MODELLING OF COST OF MECHANICAL & ELECTRICAL SERVICES BETWEEN RESIDENTIAL & COMMERCIAL BUILDING PROJECTS USING SELECTED BUILDING FORM DESCRIPTORS : A Case Study of Selected Building Projects In Abuja And Niger State, Nigeria

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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 the use of inadequate information to estimate cost of M&E services during the pre-contract stage of building projects which results in to cost overrun. The study also examined the cost relationship between M&E services and design variables which make up building forms, for residential and commercial building projects. The relationship between the variables in the data collected was examined with 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 or commercial building projects can be accessed from the building form descriptors with 95% confidence limits. This also provided a basis for developing several predictive regression models for M&E services cost for both residential and commercial 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 Modelling, Design Variables, Mechanical/Electrical Services, Residential/Commercial building.

Introduction

Background of the Study

The major concern of a client is about the quality; cost and time a building project will take 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.

Seeley (1983) 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 (1983) 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 (1983) 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.

Problem Statement and Need for the Study

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 the use of inadequate information to estimate cost of M&E services during the pre-contract stage of building projects which results in 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.

Aim and Objectives

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 and Pasquire (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 determine the statistical difference which exists in the cost of M&E services between residential and commercial buildings.
iv. To proffer recommendations with respect to properly ascertaining cost of services.

Scope and Limitation

This paper studied residential and commercial building 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 linear regression models. The building projects used are of different designs ranging from two to four bed room bungalows and one to four storey buildings.

Out of the 45 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.

Literature Review

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 (www.answer.com). Okafor (2003) classified Construction Cost in to 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 erection of the process plant and indirect costs are associated with the support of direct construction required for an orderly completion of a project.

Mechanical and Electrical Services in Buildings

Nature of Services Work

Jagboro (1995) classified services in to four categories as thus:

i. Environmental services:

These are services which are directly concerned with the control of physical environment, heating, mechanical ventilation, lighting and lift installations.

ii. Supply services:

These are concerned with providing physical materials to meet the needs of building users, hot and cold water, electricity and telephone system.

iii. Disposal services:

These cover the removal of waste products, refuse, foul and surface water drainage.

iv. Central plant services:

These are required to provide, generate or motivate the services described above.

Kolawole (2002), in his own classification considered services works into two – Mechanical and Electrical Services. He explained further that Mechanical heating/cooling/refrigeration system/ventilation and air-conditioning system are more specialized forms of mechanical engineering and are generally carried out by specially trained tradesman. Electrical system on the other hand, as described by Kolawole (2002), is designed by an electrical engineer to comprise a number of manufactured pieces of equipments, outlet and fittings, all connected by given sizes of electrical cable.

Edmeads (1973) reported that most supply of services are linear in that they are conducted through pipes, ducts, wires or cables and they can be broken down into the following groups:

i. Supply or in-coming services
ii. Circulation or distribution services
iii. Disposal or out-going services

Edmeads (1973) added that the mode of conducting and the type of services must be described in detail as these form the basis of pricing. The Standard Method of Measurement for Building Works (S.M.M.) separates services into groups relating to their use or installation and whilst this is a convenient grouping for information, it does not clarify any interrelation or peripheral problems. The SMM groups are;

(S) Plumbing and Engineering Installation
(T) Electrical Installation
(X) Drainage

Details such as common service trenches, common chases, the connections between the various services and the common builder's work become individual decisions and responsibilities.

Oforeh (1997), in his own contribution, reported that cables are protected in electrical installation with the use conduits and the common types in use in Nigeria are the following:

i. Heavy gauge welded solid drawn seamless tube.
ii. Heavy gauge welded solid drawn seam tube.
iii. Light gauge welded solid drawn seam tube.
iv. UPVC (unplasticised polyvinyl chloride pipes), which may be rigid or flexible.

Oforeh and Alufohai (1998) reported that despite the fact that the budget cost of the overall building may be determined using single price rates based on spatial units such as =N=/ m^2, =N=/ m^3 or =N=/No, these units may not be suitable for budgeting for the overall electrical works element of especially big time installations. The principal reasons, as identified by Oforeh and Alufohai (1998), are:

i. The fact that the size and scope of the trunk (mains and power) design which determines a significant aspect of the cost of electrical works in buildings, may not depend on the overall floor area of the enclosed space.
ii. Some parts of the electrical installation may be located outside the enclosed space that is the basis of the floor area being used.

However, while some aspects of the installation could sometimes be reliably based on cost/ m^2 such as final sub-circuits, other aspects such as mains, may have to be budgeted for on the basis of cost/KVA while incoming services and other externally oriented installations such as lighting would be based on approximate estimating methods.

Advantages and Disadvantages of Mechanical and Electrical Services in Buildings

Billington and Roberts (1982) reported that services in a building are intended to provide an environment which is both healthy and comfortable, and which allows people to carry on their activities (whether work or pleasure) without physiological stress. A successful design requires first a specification of the necessary environment, and then an engineering system to provide it. If the environment is to be specified, it is necessary to state how warm, how light and how quiet it should be. These are physiological needs; but there are other factors, partly physiological and partly psychological, which contribute to the acceptability. Any quantitative assessment must be based on knowledge of human physiology and human attitudes.

Jagboro (1995), in his view, added that various advantages have been attributed to highly centralized air-conditioned system, among which are:

i. Flexibility of lay out.
ii. Increased potential for communication.
iii. Greater adaptation of space.
iv. Greater utilization.

A primary problem of building design, as reported by Jagboro (1995), concerns the lay out and sizing of building services such as circulation corridors, stair ways, heating and air-conditioning ducts, plumbing, lighting and electrical systems.

Hall and Greeno (2003) contributed that building services are the dynamics in a static structure because they provide movement, communications, facilities and comfort. As they are unavoidable, it is imperative that Architects, Builders, Estate Surveyors, Quantity Surveyors, Planners and all other building professionals have a knowledge and appreciation of the subject.

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. He added that construction costs are practically derived from a number of variables which are either structural or economic in nature.

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 Abuja and Niger State, between 2001 and 2005. Abuja was chosen because of the high rate at which construction activities are going on there continuously, as it is the capital of Nigeria which could be used as a basis for predicting the situation of construction activities in Nigeria. Niger State was also chosen because of its proximity to Abuja which makes many workers in Abuja to rent or build houses to settle their families in Niger State, especially, in Minna and Suleja towns. As a result of this, the rate of construction activities in Niger State is on the increase on a regular basis.

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 statistical differences between the variables were determined with the use of T – test of significance at 5% level of significance. The regression analyses are also used to formulate predictive models in variables (dependent and independent) are observed simultaneously in relation to one another particular thing (i.e. Bivariate data). This paper assumes 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.

Data Presentation

The data used in statistical analysis are collected from selected Bills of Quantities and Contract Drawings of previously executed projects in Abuja and Niger State, Nigeria and the data show the percentage of M&E services cost out of the total cost of each of the residential building projects for the bungalow and storey buildings respectively and these were 5 – 24% and 7 – 25% respectively.6 - 22% and 5 – 25% respectively.

The percentage of M&E services cost out of the total cost of each of the commercial building projects for the bungalow and storey buildings respectively and these were 6 - 22% and 5 – 25% respectively, as shown by the data collected.

Results And Discussions

Results of Residential Bungalow Buildings Analyses

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 is 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.

Results of Residential Storey Buildings Analyses

There exists a statistically significant relationship between only 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 research findings from the results discussed above and the regression models (equations) are summarized in Tables 1 and 2 below.

Results of Commercial Bungalow Buildings Analyses

Out of the five building form descriptors (independent variables) only three were significantly related with the cost of M&E Services (dependent variable). These were Enclosing Wall Area, Gross Floor Area and Internal Perimeter Length with coefficient of determination (R^2) values of 56.7%, 74% and 71.1%, F-calculated values of 23.6, 52 and 44.2 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 was rejected. The result of this test implies that 56.7% variation in cost of M&E services is explained by Enclosing Wall Area, 72.55% variation in cost of M&E services is

accounted for by Gross Floor Area and 71.1% variation in cost of M&E services is accounted for by Internal 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 5.98% for M&E services and Wall/Floor Ratio, and 2.46% for M&E services and Percentage of Glazed Wall Area. The values of F-calculated observed were 1.14 for M&E services and Wall/Floor Ratio, 0.45 for M&E services and Percentage of Glazed Wall Area. The Probability values observed were 0.3 and 0.51 respectively for the relationships between cost of M&E services and Wall/Floor Ratio and Percentage of Glazed Wall Area respectively. 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 85.01%. This implies that 85.01% variation in contract sum is accounted for by cost of M&E services. The relationship is significant because the value of F-calculated of 102.06 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 76.3%, F-calculated value of 8.99 which was greater than the value of F-tabulated of 4.41 observed 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 76.3% variation in cost of M&E services is explained by the combined effects of the Building Form Descriptors.

Results of Commercial Storey Buildings Analyses

There exists a statistically significant relationship between only one of the Building Form Descriptors (Average Storey Height) and the Cost of M&E Services with a relatively high R^2 value of 69.7%, F-calculated value of 18.4 which is greater than the value of F-tabulated of 5.32 and a Probability value of 0.003 at 5% level of significance. The null hypothesis is therefore rejected. This implies that 69.7% variation in cost of M&E services is accounted for by the independent variable (Average Storey Height).

The Relationship between Cost of M&E Services and each of the other Building Form Descriptors (g, g^2, r, 16r, Plan/Shape Index, Floor to Floor Height and Percentage of Glazed Wall Area) was weak and not significant with R^2 values of 5.9%, 7.6%, 3.93%, 4.04%, 6.13%, 0.11% and 16.66%, F-calculated values of 0.5, 0.66, 0.33, 0.34, 0.54, 0.09 and 1.60 and Probability values of 0.5, 0.44, 0.58, 0.58, 0.49, 0.77 and 0.24 at 5% level of significance respectively. The null hypothesis in each of these cases was therefore accepted.

The null hypothesis was rejected in the analysis where the relationship between total building cost and cost of M&E services was determined because the relationship between the variables was strong and significant with a relatively high R^2 value of 54.2%, F-calculated value of 9.46 and Probability value of 0.02 at 5% level of significance.

The relationship between Cost of M&E Services and Combination of all the Building Form Descriptors in commercial storey building projects shows a very high R^2 value of 90.9%, F-calculated value of 13.79 which is greater than the value of F-tabulated (5.32) and a Probability value of 0.06 at 5% level of significance. The relationship is therefore strong and statistically significant and the null hypothesis is rejected. The result of this multiple regression analysis implies that 90.9% variation in cost of M&E services in commercial storey building projects is explained by the combined effects of the Building Form Descriptors.

The research findings from the results discussed above and the regression models (equations) are summarized in Tables 3 and 4 below.

Results of T - Test Analyses

The fifth test (T - Test) revealed that the costs of M&E services between residential and commercial bungalow building projects do not differ significantly. This was also noticed from the respective mean values of the variables which are 865781.9 and 696703.7. The null hypothesis was rejected because the T calculated value (0.507) was less than the T tabulated value (2.093).

It was observed from the sixth test, on the other hand, that there exists a statistically significant difference between the cost of M&E services for the residential and commercial storey building projects. The T calculated value was negative (-1.288) and was less than the T tabulated value (2.262).

The research findings from the results discussed above are summarized in Table 5 below.

Conclusion

This study concludes, based on findings from the research, that there is a significant and positive correlation between the cost of M&E services and the building form descriptors in both residential and commercial building projects. The linear relationship shows that the cost of M&E services of any given residential or commercial building project can be assessed 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 commercial building projects.

Analysis of Variance (i.e from the regression analysis) established that the difference between the cost of M&E services of both residential and commercial building projects and the building form descriptors is highly significant at 95% confidence limit. It was also discovered from the T – test that cost of M&E differs significantly between residential and commercial storey buildings but does not between residential and commercial bungalow buildings. 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 and commercial 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 to have a better knowledge of the importance of the use of specialists during the estimate activities at the pre-contract stage of a building project. This work, however, represents a contribution to knowledge in these important areas.

Recommendations

Due to the fact that the results of the research shows that the combination of the building form descriptors (design variables) are better descriptors of M&E services cost, this paper therefore 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.

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.

Government and non-government organizations should set up a team of professionals to carry out further research on building cost in order to regularly update findings of previous research works, in order to come up with uniform standards on cost estimating of building projects, and Quantity Surveyors and Builders should be part of the team of professionals to be set up to embark on cost research and regular review of past research works.

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Appendix

Table 1: Summary of Results for Residential Bungalow Building Projects Experiments

Test No. 1	Variables X	Variables Y	Type of Model	Observations: Regression Equation	R^2 (%)	F_{cal}	F_{tab}	P_{value}	Inferences: Strength of Relationship	Rem	Action On Hyp
(a)i.	Ewaresb	Meresb	Linear	Y_1= -125278.78+4125.28X_1	61.3	28.94	4.41	0.00	Strong	SS	Reject Ho
ii.	Gfaresb	Meresb	Linear	Y_2 = 83777.64 + 2622.94 X_2	72.6	47.58	4.41	0.00	Strong	SS	Reject Ho
iii.	Wfresb	Meresb	Linear	Y_3 = 1736840.97 - 1034305.38 X_3	13.2	2.73	4.41	0.12	Very Weak	NS	Accept Ho
iv.	Pgwaresb	Meresb	Linear	Y_4 = 2688447.99 - 312062.69P X_4	16.4	3.53	4.41	0.08	Very Weak	NS	Accept Ho
v.	Periresb	Meresb	Linear	Y_5 = -24153.22 + 10429.16 X_5	24.4	5.8	4.41	0.03	Weak	NS	Accept Ho
vi.	Cpmresb	Meresb	Linear	Y_6 = 692061.67 – 0.47 X_6	0.0	0.00	4.41	0.96	Very Weak	NS	Accept Ho

1b.	Meresb	Cwalresb	Linear	$Y_w = 231533.70 = 1.43 X_w$	76.2	57.63	4.41	0.00	Strong	SS	Reject Ho
1c.	Meresb	Cflresb	Linear	$Y_f = 178995.74 + 0.64 X_f$	74.2	51.79	4.41	0.00	Strong	SS	Reject Ho
1d.	Meresb	Csresb	Linear	$Y_c = 1598887.10 + 7.02 X_c$	80.2	72.70	4.41	0.00	Strong	SS	Reject Ho
1e.	(i) Gfaresb (ii) Periresb (iii) Ewaresb (iv) Wfresb (v) Pgwaresb	Meresb	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 (2009)

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

Table 2: 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	Rem	Action On Hyp
(a)i.	Gres	Meres	Linear	Y1= -5192060.05 + 100759.09 X1	84.6	43.9	5.32	0.002	Strong	SS	Reject Ho
ii.	G2res	Meres	Linear	Y2 = 3549501.16 + 65.42 X2	0.23	0.02	5.32	0.89	Very Weak	NS	accept Ho
iii.	Rres	Meres	Linear	Y3 = -1267525.83 + 11768.90 X3	38.6	5.02	5.32	0.06	Weak	NS	Accept Ho
iv.	Srres	Meres	Linear	Y4 = -1268877.24 +735.69 X4	38.6	5.03	5.32	0.06	Weak	NS	Accept Ho
v.	Psires	Meres	Linear	Y5 = 9955182.40 – 4579707.03 X5	7.56	0.65	5.32	0.44	Weak	NS	Accept Ho
vi.	Ashres	Meres	Linear	Y6 = -2773040.23 + 880779.85 X6	15.35	1.45	5.32	0.26	Weak	NS	Accept Ho
Vii.	Ffhres	Meres	Linear	Y7 = 100713137.68 – 33019867.60 X7	49.9	7.98	5.32	0.02	Slightly Weak	NS	Accept Ho
Viii.	Pgwares	Meres	Linear	Y8 = -2928673.36 + 999072.31 X8	21.5	2.19	5.32	0.18	Weak	NS	Accept Ho
ix.	Cpmres	Meres	Linear	Y9 = 2692173.64 + 32.26 X9	1.2	0.1	5.32	0.10	Very Weak	NS	Accept Ho
2b.	Meres	Cwalres	Linear	Yw = 1446859.85 + 0.46 Xw	85.29	46.4	5.32	0.001	Strong	SS	Reject Ho
2c.	Meres	Cflres	Linear	Yf = - 1554333.14 + 2000 Xf	98.94	746.79	5.32	0.00	Strong	SS	Reject Ho
2d.	Meres	Csres	Linear	Yc = 1391617.20 + 5.66 Xc	12%	1.13	5.32	0.32	Weak	NS	Accept Ho

2e.	(i) Gres (ii) G2res (iii) Srres (iv) Psires (v) Ashres (vi) Ffhres (vii) Pgwares	Meres	Linear (multiple)	Y = - 6498273 + 29720.48 Xi -1409.22 Xii +1245.99 Xiii -737928 Xiv +527267.3 Xv +1011678 Xvi +262946.9 Xvii	99.8	144	5.32	0.001	Strong	SS	Reject Ho

Source: Author's Field Work (2009)
Key:
SS = Statistically Significant
NS = Not Significant

Table 3: Results Summary for Commercial Bungalow Building Projects Experiments

Test No. 3	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**
(a)i.	Ewacomb	Mecomb	Linear	Mecomb= 42896.11+ 3138.99Ewacomb	56.7	23.6	4.41	0.0001	Strong	SS	Reject Ho
ii.	Gfacomb	Mecomb	Linear	Mecomb = -174942.92 + 3558.03Gfacomb	74	52	4.41	0.00	Strong	SS	Reject Ho
iii.	Pgwacomb	Mecomb	Linear	Mecomb = 643619.76 + 27092.94Pgwacomb	2.46	0.45	4.41	0.51	Very Weak	NS	Accept Ho
iv.	Cpmcomb	Mecomb	Linear	Mecomb = 1318306.68 - 18.97Cpmcomb	5.64	1,08	4.41	0.31	Very Weak	NS	Accept Ho
v.	Wfcomb	Mecomb	Linear	Mecomb = 1486306 - 615599.98Wfcomb	5.98	1.14	4.41	0.3	Very Weak	NS	Accept Ho
vi.	Pericomb	Mecomb	Linear	Mecomb = -1081946.90 + 29781.79Pericomb	71.1	44.2	4.41	0.00	Strong	SS	Reject Ho
3b.	Mecomb	Cwalcomb	Linear	Cwalcomb = 498065.64 + 0.23Mecomb	26.44	6.47	4.41	0.02	Weak	NS	Accept Ho
3c.	Mecomb	Cflrcomb	Linear	Cflrcomb = 687843.13 + 0.28Mecomb	25.07	6.02	4.41	0.025	Weak	NS	Accept Ho
3d.	Mecomb	Cscomb	Linear	Cscomb = 2510173.20 + 3.54Mecomb	85.01	102.06	4.41	0.00	Strong	SS	Reject Ho

3e.	(i) Ewacomb (ii) Pgwacomb (iii) Wfcomb (iv) Pericomb (v) Gfacomb	Mecomb	Linear (multiple)	Mecomb = - 641841 - 2149.94Ewacomb - 22784.6Pgwacomb + 303674.1 Wfcomb + 8251.503Pericomb + 4828.41Gfacomb	76.3	8.99	4.41	0.001	Strong	SS	Reject Ho

Source: Author's Analysis of Field Work Data (2009)
Key: SS = Statistically Significant
NS = Not Significant

Table 4: Results Summary for Commercial Storey Building Projects Experiments

Test No. 4	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**
(a)i.	Gcoms	Mecoms	Linear	Mecoms= 12544862.08 – 37873.19Gcoms	5.9	0.5	5.32	0.5	Very Weak	NS	accept Ho
ii.	G2coms	Mecoms	Linear	Mecoms = 10960463.56 – 181.60G2coms	7.6	066	5.32	0.44	Very Weak	NS	accept Ho
iii.	Rcoms	Mecoms	Linear	Mecoms = 10361686.81 – 2196.17Rcoms	3.93	0.33	5.32	0.58	Very Weak	NS	Accept Ho
iv.	Srcoms	Mecoms	Linear	Mecoms = 10397819.59 - 139.46Srcoms	4.04	0.34	5.32	0.58	Very Weak	NS	Accept Ho
v.	Psicoms	Mecoms	Linear	Mecoms = 18138931.38 – 7061432.07Psicoms	6.13	0.52	5.32	0.49	Very Weak	NS	Accept Ho
vi.	Ashcoms	Mecoms	Linear	Mecoms = -2878317.99 + 1818969.71Ashcoms	69.7	18.4	5.32	0.003	Strong	SS	Reject Ho
Vii.	Ffhcoms	Mecoms	Linear	Mecoms = 33153098.15 – 839538.51Ffhcoms	-0.11	0.09	5.32	0.77	Very Weak	NS	Accept Ho
Viii.	Pgwacoms	Mecoms	Linear	Mecoms = 12392482.61 – 604142.91Pgwacoms	16.66	1.6	5.32	0.24	Very Weak	NS	Accept Ho
ix.	Cpmcoms	Mecoms	Linear	Mecoms = 9489881.23 – 32.34Cpmcoms	1.00	0.07	5.32	0.79	Very Weak	NS	Accept Ho
4b.	Mecoms	Cwalcoms	Linear	Cwalcoms = 3958906.33 + 0.013Mecoms	0.17	0.01	5.32	0.91	Very Weak	NS	Accept Ho
4c.	Mecoms	Cflrcoms	Linear	Cflrcoms = 4120656.57 + 0.15Mecoms	16.81	1.62	5.32	0.24	Weak	NS	Accept Ho
4d.	Mecoms	Cscoms	Linear	Cscoms = 17870267.65 + 2.30Mecoms	54.2	9.46	5.32	0.02	Strong	SS	Reject Ho
4e.	(i) Gcoms (ii) G2coms (iii) Rcom	Mecoms	Linear (multiple)	Mecoms = - 53634418 + 164406.61Grcoms -2829.35G2coms +40853.84Rcoms +1429287.7Psicoms +2776203.2Ashcoms +7345352.3Ffhcoms	90.9	13.8	5.32	0.006	Strong	SS	Reject Ho

s (iv) Psicoms (v) Ashcoms (vi) Ffhcoms (vii) Pgwacoms	+920829.15Pgwacoms

Source: Author's Analysis of Field Work Data (2009)
Key: SS = Statistically Significant
NS = Not Significant

Table 5: Summary of T – Test Analyses

Test No.	Variables		Observations					Inferences		
	X1 (Mean Value)	**X2** (Mean Value)	**R (%)**	**R^2 (%)**	**T_{cal}**	**T_{tab}**	**P_{value}**	**Strength of Relation ship**	**Rem**	**Action On Hyp**
5	MERESB (865781.9)	MECOMB (696703.7)	- 9.3	0.86	0.507	2.093	0.697	Very Weak	NSD	Accept Ho
6	MERESS (3964926)	MECOMS (8344725)	-35.9	9.5	-1.288	2.262	0.309	Very Weak	SSD	Reject Ho

Source: Author's Field Work (2009)
Key:
SSD = Statistically Significant Difference MERESB = Cost of M&E Services in Residential Bungalow Buildings
NSD = No Significant Difference MERESS = Cost of M&E Services in Residential Storey Buildings
MECOMB = Cost of M&E Services in Commercial Bungalow Buildings
MECOMS = Cost of M&E Services in Commercial Storey Buildings