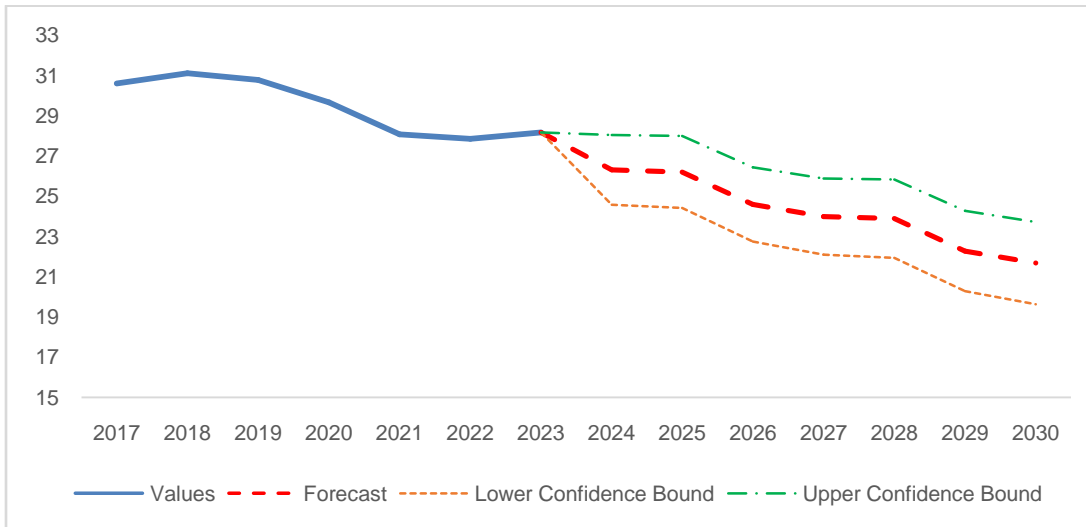


Fig. 4. Exponential Trend Forecast of Interest Rates

The currency exchange rates used in Nigeria are those from the parallel market as stated earlier. After rigorous interviews from selected parallel market dealers in 12 major cities of the country, Table 6 shows a compilation of realistic average exchange rates in Nigeria.

Table 6. Naira Exchange Rates against the US Dollar in the parallel market

Fiscal Year	Dollar Exchange rate (₦)
2017	365
2018	370
2019	390
2020	495
2021	560
2022	755
2023	1250

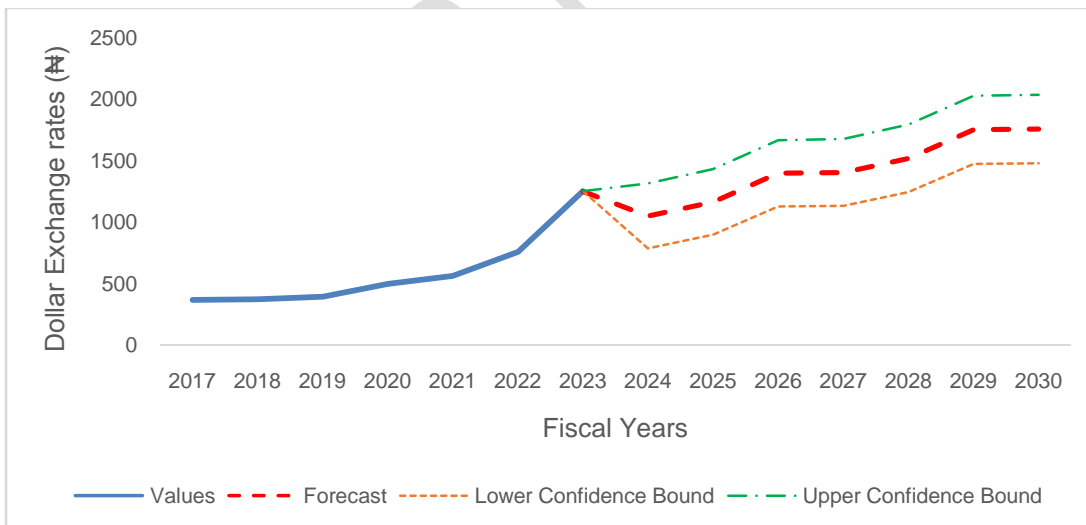


Fig. 5. Exponential Trend Forecast of Exchange Rates

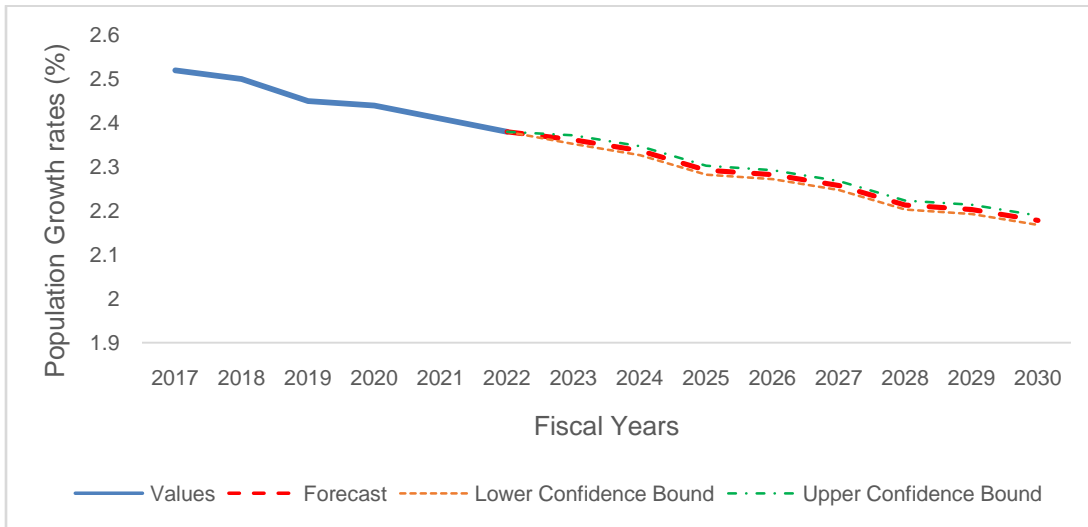


Fig. 6. Exponential Trend Forecast of Population Growth Rates

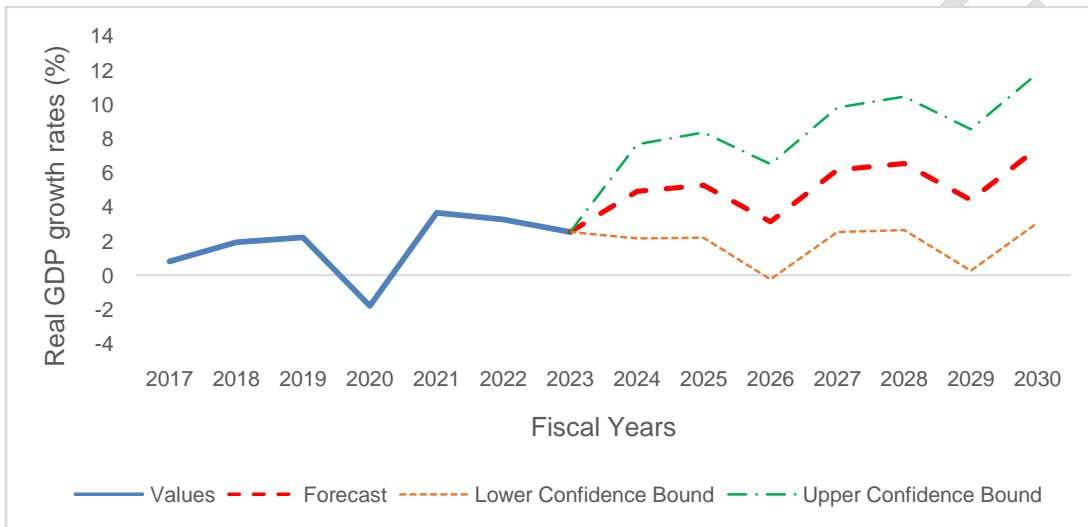


Fig. 7. Exponential Trend Forecast of Real GDP Growth Rates

The actual prices of POP cement obtained as the main primary data is shown in Table 7.

Table 7. Actual Prices of Cement in Nigeria

Fiscal Year	Actual POP Cement Prices (₦)
FY	P _A
2017	2,500
2018	3,000
2019	3,500
2020	6,000
2021	10,000
2022	6,000
2023	7,500

2.1The Multiple Linear Model Formulation

The general equation (objective function) for a multiple linear regression model for 5 decision variables as applied to the data from this study is given in eq. (2).

$$P = \beta + INTx_1 + INRx_2 + EXRx_3 + PGRx_4 + GDPx_5 \quad (2)$$

where,

β , INT, INR, EXR, PGR, and GDP are the intercept, interest rates, inflation rates, Dollar exchange rates, population growth rates, and GDP growth rates respectively. However, x_1 to x_5 are the model constants corresponding to the respective decision variables shown in eq. 2.

3. RESULTS AND DISCUSSION

Table 8 is a comprehensive compilation of the data required for the formulation of the model. Eq. (3) is a multiple linear regression model generated after the calibration was done. With this model, the price of cement was predicted for Fiscal Years 2024 to 2030.

Table 8. Model formulation data

Fiscal Year	Interest Rates (%)	Inflation Rates (%)	Exchange Rates (\$)	Population Growth Rates (%)	Real Growth Rates (%)	GDP Rates	Actual Cement (#)	POP Prices
FY	INT	INR	EXR	PGR	GDP		P_A	
2017	30.60	13.50	365.00	2.52	0.81		2,500	
2018	31.10	12.08	370.00	2.50	1.92		3,000	
2019	30.76	10.30	390.00	2.45	2.21		3,500	
2020	29.65	10.09	495.00	2.44	-1.79		6,000	
2021	28.06	12.45	560.00	2.41	3.65		10,000	
2022	27.85	14.68	755.00	2.38	3.25		6,000	
2023	28.16	18.03	1250.00	2.36	2.53		7,500	
2024	26.30	17.80	1048.89	2.34	4.90			
2025	26.19	17.58	1163.86	2.29	5.27			
2026	24.58	20.32	1395.44	2.28	3.13			
2027	23.98	20.42	1401.92	2.26	6.17			
2028	23.88	20.20	1516.89	2.21	6.54			
2029	22.27	22.94	1748.47	2.20	4.40			
2030	21.67	23.04	1754.95	2.18	7.44			

The software, Minitab version 16 was used to generate and analyse the model. This is presented in eq. 3 as the model to predict the price of POP cement in Nigeria.

$$P = -198645 - 4164.18INT - 2852.69INR + 31.71EXR + 140683.3PGR + 1150.41GDP \quad (3)$$

The summary output in Table 9 shows that the square of the correlation coefficient R^2 is 0.99. This signifies that the model is near perfect fit.

Table 9. Summary Output

Regression Statistics	
Multiple R	0.999882
R Square	0.999764
Adjusted R Square	0.998586
Standard Error	101.825
Observations	7

The Analysis of Variance (ANOVA) in Table 10 indicates that the model is adequate.

Table 10. Analysis of Variance

	df	SS	MS	F	Significance F
Regression	5	43989632	8797926	848.5376	0.026057
Residual	1	10368.34	10368.34		
Total	6	44000000			

The predictive data in Table 11 shows P-values all less than 0.15. This indicates that all the variables are predictors or are significant in the prediction process. Hence all the decision variables, INT, INR, EXR, PGR, and GDP are all excellent predictors.

Table 11. Predictive data

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-198645	9625.531	-20.6373	0.03	-320949	-76341.2	-320949	-76341.2
INT	-4164.18	103.229	-40.3393	0.02	-5475.83	-2852.53	-5475.83	-2852.53
INR	-2852.69	90.06731	-31.6729	0.02	-3997.11	-1708.28	-3997.11	-1708.28
EXR	31.70511	1.098727	28.85624	0.02	17.74447	45.66576	17.74447	45.66576
PGR	140683.8	5170.798	27.20736	0.02	74982.56	206385	74982.56	206385
GDP	1150.406	46.11831	24.94466	0.03	564.4169	1736.394	564.4169	1736.394

The model has been used to successfully predict prices of POP cement for fiscal years 2024 to 2030 as shown in Table 12. This means that the predicted values are to be expected in the coming years, given the considered factors or decision variables.

Table 12. Predicted Prices

Fiscal Year	Actual Cement (₱)	POP Prices	Predicted Cement Prices (₱)
FY	P _A		P _C
2017	2,500.00		2,456.17
2018	3,000.00		3,073.25
2019	3,500.00		3,454.17
2020	6,000.00		6,011.92
2021	10,000.00		9,988.90
2022	6,000.00		6,025.04
2023	7,500.00		7,490.54
2024			8,748.19
2025			7,579.21
2026			9,973.62
2027			12,392.25
2028			11,223.27
2029			13,617.68
2030			16,036.31

Fig. 8 shows a plot of the present and futuristic prices of cement between 2017 and 2030. This shows that the price will keep rising unless something different happens to the decision variables.

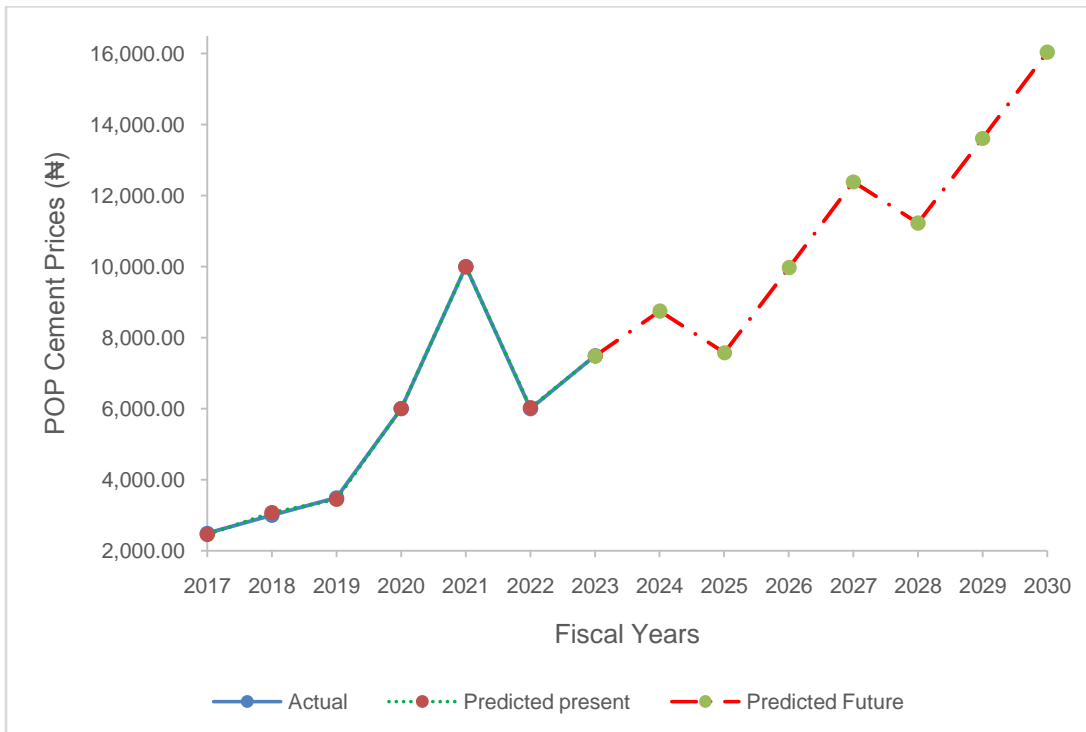


Fig. 8. POP cement price projection

4. CONCLUSION

This study was aimed at understanding the future prices of POP cement in order to effectively mitigate or reduce possible cost overruns in building construction projects. This was done with the aid of a multiple linear regression model. Quantitative data were successfully collected from secondary sources for the last 7 years (2017 to 2023). The collected data were subjected to exponential trend forecasting, given the behaviours and trends of each. The forecast data for the next 7 years (between 2024 and 2030). Primary data was also obtained to ascertain the actual prices of POP cement in the past 7 years (between 2017 and 2023). The primary data and secondary data of the past 7 years were used to obtain the model coefficients using Minitab 16. This is otherwise called the calibration process of the model. The model was then derived with which predictions were made for the prices of POP cement between 2024 and 2030. The model was tested with the Analysis of variance and found to be fit, adequate, and has a high correlation. The model has the capability to predict accurate prices of POP cement as it has a high R^2 value of 0.99. construction managers, architects, quantity surveyors, construction engineers, civil engineers, project managers, project planners, property developers, and other stakeholders in the built environment are hereby encouraged to use the model to enable them to have foresight on their construction projects in terms of cost, especially when the project involves the use of POP cement. This will help tackle cost overrun problems that come up on their projects.

CONSENT (WHEREEVER APPLICABLE)

No written consent note of any sort is required for this manuscript.

ETHICAL APPROVAL (WHEREEVER APPLICABLE)

No ethical approval of any sort is required for this manuscript.

DEFINITIONS, ACRONYMS, ABBREVIATIONS

Here is the Definitions section. This is an optional section.

GDP: Gross Domestic Product

POP: Plaster of Paris

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