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Cost Modelling Of Mechanical and Electrical Services in Institutional Building Projects in Lagos State of Nigeria Using Selected Design Variables

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ABSTRACT: *This research was carried out to study the problem of ineffective cost control technique in the process of formulating predictive models for cost of Mechanical and Electrical (M&E) services due to inadequate information resulting to cost overrun. The need for this research thus focused on the collection of suitable information for the necessary analysis and modeling of M&E services cost. This paper therefore examined the relationship between M&E services and building forms (design variables) for institutional building projects using simple and multiple regression analyses. One of the findings of the research was that the cost of M&E services of any given institutional building project can be accessed from the building form descriptors with 95% confidence limits. This provided a basis for developing several predictive models for M&E services cost of institutional building projects. Recommendations from the study included regular review of the models in the light of changing environmental circumstances by any user of the models, for the models to stand a test of time.*

Keywords: *Building Form, Cost Modeling, Design Variables, Institutional building, Mechanical/Electrical Services.*

I. INTRODUCTION

A client is very much concerned with quality, cost and time and wants the building to be soundly constructed at a reasonable cost and within a specified period of time. As a result of this it is incumbent upon the Architect who may be supported by a Quantity Surveyor to exercise a great care and skill in designing the project within desired cost checks.

According to Seeley [1] (1993) and Ibironke [2] (2004) the costs of buildings are influenced by a variety of factors, some of which are inter-related. Among the factors that make up design variables which have influence on the overall construction cost of the building project are: size of building, plan shape, circulation space, storey height, total building height, and perimeter to floor area ratio.

Seeley[1] (1993) pointed out that costs related to Mechanical and Electrical (M&E) Services may represent 10-15% of the initial capital cost and a substantial amount of cost in-use and in some buildings such as laboratories, the services constitute above 50% of the initial cost. Apart from comparisons of material costs, the most usual cost studies were directed towards comparing alternative methods of heating, ventilation, and air-conditioning and involve different compromises between capital costs and running costs. It is important to note that long thin buildings make both the provision of air-conditioning and its maintenance much more expensive.

Seeley [1] (1993) added that the significant variable in plumbing installation is the number and type of sanitary appliances. The total costs of installation may vary up to 50% between low and high quality fittings. Lift costs are a critical factor in the economic factor of some multi-storey buildings (4 storeys – 1, 8 storeys – 2). Each additional landing involves an extra wire rope, a set of ropes and some wiring. With an increase in the number of floors it may be necessary to increase the speed and capacity of the lift to deal with increased traffic – which will increase cost of this element. However, the cost of lifts is in no way proportional to the height of the building. Seeley[1] (1993) concluded that when the traffic necessitates the provision of an additional lift, it may cause the cost of lift per floor to double, but as further floors are added this cost will start to fall again until a third floor is added. In some classes of buildings such as multi-storey low-rental flats lift costs can amount to as much as 15% of the cost of the flat.

1.1 Classification of Buildings

The Nigerian National Building Code [3] (2006) classified buildings in to two major categories – Building Design classification and Building Construction Classification. Each of these classes of buildings is sub-divided in to various groups. According to the National Building Code [3] (2006) every building or structure whether existing or hereafter erected shall be as classified (under Building Design Classification) in the code according to its use or character of its occupancy in to one of the following of the Use Groups listed below:

(i) Use Group A – Assembly
(ii) Use Group B – Business and Professional
(iii) Use Group C – Education
(iv) Use Group D – Factory and Industries
(v) Use Group E – High Hazard
(vi) Use Group F – Institutional
(vii) Use Group G – Mercantile
(viii) Use Group H – Residential
(ix) Use Group I – Storage
(x) Use Group J – Mixed Use and Occupancy
(xi) Use Group K – Doubtful Use Classification
(xii) Use Group L – Utility and Miscellaneous

The code added that all buildings and structures shall also be graded in accordance with the degree of fire hazard as contained in Part 1, Section 7 of the National Fire Code.

1.2 Classification of Building/Construction Cost

Construction cost embraces the total costs, direct and indirect, associated with transforming a design plan for material and equipment in to a project ready for operation. Okafor [4] (2003) classified Construction Cost in to Direct Cost and Indirect Cost. Okafor[4] (2003) explained further that direct costs are predominantly the cost of all plant equipment as well as materials and labour involved in the actual installation and erection of the process plant and indirect costs are associated with the support of direct construction required for an orderly completion of a project.

1.3 Mechanical and Electrical services in Residential Buildings

According to Fadamiro & Ogunsemi [5] (1996), the starting point for the electrical system is the services entrance and distribution board. This equipment may be of the circuit breaker or switch and fuse type. Chudley [6] (1999) reported that a building receives the single phase electricity supply from an area electricity grid at a rating of 240 volts and a frequency of 50 hertz. These electricity grid from which the electricity supply is taken consist of four lines, three lines each carrying a 240 volts supply with the fourth serving as the common return or neutral. The line usually connected to the earth at the transformer or sub-station for safety precautions in time of fault from any electrical appliance. Each line or phase is tapped in turn together with the neutral to provide the single phase of 2400 supply.

Hall & Greeno [7] (2003) divided Mechanical Services in Residential Buildings into the following categories:

i. Cold Water Supply System
ii. Hot Water Supply System
iii. Heating System
iv. Ventilation System
v. Air – Conditioning
vi. Discharge and Waste System

Hall & Greeno [7] (2003) explained further that cold water supply system is supplied as Direct and Indirect system. In the direct system, pipework is minimal and the storage cistern supplying the hot water cylinder need only have 115 litres capacity with drinking water being made available at every draw-off point. The indirect system of cold water supply has only one drinking water outlet at the sink and it has a minimum capacity of 230 litres, for a location in the roof space.

The hot water supply system was also categorized as direct and indirect according to Hall & Greeno [7] (2003). In the hot water direct system, the hot water from the boiler mixes directly with the water in the cylinder and the system is not suited to hard water, typically of those extracted from boreholes in to chalk or limestone strata. The indirect hot water system is used in hard water areas to prevent scaling or furring of the boiler and primary circuit is not drawn off through the taps and the same water circulates continuously throughout the boiler, primary circuit and heat exchange coil inside the storage cylinder.

According to Martin & Oughton [8] (1989), the main function of services in a building is to provide comfort to the occupants. The ancient taught that man had seven senses, but it is no more than coincidence that the principal influences which affect human comfort are also seven in number – temperature, humidity, radiation, air volume, air movement, air purity and ionization.

Oforeh[9] (1997) contributed that conduit in mechanical installations functions mainly to provide protection to the cables drawn in them, thereby making the building occupants safe from hazards relating to electrical faults. Chudley[6] (1999) purported that a supply of electricity is usually required on construction sites to provide lighting to the various units of accommodation and may also be needed to provide the power to drive small and large items of plant. Chudley [8] (1999) added that for efficiency of work on site, two sources of electrical supply to the site are possible, namely:

i. Portable Self-powered generator.
ii. Metered supply from the local area electricity company.

1.4 Cost Modeling

Morenikeji [10] (2006) defined a model as an abstraction from reality and can be expressed in the form of hardware like the architect's model of a dream house or as a mathematical equation or a theory, which helps to simplify complex situation. Willis & Ashworth [11] (1987) defined cost modeling as a modern technique to be used for forecasting the estimated cost of a proposed construction project. Ferry & Brandon[12] (1991) gave a more detailed definition of cost modeling as the symbolic representation of a system expressing the content of that system in terms of the factors which influence its cost.

Jagboro [13] (1995) reported that the application of advanced cost modeling techniques depends on the utilization of a highly interactive simulation of actual situation with the aid of a computer program. Jagboro [13] (1995) added that construction costs are practically derived from a number of variables which are either structural or economic in nature. Structural variables are those that bear relationship to the structural design of the building and they include the following:

(a) Gross floor area of the building
(b) Area of suspended floor
(c) Number of floors
(d) Height of building
(e) Storey height
(f) Number of lifts
(g) Number of stair cases
(h) Perimeter of typical floor

Economic variables, according to Jagboro [13] (1995), comprise of factors which have economic bearing on the construction; among these are:

(a) Wages of skilled and unskilled labourers
(b) Cost of basic material inputs such as cement, reinforcing bars, form work, aggregate etc.
(c) Geographical location of the project
(d) Level of interest rate prevailing in the national economy
(e) Level of inflation in the national economy which may be assessed using the consumer price index.

1.5 Factors Affecting Building Design and Components

Seeley [1] (1993) reported that as a general rule the simpler the shape of building, the lower will be its unit cost. As a building becomes longer and narrower or its outline is made more complicated and irregular so the perimeter/floor area ratio will increase, accompanied by a higher unit cost. Building shape has its major impact on the areas and sizes of the vertical components such as walls, windows, partitions, etc., as well as the perimeter detailing such as ground beams, fascias and eaves of roof and these have important effects on cost. Different plans can be compared by examining the ratio of enclosing walls to floor area in square metres (known as wall/floor ratio). Seeley [1] (1993) further stated that the lower the wall/floor ratio, the more economical will be the proposal.

Ferry & Brandon [12] (1991) gave some simple example in measuring the cost efficiency of a building shape as thus:

i. wall/floor ratio

This is a very familiar method but it can only be used to compare buildings with a similar floor area and does not have an optimum reference point such as those below;

ii. length/Breadth index = $p + \sqrt{(p2 - 16a)} / p - \sqrt{(p2 - 16a)}$ -------------------------------- (1)

Where P = Perimeter of building

a = Area of building.

In this index any right angled plan shape of building is reduced to a rectangle having the same area and perimeter as the building. Curved angles can be dealt with by a weighting system. The advantage here is that the rectangular shape allows a quick mental check for efficiency.

iii. Plan/Shape index = $g + \sqrt{(g2 - 16r)}/g - \sqrt{(g2 - 16r)}$ -------------------------- (2)

Where g = sum of perimeters of each floor divided by the number of floors, and

r = gross floor area divided by the number of floors.

This is a development of the previous index to allow for multi – storey construction. Therefore, the area and perimeters are averaged out to give a guide as to the overall plan shape efficiency.

1.6 Aim and Objectives of the Study

The aim of the study is to examine the cost relationships between Mechanical and Electrical (M&E) Services and building forms in residential building projects, based on existing models of Swaffield & Pasquire[14] (1999).

In order to achieve the aim, the following are the objectives of the study:

(i) To determine the relationship between the total cost of buildings and the cost of M&E Services of the buildings.

(ii) To determine the relationship between the forms of buildings and the cost of M&E Services of the buildings.

(iii) To proffer recommendations with respect to properly ascertaining cost of services in institutional buildings.

The following null hypotheses were postulated for this research work:

Ho1: There is no significant relationship between the total cost of buildings and the cost of M&E Services of the buildings.

Ho2: There is no significant relationship between the forms and functions (shape factors) of buildings and the cost of M&E Services of the buildings.

1.7 Scope and Limitation

This paper studied institutional building projects of bungalow and storey designs. The study adopted the following building form descriptors: gross floor area, wall/floor ratio, average storey height, floor to floor height, plan/shape index, percentage of glazed area and internal perimeter length, based on the existing model of Swaffield & Pasquire[14] (1999). The building projects used are of different designs ranging from office blocks to laboratories/classrooms in bungalows and one to four storey designs.

Out of the 50 different kinds of projects investigated, only 30 were found useful because some of these projects bills do not have drawings and even those with drawings lack some essential details of M&E services cost. Some of the government parastatals approached claimed that the needed information was confidential and could not be fully released.

II. METHODOLOGY

The source of data collection for this research work was the secondary source of data collection, that is, from contract drawings and priced/unpriced Bills of Quantities of previously executed projects handled by reputable construction firms, government establishments/ministries and specialist contractors in Lagos State, between 2006 and 2011. Lagos State was chosen because of the high rate at which construction activities are going on there continuously, as it is the former capital of Nigeria and also the commercial capital of Nigeria which could be used as a basis for predicting the situation of construction activities in Nigeria.

The relationships between the variables in the data collected were determined using both Simple and Multiple Regression Analyses, the Correlation coefficient(R), coefficient of determination (R^2) and the test of significance (F-test and P-test). The regression analyses are also used to formulate predictive models with the variables (dependent and independent) tested which are observed simultaneously in relation to one another (i.e. bivariate data). This paper assures 5% significance test as probability test of significance. Hence for any value of P from 0.00 to 0.05 there is significance in the test but for values greater than 0.05 there is no significance in the test.

III. DATA PRESENTATION

The data used in statistical analysis are given in TABLES 1 – 4 presented in the Appendix section. TABLES 3 and 4, also presented in the Appendix section, show the percentage of M&E services cost out of the total cost of each of the building projects for the bungalow and storey buildings respectively and these were 5 - 15% and 5 – 25% respectively.

IV. RESULTS AND DISCUSSIONS

4.1 Results of Institutional Bungalow Buildings Analyses

Out of the five building form descriptors (independent variables) three were significantly related with the cost of M&E Services (dependent variable). These are Enclosing Wall Area, Gross Floor Area and Perimeter Length with coefficient of determination (R^2) values of 61.9%, 72.9% and 24%, F-calculated values of 29.19, 48.441 and 5.68 which were in each case greater than the value of F-tabulated of 4.41 and Probability values of 0.000, 0.000 and 0.028 at 5% level of significance respectively. These show a strong and statistically significant relationship in each case (except for Perimeter Length which shows weak relationship with cost of M & E Services) and the null hypothesis which states that there is no significant relationship between cost of M&E services and building forms is rejected. The result of this test implies that 61.9% variation in cost of M&E services is explained by Enclosing Wall

Area, 72.9% variation in cost of M&E services is accounted for by Gross Floor Area and only 24% variation in cost of M&E services is accounted for by Perimeter Length.

On the other hand the relationships between cost of M&E services and Wall/Floor Ratio and Percentage of Glazed Wall Area were weak and statistically not significant with R^2 values of 13.4% for M&E services and Wall/Floor Ratio and 14.3% for M&E services and Percentage of Glazed Wall Area. The values of F-calculated observed were 2.784 for M&E services and Wall/Floor Ratio and 3.011 for M&E services and Percentage of Glazed Wall Area. The Probability values observed were 0.112 and 0.100 respectively for the relationships between cost of M&E services and Wall/Floor Ratio, and Percentage of Glazed Wall Area. The null hypothesis in each of the cases was therefore accepted.

A very strong relationship exists between Contract Sum and Cost of M&E Services with R^2 value of 81%. This implies that 81% variation in contract sum is accounted for by cost of M&E services. The relationship is significant because the value of F-calculated of 76.877 is greater than F-tabulated value of 4.41 and the Probability value of 0.000 was less than 0.05. The null hypothesis was therefore rejected.

There exists a very strong and statistically significant relationship between Cost of M&E Services and Combination of all the Building Form Descriptors with a relatively high R^2 value of 74.3%, F-calculated value of 9.61 which is greater than the value of F-tabulated (3.03) and a Probability value of 0.001 at 5% level of significance. The null hypothesis which states that there is no significant relationship between cost of M&E services and building forms was therefore rejected. The result of this multiple regression analysis implies that 74.3% variation in cost of M&E services is explained by the combined effects of the Building Form Descriptors.

The following regression equations were formulated from the analyses:

Test 1a.

Y_1= -115086+4904.509X_1 ………… (3); Y_2 = 132832.7 +3121.1 X_2 ………… (4);
Y_3 = 2016987 - 1237683X_3 …………… (5); Y_4 = 3070483 - 346257 X_4 …………… (6);
Y_5 = 13068.181 + 12281.016X_5…………… (7); Y_6 = 852154.4 – 0.355 X_6 …………… (8)

Where Y_1 – Y_6 = Cost of M&E services (Melnsb); X_1 = Enclosing Wall Area (Ewalnsb); X_2 = Gross Floor Area (Gfaresb); X_3 = Wall/Floor Ratio (Wfresb); X_4 = Percentage of Glazed Wall Area (Pgwalnsb); X_5 = Primeter Length (Perilnsb); and X_6 = Cost per m-sq. (Cpmlnsb).

Test 1b – 1d.

Y_w = 211962.2 + 1.464 X_w ………… (9); Y_f = 190877 + 0.651 X_f ………… (10);
Y_c = 1598887.10 + 7.02 X_c …………… (11)

Where Y_w = Cost of Wall (Cwallnsb); Y_f = Cost of Floor (Cfllnsb); Y_e = Contract Sum (Cslnsb) and X_w – X_c = Cost of M&E services (Melnsb).

Test 1e.

Y = 972356 + 992.54 $_{xi}$ - 4912.71 $_{xii}$ + 3839.17 $_{xiii}$ - 637852 $_{xiv}$ - 26537.7 $_{xv}$ ……………… (12)

Where Y = Cost of M&E services (Merlnsb); Xi = Gross Floor Area (Gfalnsb); Xii = Primeter Length (Perilnsb); Xiii = Enclosing Wall Area (Ewalnsb); Xiv = Wall/Floor Ratio (wflnsb); X5 = Percentage of Glazed Wall Area (Pgwalnsb).

4.2 Results of Institutional Storey Buildings Analyses

There exists a statistically significant relationship between only two of the Building Form Descriptors (g = sum of perimeter of floors divided by total number of floors and Floor to Floor Height) and the Cost of M&E Services with strong R^2 values of 84.6% and 50%, F-calculated value of 43.872 and 7.98, which are greater than the value of F-tabulated (5.32) and Probability values of 0.000 and 0.022 respectively at 5% level of significance. The null hypothesis was therefore rejected in each of the two cases. This implies that 84.6% variation in cost of M&E services is accounted for by the independent variable (g) and 50% variation in the cost of M&E services is accounted for by Floor to Floor height.

The Relationship between Cost of M&E Services and each of the other Building Form Descriptors (g^2, r, 16r, Plan/Shape Index, Average Storey Height and Percentage of Glazed Wall Area) is weak and not significant with R^2 values of 0.2%, 38.6%, 38.6%, 7.6%, 15.3% and 21.5%, F-calculated values of 0.02, 5.02, 5.03, 0.65, 1.45 and 2.19 and Probability values of 0.89, 0.06, 0.06, 0.44, 0.26 and 0.18 at 5% level of significance respectively. The null hypothesis in each of these cases was therefore accepted.

The null hypothesis is rejected in the analysis of the relationship between total building cost and cost of M&E services because the relationship between the variables was strong and significant with a relatively high R^2 value of 97.7%, F-calculated value of 337.371 and Probability value of 0.000 at 5% level of significance.

The relationship between Cost of M&E Services and Combination of all the Building Form Descriptors was also discovered to be very strong and statistically significant with a relatively high R^2 value of 99.9%, F-calculated value of 143.475 which is greater than the value of F-tabulated (19.35) and a Probability value of 0.007 at 5% level of significance. The null hypothesis was therefore rejected.

The following regression equations were formulated from the analyses:

Test 2a.

$Y_1 = -6230472 + 120910.9\ X_1$ .... (13); $Y_2 = 4259401 + 78.503\ X_2$ .... (14);
$Y_3 = -1521031 + 14122.676\ X_3$ .... (15); $Y_4 = -1522653 + 882.833\ X_4$ .... (16);
$Y_5 = 10000000 - 5495648\ X_5$ .... (17); $Y_6 = -3327648 + 1056936\ X_6$ .... (18);
$Y_7 = 100000000 - 40000000 X_7$ .... (19); $Y_8 = -3514408 + 1198887\ X_8$ .... (20);
$Y_9 = 3230608 + 38.712 X_9$ .... (21)

Where Y1 – Y9 = Cost of M&E services (MerInsSt); X1 = g (GInsSt); X2 = g-sq. (G2InsSt); X3 = R (RInsSt); X4 = 16R (SrInsSt); X5 = Plan Shape Index (PsiInsSt); X6 = Average Storey Height (AshInsSt); X7 = Floor to Floor Height (FfhInsSt); X8 = Percentage of Glazed Wall Area (PgwaInsSt); and X9 = Cost per m-sq. (CpmInsSt).

Test 2b – 2d.

$Y_w = 1748770 + 0.461\ Xw$; $Y_f = -1865200 + 2.004\ X_f$; $Y_c = 4382940 + 4.619\ X_c$ .... (22)

Where Y_w = Cost of Wall (CwallInsSt); Y_f = Cost of Floor (CflInsSt); Y_c = Contract Sum (CsInsSt) and $X_w - X_c$ = Cost of M&E services (MeInsSt).

Test 2c.

Y = 972356 + 992.54 Xi - 4912.71 Xii + 3839.17 Xiii - 637852 Xiv - 26537.7 Xv .... (23)

Where Y = Cost of M&E services (MerInsSt); Xi = g (GInsSt); Xii = g-sq. (G2res); Xiii = 16R (SrInsSt) Xiv = Enclosing Wall Area (EwaInsSt); Xv = Plan Shape Index (PsiInsSt); Xvi = Average Storey Height; Xvii = Floor to Height (FfhInsSt); and Xviii = Percentage of Glazes Wall Area (PgwaInsSt).

The research findings from the results discussed above and the regression models (equations) are summarized in TABLES 5 and 6 which are presented in the Appendix section.

V. CONCLUSIONS

It can be concluded from the research findings that there is a significant and positive correlation between the cost of M&E services and the building form descriptors in institutional building projects. The linear relationship shows that the cost of M&E services of any given institutional building project can be accessed from the building form descriptors with 95% confidence limits using multiple regression models and this provided a basis for developing several regression models for the institutional building projects in Lagos State of Nigeria. This is in line with the findings of Shittu et al[15] (2008) and Shittu & Izam[16] (2011) where it was discovered that cost of M&E services of any given residential and commercial building projects can be respectively accessed from the building form descriptors with 95% confidence limits using multiple regression models in Abuja and Niger State, Nigeria.

This study contributes to knowledge by offering information on cost implication of architectural design parameters (based on the building form descriptors) on the prediction of the cost of M&E services in institutional building projects in Nigeria, to clients especially the government which is the largest initiator and financier of building and construction works in Nigeria.

IV. RECOMMENDATIONS

1. This paper recommends that consultants should consider all the building forms adopted by this research when estimating total cost of building during the pre-contract stage in order to get a more accurate forecast it was discovered from the study that the combination of the building form descriptors are better descriptors of M&E services cost.
2. The design of a building should incorporate a floor and walling type which will suitably accommodate building services so as not to cause increase in labour effort during services installation because there exist a significant relationship between the cost of M&E services and wall and floor costs from the research results.
3. The research also recommends a review of the models formulated in this study at regular intervals in the light of changing environmental circumstances by any user of the models for the models to stand the test of time.

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APPENDIX

Table 1: Contract Sum and Cost of M&E for Institutional Building Projects with Shape Factors

S/NO.	CONTRACT SUM (N)	COST/m² (N)	GROSS FLOOR AREA (m²)	COST OF M&E SERVICES (N)	COST OF WALL (N)	COST OF FLOOR (N)	PERIMETER LENGTH (m)	ENCLOSING WALL AREA (m²)	WALL TO FLOOR RATIO	% OF GLAZED WALL AREA (%)
1	5,221,080.00	26,368.80	198	540,000.00	623,442.00	364,914.00	45	170	0.86	6
2	6,518,024.40	108,633.60	60	368,328.00	1,641,600.00	764,984.40	25	80	1.33	8
3	4,317,116.40	20,557.20	210	218,700.00	661,506.00	593,782.80	61	183	0.87	7
4	4,119,297.60	37,448.40	110	365,040.00	1,002,807.60	306,134.40	42	125	1.14	6
5	4,466,400.00	35,448.00	126	600,000.00	478,080.00	309,000.00	45	136	1.08	7
6	3,656,523.00	24,376.80	150	576,000.00	345,600.00	219,000.00	50	81	0.54	6
7	3,480,716.40	26,368.80	132	360,000.00	415,628.40	243,276.00	47	157	1.19	5
8	2,725,636.80	26,208.00	104	276,000.00	287,443.20	194,562.00	40	108	1.04	6
9	5,621,354.40	21,292.80	264	781,446.00	1,038,600.00	415,716.00	164	442	1.67	5
10	2,828,527.20	16,162.80	175	294,462.00	459,600.00	223,692.00	136	305	1.74	5
11	4,200,000.00	20,095.20	209	720,954.00	636,696.00	159,885.60	58	120	0.58	8
12	13,036,048.80	119,596.80	109	736,656.00	3,283,200.00	1,529,968.80	45	135	1.24	7
13	13,036,048.00	115,992.00	109	736,656.00	1,617,768.00	1,702,890.00	43	128	1.17	5
14	1,469,376.00	34,171.20	43	94,278.00	471,384.00	122,400.00	27	48	1.17	7
15	1,777,810.80	41,344.80	43	112,818.00	766,080.00	128,400.00	27	46	1.07	8
16	13,720,122.00	49,891.20	275	3,267,903.60	2,877,022.80	1,625,959.20	63	240	0.87	7
17	5,756,155.20	20,412.00	282	291,600.00	882,056.40	791,710.80	68	205	0.72	8
18	7,756,680.00	26,749.20	282	1,124,046.00	1,108,162.80	889,926.00	146	174	0.62	6
19	42,483,201.60	28,378.80	1,497	4,694,400.00	8,604,200.40	3,659,954.40	160	860	0.58	4
20	6,337,380.00	46,944.00	135	583,200.00	1,542,780.00	470,976.00	50	140	1.04	8

Source: Authors' Field Work (2012)

Table 2: Contract Sum and Cost of M&E for Institutional Storey Building Projects with Shape Factors

S/NO	CONTRACT SUM (N)	COST/m² (N)	COST OF M&E SERVICES (N)	COST OF WALL (N)	COST OF FLOOR (N)	g (m)	g² (m²)	r (m²)	16r (m²)	PLAN/SHAPE INDEX	STOREY HEIGHT	FLOOR TO FLOOR HEIGHT	% OF GLAZED WALL AREA (%)	NO. OF FLRS
1	19,800,000.00	53,226	2,225,874.00	2,400,900.00	2,989,200.00	70.8	5012.6	310	4960	1.23	6	3	5	2
2	25,826,400.00	35,870	4,132,224.00	3,570,144.00	6,231,600.00	98	9604	600	9600	1.04	9	3	7	3
3	21,000,000.00	65,500	5,250,000.00	6,000,374.40	7,672,860.00	67	4489	272	4352	1.42	11.2	2.8	8	4
4	28,080,000.00	24,224	5,616,000.00	6,324,012.00	8,683,008.00	125	15625	968	15488	1.21	12	3	6	4
5	6,778,348.80	10,526	1,021,446.00	1,158,600.00	535,716.00	94	8836	540	8640	1.35	6	3	5	2
6	9,648,624.00	13,582	1,509,816.00	616,560.00	1,691,796.00	74	5476	296	4736	2.15	5.6	2.8	12	2
7	110,670,898.00	43,180	22,576,863.60	11,487,590.40	44,043,300.00	215	5126	854	13669	1.12	8.7	2.7	10	3
8	13,720,122.00	41,576	3,267,903.60	2,877,022.80	1,625,959.20	63	3969	276	4416	1	6	3	7	2
9	14,236,048.80	53,924	1,002,324.00	3,283,200.00	1,529,968.80	60	3600	220	3520	1.35	6	3	4	2
10	13,843,120.80	52,917	976,656.00	1,702,890.00	1,702,890.00	42	1764	110	1760	1.21	6	3	5	2

Source: Authors' Field Work (2012)

<u>**KEY**</u>:

g = sum of perimeter of floors divided by number of floors

r = Gross Floor Area divided by number of floor

Table 3: M&E as a Percentage of Total Cost for Institutional Bungalow **Building Projects**

S/NO.	CONTRACT SUM (N)	COST OF M&E SERVICES (N)	Percentage M&E from Total Cost
1	5,221,080.00	540,000.00	10%
2	6,518,024.40	368,328.00	6%
3	4,317,116.40	218,700.00	5%
4	4,119,297.60	365,040.00	9%
5	4,466,400.00	600,000.00	13%
6	3,656,523.00	576,000.00	16%
7	3,480,716.40	360,000.00	10%
8	2,725,636.80	276,000.00	10%
9	5,621,354.40	781,446.00	14%
10	2,828,527.20	294,462.00	10%
11	4,200,000.00	720,954.00	17%
12	13,036,048.80	736,656.00	6%
13	13,036,048.00	736,656.00	6%
14	1,469,376.00	94,278.00	6%
15	1,777,810.80	112,818.00	6%
16	13,720,122.00	3,267,903.60	24%
17	5,756,155.20	291,600.00	5%
18	7,756,680.00	1,124,046.00	15%
19	42,483,201.60	4,694,400.00	11%
20	6,337,380.00	583,200.00	9%

Source: Authors' Field Work (2012)

Table 4: M&E as a Percentage of Total Cost for Institutional Storey **Building Projects**

S/NO	CONTRACT SUM (N)	COST OF M&E SERVICES (N)	Percentage M&E from Total Cost
1	19,800,000.00	2,225,874.00	11%
2	25,826,400.00	4,132,224.00	16%
3	21,000,000.00	5,250,000.00	25%
4	28,080,000.00	5,616,000.00	20%
5	6,778,348.80	1,021,446.00	15%
6	9,648,624.00	1,509,816.00	16%
7	110,670,898.00	22,576,863.60	17%
8	13,720,122.00	3,267,903.60	24%
9	14,236,048.80	1,002,324.00	7%
10	13,843,120.80	976,656.00	7%

Source: Authors' Field Work (2012)

TABLE 5: Summary of Results for Institutional Bungalow Building Projects Experiments

Test No. 1	Variables		Type of Model	Observations					Inferences		
	X	Y		Regression Equation	R^2 (%)	F_{cal}	F_{tab}	P_{value}	Strength of Relationship	Remark	Action On Hypothesis
(a)i.	Ewalnsb	Melnsb	Linear	Y1= -115086+4904.509X1	61.9	28.19	4.41	0.00	Strong	SS	Reject Ho
ii.	Gfalnsb	Melnsb	Linear	Y2 = 132832.7 +3121.1 X2	72.9	48.441	4.41	0.00	Strong	SS	Reject Ho
iii.	Wfrlnsb	Melnsb	Linear	Y3 = 2016987 - 1237683X3	13.4	2.784	4.41	0.112	Weak	NS	Accept Ho
iv.	Pgwalnsb	Melnsb	Linear	Y4 = 3070483 - 346257 X4	14.3	3.011	4.41	0.100	Weak	NS	Accept Ho
v.	Perilnsb	Melnsb	Linear	Y5 = 13068.181 + 12281.016X5	24	5.68	4.41	0.028	Weak	SS	Reject Ho
vi.	Cpmlnsb	Melnsb	Linear	Y6 = 852154.4 – 0.355 X6	0.0	0.002	4.41	0.966	Weak	NS	Accept Ho
1b.	Melnsb	Cwallnsb	Linear	Yw = 211962.2 + 1.464 Xw	78.1	64.25	4.41	0.00	Strong	SS	Reject Ho
1c.	Melnsb	Cfllnsb	Linear	Yf = 190877 + 0.651 Xf	74.5	52.628	4.41	0.00	Strong	SS	Reject Ho
1d.	Melnsb	Cslnsb	Linear	Yc = 1598887.10 + 7.02 Xc	81	76.877	4.41	0.00	Strong	SS	Reject Ho
1e.	(i) Gfalnsb (ii) Perilnsb (iii) Ewalnsb (iv) Wfresb (v) Pgwalnsb	Melnsb	Linear (multiple)	Y = 972356 + 992.54 Xi -4912.71 Xii +3839.17 Xiii -637852 Xiv -26537.7 Xv	74.3	9.61	3.03	0.001	Strong	SS	Reject Ho

Source: Authors' Analysis of Data (2012)

Key:
SS = Statistically Significant
NS = Not Significant

TABLE 6: Results Summary for Residential Storey Building Projects Experiments

Test No. 2	Variables		Type of Model	Observations					Inferences		
	X	Y		Regression Equation	R^2 (%)	F_{cal}	F_{tab}	P_{value}	Strength of Relationship	Remark	Action On Hypothesis
(a)i.	GlnsSt	MelnsSt	Linear	Y1= -6230472 + 120910.9 X1	84.6	43.872	5.32	0.000	Strong	SS	Reject Ho
ii.	G2lnsSt	MelnsSt	Linear	Y2 = 4259401 + 78.503 X2	0.20	0.019	5.32	0.894	Weak	NS	Accept Ho
iii.	RlnsSt	MelnsSt	Linear	Y3 = -1521031 + 14122.676 X3	38.6	5.022	5.32	0.055	Weak	NS	Accept Ho
iv.	SrlnsSt	MelnsSt	Linear	Y4 = -1522653 + 882.833 X4	38.6	5.028	5.32	0.055	Weak	NS	Accept Ho
v.	PsilnsSt	MelnsSt	Linear	Y5 = 10000000 – 5495648 X5	7.6	0.654	5.32	0.442	Weak	NS	Accept Ho
vi.	AshlnsSt	MelnsSt	Linear	Y6 = -3327648 +1056936 X6	15.3	1.45	5.32	0.263	Weak	NS	Accept Ho
Vii.	FfhlnsSt	MelnsSt	Linear	Y7 = 100000000 – 40000000X7	50	7.98	5.32	0.022	Strong	SS	Reject Ho
Viii.	PgwalnsSt	MelnsSt	Linear	Y8 = -3514408 +1198887 X8	21.5	2.191	5.32	0.177	Weak	NS	Accept Ho
ix.	CpmlnsSt	MelnsSt	Linear	Y9 = 3230608 + 38.712X9	1.2	0.1	5.32	0.764	Weak	NS	Accept Ho
2b.	MelnsSt	CwalInsSt	Linear	Yw = 1748770 + 0.461 Xw	85.3	46.527	5.32	0.000	Strong	SS	Reject Ho
2c.	MelnsSt	CfllnsSt	Linear	Yf = - 1865200 + 2.004 Xf	98.9	746.795	5.32	0.000	Strong	SS	Reject Ho
2d.	MelnsSt	CslnsSt	Linear	Yc = 4382940 + 4.619 Xc	97.7	337.371	5.32	0.000	Strong	SS	Reject Ho
2e.	(i) GlnsSt (ii) G2lnsSt (iii) SrlnsSt (iv) PsilnsSt (v) AshlnsSt (vi) FfhlnsSt (vii) PgwaInsSt	MelnsSt	Linear (multiple)	Y = - 7797928 + 35664.576 Xi -1691.068 Xii +1495.182 Xiii -885513Xiv +6326720.8 Xv +1214013 Xvi +315536.2 Xvii	99.9	143.475	19.35	0.007	Strong	SS	Reject Ho

Source: Authors' Analysis of Data (2012)

<u>Key:</u>
SS = Statistically Significant
NS = Not Significant