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EDITORIAL COMMENT

The environment that surrounds us, and shapes our lives has its origin long before we were born and will continue to exist long after we die. The environment is therefore an evolving heritage which one generation passes to another. Each generation changes the environment it inherits in order to make it safer, more comfortable and more convenient for itself.

For over a decade now, JOES has continued to devote itself to the dissemination of academic research findings on environmental issues. These cover the theoretical and practical aspects of our built and natural environment, thereby also providing useful material for environmental and national development. The present edition is therefore situated within this context. As an evolving heritage, timely circulation of the journal among members of the academic community and beyond has also been a foremost priority since 1998.

The late publication of this edition is highly regretted. In addition to some in house editorial changes experienced; social and political unrest that took place in November 2008 at Jos, adversely affected production, inflicting major delays. This led to the merger of two editions of 2008 in this one volume. It is our desire to return back with two editions (June and December) in the year 2009 and on schedule!

Dr.Y.D.M.Izam
Editorial Secretary.

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MODELLING OF COST OF MECHANICAL AND ELECTRICAL SERVICES IN SELECTED RESIDENTIAL BUILDING PROJECTS IN ABUJA AND NIGER STATE USING SELECTED DESIGN VARIABLES

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ABSTRACT: *This research was carried out to address the problem of ineffective cost control and the difficulty of formulating cost of Mechanical and Electrical (M&E) services at the onset of building projects which often led to project cost overrun. The research thus analysed appropriate data that led to the modeling of M&E services cost. The paper also examined the cost relationship between M&E services and building forms for residential building projects. The relationship between the variables in the data collected was examined by linearity tests and the use of simple and multiple regression analyses, correlation analysis and descriptive statistics. One of the major findings of the research was that the cost of M&E services of any given residential building project could be assessed from the building form descriptors with 95% confidence limits. This also provided a basis for developing the several predictive regression models for M&E services cost of residential building projects. A major recommendation from the study was the need for regular review of the models in the light of changing environmental circumstances.*

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 Ibironke (2004) and Seeley (1993), 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 (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.

Seeley (1993) further pointed out 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 additonal 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 (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.

Apart from comparisons of material costs, the most usual cost studies on M&E services were directed towards comparing alternative methods of heating, ventilation, and air-conditioning and involve different compromises between capital costs and running costs. Little also appears to have been done to improve the predictability of M&E costs in Nigerian building projects. This is with the result that in most contracts M&E services were provisional sums unempirically engineered and often lending itself to abuse.

This study was therefore established to bridge this informational gap by examining the cost relationships between Mechanical and Electrical (M&E) Services and building forms in residential building projects, based on existing procedures developed by Swaffield and Pasquire (1999). Specifically, the study's major objectives are:

(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

LITERATURE

Classification of Building

The Nigerian National Building Code (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 (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 Use Groups:

(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 I, Section 7 of the National Fire Code.

Construction Cost

Construction cost embraces the total costs, direct and indirect, associated with transforming a design plan for material and equipment into a project ready for operation (www.answer.com). Okafor (2003) classified Construction Cost into *Direct Cost* and *Indirect Cost*. Okafor (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 indirect costs are associated with the support of direct construction required for an orderly completion of a project.

Mechanical and Electrical services in Residential Buildings

According to Fadamiro and Ogunsemi (1996) the starting point for the electrical system is the services entrance and distribution board. The equipment may be of the circuit breaker or switch and fuse type. Chudley (1988) 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 grids 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 lines are 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 and Greeno (2003) divided Mechanical Services in Residential Buildings into the following categories: Cold Water Supply System,Hot Water Supply System,Heating System,Ventilation System,Air – Conditioning,Discharge and Waste System.Hall and Greeno (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 and Greeno (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 and Oughton (1989) the main function of services in a building is to provide comfort to the occupants. The ancient thought was 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 (1997) indicated that conduits in mechanical installations function mainly to provide protection to the cables drawn in them, there by making the building occupants safe from hazards relating to electrical faults. Chudley (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 (1999) added that, for efficiency of work on site, two sources of electrical supply to the site are possible, namely: portable self-powered generator and metered supply from the local area electricity company.

Cost Modelling

Morenikeji (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 and Ashworth (1987) defined cost modeling as a modern technique to be used for forecasting the estimated cost of a proposed construction project. Ferry and Brandon (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 (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 (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 may include the following:Gross floor area of the building.Area of suspended floor,Number of floors,Height of building,Storey height,Number of lifts,Number of staircases,Perimeter of typical floor

Economic variables, according to Jagboro (1995), comprise of factors which have economic bearing on the construction; among these are: Wages of skilled and unskilled labourers, Cost of basic material inputs such as cement, reinforcing bars, form work, aggregate etc., Geographical location of the project, Level of interest rate prevailing in the national economy, Level of inflation in the national economy which may be assessed using the consumer price index.

Factors Affecting Building Design and Components

Seeley (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 (1993) further stated that the lower the wall/floor ratio, the more economical will be the proposal.

Ferry and Brandon (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 (D. Banks)

$p + \sqrt{(p2 - 16a)}/ p - \sqrt{(p2 - 16a)}$.............. (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 (D. Bank)

$g + \sqrt{(g2 - 16r)}/g - \sqrt{(g2 - 16r)}$..............(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.

METHODOLOGY

Cost data for this research work was sourced 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 Abuja and Niger State, between 2001 and 2005. Abuja was chosen because of the high intensity of construction activities being the capital of Nigeria; Niger State was also chosen because of its proximity to Abuja in terms of variety and intensity of construction activities. Both locations reflect the common practices in the Nigerian Building industry.

This study concentrated on data from residential projects of bungalow and storey buildings. 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 and Pasquire (1999). The building projects used are of different designs ranging from two to four bedroom bungalows and one to four storey buildings. Out of the 45 different kinds of projects investigated, only

30 were found useful because some of the projects 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 released.

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 regressions analyses were also used to formulate predictive models of the variables (dependent and independent) simultaneously observed in relation to one another.

Generally, the following null hypotheses were tested at the 95% confidence level in order to promote the achievement of the objectives of the study:

H_1: There is no significant relationship between the total cost of buildings and the cost of M&E Services of the buildings.

H_2: There is no significant relationship between the forms and functions of buildings and the cost of M&E Services of the buildings.

RESULTS AND DISCUSSIONS

The data used in statistical analysis are given in tables 1 – 4. Tables 3 and 4 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.

Residential Bungalow Buildings

Out of the five building form descriptors (independent variables) only two were significantly related with the cost of M&E Services (dependent variable). These are Enclosing Wall Area and Gross Floor Area with coefficient of determination (R^2) values of 61.28% and 72.55%, F-calculated values of 28.94 and 47.58 which were in each case greater than the value of F-tabulated of 4.41 and probability values of 0.00 each at 5% level of significance respectively. These show a strong and statistically significant relationship in each case 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 61.28% variation in cost of M&E services is explained by Enclosing Wall Area and 72.55% variation in cost of M&E services is accounted for by Gross Floor Area.

On the other hand the relationships between cost of M&E services and Wall/Floor Ratio, Percentage of Glazed Wall Area and Perimeter Length were weak and statistically not significant with R^2 values of 13.18% for M&E services and Wall/Floor Ratio, 2.73% for M&E services and Percentage of Glazed Wall Area and 3.53% for M&E services and Perimeter Length. The values of F-calculated observed were 2.73 for M&E services and Wall/Floor Ratio, 3.53 for M&E services and Percentage of Glazed Wall Area and 5.80 for M&E services and Perimeter Length. The probability values observed were 0.92, 0.08 and 0.03 respectively for the relationships between cost of M&E services and Wall/Floor Ratio, Percentage of Glazed Wall Area and Perimeter Length. 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 80.16%. This implies that 80.16% variation in contract sum is accounted for by cost of M&E services. The relationship is significant because the value of F-calculated of 72.7 is greater than F-tabulated value of 4.41 and the probability value of 0.00 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 73.9%, F-calculated value of 7.93 which is greater than the value of F-tabulated (4.41) and a

Probability value of 0.01 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 73.9% 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.

$Y_1 = -125278.78 + 4125.28X_1$ ………………… (3)

$Y_2 = 83777.64 + 2622.94X_2$ ………………… (4)

$Y_3 = 1736840.97 - 1034305.38X_3$ ………………… (5)

$Y_4 = 2688447.99 - 312062.69X_4$ ………………… (6)

$Y_5 = -24153.22 + 10429.16X_5$ ………………… (7)

$Y_6 = 692061.67 - 0.47X_6$ ………………… (8)

Where $Y_1 - Y_6$ = Cost of M&E services (Meresb);

X_1 = Enclosing Wall Area (Ewaresb);

X_2 = Gross Floor Area (Gfaresb);

X_3 = Wall/Floor Ratio (wfresb);

X_4 = Percentage of Glazed Wall Area (Pgwaresb);

X_5 = Primeter Length (Periresb); and

X_6 = Cost per m-sq. (Cpmresb).

Test 1b – 1d.

$Y_w = 231533.70 + 1.43X_w$ ………………… (9)

$Y_f = 17899.74 + 0.64X_f$ ………………… (10)

$Y_c = 1598887.10 + 7.02X_c$ ………………… (11)

Where Y_w = Cost of Wall (Cwalresb);

Y_f = Cost of Floor (Cflresb);

Y_c = Contract Sum (Csresb) and

$X_w - X_c$ = Cost of M&E services (Meresb).

Test 1e.

$Y = 856189.80 + 848.92X_i - 3949.26X_{ii} + 3393.65X_{iii} - 605922X_{iv} - 22446.9X_v$.(12)

Where Y = Cost of M&E services (Meresb);

X_i = Gross Floor Area (Gfaresb);

X_{ii} = Primeter Length (Periresb);

X_{iii} = Enclosing Wall Area (Ewaresb);

X_{iv} = Wall/Floor Ratio (wfresb);

X_v = Percentage of Glazed Wall Area (Pgwaresb)

Residential Storey Buildings Analyses

There is a significant relationship between one of the Building Form Descriptors (g = sum of perimeter of floors divided by total number of floors) and the Cost of M&E Services with a relatively high R^2 value of 84.58%, F-calculated value of 43.87 which is greater than the value of F-tabulated (5.32) and a probability value of 0.002 at 5% level of significance. The null hypothesis is therefore rejected. This implies that 84.58% variation in cost of M&E services is accounted for by the independent variable (g). 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, Floor to Floor Height and Percentage of Glazed Wall Area) is weak and not significant with R^2 values of 0.23%, 38.57%, 38.6%, 7.56%, 15.35%, 49.94% and 21.5%, F-calculated values of 0.02, 5.02, 5.03, 0.65, 1.45, 7.98 and 2.19 and probability values of 0.89, 0.06, 0.06, 0.44, 0.26, 0.02 and 0.18 at 5% level of significance respectively. The null hypothesis in each of these cases is 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 97.49%, F-calculated value of 310.9 and Probability value of 0.00 at 5% level of significance.

The following regression equations were formulated from the analyses:

Test 2a.

$Y_1 = -5192060.05 + 100759.09X_1$ ………… (13)

$Y_2 = 3549501.16 + 65.42X_2$ ………… (14)

$Y_3 = -1267525.83 + 11768.90X_3$ ………… (15)

$Y_4 = -1268877.24 + 735.69X_4$ ………… (16)

$Y_5 = 9955182.40 - 4579707.03X_5$ ………… (17)

$Y_6 = -2773040.23 + 880779.85X_6$ ………… (18)

$Y_7 = 100713137.68 - 33019867X_7$ ………… (19)

$Y_8 = -2928673.36 + 999072.3X_8$ ………… (20)

$Y_9 = 2692173.64 + 32.26X_9$ ....(21)

Where $Y_1 - Y_9$ = Cost of M&E services (Meres);

X_1 = g (Gres);

X_2 = g-sq (G2res);

X_3 = R (Rres);

X_4 = 16R (Srres);

X_5 = Plan Shape Index (Psires);

X_6 = Average Storey Height (Ashres);

X_7 = Floor to Floor Height (Ffhres);

X_8 = Percentage of Glazed Wall Area (Pgwares); and

X_9 = Cost per m-sq. (Cpmres).

Test 2b – 2d.

$Y_w = 1446859.85 + 0.46X_w$.................. (22)

$Y_f = -1554333.14 + 2000X_f$...................(23)

$Y_c = 1391617.20 + 5.66X_c$ .... (24)

Where Y_w = Cost of Wall (Cwalres);

Y_f = Cost of Floor (Cflres);

Y_c = Contract Sum (Csres) and

$X_w - X_c$ = Cost of M&E services (Meres).

Test 2e.

$$Y = -6498273 + 29720.48X_i - 1409.22X_{ii} + 1245.99X_{iii} - 727928X_{iv} + 527267.3X_v + 10116787X_{vi} + 262946.9X_{vii} \quad ....(25)$$

Where Y = Cost of M&E services (Meres);

X_i = g (Gres);

X_{ii} = g-sq. (G2res);

X_{iii} = 16R (Srres)Enclosing Wall Area (Ewaresb);

X_{iv} = Plan Shape Index (Psires);

X_v = Average Storey Height; X_{vi} = Floor to Height (Ffhres); and

X_{vii} = Percentage of Glazes Wall Area (Pgwares)

The summary of findings from the results discussed above and the regression models are shown in tables 5 and 6.

CONCLUSIONS

It can be concluded from the study that there is a positive predictive relationship between the cost of M&E services and the building form descriptors in residential building projects. The linear relationship shows that the cost of M&E services of any given residential building project can be assessed from the building form descriptors within the 95% confidence limits.

Analysis of Variance established that the difference between the cost of M&E services of residential building projects and the building form descriptors is highly significant at 95% confidence limit. As a result of this, the findings will offer 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 residential building projects in Nigeria. The results of this research will also be useful to clients especially the government which is the largest initiator and financier of building and construction works in Nigeria.

RECOMMENDATIONS

1. Since the research results shows that the combination of the building form descriptors are better descriptors of M&E services cost, 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.

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 both wall and floor costs from the research results.

3. The research also recommends a modification of the models formulated in this study at regular intervals within the context of the constructor's changing environmental circumstances.

Table 1: Contract Sum and Cost of M&E for Residential 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	5,281,150	39,120	135	468,000	1,285,650	392,480	50	140	1.04	8
2	35,402,668	23,649	1,497	3,912,000	7,170,167	3,049,962	160	860	0.58	4
3	6,463,900	22,921	282	936,705	923,469	741,605	146	174	0.62	6
4	4,796,796	17,010	282	243,000	735,047	659,759	68	205	0.72	8
5	11,433,435	41,576	275	2,723,253	2,397,519	1,354,966	63	240	0.87	7
6	1,481,509	34,454	43	94,015	638,400	107,000	27	46	1.07	8
7	1,224,480	28,476	43	78,565	392,820	102,000	27	48	1.17	7
8	10,535,935	96,660	109	613,880	1,348,140	1,419,075	43	128	1.17	5
9	10,863,374	99,664	109	613,880	2,736,000	1,274,974	45	135	1.24	7
10	3,500,000	16,746	209	600,795	530,580	133,238	58	120	0.58	8
11	2,357,106	13,469	175	245,385	383,000	186,410	136	305	1.74	5
12	4,684,462	17,744	264	651,205	865,500	346,430	164	442	1.67	5
13	2,271,364	21,840	104	230,000	239,536	162,135	40	108	1.04	6
14	2,900,597	21,974	132	300,000	346,357	202,730	47	157	1.19	5
15	3,047,110	20,314	150	480,000	288,000	182,500	50	81	0.54	6
16	3,722,000	29,540	126	500,000	398,400	257,500	45	136	1.08	7
17	3,432,748	31,207	110	304,200	835,673	255,112	42	125	1.14	6
18	3,597,597	17,131	210	182,250	551,255	494,819	61	183	0.87	7
19	5,431,687	90,528	60	306,940	1,368,000	637,487	25	80	1.33	8
20	4,350,900	21,974	198	450,000	519, 535	304,095	45	170	0.86	6

Source: Author's Field Work (2008)

Table 2: Contract Sum and Cost of M&E for Residential 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)	PLANSHAPE INDEX	STOREY HEIGHT	FLOOR TO FLOOR HEIGHT	% OF GLAZED WALL AREA (%)	NO OF FLRS
1	11,535, 934	52,91 7	813,880	1,348,140	1,419,075	42	1764	110	1760	1.21	6	3	5	2
2	11,863, 374	53,92 4	835,270	2,736,000	1,274,974	60	3600	220	3520	1.35	6	3	4	2
3	11,433, 435	41,57 6	2,723,253	2,397,519	1,354,966	63	3969	276	4416	1.00	6	3	7	2
4	110,670 ,898	43,18 0	18,814,05 3	9,572,992	36,702,750	215	5126	854	13669	1.12	8.7	2.7	10	3
5	8,040,5 20	13,58 2	1,258,180	513,800	1,409,830	74	5476	296	4736	2.15	5.6	2.8	12	2
6	5,684,4 62	10,52 6	851,205	965,500	446,430	94	8836	540	8640	1.35	6	3	5	2
7	23,400, 000	24,22 4	4,680,000	5,270,010	7,235,840	125	15625	968	15488	1.21	12	3	6	4
8	17,500, 000	65,50 0	4,375,000	5,000,312	6,394,050	67	4489	272	4352	1.42	11.2	2.8	8	4
9	21,522, 000	35,87 0	3,443,520	2,975,120	5,193,000	98	9604	600	9600	1.04	9	3	7	3
10	16,500, 000	53,22 6	1,854,895	2,000,750	2,491,000	70.8	5012.6	310	4960	1.23	6	3	5	2

Source: Author's Field Work (2007)

KEY

– sum of perimeter of floors divided by number of floors

– Gross Floor Area divided by number of floors

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

Project S/No.	Total Cost/Contract Sum (=N=)	Cost of M&E Services (=N=)	Percentage M&E from Total Cost
1	5,281,150	468,000	9%
2	35,402,668	3,912,000	11%
3	6,463,900	936,705	15%
4	4,796,796	243,000	5%
5	11,433,435	2,723,253	24%
6	1,481,509	94,015	6%
7	1,224,480	78,565	6%
8	10,535,935	613,880	6%
9	10,863,374	613,880	6%
10	3,500,000	600,795	17%
11	2,357,106	245,385	10%
12	4,684,462	651,205	14%
13	2,271,364	230,000	10%
14	2,900,597	300,000	10%
15	3,047,110	480,000	16%
16	3,722,000	500,000	13%
17	3,432,748	304,200	9%
18	3,597,597	182,250	5%
19	5,431,687	306,940	6%
20	4,350,900	450,000	10%

Source: Author's Field Work (2008)

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

Project S/No.	Total Cost/Contract Sum (=N=)	Cost of M&E Services (=N=)	Percentage M&E from Total Cost
1	11,535,934	813,880	7%
2	11,863,374	835,270	7%
3	11,433,435	2,723,253	24%
4	110,670,898	18,814,053	17%
5	8,040,520	1,258,180	16%
6	5,684,462	851,205	15%
7	23,400,000	4,680,000	20%
8	17,500,000	4,375,000	25%
9	21,522,000	3,443,520	16%
10	16,500,000	1,854,895	11%

Source: Author's Field Work (2008)

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

Test No.	Variables		Type of Model	Observations					Inferences		
	X	Y		Regression Equation	R^2 (%)	F_{cal}	F_{tab}	P_{value}	Strength of Relationship	Rem	Action On Hyp
ji.	Ewaresh	Meresh	Linear	$Y_1 = -125278.78 + 4125.28 X_1$	61.3	28.94	4.41	0.00	Strong	SS	Reject Ho
	Gfaresh	Meresb	Linear	$Y_2 = 83777.64 + 2622.94 X_2$	72.6	47.58	4.41	0.00	Strong	SS	Reject Ho
	Wfresb	Meresh	Linear	$Y_3 = 1736840.97 - 1034305.38 X_3$	13.2	2.73	4.41	0.12	Very Weak	NS	Accept Ho
	Pgwaresb	Meresb	Linear	$Y_4 = 2688447.99 - 312062.69P X_4$	16.4	3.53	4.41	0.08	Very Weak	NS	Accept Ho
	Periresb	Meresb	Linear	$Y_5 = -24153.22 + 10429.16 X_5$	24.4	5.8	4.41	0.03	Weak	NS	Accept Ho
	Cpmresb	Meresb	Linear	$Y_6 = 692061.67 - 0.47 X_6$	0.0	0.00	4.41	0.96	Very Weak	NS	Accept Ho
	Meresb	Cwairesb	Linear	$Y_w = 231533.70 = 1.43 X_w$	76.2	57.63	4.41	0.00	Strong	SS	Reject Ho
	Meresb	Cfresb	Linear	$Y_f = 178995.74 + 0.64 X_f$	74.2	51.79	4.41	0.00	Strong	SS	Reject Ho
	Meresb	Csresb	Linear	$Y_s = 1598887.10 + 7.02 X_s$	80.2	72.70	4.41	0.00	Strong	SS	Reject Ho
	(i) Gfaresb (ii) Periresb (iii) Ewaresh (iv) Wfresb (v) Pgwaresh	Meresh	Linear (multiple)	$Y = 856189.8 + 848.92 X_i - 3942.26 X_{ii} + 3393.65 X_{iii} - 605922 X_{iv} - 22446.9 X_v$	73.9	7.93	4.41	0.001	Strong	SS	Reject Ho

Source: Author's Field Work (2008)

Key: SS = Statistically Significant

NS = Not Significant

TABLE 6: Results Summary for Residential Storey Building Projects Experiments

Test No. 2	Variables X	Variables Y	Type of Model	Observations: Regression Equation	R^2 (%)	F_{cal}	F_{tab}	P_{value}	Inferences: Strength of Relationship	Rem	Actio… On H…
(a.)i.	Gres	Meres	Linear	$Y_1 = -5192060.05 + 100759.09 X_1$	84.6	43.9	5.32	0.002	Strong	SS	Reje…
ii.	G2res	Meres	Linear	$Y_2 = 3549501.16 - 65.42 X_2$	0.23	0.02	5.32	0.89	Very Weak	NS	accep…
iii.	Rres	Meres	Linear	$Y_3 = -1267525.83 + 11768.90 X_3$	38.6	5.02	5.32	0.06	Weak	NS	Accep…
iv.	Sres	Meres	Linear	$Y_4 = -1268877.24 + 735.69 X_4$	38.6	5.03	5.32	0.06	Weak	NS	Accep…
v.	Pures	Meres	Linear	$Y_5 = 9955182.40 - 4579707.03 X_5$	7.56	0.65	5.32	0.44	Weak	NS	Accep…
vi.	Autres	Meres	Linear	$Y_6 = -2773040.23 + 880779.85 X_6$	15.35	1.45	5.32	0.26	Weak	NS	Accep…
Vii.	Pfres	Meres	Linear	$Y_7 = 100713137.68 - 33019867.60 X_7$	49.9	7.98	5.32	0.02	Slightly Weak	NS	Accept…
Viii.	Pgwres	Meres	Linear	$Y_8 = -2928673.36 + 999072.31 X_8$	21.5	2.19	5.32	0.18	Weak	NS	Accept…
ix.	Cpmres	Meres	Linear	$Y_9 = 2692173.64 + 32.26 X_9$	1.2	0.1	5.32	0.10	Very Weak	NS	Accept…
2b.	Meres	Cwalres	Linear	$Y_{10} = 1446859.85 + 0.46 X_{10}$	85.29	46.4	5.32	0.001	Strong	SS	Reject…
2c.	Meres	Cflres	Linear	$Y_{11} = -1554333.14 + 2000 X_{11}$	98.94	746.79	5.32	0.00	Strong	SS	Reject…
2d.	Meres	Cures	Linear	$Y_{12} = 1391617.20 + 5.66 X_{12}$	129	1.13	5.32	0.32	Weak	NS	Accep…
2e	(i) Gres (ii) G2res (iii) Sres (iv) Pures (v) Autres (vi) Pfres (vii) Pgwres	Meres	Linear (multiple)	$Y = 6498273 + 29720.48 X_1 - 1409.22 X_3 + 1245.99 X_4 - 737928 X_5 + 527267.3 X_6 + 1011678 X_7 + 262946.9 X_8$	99.8	144	5.32	0.001	Strong	SS	Reje…

Source: Author's Field Work (2008)

Key:

SS = Statistically Significant. NS = Not Significant

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