Predictive Modelling for Sustainable Residential Building Maintenance In Developing Countries: A Nigeria Case

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Abstract

In developing countries, building maintenance is gaining an increasing recognition in many field of study. Meanwhile, in Nigeria there is lack of effective building maintenance setup that can sustain the current inadequate housing provision. With ever increasing demand and cost for housing provision in the country, a lack of appropriate predictive tool for the maintenance of the existing buildings can have a significant detrimental effect on future housing development. Presently, there is a remarkable gap and paradigm shift in building maintenance management from preventive approach to predictive approach that is achievable through building of an evaluative model to assess a variety of alternative decisions. This paper thus aimed at developing mathematical models for the maintenance of residential buildings with reference to Niger state, Nigeria. It identified factors that influence the level of maintenance of residential buildings standards. The paper employed descriptive and inferential survey research method and subjected data collected to bi-variate and multi-variate analysis, using Statistical Package for Social Sciences (SPSS). The analysis enabled the development of a mathematical model which was tested and found adequate with 94% predictive value respectively for the assessment and maintenance of residential buildings. The result shows that long term sustainability of these building could be enhanced through the adoption of appropriate predictive tool for their maintenance. This will help to achieve their optimum performance throughout their life span. The paper recommended the adoption of the model for appropriate monitoring and quick evaluation of residential buildings' performance in developing countries. It concluded that this can aid government policy formulation on minimum building maintenance standards to avoid cumulative decay and deterioration that leads buildings to the point of collapse. It will also assist architects to make predictions through scientific means rather than perception in their design.

Keywords: Development, Maintenance, Mathematical Model, Residential Building, Sustainability.

1. Introduction

Modelling is an extremely powerful tool, a framework for research, debate and planning, which provides a valuable source of information (Saifullah, 2005). Moreover, Olgunju (2011) also described model as a simplified version of something complex used in analysing and solving problems or making predictions or used as the basis for a related idea, process or system. According to Barnes and Fulford (2002), mathematical model can as well be described as a simplification of a complex real world problem, which is cast into the form of mathematical equation.

In line with Saifullah (2005), Olagunju (2011), and Barnes and Fulford (2002) statements, predictive modelling can therefore be described as a building of an evaluative model, usually mathematical, used to assess a variety of alternative decisions. Thus, for residential building maintenance, predictive modelling can be used for monitoring and quick evaluation of buildings. This could be done through assessment of few specific components of a building, analyse the data with the model and use it to predict the status of the building in objective manner rather than subjective manner. Furthermore, sustainability of residential building can be described as a residential building in which optimum performance can be achieved throughout its life span within its minimum life cycle cost. That is when optimum performance of a sustainable building can be achieved at the best point where building function at its best.

Building maintenance is fast gaining an increasing recognition in many field of study, especially in environmental studies. In Nigeria like many other developing countries, there is lack of effective building maintenance setup that can sustain the current inadequate housing provision in quantitative and qualitative terms. According to Lee (1998), the condition and quality of buildings reflect public pride or indifference, the level of prosperity in the area, social values and behaviour and all the many influences both past and present which combine to give a community its unique character. In line with the Lee's assertion, lack of effective building maintenance setup that can sustain regular maintenance of building in a country can further affect communities and even nations' unique characters.

This problem forms the basis of this study which is a report of part of a research conducted by the author between 2006 and 2010. The study assessed the level of maintenance of the private residential buildings (excluding all agencies provided housing), located in one most populous Local Government Authorities (LGA) headquarters of each of the three senatorial districts as existed in Niger state.

1.1 Objectives

The main objectives of the study are to assess the levels of physical condition of residential buildings in Niger State and to develop a predictive mathematical model for sustainable residential building maintenance in Niger state, Nigeria and other allied countries.

1.2 Research justification

The study area, Niger state is located in the North Central Geopolitical Zone of Nigeria. The study area is located in the Middle-belt of Nigeria which by influence, houses developments and settlement of migrants from the Northern and Southern parts of Nigeria. The residents' attitude towards building maintenance also reflects varieties from various part of the country, Nigeria. These further indicate that the research result will be applicable in either Northern or southern part of Nigeria.

In addition, urban centres in Niger State, such as Minna Suleja, Bida and Kontagora are experiencing rapid rural-urban migration problem, in the face of the prevalence of large quantity of indecent and substandard houses, coupled with poor supply of basic services in the state. Thus, this called for a total overhauling of the building maintenance culture, practice and management and change to the current building maintenance best practices. This will be in line with the paradigm shift of building maintenance management from corrective approach to preventive and presently to predictive approach.

2. Methodology

The study covers three selected Local Government Authority (LGA) headquarters, which include Bida LGA, Minna LGA and Kontagora LGA . One Local Government Councils' headquarter was selected from each of the three Senatorial districts, based on the hierarchy of settlements in the state (100 km radius influence) and population density (highest), see table 1. Based on the nature of the study, a combination of descriptive and inferential method was employed for physical assessment, using audit inspection approach.

Table 1: **Niger State Senatorial District, Local Government Councils, Hierarchy of Settlements and Selected Towns**

	Senatorial District	Composition by lga	Lga hq	Population Density	Hierarchy of settlements (km radius influence)	Remarks
1.	A	Bida	Bida	3762.87	Rank 1 (100km)	Selected
2.		Lavun	Kutigi	497.61	Rank 2 (50km)	
3.		Edati	Enagi	211.02		
4.		Katcha	Katcha	72.46		
5.		Gbako	Lemu	66.64	Rank 3 (30km)	
6.		Mokwa	Mokwa	54.69	Rank 2 (50km)	
7.		Agaie	Agaie	67.37	Rank 2 (50km)	
8.		Lapai	Lapai	33.72	Rank 2 (50km)	
9.	B	Chanchaga	Minna	2745.76	Rank 1 (100km)	Selected
10.		Bosso	Maikukele	91.75		
11.		Paikoro	Paiko	69.97	Rank 3 (30km)	
12.		Munya	Sarkin Pawa	44.87		
13.		Shiroro	Kuta	42.35	Rank 2 (50km)	
14.		Suleja	Suleja	1411.48	Rank 1 (100km)	
15.		Tafa	New Wuse	368.88		
16.		Gurara	Gawu-Babangida	80.77		
17.		Rafi	Kagara	51.12	Rank 2 (50km)	
18.	C	Kotangora	Kontagora	69.72	Rank 1 (100km)	Selected
19.		Rijau	Rijau	51.30	Rank 2 (50km)	
20		Wushishi	Wushishi	45.96	Rank 3 (30km)	
21.		Magama	Nasko	45.58		
22.		Mariga	Bangi	33.29		
23		Mashegu	Mashegu	21.48	Rank 3 (30km)	
24		Agwara	Agwara	27.26		
25		Borgu	New-Bussa	14.59	Rank 3 (30km)	
Total		**25 Nos**	**25 Nos**	**51.65**		**3 Nos**

Source: Adapted from Niger State of Nigeria Gazette, Notice No 14, 2001, Niger State Regional Plan, 1979 – 2000, and National Population Commission, Abuja, 2006

Probability sampling method was used for the research. Ibanga (2006), described probability sampling as a procedure which permits the elements in the population to have known probabilities of selection, and allows the units to be selected independently. Probability sampling method was adopted so as to allow equal opportunity of being selected to every data collected, and also to allow selection of every data independently without influencing each other.

Systematic sampling method was used for the selection of neighbourhood centres available in each of the urban centres. Systematic sampling method was also adopted for the selection of the private residential building units in each town (sample). Based on the population size, sampling frame of 1216, which is (2%) of the research population (60,800) was used. The sampling frame of 1216 buildings was further distributed on pro-data basis among Bida (370), Minna (681) and Kontagora (265) for the data to be fully representative (see table 2)

Table 2: **Power Holding Company Of Nigeria (PHCN) Private Residential Customers In Bida, Minna And Kontagora**

S/No	Town	No of Private Residential Customers (Population)	No for Inspection (2% of the Population)
1.	BIDA	(14740 x *1.25439) = 18489	370
2.	MINNA	(23154 x *1.25439) = 29044	581
3.	KONTAGORA	(10576 x *1.25439) = 13266	265
Total		(48470 x *1.25439) = 60800	1216

Source: Author, 2009

Note: *Denotes multiplier derived from Kpakungu area, Kpakungu actual and available PHCN record.

Source: Adapted from Power Holding Company of Nigeria (PHCN), Minna, Nigeria, 2009

The questionnaire was designed to reflect on the research problems. A questionnaire was administered in each of the 1216 buildings selected at random. The questionnaires were retrieved from a respondent in each of the buildings immediately after completion and collated for analysis.

Table 3 is the adapted building condition rating and index used for the building physical condition and infrastructure adequacy ratings in this study. The table 3 shows that building/component condition can be rated ranges from very poor to excellent. All the building/component conditions itemised are well defined, with corresponding condition rating and building condition index.

Table 3: **Condition Rating: Scale of Asset Condition and Definitions**

Building/ component Condition	General description (definition of rating/condition of building asset)	Condition rating (c)	Building condition index
Very poor	▪ Building has failed ▪ Not operational ▪ Not viable ▪ Unfit for occupancy ▪ Environmental/contamination/pollution issues exist	1	0.00 to 0.19
Poor	▪ Badly deteriorated ▪ Potential structural problems (e.g. structural cracks) ▪ Inferior appearance ▪ Major defects ▪ Components fail frequently	2	0.20 to 0.49
Fair	▪ Average condition ▪ Significant defects are evident (e.g. non – structural cracks) ▪ Worn finishes require maintenance ▪ Services are functional but need attention ▪ Deferred maintenance work exists	3	0.50 to 0.74
Good	▪ Minor defects (e.g. hairline cracks) ▪ Superficial wear and tear ▪ Some deterioration to finishes ▪ Major maintenance not required	4	0.75 to 0.94
Excellent	▪ Asset has no defects ▪ As new condition and appearance	5	0.95 to 1.00

Source: Adapted from AAPPA - Australasian Association of Higher Education Facilities Officers, 2000

NOTE:

Facility/Building Condition Index

The Building Condition Index (BCI) is an index number that indicates the current condition of the asset measured relative to its 'as-new' condition.

$$BCI = \frac{\text{Asset Current Condition}}{\text{As-new Condition}}$$

Statistical Package for Social Sciences (SPSS) version 17 computer program was used for the analysis. The data collected were subjected to uni-variate analysis (i.e. Descriptive summary measure; frequencies) and multi-variate analysis {i.e. multiple regressions (linear), using stepwise method)}.

3. Research findings

3.1 Niger State (Bida, Minna and Kontagora) Model Development

(i) Multiple regression model was used to establish relationships between dependent variable (Physical condition of buildings) and other 25 predictor variables (Post Occupancy Evaluation, POE variables for buildings' condition), **using forced entry method**. The forced entry method was adopted so as to detect the strongest variables among the twenty five (25) predictor variables (see table 4).

The result is as follows: -

(i) The regression coefficient table reveals that all the predictor variables are significant

(ii) The multiple correlation coefficient 'r' is 0.996. This means that there is strong and positive relationship between physical condition of buildings (dependent variable) and predictor variables.

(iii) The coefficient of determination 'r^2' is 0.992. This means that the predictor variables can give about 99.6% explanation for residual variation in physical condition of buildings.

(iv) However, the strongest variables among the twenty five (25) predictor variables could not be detected.

Table 4: **Specification of Variables**

S/No	Variable Number	Code	Name
1	V01	AGEBLD	Age of Building/Date built
2	V02	NOFLRS	Number of Floors
3	V03	FLAREA	Floor Area
4	V04	TNOOCC	Total Number of Occupants
5	V05	TNOMOC	Total Number of Male Occupants
6	V06	TNOFOC	Total Number of Female Occupants
7	V07	NOBDRM	Number of Bedrooms
8	V08	PLOTDEV	Plot Development Ratio (Percentage)
9	V09	NOFNTL	Number of Functional Toilets
10	V10	NOFNBA	Number of Functional Bathrooms
11	V11	BLDTPE	Building Type
12	V12	TPETEN	Type of Tenure
13	V13	RESEDU	Respondent's Highest Education Level
14	V14	RESOCC	Respondents Occupation
15	V15	WALMAT	Wall Material
16	V16	BLDREP	Building State of Repair
17	V17	BLDFAC	Building Facilities

Source: Author's Research Design, 2010

(ii) Multiple regression model was again used to establish relationships between dependent variable (Physical condition of buildings) and other 25 predictor variables (Post Occupancy Evaluation, POE variables for buildings' condition), **using stepwise method**. The stepwise method was adopted so as to detect the strongest variables among the twenty five (25) predictor variables and to get the equation of best regression that can describe the relationship and be used for prediction. The result is as follows: -

Table 5: **Model Summary of Physical Condition and Other Variables – 25 (Bida, Minna and**

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.806[a]	.650	.650	7.885	.650	2223.478	1	1197	.000
2	.888[b]	.789	.789	6.125	.139	787.582	1	1196	.000
3	.920[c]	.846	.845	5.237	.057	440.889	1	1195	.000
4	.938[d]	.881	.880	4.609	.035	349.300	1	1194	.000
5	.950[e]	.902	.902	4.171	.022	264.642	1	1193	.000
6	.959[f]	.919	.919	3.801	.017	244.234	1	1192	.000
7	.964[g]	.930	.930	3.537	.011	185.856	1	1191	.000
8	.970[h]	.940	.940	3.272	.010	201.606	1	1190	.000
9	.974[i]	.948	.948	3.040	.008	189.890	1	1189	.000
10	.978[j]	.956	.955	2.816	.007	197.220	1	1188	.000
11	.980[k]	.961	.961	2.644	.005	161.268	1	1187	.000
12	.983[l]	.966	.966	2.472	.005	171.492	1	1186	.000
13	.985[m]	.970	.969	2.327	.004	153.661	1	1185	.000
14	.987[n]	.973	.973	2.188	.004	156.069	1	1184	.000
15	.988[o]	.977	.976	2.051	.003	164.012	1	1183	.000
16	.990[p]	.979	.979	1.932	.003	151.951	1	1182	.000
17	.991[q]	.982	.981	1.819	.002	152.180	1	1181	.000
18	.992[r]	.984	.984	1.711	.002	154.933	1	1180	.000
19	.993[s]	.986	.986	1.579	.002	205.927	1	1179	.000
20	.994[t]	.988	.988	1.474	.002	174.584	1	1178	.000
21	.995[u]	.990	.989	1.377	.002	173.312	1	1177	.000
22	.995[v]	.990	.990	1.316	.001	112.789	1	1176	.000
23	.996[w]	.991	.991	1.256	.001	116.366	1	1175	.000
24	.996[x]	.992	.992	1.207	.001	97.932	1	1174	.000
25	.996[y]	.993	.992	1.158	.001	102.659	1	1173	.000

a. Predictors: (Constant), Interior walls' surface condition

b. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition

c. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition, Discharge of waste water's condition

d. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition, Discharge of waste water's condition, Roof's condition

e. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition, Discharge of waste water's condition, Roof's condition, Structural components' condition

f. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition, Discharge of waste water's condition, Roof's condition, Structural components' condition, Walkway within the building premise's condition

g. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition, Discharge of waste water's condition, Roof's condition, Structural components' condition, Walkway within the building premise's condition, Exterior walls' condition

h. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition, Discharge of waste water's condition, Roof's condition, Structural components' condition, Walkway within the building premise's condition, Exterior walls' condition, Electrical wires & switches condition

i. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition, Discharge of waste water's condition, Roof's condition, Structural components' condition, Walkway within the building premise's condition, Exterior walls' condition, Electrical wires & switches condition, Exit condition

j. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition, Discharge of waste water's condition, Roof's condition, Structural components' condition, Walkway within the building premise's condition, Exterior walls' condition, Electrical wires & switches condition, Exit condition, Surface drainage's condition

k. Predictors: (Constant), Interior walls' surface condition, Toilet facilities' condition, Discharge of waste water's condition, Roof's condition, Structural components' condition, Walkway within the building premise's condition, Exterior walls' condition, Electrical wires & switches condition, Exit condition, Surface drainage's condition, Plumbing facilities' condition

- The multiple regression analysis for dependent variable, Physical condition actual percentage yielded twenty five (25) models. From table 5, only the first eight models are significant, with R Square Change not less than 0.01. Thus, the eighth stepwise regression model have eight variables which are the following (see table 6):

Table 6: **Model's Variables**

S/N	CODE	PARTICULARS
1	STRUCT	Structural components' condition
2	ROOFCO	Roof's condition
3	TOILFAC	Toilet facilities' condition
4	WASTEW	Discharge of waste water's condition
5	EXTWAL	Exterior walls' condition
6	WAKWAY	Walkways within the building premises' condition
7	ELECTW	Electrical wires & switches' condition
8	INTWSU	Interior walls' surface condition

Source: Author, 2010

From table 5 again:

(i) The multiple correlation coefficient 'r' is 0.970. This means that there is strong and positive relationship between physical condition of buildings (dependent variable) and predictor variables.

(ii) The coefficient of determination 'r^2' is 0.940. This means that the predictor variables can give about 94% explanation for residual variation in physical condition of buildings (dependent variable). Others may be as a result of chance effect which may not be measurable (i.e. the remaining 6%).

(iii) Therefore, Model equation is,

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \ell \quad (1)$$

Where:

Y = Physical condition of buildings (dependable variable, PHYCON)
X_1 = Structural components' condition (STRUCT)
X_2 = Roof's condition (ROOFCO)
X_3 = Toilet facilities' condition (TOILFAC)
X_4 = Discharge of waste water's condition (WASTEWT)
X_5 = Exterior walls' condition (EXTWAL)
X_6 = Walkways within the building premise condition (WAKWAY)
X_7 = Electrical wires & switches' condition (ELECTWR)
X_8 = Interior walls' surface condition (INTWALS)

Table 7: **Regression Model's Coefficient and the Corresponding Beta Values**

S/No	Regression Model Coefficients Particulars	Value	Beta Value
1	Constant β_0	4.368	
2	β_1	2.305	0.164
3	β_2	2.555	0.184
4	β_3	2.699	0.186
5	β_4	2.096	0.170
6	β_5	2.295	0.158
7	β_6	1.805	0.135
8	β_7	2.031	0.142
9	β_8	1.853	0.128

Source: Author, Using SPSS program, 2010

The table 7, shows the emerging model equation's regression coefficients estimates,

Therefore, Model equation is,

$$\hat{Y} = 4.368 + 2.305X_1 + 2.555X_2 + 2.699X_3 + 2.096X_4 + 2.295X_5 + 1.805X_6 + 2.031X_7 + 1.853X_8 \quad (2)$$

Table 8: **Mean Values of Model's Variables**

S/N	CODE	PARTICULARS	MEAN VALUE
1	X_1	Structural components' condition (STRUCT)	3.04
2	X_2	Roof's condition (ROOFCO)	3.02
3	X_3	Toilet facilities' condition (TOILTFAC)	2.94
4	X_4	Discharge of waste water's condition (WASTEWT)	2.46
5	X_5	Exterior walls' condition (EXTWAL)	2.97
6	X_6	Walkways within the building premise condition (WAKWAY)	2.1541
7	X_7	Electrical wires & switches' condition (ELECTWR)	3.02
8	X_8	Interior walls' surface condition (INTWALS)	3.30
9	Y	Physical condition of buildings (dependable variable)	55.02

Source: Author, Using SPSS program, 2010

From the data, the mean values of the above variables are as shown in table 8.

Therefore, the model estimate is,

1) $\hat{Y} = 4.368 + 2.305(3.04) + 2.555(3.02) + 2.699(2.94) + 2.096(2.46) + 2.295(2.97)$ $1.805(2.1541) + 2.031(3.2) + 1.853(3.3)$ (3)

2) $\hat{Y} = 55.05009205$

3) Model estimate, $\hat{Y} = 55.05009205$, while actual observation, $Y = 55.02$).

4) Where error term is given as:

(a) $\ell^2 = (Y - \hat{Y})^2$

(b) $\ell^2 = (55.02 – 55.050009205)^2$

(c) $\ell^2 = 0.0009055314732$

5) This means that

(a) the error term is 0.0009055314732, which explains the deviation of (Y) from the fitted regression line/model (Ŷ)

(b) In Niger state, the physical condition of all the private residential buildings is fair for human habitation.

(c) Eight maintenance factors are significant to physical condition of buildings in the Niger state. These factors are listed in order of importance, namely,

(i) Toilet facilities' condition
(ii) Roof's condition
(iii) Discharge of waste water's condition
(iv) Structural components' condition
(v) Exterior walls' condition
(vi) Electrical wires & switches' condition
(vii) Walkways within the building premise condition
(viii) Interior walls' surface condition

(d) The quantitative regression equation is -

Ŷ = 4.368 + 2.305 STRUCT + 2.555 ROOFCO + 2.699 TOILFAC + 2.096 WASTEWT + 2.295 EXTWAL + 1.805 WAKWAY + 2.031 ELECTWR + 1.853 INTWALS (4)

Where:

Y = Physical condition of buildings (dependent maintenance factor - PHYCON), while others (physical condition of buildings' predictors) are the following:

(i) STRUT is Structural components' condition
(ii) ROOFCO is Roof's condition
(iii) TOILFAC is Toilet facilities' condition
(iv) WASTEWT is Discharge of waste water's condition
(v) EXTWAL is Exterior walls' condition
(vi) WAKWAY is Walkways within the building premise condition
(vii) ELECTWR is Electrical wires & switches' condition
(viii) INTWALS is Interior walls' surface condition

All the above eight listed building maintenance factors as physical condition of buildings' predictor can give about 94% explanation for residual variation in physical condition of buildings in Niger state. Thus, they have the best building maintenance factors with 94% predictive value for assessments of physical condition of buildings in the Niger state.

4. Recommendations and implementation

4.1 Recommendations

For full utilization of the accrued benefits derivable from the study findings, the residential building maintenance stakeholders have to take the following into consideration,

(i) Re-introduction of the Buildings and Building Premise Inspection Programme (BBPIP) in the state, whereby the developed maintenance model will be used for quick assessment of residential buildings' physical condition. The mathematical models' adoption will eliminate doubts on the parts of the government officials and the house owners or housing agents or tenants, most especially in Investigative Post-Occupancy Evaluation decision making which may later demand for Diagnostic Post-Occupancy Evaluation.

(ii) The physical condition assessment model developed, Ŷ = 4.368 + 2.305 STRUCT + 2.555 ROOFCO + 2.699 TOILFAC + 2.096 WASTEWT + 2.295 EXTWAL + 1.805 WAKWAY +

2.031 ELECTWR + 1.853 INTWALS should be adopted and used by Government at all levels for quick assessment of residential buildings within their jurisdictions.

4.2 Implementation

For effective implementation of the above recommendations, the following have to be strictly adhered to:

(i) Government at all levels need to formulate policy and strategy for planning and development permit and control in order to set minimum maintenance standards for residential buildings within their jurisdictions. This may be through renovation permit such as;

– Minor repair works,

a. Major repair works and
b. Total redevelopment, decoration and improvement notice.

(ii) Government at all levels need to educate the residents on the need for residential buildings and buildings' premises maintenance and the implications for failure to maintain buildings and building's premises through radio and television announcement and discussions. In addition, strategic placement of posters and effective distribution of hand bills can also be employed for the enlightenment campaign.

(iii) Use of the developed model for the prediction of residential buildings' physical condition should be enforced and used for quick assessment of residential buildings' physical condition by the Buildings and Building Premise Inspection Programme (BBPIP) agents at all levels.

Conclusion

The research set out to assess the levels of physical condition of residential buildings in Niger State and to develop a predictive mathematical model for sustainable residential building maintenance in Niger state, Nigeria and other allied countries. Thus, the research has shown that physical condition of residential buildings in Niger state is better assessed with the equation, $\hat{Y}$ = 4.368 + 2.305 STRUCT + 2.555 ROOFCO + 2.699 TOILFAC + 2.096 WASTEWT + 2.295 EXTWAL + 1.805 WAKWAY + 2.031 ELECTWR + 1.853 INTWALS

Based on its level of prediction, the model can be used for quick assessments of physical condition of residential buildings. Thus, it aids sustainability of residential buildings maintenance in Nigeria, since the findings are applicable in either northern or southern part of Nigeria and possibly in other developing countries with similar conditions.

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