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SAMPLE ANALYSIS OF CORRELATION OF COST INPUTS OF TIMBER PRODUCTS IN ROOF CONSTRUCTION

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Abstract

Timber is widely used in the construction of buildings. It is a very visible component of roof structure and it forms the structure upon which the covering is laid. The cost of roofing is on the increase owing to the difficulties in sourcing timber in lumber forms nowadays. In Nigeria the construction of roof for residential buildings mostly in bungalows depend much on timber. A sample of thirty units of cost of timber roof structure from three (3) bedrooms flat under construction was collected from Contractors and Developers. Correlation was used to find out the cost input of timber in roof vs. the total cost of roof, the critical value of r =.195, cost input of roof in the total cost of building, r =.090, as well as cost input of timber in roof on the total cost of building, result shows r =-.063. Weak strength of relationship for the first two cases and negative was seen in the last case.

Keywords: Building, Construction, Cost, Roof, Timber.

Introduction

The Longman Dictionary Of Contemporary English (1995) defined timber as a wooden beam, especially one that forms part of the main structure of a house, while Barry (1996) agreed that timber is wood, which has been cut for house building. Krieger (1979), divided timber into hard wood and soft wood. The use of timber for housing construction is as old as man. With the advent of civilization however, many materials were developed and these have continually been integrated with timber to arrive at a finished house. Timber can be found in substructure as earth work supports and form work to footings and slab, it is present in block work as formwork to lintels and columns, it exists as doors and windows including frames and panels. Timber products have also made their way in finishes as skirting, dado, timber tiles and so on. Internal fittings and furniture of bungalow construction are also made up of timber. These are all wonderful components. Many materials used for building construction which are sourced locally have undergone one or two modifications or rated out-fashioned, but timber has remained unchanged, though some form of finishes are known to be applied either to improve its longevity or appearance, and the use of pre-stressed timber is also on the increase for special purposes. Whitney et al (1981) made mention that wood is the hard fibrous substance forming the truck, lumber is the product of the saw or planning mill, not processed beyond sawing. Timber is a lumber 5 inches or larger. They also reasoned that wood should be identified by their botanical name when specifying them for housing construction (Jakson, 1988).

The standard method of measurement recognized the importance of timber and allocated a special class to it as class ‘N’. In this class, various forms which timber and associated components are found in buildings are detailed out (Fadamiro *et al*, 1996).

The use of timber as a building material is found in roof and almost all the building elements but the extent of its cost on these elements appears to be unknown. Ignorance on costs of timber in building could lead a client to embark on building construction only to discover at a later date that his budget underestimated cost of timber in the project. This has lead too many projects being unduly modified and at sometimes abandoned. Moreover the cost of timber and labour costs have been on the increase and there is the need for cost planners to be provided with researched cases for proper planning in order to save the cost of explanation on project differences.

Using traditional method of bungalow construction for medium income earners, timber remains the only building component which appears to be used for roof construction than steel in most part of the world and particularly, Nigeria where this study was carried out.

Aim And Objectives

The aim of this work is to find out the cost input of timber products in a simple roof (bungalow) construction.
The objectives are:

i. To determine the relationship existing between total cost of timber in roof element and the total cost of roof in a simple bungalow.
ii. To determine the relationship existing between total cost of timber in roof and cost of building in a simple bungalow.

Literature Review

Timber For Roof

Today, the growing stock volume of timber worldwide is estimated to 490 billion m^3 (FAO, 2000a).The total world production of timber in 1999 was 3275 million m^3 (FAO, 2000b).Wood possesses the same fundamental composite structure as some of the best man made materials developed. Kreiger (1979) wrote that timber in the past was used extensively in any type of construction, such as non-standard scaffolding and concrete form. The advent of precast reinforced concrete and other progressive materials as well as more rational use of waste wood, has resulted in an increasingly more economical and efficient use of timber products in roof and housing construction. It is submitted that wood is one of the most valuable raw materials supplied by nature and that each kind of wood qualities suit it to a particular type of use, for instance, Douglas Fir is a strong, moderately heavy wood which is used for construction, lumber , plywood boxes and heavy timbers. Western Cedar is a light and rather weak wood; however it has natural preservation that protects it from decaying, so it is valuable for Shingles, Posts and Facings. Oak is heavy, hard and strong and long lasting, so it is used for flooring and furniture. There are more roofs constructed with wood than any other structural materials. The wide spread use of wood for construction of roof has both economic and aesthetic basis. Oyetola (2001) concluded that timber is known for its beauty, versatility, strength, durability and workability. There are few materials that cost less per kilogram than timber. He emphasized the need to get acquainted with timber designs (Feirer et al, 1976)

Roof Cost and Timber Products

Building costs in our contemporary society have been on the increase and this has drawn a point of concern to both private and public developers (Ashworth, 1991). Roof is one major component of building that has been improved with construction techniques for improvements, modifications and innovations on the materials of covering particularly with the advent of long-span aluminium. The rapid increase in building costs and particularly timber which is the core of roof structure has been a source of concern. Nigeria has been witnessing mass felling of trees in the bid to cope with the high demand for timber products in building construction. The last decade has witnessed more buildings constructed compared with the previous ones. This is not unconnected with the democratic government that is now in place bringing about mass housing scheme both at the State, Federal and private development levels. The result is that the demand on building materials has increased being that the buildings constructed are done through the conventional and traditional processes involving the use of blocks, cement, stones, concrete, timber and other materials. Cost of wood for roof construction and other timber component of building are observed to be influenced by various variables among which is the rapid increase in population as well as the demand. Submissions in recent times at conferences seminars and workshops organized by professional bodies have been repeatedly calling on both State and Federal Government to encourage the use of local building materials and studying of new technologies on processing of timber, (Mabogunje, 1991).

Materials And Methods

Scope and Assumptions of Study

i. cost inputs of timber roof (bungalow) construction were carried out on a homogenous 30 units of 3 bedrooms flat constructed in Niger State, Nigeria.
ii. Cost of roof timber is exclusive of labour for the roof structure.
iii. Roof covering cost was arrived at with the use of .50mm gauge long span aluminium profile corrugated sheets.
iv. It is also limited to initial costs of timber construction
v. Tender figures forwarded by various contractors and Quantity Surveyors for the priced bills were accepted by various clients.

Data Instruments

Primary data from Bills of Quantities and Contractors quotations were used for the study The statistical instrument employed in this study was correlation. This was to determine whether the variables are related and their degree of relationship if any.

Hypothesis

i. To determine the correlation coefficient between the cost of roof and its component cost of timber structure.

ii. The correlation co-efficient at 5%level of confidence using Ho: $\mu1=\mu2=0$, H1: $\mu1/\mu2$

Discussion of Results

Roof Cost VS Timber Cost

Taking correlation as a good measure of the degree of relationship from the data of the result print out of the correlation matrix:

i r = .195, ii. α= .05 level of significance.

Based on the set of data used, the correlation coefficient calculated r =.195. The number of data pairs is 30 therefore n = 30, from the table, we use the critical value r =.305. Since this is a two tailed test r = .305*2=.610. For us to conclude on their relationship, the calculated value for r must be more than .610. since we found r =.195 we reject the null hypothesis being that the coefficient of determination r is positive and also conclude that there is a very weak but positive correlation between the two variables of roof cost and the constituent cost of timber structure at the 5% level of significance.

Roof Cost VS Total Building Cost

Based on the set of data used, the correlation coefficient calculated r =.090. since we found r =.090 we reject the null hypothesis also and conclude that there is a very weak but positive correlation between the two variables of roof cost and the total building cost at the 5% level of significance.

Timber Cost VS Total Building Cost

Based on the set of data used, the correlation coefficient calculated r = -.063. since we found r = -.063 we accept the null hypothesis and conclude that there is a very weak and negative correlation between the two variables of timber cost vs. total building cost at the 5% level of significance.

Summary of Descriptive Analysis

The descriptive analysis of this research work was made up of three different charts, which explained the result and gave a general impression of the variable used.

In figure 1.0 - 3.0, it can be observed that the cost of timber in roof element vs. the cost of roof fluctuates. It is irregular, but it is not to say that it could be out of range. The same thing can be said of the cost of roof vs. the total cost of the building and the cost of timber vs. total cost of the building studied.

Conclusion

The essence of this study is to generate facts about the influences of the individual cost items in a simple roof cost.

i. the cost of timber in roof elements did not appear to put-forth or exert any strong effect on the total cost of the roof

ii. The correlation between cost of roof work and the total cost of the building was weak in their strength of relationship, meaning it does not exert much on the total cost of the building.

iii. Total cost of timber in roof of three bedroom bungalows has insignificant impact on the total cost of three bedroom bungalows.

Recommendations

Results show positive correlation but weak relationship in the first two instances. This study was based on the use of long-span aluminium roof covering which of course enjoys some level of dignity than the conventional zinc (iron) corrugated sheet roof covering. It is much likely that the correlation with the conventional roof covering will tend towards negative than this. However the cost of roofing in timber cannot be seen to be too burdensome as the correlation shows some measure of weakness in the timber vs. total roof and total roof vs. total building cost. In the case of cost of timber in roofing vs. the total cost of the building it was seen to be negative and very weak, meaning that the cost was insignificant to the cost of building the studied three (3) bedrooms under construction. This may as well apply to other building forms in the same category employing similar materials and construction technique.

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Appendix

Table 1 : Cost of timber in Roof Element and total cost of the Element in the Building

s/no	cost of timber in roof (N)	Total cost of roof (N)	Total cost of building (N)
1	287845	930395	3926156
2	456224	1065985	4259883
3	243172	912407	4715208
4	417030	801750	3744707
5	571759	1120397	4433238
6	247920	838560	3956601
7	300979	866841	3647609
8	463476	1188972	4409227
9	372577	978825	4025699
10	413983	789658	3974051
11	700179	987465	4264995
12	328688	1217027	4283273
13	480254	840358	4190593
14	543210	903126	3575376
15	373591	910216	9070247
16	612255	1242662	4367150
17	534270	1314018	4718488
18	262998	1408427	5314316
19	280508	839654	3259193
20	391004	907728	3950791
21	481225	892103	4040379
22	450171	1026148	4126642
23	383910	921423	5912849
24	441936	900000	2942859
25	480000	932000	4422760
26	390000	835000	4875000
27	435000	910000	4970000
28	412000	895000	5865000
29	405000	905000	5250000
30	455000	890900	5380000

Table 2: Roof Cost Vs Timber Cost

Correlations

		TMBRF	TTR
TMBRF	Pearson Correlation	1.000	.195
	Sig. (2-tailed)	.	.302
	N	30	30
TTRF	Pearson Correlation	.195	1.000
	Sig. (2-tailed)	.302	.
	N	30	30

Table 3: Roof Cost Vs total building cost

Correlations

		TTRF	TTBLD
TTRF	Pearson Correlation	1.000	.090
	Sig. (2-tailed)	.	.637
	N	30	30
TTBLD	Pearson Correlation	.090	1.000
	Sig. (2-tailed)	.637	.
	N	30	30

Table 4: Timber Cost Vs total building cost

Correlations

		TMBRF	TTBLD
TMBRF	Pearson Correlation	1.000	-.063
	Sig. (2-tailed)	.	.741
	N	30	30
TTBLD	Pearson Correlation	-.063	1.000
	Sig. (2-tailed)	.741	.
	N	30	30

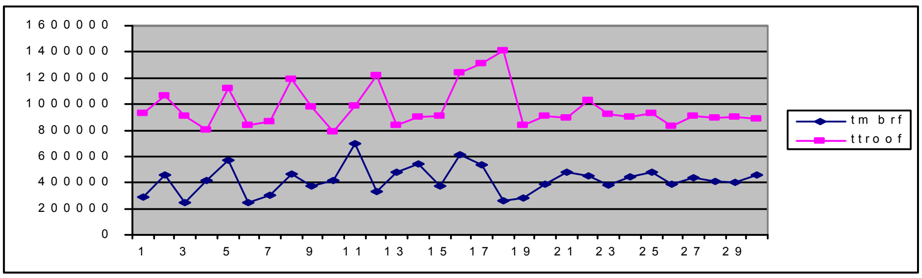

Figure 1: Roof Cost Vs Timber Cost

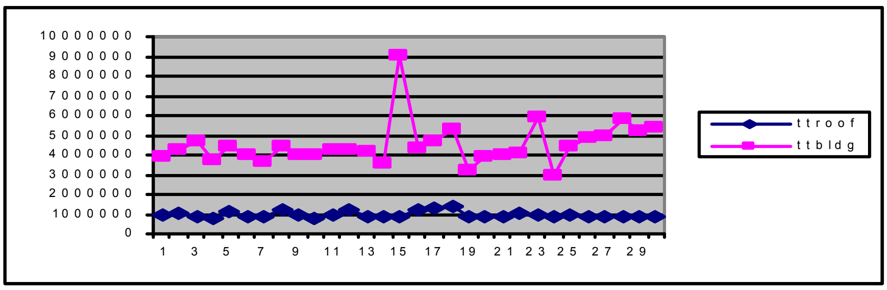

Figure 2: Roof Cost Vs total building cost

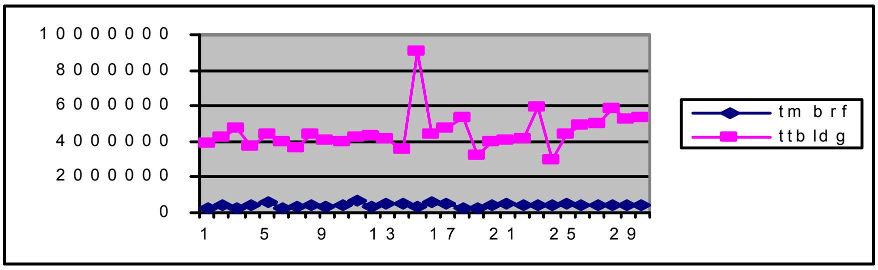

Fig 3: Timber Cost Vs total building cost

Legend:

TMBRF = Total timber cost, TTRF = Total roof cost, TTBLD = Total building cost

ANALYSIS OF COSTS AND PRICES OF BUILDING REHABILITATION WORK IN FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA USING IN-HOUSE CONSULTANTS

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Abstract

The paper is a detailed analysis of costs and prices of rehabilitation work carried out on some of the Federal University of Technology, Minna buildings on two of its campuses in the last quarter of 2006. Lecturers of the built-environment faculties were the supervising consultants. The aim was to verify the merits of using in-house consultants in place of the conventional ones. Method used in data collection was historical- collecting from the archives of the Task-force (consultants) and percentages was the analytical tool employed. Figures of savings made for the client by the consultants from both the pre-contract estimates and the various contractors' variation claims were collated and analyzed. It was discovered that savings of between 9 and 43 percents were made on the cost of each of the contracts (lots), culminating in savings of about N9 million. The normal consultancy fee was waived for a flat-rate allowance The further patronage of this type of in-house consultants was recommended for tertiary institutions' infrastructural facilities rehabilitation work.

Keywords: Facility, In-house, Professionals, Rehabilitation, Task-Force, Value-for-money.

Introduction

In the current dispensation world over, where needs for physical structures development outweighs the budget allocation of government to its various organs, parastatals, departments, ministries, managers of such organs look for the best way to optimize use of the limited fund. Thus where a developer wishes to provide modern accommodation and a suitable existing building is available in the right location, it is likely that refurbishment and re-use of the building may well be a more viable means of providing the accommodation than opting for new construction (Gorse and Highfield, 2009). Another merit of refurbishment option, apart from cost saving, is the shorter period for development. Thus this economic advantage of time and cost saving makes the refurbishment option a preferred choice for developers more especially if the buildings are still structurally sound.

By definition, a consultant is a professional in a specific field who provides expert advice based on his or her wide knowledge of the subject matter (Wikipedia; Tordoir, 1995).

Facility Maintenance

Facilities are known to be the largest single class of assets on the balance sheet of a nation (Hamer,1988; Ameh and Oko, 2002). Maintenance can be defined as a combination of any actions carried out to retain an item in or restore it to an acceptable condition (Lee, 1981; ICE, 1983; Davis, 1986, Lee; 1987). Maintenance, be it periodic, preventive or routine serves the primary purpose of preventing the premature failure of the facility and restoring it to its initial status or at least to a level comparable to its initial condition. (Bokinni, 2006). It is however appreciated that a gap continues to emerge throughout the life of the facility due to some legally or environmentally imposed factors or due to what Salihijo (1998) termed the dynamism of user expectations and changes in internal organization. The merits of well maintained facilities are innumerable, majorly among these are, as Doherty (2009) opined; (a) the creation of right impression, (b) improvement in employee efficiency and (c) reduction in operational costs. Maintenance management can be regarded as the main thrust of facility management as adopted in the Nigerian context (Opaluwa, 2002).

Under normal condition, the main concern of the chief executive of any (public) institution, regarding the state of habitability of the facilities under his/her domain, is to achieve sustainable rehabilitation and maintenance of such assets and at optimum costs. This research is aimed at investigating into the relevance or otherwise of engaging the construction professionals who are in the academy in pre- and post-contract consultancy services. It is also to showcase whether the University was going on a profit making venture or not and to verify the magnitude of profit or loss being incurred by such ventures. The study was prompted by the fact that the idea of using the services of relevant academic staff as consultant to administer the renovation contracts was novel to that University. The only known system that had been in use by the University was the use of private sector consultants appointed through the Federal Government's "Due Process".

Background To The F.U.T. Minna Building Rehabilitation Work

By the end of September 2006, the Vice Chancellor of the University came out with priced bills of quantities for several of the buildings in the initial phase, packaged into sixteen contracts (called lots). While each of the lots for the male hostels contained a building, female hostels had two buildings per lot, and the remaining lots had varying numbers of buildings (2 to 7 buildings) per lot. The pre-contract documentation was carried out by the Works and Services department of the University. The main documents of the contract included mainly the priced bills of quantities (BOQ) with provision for contingency allowances of 10% of the sum and 5% for preliminaries. Profit and overhead were inbuilt into the items of work.

A task-force group (in-house consultants) was raised by the university authority to work as the resident post contract consultants who were to monitor the progress of the work on daily basis including the weekends. This group consisted of academic staff one each from Architecture, Electrical/Mechanical and Civil Engineering and Quantity Surveying disciplines. The team composition cut across gender barriers. The team was headed by a Civil Engineer. Moreover the staff of Works and Services Department of the University served as the pre-contract consultants.

Contractor selection process was carried out by another organ of the University- the Management. It was a variant of fixed price contract arrangement subject to re-measurement of quantities of work done.

The contracts were each to last a period of eight weeks. There was no advance (mobilization) payment to the contactors. Each contract was to have only one valuation payment and this was at 100% (practical) completion of the job.

The veracity of site visits carried out by the consultants at the post contract stage was virtually equivalent to resident supervision. The task force group was given power to order additional work (variation) within the amount of the contingency sum provision.

Method

Oral narrations by the representative of the Director of Works and Services Department on the physical state of the University buildings revealed that by 2006. Most of the buildings of the University, especially on the Bosso campus had been in use for well over 14 years and without any organized, routine maintenance interventions carried out on them. A few of the buildings that were affected by one intervention programme or other such as the Education Trust Fund (ETF) programme did not experience an 'all

encompassing' repairs. This type of complete overhauling of the defective elements is regarded as the best among the various types of maintenance methods (Cruzan, 2009).
Records of the pre- and post-contract arrangements for the renovation work were sought for and obtained from the Physical Planning and Development Unit (PPDU) of the University.

On the Gidan Kwano campus of the university record showed that the two buildings (male hostels) which form part of the subject of this paper had been built complete and remained unoccupied for ten years (1994-2003). The first set of the human occupants of the two hostels moved in during the 2003/2004 academic year after an extensive fumigation work. The state of these old buildings on both campuses could be described as, at 2006, deplorable.

The records further showed that the renovation/rehabilitation works were carried out in 2006/2007 academic year employing the services of the in-house consultants.

Information on the Lots, figures of award, actual work done, additional work ordered on each lot was obtained from the post contract administrators of the projects (the Taskforce team). The data obtained were tabulated and the savings made on the lots were analyzed using percentages to verify the type of relationships, if any, that might exist among the variables, specifically between the amount of the original contract sum and those of the actual work measured at completion on the one hand and between the amounts of variation claims submitted by the contractors and those approved by the Taskforce on the other hand.

Finding/Discussion

An informal interview with the Vice Chancellor on his reason for adopting the in-house consultancy option revealed that he desired that lecturers in the Built Environment disciplines use the field experience on current 'live' projects to impart up-to-date knowledge in the classrooms. It was further discovered that the affected lecturers had to reschedule whichever of their lectures that coincided with the site visits.

Table 1 presented the raw data as obtained from the Taskforce team. The original bill of quantities (BOQ) presented all items requiring renovation as at the date of its (BOQ's) preparation The Taskforce team said it based its recommendations for payments on the actual work done. This formed the basis for the differences in the figures of columns 2 and 4 of Table 1.

Due to the fairly long time between the bill preparation date and the date of taking possession of the sites by the contractors, quite notable differences had taken place in the state of disrepair of the facilities. Some of the buildings required more items than were in the BOQ while some required less. Consequently, there were other obvious necessary items for repair which the BOQ did not include.

The Taskforce team instructed the contractors to carry out such specified items of renovation as additional work whose total costs were mostly within the contingency sums provided for in each lot. The contractors' submissions for the price of the extra work and the sums approved by the taskforce are respectively presented in columns 3 and 5 of Table 1.
Table 2 presents the figures of the work as originally envisaged by the BOQ (column b) side by side with the 'as-built figures' (column c). The differences, as shown in column d, were very minimal. Except in the cases of lots 4 and 7 where the differences were more than twenty percent each, all other lots experienced a difference of less than fifteen percent. This is normal, considering the nature of the work involved – renovation work.

The case of lot 11 was uniquely different in that it was a case of under-measurement at the pre-contract stage. The under-measurement was to the tune of eighty-nine thousand naira which amounted to 8.63 per cent.

Table 3 consists of variation figures for each lot as presented by the contractors (column b) followed by the figures approved by the in-house consultants (column c). Columns d and e of the table present the descriptive statistics of the previous two columns. From Table 3, it could be seen that while the entire claims put forward by the contractor for Lot No. 8 were approved by the consultants, about 92 per cent of the claims presented by the contractor for Lot 16 (N1,610,290 out of N1,751,400) were regarded frivolous by the committee and therefore rejected. Thus savings made from the claims of the sixteen contractors ranged between zero and ninety-two percent. Generally, the claims presented by the contractor were far out of proportion when compared with what the in-house consultant team finally approved (which was based on the actual extra work done by each of the contractors).

Table 4 is the analysis of the total sum the contractor would have claimed -original BOQ figure plus the contractor's figure for additional work (column b) and actual work done as per the BOQ plus the approved additional work (column c). The difference between columns b and c produced column d which is the savings (if positive) made for the employer by the Taskforce team. The savings were converted to percentages of the work done (column e).

It could be seen from Table 4 that savings made for the University on each of the lots ranged between about 5% and 43% of the work done. The highest figure of savings was achieved on lot No.16 which is N1 615 500 (41.1%) while the lot with the highest percentage savings of 43% is lot No.7 with the savings on the lot amounting to N856 887. The total savings amounted to N8 910 507 which gave an average savings of N556, 906.70 per lot. This interprets to mean that if the taskforce had not been engaged, the University would have lost at least that total amount of N8 910 507 to the contractors. This total savings of N8 910 507 made on the 16 lots put together was a landmark achievement that the Taskforce made for the University. This was especially so, given that the Nigerian nation was generally believed to be bedeviled with "consultants colluding with contractors to defraud the clients". From the analysis above, it could be seen that there was statistically significant difference between the figure of the measured work in the original boq and the figure of the actual work done. Also there was statistically significant difference between the figure of the contractor's claim for additional work and the Taskforce approved figure.

Conclusion

The deliberate separation of pre-contract consultancy from the post-contract consultancy on work of short-time durations (eight weeks) is a novel approach and was observed to have achieved value for the money of the employer. The use of in-house consultants (academic staff) for the post-contract stage of the work helps to reduce the total cost of the project management. If the consultants were drawn from the private sector the chargeable fees would have been imputed as cost to the client and there would have been no savings made for the employer on the lots because the consultants from the private sector would not have done the residence supervision as the in-house consultants did and without extra fee charged. Thirdly, the experience gained on site by these lecturers could easily be plowed back into the classroom to give the students relevant and up-to-date applied knowledge. These renovated buildings as observed by the researcher, are likely to attain optimum utilization during the post-rehabilitation period. This in turns gives justification for the huge resources expended on the buildings.

Recommendations

This type of comprehensive maintenance programme should be carried out at regular intervals not exceeding say, four years to help elongate the life span of the facilities. Moreover a well maintained facility is generally known to have opportunities of optimal operation for capacity utilization that enhances productivity of the user. For instance good and neat classroom is said to enhance good student performances.

The university's yearly budgets should consciously incorporate setting aside fund for the facility maintenance. This reduces the chance of leaving the facilities unmaintained for so many years as was the experience in this case study.

Regular consultancy engagement of construction professionals in the academic departments should be encouraged and intensified to further consolidate the savings from consultancy fees. This regular involvement of lecturers in consultancy in turns helps in impartation of relevant practical knowledge of site happenings on students. It is therefore recommended to other Nigerian universities to emulate the idea of engaging in-house consultants in the university construction or rehabilitation projects.

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Appendix

Results

Table 1: Renovation Contracts of FUT Minna Buildings Oct – Dec.2006

LOT	BOQ SUM LESS CONTINGENCY	ADDITIONAL WORK (CONTRACTOR'S FIGURE)	WORK DONE PER BOQ	ADDITIONAL WORK (TASK FORCE APPROVED)
	₦	₦	₦	₦
1	2,643,505	483,250	2,351,545	**207,840**
2	2,620,830	498,461	2,440,130	**300,790**
3	4,499,286	703,257	4,356,123	**583,383**
4	4,985,342	679,600	3,961,400	**470,160**
5	2,961,530	517,300	2,944,830	**240,800**
6	2,372,810	350,430	2,089,730	**257,730**
7	2,446,000	400,480	1784,783	**204,820**
8	1,899,425	120,280	1,722,022	**120,280**
9	3,175,356	283,100	2,745,300	**228,190**
10	3,040,440	272,344	2,590,453	**214,490**
11	3,213,330	1,224,510	3,302,454	**330,410**
12	1,762,007	197,150	1,651,367	**142,713**
13	1,937,444	359,375	1,772,892	**148,295**
14	3,413,680	611,550	2,974,020	**389,030**
15	1,964,835	261,030	1,842,470	**146,940**
16	**3,781,740**	**1,751,400**	**3,779,530**	**141,110**

Source: Field survey 2007.

Table 2: Analysis of Differences in Bill Provision for Measured Work and the Actual Work Done

LOT (a)	BOQ SUM LESS CONTINGENCY ~~(N)~~ (b)	ACTUAL MEASURED WORK AT COMPLETION ~~(N)~~ (c)	DIFFERENCE ~~(N)~~ (b) - (c) (d)	AS % (d/b)x100 (e)
1	2,643,505	2,351,545	291,960	**11.04**
2	2,620,830	2,440,130	180,700	**6.89**
3	4,499,286	4,356,126	143,160	**3.18**
4	4,985,342	3,961,400	1,023,942	**20.53**
5	2,961,530	2,944,830	16,700	**0.56**
6	2,372,810	2,089,730	283,080	**11.93**
7	2,446,000	1,784,783	661,217	**27.03**
8	1,899,425	1,722,022	177,403	**9.33**
9	3,175,356	2,745,300	430,056	**13.54**
10	3,040,440	2,590,453	449,987	**14.80**
11	3,213,330	3,302,454	-89,124	**(8.63)**
12	1,762,007	1,651,367	110,640	**6.27**
13	1,937,444	1,772,892	164,552	**8.49**
14	3,413,680	2,974,020	439,660	**12.87**
15	1,964,835	1,842,470	122,365	**6.22**
16	**3,781,740**	**3,779,530**	**2,210**	**0.05**

Source: Field Survey 2007

Table 3: Analysis of Differences in Claims and the Approved Variation

LOT a	CONTRACTORS' VARIATION CLAIMS ₦ B	APPROVED VARIATIONS ₦ c	DIFFERENCE (b)-(c) ₦ d	% SAVED (d/b)x100 ₦ e
1	483,250	207,840	275,410	**56.99**
2	498,461	300,790	197,691	**39.66**
3	703,257	583,383	119,874	**17.63**
4	679,600	470,160	209,440	**30.81**
5	517,300	240,800	276,500	**53.45**
6	350,430	257,730	92,700	**26.45**
7	400,480	204,820	195,660	**48.85**
8	120,280	120,280	0	**0**
9	283,100	228,190	54,910	**19.39**
10	272,344	214,490	57,854	**21.24**
11	1,224,500	330,410	894,090	**73.01**
12	197,150	142,713	54,437	**27.61**
13	359,375	148,295	211,080	**58.73**
14	611,530	380,030	231,500	**37.85**
15	261,030	146,940	114,090	**43.70**
16	**1,751,400**	**141,110**	**1,610,290**	**91.94**

Source: Table 1

Table 4: Analysis of Overall Savings made by the In-House Consultants.

(a) LOT	(b) Contractor's anticipated sum.	(c) Total work done approved.	(d) Amount saved. (Col. 2- 3 Table 2)	(e) Amount saved as % of work
	₦	₦	₦	₦
1	3,126,755	2,559,385	567,370	**22.2**
2	3,119,291	2,740,920	378,371	**13.8**
3	5,202,543	4,939,506	263,037	**5.3**
4.	45,664,942	4,431,560	1,233,382	**27.8**
5	3,478,830	3,185,630	293,200	**9.20**
6	2,723,240	2,347,460	375,780	**16.0**
7	2,846,480	1,989,603	856,877	**43.1**
8	2,019,705	1,926,842	92,863	**4.8**
9	3,458,456	2,973,490	484,966	**16.3**
10	3,312,784	2,804,943	507,841	**18.1**
11	4,437,840	3,632,864	804,976	**22.2**
12	1,959,157	1,794,080	165,077	**9.2**
13	2,296,819	1,921,187	375,632	**19.6**
14	4,025,230	3,363,050	662,180	**19.7**
15	2,225,865	1,989,410	236,455	**11.9**
16	5,533,140	3,920,640	1,612,500	**41.1**
	Total:	**8,910 507**		

COST COMPARISON BETWEEN BUILT-IN SECURITY COMPONENTS AND SOME PHYSICAL CHARACTERISTICS OF BUILDINGS IN NIGERIA: Case Studies of Residential, Commercial and Institutional Buildings in Abuja and Minna

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ABSTRACT

This paper examines the impact of physical characteristics of buildings on the costs of providing security in building projects. The study achieved this by establishing the existence or otherwise of significant differences between total costs of security components in buildings and (i) the nature of the use of the buildings, (ii) the number of floors in the buildings and (iii) the location of the buildings. The paper employs a survey approach, by utilizing a data collection proforma to capture eighteen (18) different variables spread over various elements in building and security components. The results showed that the total costs of built-in security differed significantly amongst the various uses of the building and buildings located in Abuja, as compared to those located in Minna. (P0.05 = 0.041; 0.022); buildings located in Abuja had a relatively lower value (323.91 compared to 964.57 for buildings located in Minna). The study concluded that, the commercial buildings included in the study samples were mainly simple market stall/warehouse buildings that had few openings, and thus lower costs of securing the buildings. The paper recommended that appropriate designs that incorporate built-in security components should always be the focus/priority of the building owners.

Keywords: Building Cost, Crime Prevention, Built-In Security Components, Housing.

Introduction

No nation, not even the highly developed ones, is crime free. Crime occurs in various forms: cheating, stealing, in various degrees *viz*; pick-pocketing, armed robbery, advance fee fraud, embezzlement and drug-peddling. Crime takes place at different locations: at offices, homes, recreational centers, and in transit. The historical background of housing developments cannot be divorced from criminal activities committed within houses, usually following forceful entry by the perpetrators. Such crimes include burglary, breaking and entering, and armed robbery, as reported by Gashash (1996) and Ikoro (1997). According to Anthony and Paul (1992), the developments of houses for human residence, commercial and other types of buildings have responded to the need to fortify them to forestall the commitment of crimes.

The increasing importance of infrastructure security against the backdrop of well documented threats such as vandalism, fire outbreaks, armed robbery, burglary and terrorism contrasts sharply with the reality that empirical relationship and comparison between infrastructure facility characteristics and costs implications of security concerns are non-existent. This paper is focused on deriving and explaining such relationship in the case of buildings devoted to residential, commercial and institutional uses. Anifowose and Oke (2008) established that the security concerns of private individuals are expressed through the provision of built-in security components in their houses. Such components are intended to fortify the buildings against external attacks by criminals, and include the provision of burglar proofing, perimeter fencing, guard huts and external floodlighting. Other security devices such as anti-burglar alarms are usually not within the financial reach of the majority of low and medium income owners of houses. Anifowose (2003; 2007) have tried to establish the proportions of total building costs that are devoted to security-related components in buildings. Such works have been based on an arbitrarily selected residential building type which limits its applicability to buildings devoted to other uses. However, the aim of this study is to examine the impact of physical characteristics of buildings on the costs of providing security in building projects. The study intends to achieve this by meeting the following objectives; Establishing the existence or otherwise of significant differences between total costs of security components in buildings and (i) the nature of the use of the buildings, (ii) the number of floors in the buildings and (iii) the location of the buildings.

This study is based on the following null hypotheses that no significant linear relationship exists between the following pairs of variables:-

H_{o1}: There is no significant difference between the total costs of security components of the sampled buildings with respect to the function.

H_{o2}: There is no significant difference between the total costs of security components of the sampled buildings with respect to the number of floors.

H_{o3}: There is no significant difference between the total costs of security components of the sampled buildings with respect to the location of the buildings.

The scope of this paper is however limited to those components that are included in building for their security characteristics, and are built in as the building work progresses. Security systems external to the building, not forming an integral part of it, such as guard patrols are not covered by this paper.

The data utilized by this paper was sourced from buildings of a residential, commercial and institutional building nature constructed within the study area, which covers the federal capital of Nigeria, Abuja, as well as the capital city of Niger State, Minna. Minna is located about 200 kilometres north-west of Abuja (see Map 1). The monetary values of security components employed by the study refer to projects proposed and executed between 2005 and 2007, and are expressed in Naira. The average official rate of exchange over this period of time was about 120 Naira to 1 US Dollar.

Related Works

According to Faruqee (1994), Crimes and criminal activities escalated in Nigeria following the Nigerian civil war {1967-1970}. This escalation became a national embarrassment in the year following the collapse of the Nigerian economy {1980-1981}.The harsh effects of the various prescriptions for recovery also fuelled this escalation. New forms of criminal activities gained prominence in structural adjustment programme (SAP) and post structural adjustment programme (SAP) years {1985 – date}. Thus, armed robbery, drug trafficking and advance fee fraud {419} became celebrated crimes. Drastic measures to curb the expansion of criminal activities such as the application of the death penalty do not have the desired effect. Property security is an important research topic; security in this respect covers the incidence rate of fire in residential buildings, which in Saudi Arabia accounts for 69% of all building fires. Al-Homoud and Khan (2004) carried out a field assessment of current safety issues for residential buildings in Saudi Arabia to identify common safety deficiencies. The survey showed that most residents were ignorant of many safety aspects in their homes. Abrahamsen and Williams (2006) postulated that Security Sector Reform (SSR) has become a central part of development policy, given an increasing recognition of the links between security and development. They observed however that following a traditional weberian conception of the state, such reform programmes are almost exclusively focused on the public security sector, neglecting the extent to which people in developing countries have come to rely on private security providers for their day-to-day security needs.

Theoretical writings on security have tended to explore the increasing connections between capital and security. Neocleous (2007) did so by first exploring the rise of the security industry in the context of the current 'war on terror', before linking this to the rise of a parallel industry in policing and incarceration. These three dimensions of the security industry have tended to be understood through the notion of privatization and instead of taking this route; Neocleous (2007) tries to understand the security industry through the concepts of commodification and fetishism. A further feature of recent writings on security is the idea of a convergence of internal and external security (no doubt influenced by the notion of the world as a global village). Lutterbeck (2005) considers that in post-Cold War-era Western Europe the dividing line between internal and external security has become increasingly obsolete. This convergence of internal and external security agendas point to a militarisation and externalisation of policing, and an internalisation and 'policisation' of soldiering: while police forces are taking on military characteristics, and are extending their activities beyond the borders of the state, military forces are turning to internal security missions, and are adopting certain police features. Moreover, agencies which have traditionally been located at the interface between police and military forces, i.e. gendarmerie-type or paramilitary forces, are assuming an increasingly important role.

Terms such as "terrorism" and "anti-terrorism" have been thrust into modern vocabulary following post-9/11 conservative political agenda that has fuelled attempts to blur the boundaries between dissent or even crimes of property and what the state defines as acts of terrorism, particularly when these involve progressive movements (Wekerle and Jackson, 2005). Violence impedes human freedom to live safely and securely, and can sustain poverty traps in many communities. A key challenge for academics, policy-makers and practitioners working broadly in programmes aimed at poverty alleviation, including violence prevention, is the lack of reliable and comparable data on the incidence and nature of violence. Violence and poverty are inextricably linked, although the direction of causality is contested if not circular (Diprose, 2007).

Methodology

This paper employs a survey approach to the study of security-related construction costs of commercial buildings. A data collection proforma was designed to capture eighteen (18) different variables comprising physical characteristics of the buildings as well as costs of erecting the various elements of the buildings. The research instrument employed compares with those adopted by Al-Homoud and Khan (2004) in their study of safety design practices in residential buildings in Saudi Arabia, and Diprose (2007) in her work on internationally comparable indicators of violence, which relied on a questionnaire to elicit relevant information.

Data for this research work was sourced from quantity surveyors by a convenience sampling method that was supported by a snowballing methodology. Attempts were made to collect all of the available data that was relevant in line with the research design. Quantity surveyors were asked to suggest the names of others of their colleagues who might possess further relevant data. This technique (snowballing) resulted in the sourcing of a fair sized number of projects that had official documents (mainly bills of quantities) from where the research data could be extracted. Only 19 building projects that had data suitable for analysis were obtained in Minna. Inclusion of Abuja as a part of the study area resulted in the sourcing of an additional 30 building projects. This brought the total research data to 49 buildings which were used for the statistical analysis in this paper. These were buildings that had complete information on security-related costs, detailed in an elemental format. Line graphs of the data were plotted, in order to allow trends be examined visually. Quantification of the proportion of variation in the dependent variable (security-related costs) related to variations in the independent variables (total floor areas, and total areas of openings requiring protection such as doors and windows) were effected through the use of simple regression analysis.

The research data were analyzed using descriptive techniques of analysis in order to reveal any apparent patterns of location or dispersal of the data around the mean values as shown in table 1. The results of such data using analysis of variance (ANOVA) are presented in table 2. In addition, graphical illustrations were produced which provide visual evidence of patterns within the data. The results are presented in Figures 2, 3 and 4 in the appendix.

Discussion of Results

The results of the analysis of variance (ANOVA) statistical technique employed by the study in testing the validity or otherwise of the hypotheses are provided in Table 2 below. As previously detailed in this paper, hypotheses H_{o1} to H_{o3} were formulated to establish whether the mean values obtained differed significantly amongst the following characteristics of the projects sampled by the study: Type of use of building (residential, commercial or institutional buildings), number of floors in building (bungalow or multi-storey), and the location of the buildings (Abuja or Minna).

The mean values for the three types of use recorded for the sampled buildings were significantly different. Residential uses had a mean value of 806.97 Naira per square meter for total built-in security, while for commercial buildings the value was 328.81 Naira. Institutional buildings had the highest value of 1379.46 Naira per square meter. The calculated value of the F statistic was higher than the $F_{0.05}$ critical value (3.436 compared to 3.23). The $P_{0.05}$ value was lower than the 0.05 threshold (0.041). Null hypothesis H_{o1} was thus rejected for this analysis.

The mean values for the bungalow and storey buildings were highly differentiated. The bungalow buildings in the sample had a mean value of 529.03 Naira per square meter for total built-in security, while for storey buildings the value was 1059.41 Naira. The calculated value of the F statistic was lower than the $F_{0.05}$ critical value (1.118 compared to 4.08). The $P_{0.05}$ value was higher than the 0.05 threshold (0.296). Null hypothesis H_{o2} was thus accepted for this analysis.

The mean values for buildings in the two locations sampled by this study were highly differentiated. The buildings located in Minna in the sample had a mean value of 964.67 Naira per square meter for total built-in security, while for buildings located in Abuja the value was 323.91 Naira. The calculated value of the F statistic was higher than the $F_{0.05}$ critical value (5.650 compared to 4.08). The $P_{0.05}$ value was lower than the 0.05 threshold (0.022). Null hypothesis H_{o3} was thus rejected for this analysis.

Main Findings from Analysis

The following constitute the main findings from the analysis of data carried out thus far by this study.

i. Costs of built-in security in buildings were lowest for buildings subjected to commercial uses as opposed to residential or institutional uses.
ii. Costs of built-in security were also lowest for bungalow buildings as opposed to storey buildings, and for buildings located in Abuja, as compared to those located in Minna.

Findings and Discussion

Using Jerrell/Slevin management instrument, table 1 shows that Nigerian quantity surveyors do exhibit autocratic leadership style on the general note while only 2 of the identified categories exhibits shareholder and consensus styles. Based on the survey, the respondents were of the opinion that Nigerian quantity surveyors do exhibit more of task-oriented leadership style than other identified styles. Giritli and Oraz (2003) classified leadership styles into democratic and autocratic. The former was described as employee-centred and the latter was described as task-centred depicting a relationship between the result of the management instrument and the perception of construction professionals. As expected, laissez-faire leadership style – described as “hands-off” or “leave it be” style - was ranked least in term of execution by Nigerian quantity surveyors.

Conclusion and Recommendations

When the study data was segmented by various inherent characteristics such as use, height and location of the building, was homogenous in nature. The results showed that the total costs of built-in security differed significantly amongst the various uses of the building (P0.05 = 0.041). Such costs were lowest for commercial buildings, for bungalow buildings, and for buildings located in Abuja, as compared to those located in Minna. These results can be explained partially as being due to the fact that the commercial buildings included in the study sample were mainly simple market stall/warehouse buildings that had few openings, and thus lower costs of securing the buildings.

The costs of security for buildings of different heights were not significantly different (P0.05 = 0.296), even though bungalow buildings had a relatively lower value (529.03 compared to 1059.41 for storey buildings). This could be explained as due to the fact that the study data was skewed in favour of bungalow buildings. A more balanced data might have yielded a different result.

The costs of security for buildings located in Abuja was significantly different (P0.05 = 0.022); buildings located in Abuja had a relatively lower value (323.91 compared to 964.57 for buildings located in Minna). This could also be explained as due to the fact that the study data was skewed in favour of buildings located in Abuja. At the same time the buildings located in Abuja were mainly commercial buildings, which as observed earlier had lower costs of security owing to their architectural design peculiarities. All of the institutional buildings (which had high costs of security) were located in Minna.

This study makes the following recommendations:-

i. It was revealed that buildings subjected to commercial uses had the least cost of built-in security. However, the study recommended that appropriate designs that incorporate built-in security components should always be the focus/priority of the building owners. Most importantly Architects should always reveal the design implications of inclusion of the security-related components to their clients' right from the initial planning stage of the project.
ii. The buildings located in Abuja were mainly commercial buildings, which as observed earlier had lower costs of security owing to their architectural design peculiarities. All of the institutional buildings (which had high costs of security) were located in Minna. However, architectural designs for buildings should always include built-in security components which could forestall any future breach of security in the different types of buildings, such as commercial, residential, bungalow buildings and the likes.

Strategies for Implementations

The above recommendations can be implemented in the following ways;

i. Cost of items of built-in security in buildings should be based on full details of construction and timely preparation of working drawings should be encouraged.
ii. The actual costs of the components of the buildings, which would have been provided in a statement of final account, might yield results that would be different from that of this study.

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Appendix

Table 1: Descriptive Summaries of the research Data

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	statistic	statistic	statistic	statistic	statistic	statistic	statistic	statistic	statistic
TFA	49	2102	50	2152	445.78	438.431	192221.471	2.319	.340	6.147	.668
OpgArea	49	359	12	371	104.35	85.838	7368.148	1.297	.340	1.301	.668
WallArea	49	1081	71	1152	343.67	250.727	62863.849	1.456	.340	1.538	.668
OpgNum	49	114	6	120	37.94	29.151	849.767	1.525	.340	1.702	.668
ContractSum	49	66194497.87	1264479.38	67458977.25	10698979.4837	11713317.48403	137201806481755.300	3.031	.340	11.430	.668
TotalSecurity	49	4950000	0	4950000	238579.90	715887.272	512494586925.511	6.212	.340	41.138	.668

Source: Author's analysis of field work data,2008
Key: unit of measurement is Nigeria currency (Naira and kobo)

Table 2: Results of Analysis of Variance

Exp No	**Variables (Mean values)**			**Observations**				**Inferences**	
	Variable 1	**Variable 2**	**Variable 3**	**Parameter tested**	**F_{cal}**	**F_{tab}**	**P_{value}**	**Rmk**	**Action on Hypothesis**
1	Residential N806.97 (14)	Commercial N 328.81 (30)	Institutional N1376.46 (5)	Total costs of security (per m^2) segregated by use of building.	3.436	3.23	0.041	SS	Reject H_{o5}
2	Bungalow N529.03 (45)	Storey N1059.41 (4)	-	Total costs of security (per m^2) segregated by height of building.	1.118	4.08	0.296	NS	Accept H_{o6}
3	Minna N964.57 (19)	Abuja N323.91 (30)	-	Total costs of security (per m^2) segregated by location of building.	5.650	4.08	0.022	SS	Reject H_{o7}

Key: SS = Statistically Significant
NS = Not Significant
Rmk = Remark
Values in (brackets) refer to number of cases of the variable.

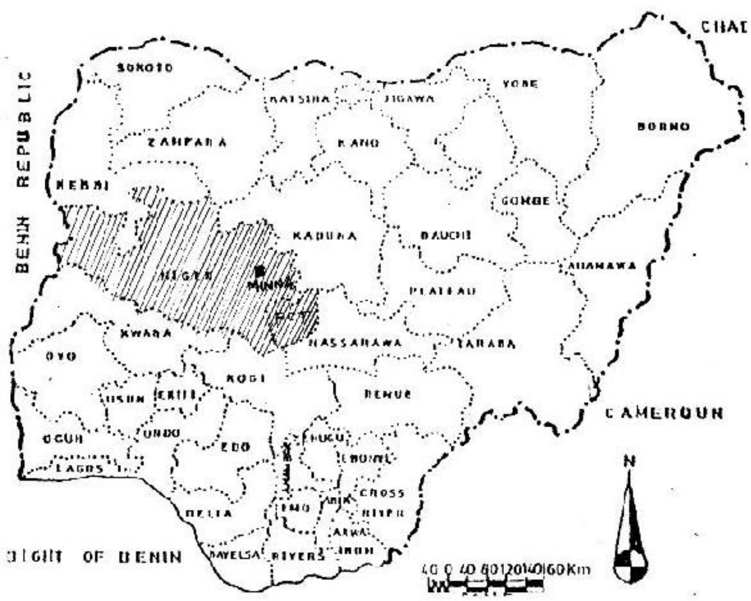

Figure 1: Map of Nigeria (the study area is shown hatched)

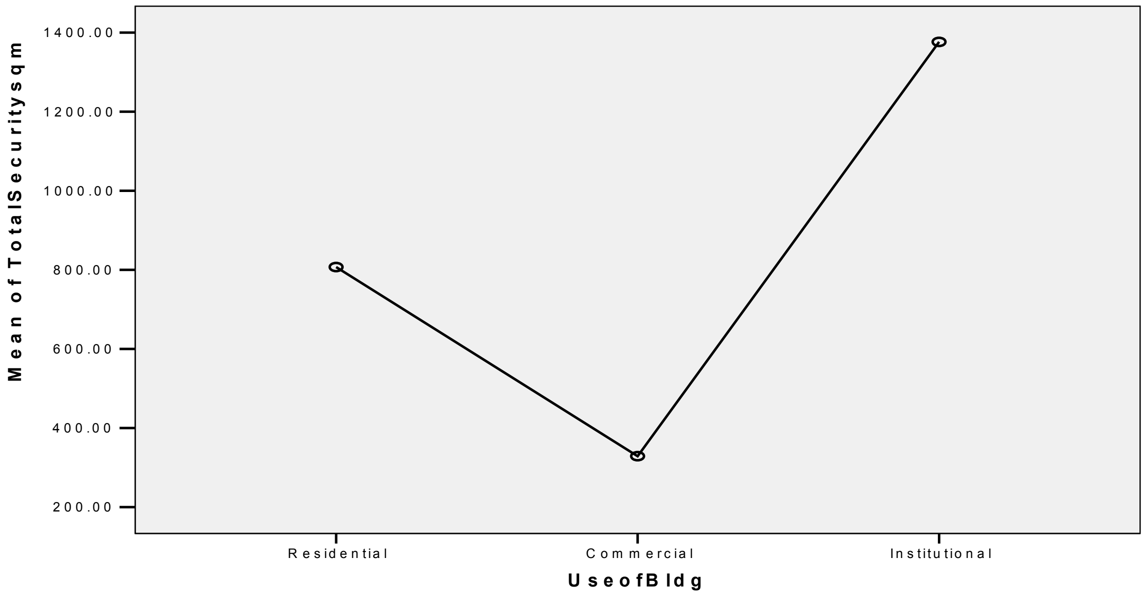

Figure 2: Total security costs per unit area compared amongst building uses.

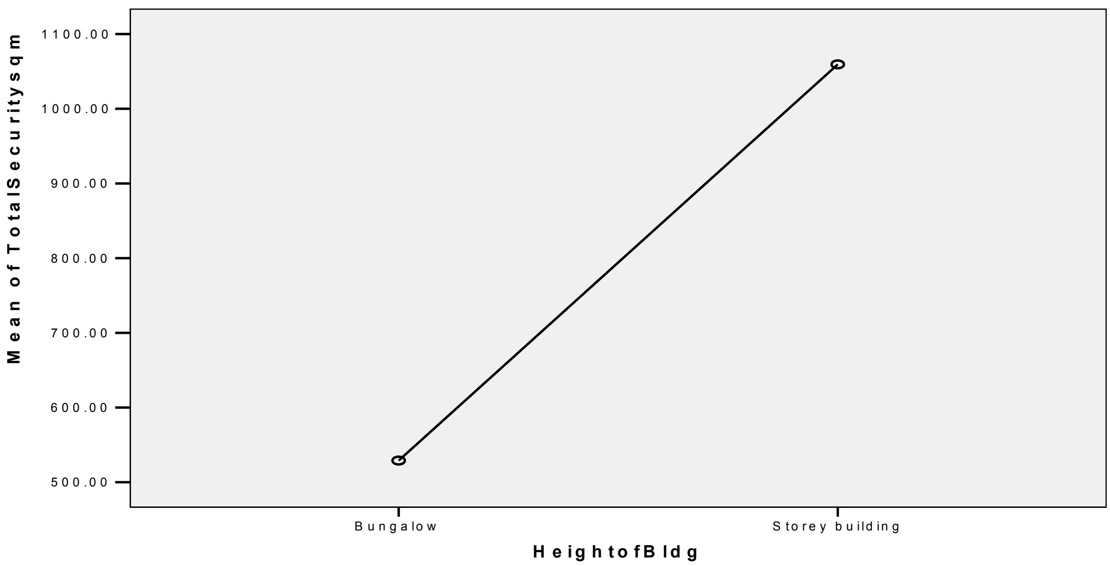

Figure 3: Total security costs per unit area compared between bungalow and storey buildings.

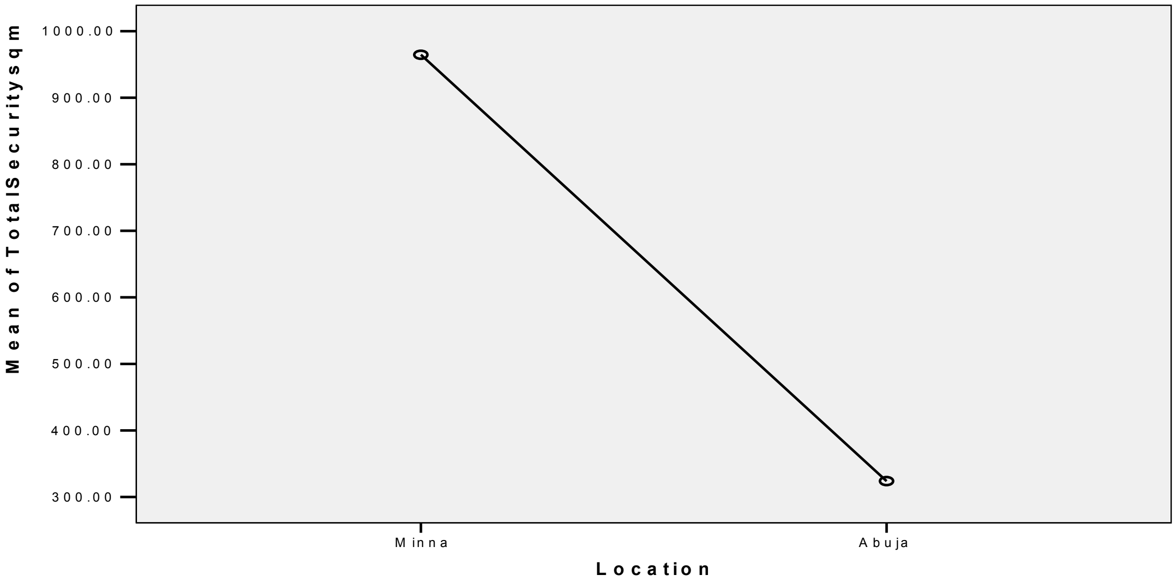

Figure 4: Total security costs per unit area compared by location of building.

EVALUATION OF THE CAPITAL BUDGET PLANNING PRACTICE OF CONTRACTORS IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

Poor and unrealistic budgeting has been traced to the inefficiency and neck-deep poverty of contractors in the construction industry, this attributes to the economic decline of firms and capital disappearance in the industry. This research work seeks to evaluate the capital budget planning practice of contractors in the Nigerian construction industry. The research made use of questionnaires for data collection and the statistical tools employed in the analysis are frequency tables, percentages, cumulative percentages, and mean score ranking. The variables used for the evaluation include long-term capital budgets, capital budgeting manual/written procedures, formal bodies responsible for screening and reviewing projects, capital budgeting personnel and regular minimum rate of return review. The study revealed that about 50% of contractors do not make plan for long-term capital budgets and therefore cannot handle large projects. It is recommended that contractors make plan for long-term capital budgeting and devote more personnel to capital budget planning to ensure that they can handle the numerous large construction projects in the industry.

Keywords: Capital Budget, Contractors, Construction Industry, Planning processes.

Introduction

Capital budgeting is one of the key issues in corporate finance (Truong, Partington & Peat, 2006). It is an integral part of the corporate plan of an organization, which reflects the basic objectives of an organization (Osaze, 1996). One of the most important decisions to be taken by a financial manager is corporate capital budgeting (Ryan, 2002). Capital budgeting is one of the fundamental parts of the budgetary process employed as a tool for planning, controlling and allocating scarce resources among competing demands in any locality (Sekwat, 1999). Capital budgeting involves making investment decisions concerning the financing of capital projects by firms (Elumilade, Asaolu, & Ologunde 2006).

Capital budgeting is an important management process that certainly influences the long-run survival and value of a firm, because of the amounts involved are so large that managers need to carefully plan and evaluate expenditures for capital assets (Lam, K., Wang & Lam, M., 2007) . Capital budgeting in a developing economy is very vital and must be approached with all sense of diligence. The rate of economic development in the third world has been relatively slow and needs to be accelerated (Elumilade, Asaolu, & Ologunde 2006). The capital investment decision is more than investment in capital assets such as fixed assets, e.g., land and buildings, plant and equipments etc.; it can include intangible fixed assets (e.g., research and development) and working capital. The capital investment decision is therefore one of the most critical and crucial decisions that any country or organization can take to achieve economic development (Osaze, 1996).

Elumilade, Asaolu & Ologunde (2006) opined that technological backwardness and poverty are the resultant effect of poor and unrealistic budgeting in African countries including. Lack of financial control and poor management have contributed significantly to the high level of insolvencies experienced in the construction industry when compared with other industry sectors (Mutti & Hughes 2002). Mutti and Hughes (2002) further suggested that models available for cash flow management and forecasting can be used as a starting point for managers in rethinking management practices.

This paper seeks to evaluate the capital budget planning practice of contractors in the Nigerian construction industry with a view to ascertaining the ability of contractors in Nigeria to meet up with the challenges of carrying out large construction works.

Theoretical Background

Insolvency in construction

Most contractors in Hong Kong are suffering from business reduction, profitability deterioration and struggling very hard to retain their financial performance (Chan, Tam & Cheung, 2005). Mutti and Hughes (2002) reveal that the number of firms in the industry and the differences in the degree of risk has been identified as the most responsible factor for the high proportion of liquidation in the construction industry. Mutti & Hughes (2002) also noted that the level of insolvencies in the construction industry is high, ranging from about 12.5% to 60% when compared with the total industries which is due to the fact that the construction industry has a large number of company leading to a greater likelihood of high failure rates.

The period of instability in financial operations have made companies retain their policy through the maintenance of sound financial structures, reflecting the proliferation of government financial regulations, backed up by the aim of a controllable and dynamic investment pursuit for the sustenance of national economy. Empirical studies emerging from established theoretical apparatus have filled up the vacuum in business procedures, which continually arouse the interest of experts in making positive contributions required to compare the financial condition and performance of various firms. It is also important to be conscious of the fact that, the idea of rigorous pursuit of firm's stabilization through debt funding unravelled the negligence of financing decision in business organizations (Elumilade, Asaolu & Ologunde 2006).

Capital Budget Planning Process

A strategic plan is the principal strategy of the firm identifying the business the firm is in and where it intends to position itself in the future. Strategic planning translates the firm's goals into specific policies and directions, self priorities, specifies the structural, strategic and tactical areas of business development and guides the planning process in the pursuit of solid objectives. A firm's vision and mission is encapsulated in its strategic planning framework (Dayananda, Irons, Harrison, Herbohn, & Rowland 2002).

Strategic planning has always been one of the most crucial functions in any organization. An essential element in a company's overall strategy is its financial plan, which should be designed to ensure the provision of adequate finance for the company's needs. Budgeting is a fundamental part of planning. Annual budget forms a vital part of any corporate plan and financial control cannot be exercised without budgets (Dayananda et al., 2002).

Capital budgeting is a systematic decision process whose goal is to ensure that resources are allocated within an organization in such a manner so as to guarantee the long-term economic survival and growth of that organization (Chandan, 1984). More specifically, the capital budgeting process identifies prospective investments, selects investments based on some decision criteria, and plans for the implementation and financing of the selected investments. Therefore, a capital budget is a plan for future investments and as such it is similar to the methodology of life-cycle cost analysis. With specific reference to buildings, capital budgeting evaluates the impact of facilities on the ability of the enterprise to meet its long-term goals and objectives.

Capital budgeting procedure is based on firm's perception of planning for financial increment due to successful market performance, customers' satisfaction and retention, capacity to launch new products or possibility of improving old ones (Elumilade, Asaolu & Ologunde 2006). Bodernhorn (1959) advocates that difficulties emanate from capital budgeting. Bodernhorn notes the obstacle of making decision in budgeting of capital and observes that the formulation of such decision is centred on the available investment opportunities that will make firm to accept or reject a project.

According to Dayananda et al., (2002), capital budgeting is a multi-faceted activity and the critical nature of capital planning requires a systematic approach to investment decision making. However, the classification of capital budgeting as part of the strategic planning process suggests that it is difficult to formalize a methodology that can be applied in all cases. The several sequential stages in the capital budgeting process are depicted in the form of a highly simplified flow chart as shown in figure 1.

Capital Budget Planning Practice

According to Lam *et al*., (2001), the planning and administrative aspects of capital budgeting should cover:

Long-term capital budgets

It is one of the core corporate strategies to be incorporated in a company's business plan usually covering between three – five years review of the investments and financial prospects of the firm.

Capital budgeting manual/written procedures

It involves companies or organizations having an existing up-to-date systematic capital budgeting manual or written procedures.

Formal bodies responsible for screening and reviewing projects

It involves identifying potential projects and screening them to ensure they measure up to the corporate policy and objectives (short or long term), resource availability, technical and financial feasibility of the organization.

Capital budgeting personnel

This involves devoting a full time staff member exclusively for capital budgeting. For instance in large organizations, project/contract managers are responsible for project finance and general managers for capital budgeting while in small organizations, the manager performs the two responsibilities.

Regular minimum rate of return

This involves a regular review of the minimum rate of return require from implemented projects by the firm.

Research Methodology

The data for the study was collected through the administration of well structured questionnaires to contractors in Lagos State, Nigeria. The state was chosen as a result of large concentration of construction taken place in the locality and also most organizations in the other states of the federation have their head office located in Lagos state. The total population for this study included all registered contractors with the Federation of Construction Industry (FOCI) practicing within Lagos state of Nigeria from which a sizeable number was selected to serve as a good representation of the population under study. The population consisted of 108 contractors registered with FOCI practicing within Lagos State. Of this number, 70 contractors were selected and questionnaires sent out to them using the non-probability sampling. 52 questionnaires were returned indicating a return rate of 74.3%.

The data was analyzed using the calculation of descriptive statistics to present the frequencies and mean of responses to questions with fixed responses to determine the characteristic information of respondents, capital budget planning process and capital budget control measures. The medium of presenting the findings of the research is the use of tables.

Results and Discussion

Findings are discussed on the capital budget planning practices of contractors in the Nigerian Construction Industry as revealed by literatures. Meanwhile, only 52 of the 70 questionnaires administered were retrieved and used for the data analysis, representing 74% of the expected responses.

The table 1 shows the characteristic information of respondent organization indicating the size of the firm through the number of employees, the registration category and the nature of construction works executed by the respondent firms.

Table 2 shows the capital budget planning process which covers areas such as long-term capital budgets, up-to-date capital budgeting manual or written procedures, formal bodies responsible for screening and reviewing projects, capital budgeting personnel and regular review of minimum acceptable rate of return (Lam et al., 2001).

The result of contractor’s long term capital budget indicates that more than half of the contracting firms that responded to the survey had ‘a capital budget which looks beyond 2 years’.

The result of the availability of an up-to date capital budgeting manual reveals that only about 30.8% of contractors have an up-to-date capital budgeting manual which is in use. The level of staff governing administrative operating procedures among contractors shows that about 69.2% of respondents had a formal system governing administrative procedures.

From the survey, it shows that 65.4% of the respondents have formal bodies responsible for screening and reviewing of their projects signifying the level of importance attached to screening and reviewing of projects by contractors in the Nigerian Construction Industry. It is also worthy of note that over 90% of respondents devote at least a unit of the organization to capital budgeting because of the perception that the personnel strength devoted to capital budgeting may influence the achievement of organization policies and goals.

Table 2 revealed that half (i.e. 50%) of respondents review their minimum acceptable rate of return yearly. It was also observed that the minimum acceptable rate of return by respondents ranges from 6% to 25%.

Table 3 shows the basic factors to be considered in planning for long capital budgets. It is revealed from the table that sufficient foresight is the most important factor to be considered when planning for long capital budgets.

Capital budgeting control measures

Lam et al., (2001) reveals that capital budgeting control and evaluation entails the following: (a) pre-operational control (i.e. evaluation of projects due to cost overrun) (b) monitoring of project performance, and (c) post-completion audits.

The survey reveals that majority of contractors (i.e. about 88.5% of respondents) will reconsider an investment whose estimated costs will likely exceed the budgeted costs while about 11.5% will reject such offer. None of the respondents volunteered to accept such proposal. This confirms that the reconsideration of cost overruns was very popular in contracting firms irrespective of the size of the firm.

Table 5 indicates the importance place on monitoring project performance by contractors. The result shows clearly that project performance monitoring is a very high and common phenomenon among contracting firms. This is regarded as one of the cost control systems used in the construction industry, particularly for controlling small projects so as to provide feedback information for similar projects in the future. Firms place high importance on the benefits of the post-completion audits as indicated in table 6.

Conclusion

Following the evaluation of capital budget planning process among contractors, the study shows that one of the most important planning process is the horizon of contractor’s capital budget and the personnel strength devoted to capital budgeting revealing that the horizon of a contractor’s capital budget and personnel strength devoted to capital budgeting determines the extent of firm’s financial growth and its ability to handle large construction projects.

From the foregoing, about 50% of contractors do not have the ability to handle large construction projects, hence, it is recommended that contractors make plan for long-term capital budgets and devote more personnel to capital budget planning to ensure that they can handle the numerous large construction projects in the industry.

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Appendix

Table 1: Characteristic information of respondent organization

	Size	Frequency	Percentage
Number of employees	Less than 50	20	38.5
	51 – 150	20	38.5
	Above 150	12	23.1
	Total	**52**	**100.0**
Registration Category	Category A	8	15.4
	Category B	24	46.2
	Category C	7	13.5
	Category D	7	13.5
	Category E	6	11.5
	Total	**52**	**100.0**
Nature of Construction Work	Building	18	34.6
	Civil engineering	8	15.4
	Heavy/Industrial engineering	2	3.8
	Building/Civil engineering	24	46.2
	Total	**52**	**100.0**

Table 2: Capital Budget Planning Processes

		Frequency	Percentage
Horizon of contractor's capital budget	Not applicable	14	26.9
	1 – 2 years	10	19.2
	3 – 5 years	24	46.2
	6 - 10 years	4	7.7
	Above 10 years	0	0.0
	Total	**52**	**100.0**
Availability of up-to-date capital budgeting manual	Not available	14	26.9
	Available but not defined	14	26.9
	Available but obsolete	0	0.0
	Available but not in use	8	15.4
	Available and in use	16	30.8
	Total	**52**	**100.0**
Level of staff governing administrative operating procedures	Highly formal	8	15.4
	Formal	28	53.8
	Slightly formal	8	15.4
	Informal	6	11.5
	Not available	2	3.8
	Total	**52**	**100.0**
Level of screening and reviewing of projects	Highly formal	20	38.5
	Formal	14	26.9
	Slightly formal	14	26.9
	Informal	2	3.8
	Not available	2	3.8
	Total	**52**	**100.0**
Personnel strength devoted to capital budgeting	None	4	7.7
	A unit	12	23.1
	A department	24	46.2
	A section	12	23.1

	Total	**52**	**100.0**
Review of minimum acceptable rate of return	Monthly	4	7.7
	Bi-annually	2	3.8
	Yearly	26	50.0
	Biennially	2	3.8
	Dependent on project	18	34.6
	Total	**52**	**100.0**
Minimum acceptable rate of return on investments	Less than 5%	0	0.0
	6 – 10%	14	26.9
	11 – 15%	18	34.6
	16 – 20%	12	23.1
	21 – 25%	8	15.4
	26 – 30%	0	0.0
	Total	**52**	**100.0**

Table 3: Factors considered in planning for long capital budgets

Factors	**N**	**Mean**	**Standard deviation**	**Rank**
Sufficient foresight	52	4.27	1.07	1
Thorough prediction	52	4.15	0.87	2
Inflation	52	4.00	1.09	4
Risk	52	4.12	1.06	3

Table 4: Evaluation of projects due to cost overrun

	Frequency	**Percentage**
Accept	0	0.0
Reconsider	46	88.5
Reject	6	11.5
Total	**52**	**100**

Table 5: Monitoring of project performance

Project performance	**N**	**Mean**	**Standard deviation**	**Rank**
Productivity of labour	52	4.77	0.58	1
Productivity of plant	52	4.54	0.90	3
Usage of materials	52	4.46	1.02	4
Inflow of project cash flow	52	4.73	0.45	2
Outflow of project cash flow	52	4.27	0.91	5

TOWARDS NEW APPROACHES FOR CONVERTING PRINCIPLES OF VERNACULAR ARCHITECTURE INTO ENERGY EFFICIENT BUILDINGS IN HOT AND DRY CLIMATES

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ABSTRACT

Buildings can be designed to require far less than the energy of today's average. Reducing energy consumption of buildings in hot-dry climates by using natural energy sources to provide comfortable microclimate is the main concern of this study. In this paper design strategies in terms of energy efficiency is considered based on proper building form, material selection and orientation and by taking advantages of passive cooling strategies and ventilation. The study aims to show that the idea of using natural energy and passive cooling strategies came from the vernacular principles.

Keywords: Energy efficiency, Natural Energy, Vernacular Principles, Architectural Design Strategy

Introduction

From the last few decades of the 20th Century till now, our planet did warm quickly. The beginning of global warming was caused by fossil fuels being burned to provide energy and emitting plenty of CO2. Globally, buildings account for close to 40% of total end use of energy (J.Laustsen, 2008) In this matter architects and building designers hold the key to turning down the global thermostat and lessen our dependence on fossil fuels. Architects have a moral responsibility to consider whatever may affect the efficiency of the building. Every climate produces certain observed effects on architectural form. The architecture is valuable when it is rooted in the location and the culture of a region and responsible for its surrounding environment. Vernacular responses to the every climate conditions embody a wealth of design principles which should be retrieved and applied today. All traditional solutions should be evaluated scientifically before they are discarded or substitutes proposed. The phenomena of the microclimate should be analyzed and new building materials, methods, and designs must be tested until the complex relationships among buildings, microclimate, and human being are fully understood (Hassan Fathy, 1986). Rational solutions from vernacular architecture should be resurged in contemporary architecture and a comprehension of how they might accomplish truly sustainable building in future should be considered. The work of some proponents of vernacular architectures Such as Hassn Fathy, Paul Oliver, Kamran Diba and etc, all of whom have demonstrated how vernacular technologies, materials and forms may be applied in contemporary design. Few attempts have been made to investigate the vernacular architecture, but most of existing literatures in this field are introduction or historical materials and do not deal with vernacular techniques in term of the integrating of vernacular strategies to contemporary development.

This study is based on a research thesis which has been carried out for the hot and dry climate of Iran. The study first aims to show the advantages of traditional architectural principles in climate responsive design aspect. Secondly it attempts to put forward the rational principles of vernacular architecture of Iran that can be used in energy efficient architectural design.

In this paper climatic design strategies in hot and dry climate were examined and architectural principles in terms of design criteria such as minimizing solar gain inside the building, minimizing conductive heat flow, promoting ventilation, promoting earth cooling, promoting radiant cooling and promoting evaporation were evaluated. In this matter reducing the costs of fossil fuel energy consumption and greenhouse gas emissions by using of renewable energy source was considered. As the most problematic feature of designing in hot and dry climate is its harsh summers therefore this study is focusing on the design strategies of the hot summertime.

Climate Responsive Design In Traditional Architecture Of Hot Dry Climate

Climate is a dominant factor in traditional town planning. The climate of a given region plays a great role in the designing of a building. In order to design a structure responding to environment all factors that effect on the external environment as well as all aspects of internal environment should be considered. Many vernacular techniques are environmentally responsible and sustainable, but nowadays because of altered lifestyle and ecological situations some of them are no longer properly functioning. In this regard, the challenging issue is to discover essential principles of vernacular architecture, and observe the ways to integrate those principles into development progress. Revising traditional techniques which used in hot-arid climate of central Iran could be a spark to this matter.

One of the greatest examples of climate responsive design in central part of Iran is *Boroujerdi-ha* house (fig 1). The house is built around a central courtyard-atrium with windows, doors, arches and other architectural features facing in, rather than out. In winter, the family would gather in the south-facing side of the house which has larger windows to make the best of the winter light and sunshine. Then in summer, more activities would take place in the north-facing side where the windows were smaller. The summer residence is higher than winter residence and the reason for this is because warm air is raised and the cooler air moves to the lower area (Fig2). Aspirator and wind catchers were installed in the southern part of the building in order to make better ventilation. Wind catchers were connected to the main living room in the ground floor and connected to cellar in winter residence. In this house *Eyvan* (porch) and *Revak* (veranda) are used to create shady and cool living spaces during the day.

The most important design parameters that affect on the indoor thermal comfort and energy conservation in a building are thermo physical properties of the building envelope, form of the building and architectural elements affecting the indoor climate, distance between buildings, and orientation of the building. When evaluating traditional architectural examples, it can be seen that architects were more sensitive and they accomplished the most suitable design and settlement examples according to each climate condition (G Manioglu, Z. Yılmaz, 2008).

Energy Efficient Design Strategies In Hot-Dry Climate

The physical comfort we feel in a building is the result of the heating energy balance between ourselves and the surrounding spaces. To design energy efficient buildings and keep the inside of the building thermally pleasant, solar gain and heat conduction into the building should be minimized while ventilation, evaporation, earth cooling, and radiant cooling should be promoted. In the past, architects were obliged to observe these factors, without the benefit of technology and without using polluting, mechanical devices, reliant on electricity. Therefore there should be solutions to render inside the buildings thermally comfortable while keeping our environment clean. The purpose of climate responsive and energy efficient design is to minimize the environment pollutions outside the building and reduce the energy cost of maintaining thermal comfort conditions inside the building.

Minimize Solar Gain

When solar energy hits a surface, some of the energy is absorbed, some is reflected, and a portion is transmitted. In order to control solar gain there should be either interception, reflection against solar beams or select a proper orientation and size for building shell and openings due to minimizing exposure area to summer sun. These factors can be seen in traditional courtyard houses of hot-dry climate.

Interception

In traditional courtyard houses in hot-dry climates trees as interception devices protect buildings from direct sunbeams and make shady area within the courtyard and on the building walls. Trees collect solar energy using molecular devices, the photosynthetic reaction centers of chloroplasts, and use that energy to drive molecular machines, which process carbon dioxide and water into the oxygen and molecular building blocks that form the whole plant. A tree is more sophisticates than an aircraft or microchip, created without harmful waste, noise and fumes while consuming its own pollutants (Ivan Margolius, 2002) Therefore the nature can teach us to emulate such a process to creating flexible behavior in man-made devices. Furthermore these houses are surrounded by high walls and isolated from the street. During the day, external walls of houses provide shady areas in narrow streets and especially in courtyards.

Walls and particularly windows exposed to summer sun should be shaded by overhangs and shading devices. Windows normally serve three functions: to allow in sunlight, to let in air, and to provide a view. In the hot and dry climates it is rarely possible to integrate these three functions in a single architectural solution. In the traditional Middle East architecture several solutions were developed which concentrate on each function. The principles of those elements and the combination of them can be used to invent new modern devices in order to afford all advantages of sustainable design. As an instance the window opening called *Shabak* (a reticular element) was used in traditional houses of hot-dry climate. They block the direct sun rays while the breeze and wind flow is not obstructed (Fig 3).

A study of the weather condition and the sun angles at various locations between 30° and 50° latitude indicates that a standard 76, 40 cm overhang (horizontal projection of 76 cm located 40 cm above the top of the window) will provide good sun control on south windows for this range of latitudes, when glass doors or tall windows are used it is desirable to increase the overhang to provide more shade (Donald Watson,1983).

Reflection

The exterior colors of the building’s envelope chosen by the architect are among the very distinctive features of the building. When a color absorbs light, it turns the light into thermal energy (heat). The more light a color absorbs, the more thermal energy it produces. Black fabric absorbs all colors of light and is therefore warmer than white fabric which reflects all colors. Figure 4 is the result of experimental studies by (Baruch Giovani,1998) which shows the external and internal surface temperatures of a horizontal roof with white and grey colors. The experiment was carried out in Haifa, Israel which has hot-dry climate in summer. A dark roof can be 50°C hotter than the ambient air temperature while a white roof will be only about 10°C hotter.

Size and orientation of building shell and openings

With good orientation the need for supporting heating and cooling is reduced, resulting in lower energy consumption. With regard to the sun factor the best lineup for building is along East-West direction. In fact the length of the building should be along East-West axis and the width of the building along North-South axis (Ghobadian Vahid, 1998). The southern wall absorbs the most of sun energy in winter and because the sun is high over the horizon in summer southern wall can be shaded using a relatively small overhang. The eastern and western façades get the undesirable heat in summer therefore they should have less surface exposed to the sun and it is better to cover them with the shadow of trees or nearby buildings. An orientation slightly east of south (typically 15° east of south) is often more effective, because in this way the eastern façade absorbs lesser sun heats in the summer (Fig 5).

Windows should be relatively small, particularly on outside walls and must be shielded from direct radiation and glare. Large windows should face north and south. The worst orientation is west-east and it can be used for non-habitable spaces to form a thermal barrier.

Minimize Conductive Heat Flow

Using materials with the poor heat conductivity will reduce the heat flow through the building in hot-dry climates resulting in reducing energy cost inside the buildings. The process of heat transfer through the building materials described as thermal conduction, and the value of heat transfer through a material is the thermal transmission. The thermal conductivity of a material is the amount of heat transfer per unit of thickness for a given temperature difference. Organic materials such as wood tend to be poor conductors. Aerated materials, which have solid conduction paths broken by air or gas gaps such as foam and glass fiber quilt are very poor conductors and they are good insulators as they have low thermal conductivities (Randall Thomas & Max Fordhams, 1999). In hot-dry climate in the past, vernacular architects made use of materials with poor thermal conductions. In traditional houses of hot-dry regions walls were made out of mud, brick clay or mud clay and plaster of straw and mud with high thickness. Thick and heavy walls made of construction materials with the poor thermal conduction provide cool environment in summer and warm environment in winter (Thermal flywheel effect). Table 1 shows a range of thermal conductivities of some materials.

The heat flow rate is associated with a property of the materials or assembly section known as its conduction and it is defined by the relation:

$q = C (T_h - T_c) A$

Where q is heat transmission, C is materials' conductance, T_h is temperature of the warmer face, T_c is temperature of the cooler face, and A is surface area (Donald Watson,1983)

Air is one of the best insulators and has low heat transfer characteristics. Walls, roofs and windows which made up of two or more layers separated by air space provide resistance to heat flow. Highly reflective materials, such as foil, used in air space can reduce the thermal conductivity of windows by over two or three times lesser. The heat enters through glazed area is trapped and increase the indoor temperature too far above the air outdoors. Therefore the indiscriminate use of glass in hot climate like many of 21st century buildings of hot regions can produce a giant energy consumer and uncomfortable living space.

Promote Ventilation

Ventilation is defined as the act of supplying fresh air and getting rid of foul air. Normally in this process outdoor air is the source of fresh air and the inside air is pollutant air which should be replaced. Building component and technical solutions providing ventilation, both for building and structural cooling, in hot climates were already used in ancient times. For example in Iran, curved-roof air vent systems were incorporated in building as early 3000 BC, and wind tower system, the cistern and the ice maker, may have appeared about 900 AD (Bahadori, 1978). The wind catcher is a shaft rising high above the building with an opening facing the prevailing wind. It traps the air where it is cooler and at higher velocity and channels it down into the interior of the building(Francis Allard,1998).This device is used in the hot arid zones of the Middle East.

A wind catcher operates in two different physical mechanisms: First is the function according to the principle of traction of opening facing the wind and the suction of openings back against the wind (Fig 6). Wind catchers mainly perform by this mechanism which works under windy condition. In fact a wind catcher takes the fresh air into the building and sends the hot and polluted air out.

Second is the function according to temperature difference. During the day, when the sun hits on the southern face of the wind catcher, the air heats in the southern shaft of the wind catcher, and goes up. This air is taken above through the inner air of the porch. On the other hand in the morning, hot ambient air enters into the another shaft of wind tower and it becomes cool when it contacts with the tower walls, which have enough thermal inertia to release at night the heat absorbed during the day. In fact it makes a kind of proportional vacuum inside the building, and takes the cool air of the inner court into itself, so the existing air in the northern opening which was cooled is pulled down too. During the night outside temperature becomes cold, and the cold air moves down through the wind tower. This air becomes warm by walls and parapets and then goes up. This circle continues till the temperature of the walls and outside temperature become equal. Therefore in this point night ends and once again the wind catcher acts its function as mentioned above (Fig 7).

Ventilation appears as a logical and suitable strategy for many types of buildings. Great deal of air flow is needed for summer thermal control of the building in hot and dry climates. Air changes provide people with fresh air to breath, take away pollutants, contribute to the thermal behavior of the building and are an important parameter in the feeling of wellbeing. To increase the amount of air flow through the building few small fans can be added to traditional wind catchers to enhance ventilation within the building (Fig 8).

Window opening and doors can be oriented to facilitate natural ventilation from prevailing summer breezes. The greatest volume of air will occur when windows are located in the portion of the façade that experience the greatest pressure differential between them. For a better cross ventilation inlet and outlet size of the windows should be the same size. If they cannot be the same size, the inlet should be smaller to maximize the velocity which has the greatest effect on comfort. Air movement is depend on many factors, such as furniture location, exterior planning, wind direction and etc, however some decision can be made for the best ventilation. For example placing windows in line with the direction of air flow in opposite walls will result in a narrow air stem of high velocity (Fig 9.a). By relocating outlet to side wall better ventilation will be produced (Fig 9.b) and by shifting intake window away from center of the façade greater ventilation will be occurred (Fig 9.c) (Donald Watson,1983).

Promote Earth Cooling (Conductive Cooling)

Air is heated mainly by its contact with the earth; the surface soil temperature is about the same as the air temperature with its large annual fluctuations. However due to the large time lag of earth the soil temperature fluctuates less and less as the soil depth increases at about 6m in depth. In traditional house of hot regions in Iran, there was a space development consists of a room or rooms at 6-7 meters lower than ground surface and ground floor. These rooms have rather the same temperature in all seasons of year and it is equal with the average temperature in a year which is about 25°c.

Since the ground temperature is always below the maximum air temperature, the deep earth can always be used as a heat sink in the summer. When a building is constructed without any excavation, the contact surface of building with ground would be equal to its area but once the excavation is done, meaning that construction a part of the building into ground, the contact size would be increased resulting in a cooler interior as compared to the outer ambient temperature in summer. In Hot-dry regions of Iran in some traditional houses the depth of the yards was more than the usual, these yards are called *Godal Baghche* (Profound garden) (Fig 10). These profound gardens are covered by plants, trees, and shrubs and by evaporation, cool and fresh air is generated for the upper yard spaces.

Nevertheless the constant deep-earth temperature which is the coolest available air in summer could be a major source as a passive cooling system. A building can be indirectly coupled to the earth by means of tubes buried in the ground. Slope tubes and sump are required to catch condensation. To get the maximum cooling effect the tubes should be buried as deeply as possible to take advantage of that constant, deep-earth temperature which is the coolest available in summer and the soil is more moist during the summer .When cooling is desired, air is drawn through the tubes into the building. The earth acts as a heat sink to cool the air (Fig 11) (Lechner Norbert,2009). Despite of taking advantage of the earth cooling, the ground of surrounding area of the structure can be covered by light colored gravels. This covering shades the soil and allows evaporation to occur resulting in a cooler earth ground.

Promote Radiant Cooling

Thermal radiation is defined as the transfer of heat energy through space by electromagnetic radiation passing from one object to another without warming the air in between Donald (Watson, 1983)

In the past, there were several ways of reducing the heat inside the buildings with the benefit of radiant cooling. In traditional architecture of hot and dry climate, architects used deep courtyards and narrow allay with high walls to minimize hours of direct sunlight during the day. However all of the walls radiated to the cold sky during the night. Thus the walls were quite cool by the morning. In addition domed roofs have been widely used in traditional architecture mainly in hot and dry climates and have had an extreme effect on the reducing the building’s loads. The form of domes presents two different benefits. During the day, always some area of the dome is in shadow while at night full hemisphere sees the night sky (Fig 12). Thus, radiant heating is minimized while radiant cooling is maximized.

Since the roof is the greater surface exposures to the sky, is the best location for considering the long-wave radiant cooling. The most efficient approach to radiant cooling is to make the roof itself the radiator. For example a movable cover on the roof can be designed to prevent the heat radiation during the day and at night by removing the cover, the entire roof surface is exposure to the night. Therefore the roof takes full advantage of radiant cooling while radiant heating decreases (fig 13). Small gap between the cover and the roof is required to allow het convection during the day. Solar panels can be stuck on the movable devises to capture solar energy during the day to provide the electricity needed to move the covers. In this matter high thermal mass materials are the best choice for the roofs. The reason for this is because high thermal mass building materials allow the heating and cooling air to be stored within the home's roof and perform as a cool storage during the night, thus the next day, can cool inside the building gradually.

Promote Evaporation

The evaporation of moisture is an important mechanism for cooling of various surfaces. The evaporation of water from surfaces in evaporative coolers is an important method for cooling buildings in arid part of the world (Jan F. Kreider & Ari Rabl,1994). Thus traditional wind catchers can be turned into evaporative coolers. This is possible by adding a pump and a fan directly in the entrance duct. The fan is used to flow greater amount of air into the building and the pump is moisturizes the dry air (Fig 14). To maintain comfort, a high rate of ventilation is required during the day. This phenomenon which cools the indoor air through the increasing humidity called direct evaporative cooling system.

Traditional court yard houses with central pool in hot and dry climate provide comfortable weather condition within the house. Once water of the pool evaporates into the air, temperature decreases. The amount of heat needed to vapor water is taken from the surrounded air within the yard, hence air itself becomes cooler. Furthermore by evaporation, the moistures in the air decrease and humidity of dry air goes up resulting in a comfortable weather condition for dry climate.

Evaporation can be highly promoted by means of sprinklers and a small pond on the roof. A slight slope is required on the roof to lead the water into the pond. Thus the roof is always wet and additional water is kept in the pond. Water from the pond is directed to the court yard over a solid surface. This surface keeps the wall safe from water penetration. Then water bunch up in the central pool in court yard. At all the time in this process the water is being evaporated and the surrounding area is getting cold and moisturized because of evaporation (Fig 15).

Conclusion

Before using any technology and mechanical devices to render the inside condition of the buildings pleasant vernacular solution should be examined. The paper pointed out the simple strategies that can be impressively improving contemporary buildings of hot and dry climate without the benefit of high technology devices. Strategies that can struggle with harsh climate of hot and dry regions such as interception from the sunbeams before getting heat and using cooling devices, rising the amount of air flow and ventilation, moisturize the dry air and etc .Primitive and vernacular dwellings and settlements of the past can be used today in their present form and should be altered as little as possible. Traditional architects of the hot and dry climate presented numbers of logical methods into the building to provide thermal comfort for resident .To decrease the cost of the today's energy and in order to keep our environment clean, those methods can be evaluated and implemented into the contemporary buildings. If traditional solutions are not enough, then they can be integrated with the minimum technology.

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Appendix

Figure 1: *Boroujerdi-ha* house in the Iranian city of Kashan

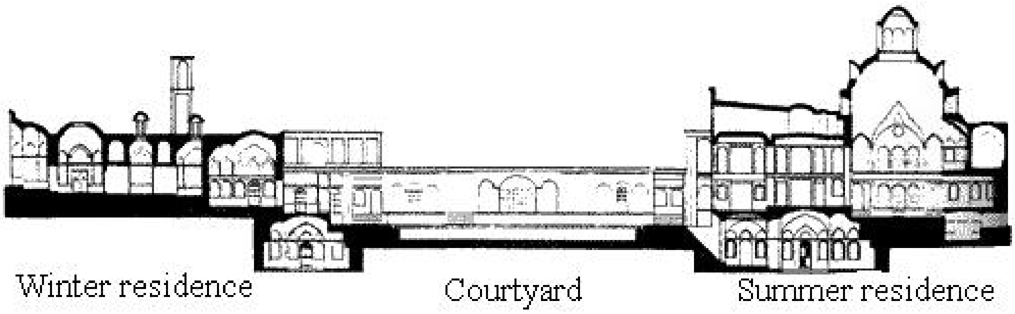

Figure 2: Notice the difference between the summer and winter residence of the four season house in term of the height of the ceilings

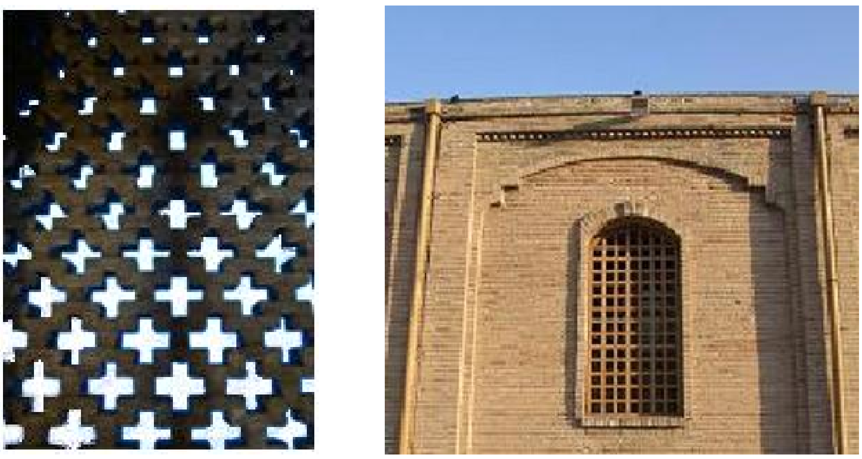

Figure 3:Traditional reticular window

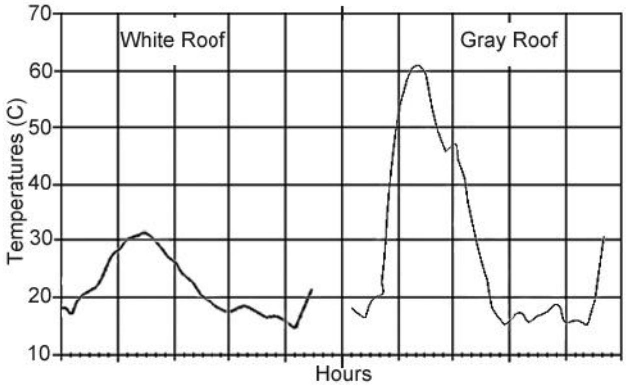

Figure 4: Exterior surface temperature of white and gray roofs, same day, two roofs
Source: Baruch Giovani, 1998.

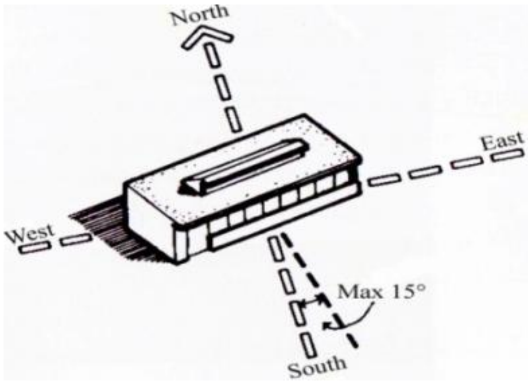

Figure 5 :Building orientation relative to South-North axis

Table 1: Thermal Conductivity Of Some Materials

Material	Thermal conductivity (W/mK)
Aluminum	214
Steel (carbon 1%)*	43
Concrete, dense	1.13
Bricks	0.73
Water (20°C)	0.60
Sand (dry)	0.30
Wood (oak)*	0.17
Glass fiber quilt	0.035
Air*	0.024

Source: Anon, 1988 & http://www.engineeringtoolbox.com/thermal-conductivity-d_429.html

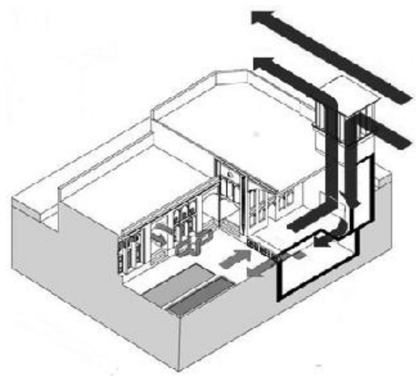

Figure 6: Function according to the traction and suction

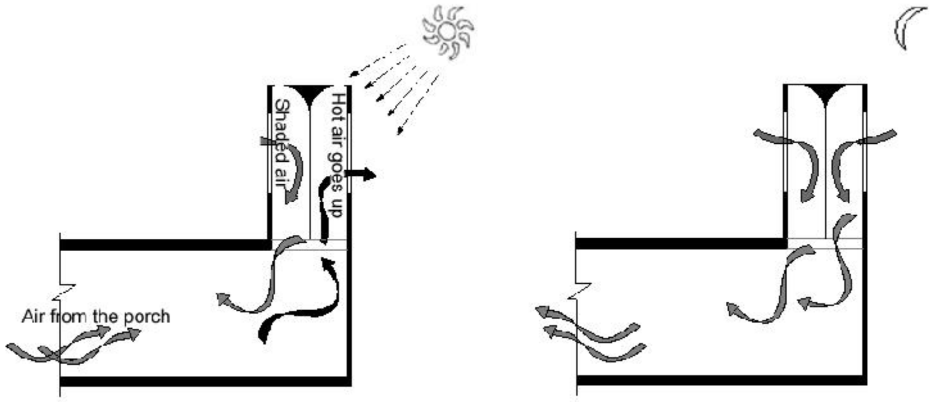

Figure 7:Function according to the temperature difference

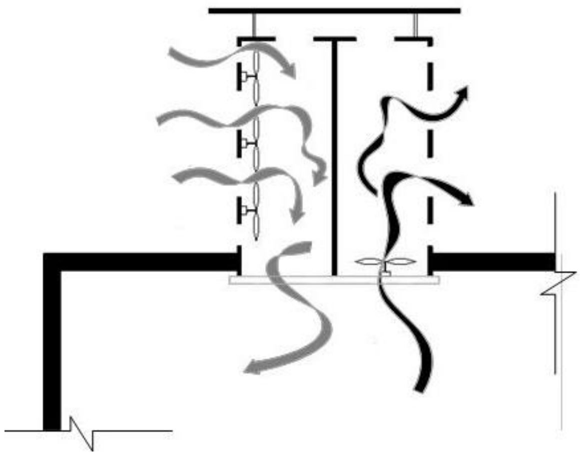

Figure 8: Adding small fans into traditional wind catcher for increasing the amount of air flow

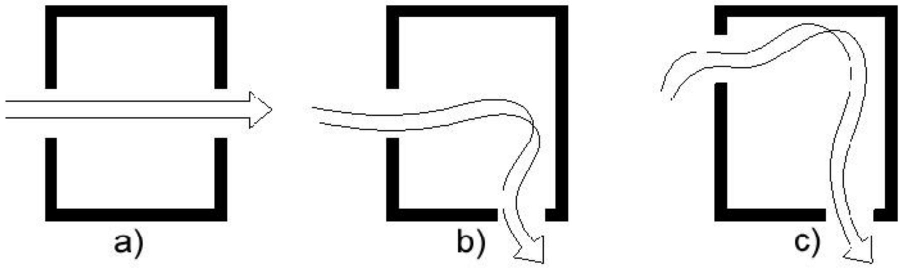

Figure 9: Direction of draught according to the location of inlet and outlet windows
Source: Donald Watson, 1983.

Figure 10: Profound garden in a traditional Iranian house

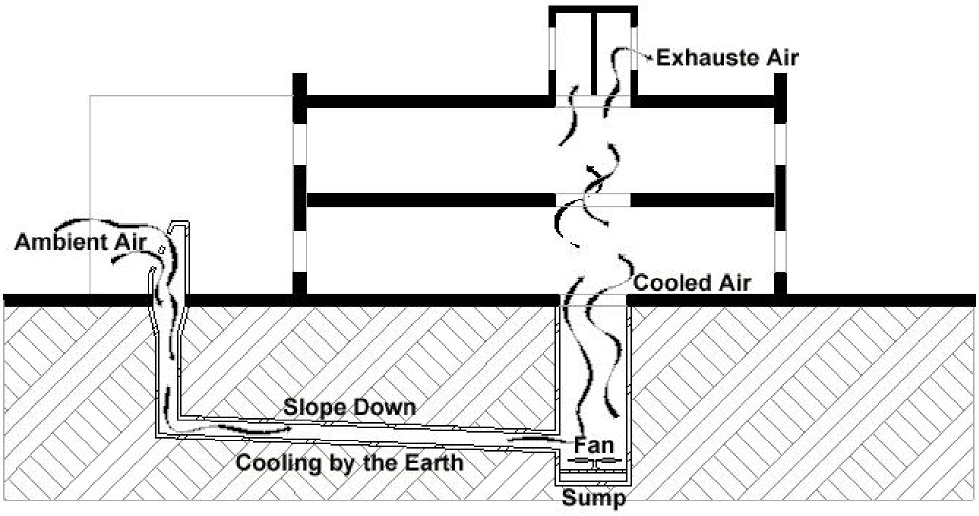

Figure 11: Indirect earth cooling by means of tubes buried in the ground

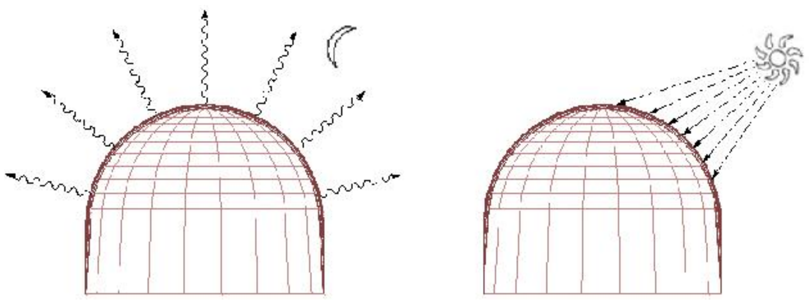

Figure 12: Low radiant heating during the day and high radiant cooling at the night

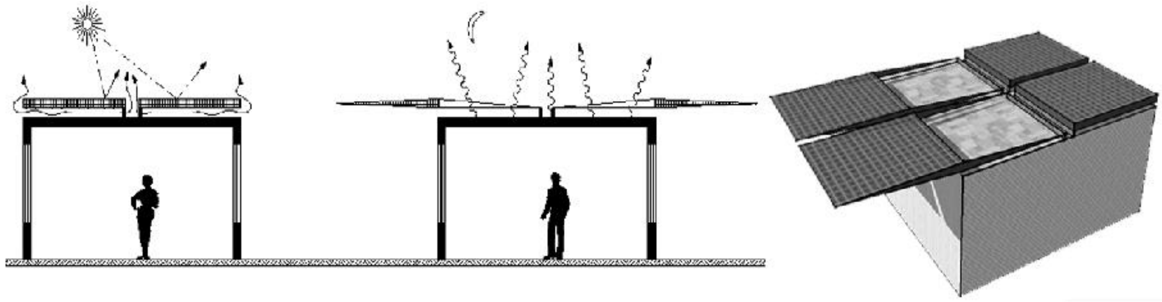

Figure 13: Movable cover on the roof can reduce radiant heating and increase radiant cooling

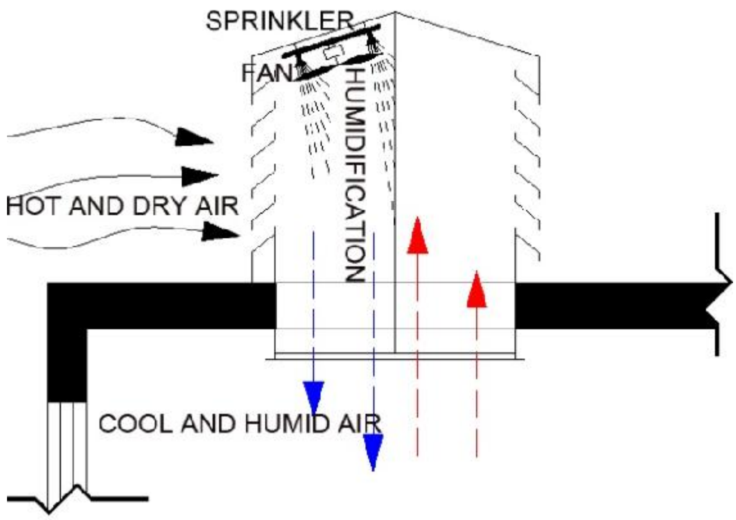

Figure 14.:Adding moisturizing element into traditional wind catcher

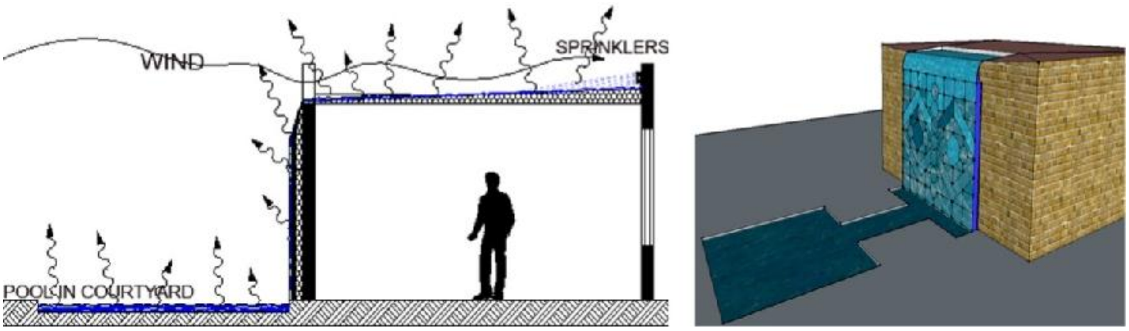

Figure 15: Promote evaporation over the building's envelope

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) Perireb (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)

Key: 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 X	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.	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)	Mecoms	Linear (multiple)	Mecoms = - 53634418 + 164406.61Grcoms -2829.35G2coms +40853.84Rcoms +1429287.7Psicoms +2776203.2Ashcoms	90.9	13.8	5.32	0.006	Strong	SS	Reject Ho

Rcoms (iv) Psicoms (v) Ashcoms (vi) Ffhcoms (vii) Pgwacoms	+7345352.3Ffhcoms +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 Relationship	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

BUILDING DEFECTS: POSSIBLE SOLUTION FOR POOR CONSTRUCTION WORKMANSHIP

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ABSTRACT

This paper aims to investigate workmanship quality performance of construction projects referring to number of defects occurred for new completed building. The research objectives are the factors contribute to poor workmanship and possible measures to minimise the problem, and also the relationship between measures identified with the factors. Based on a combination of literature review and questionnaire surveys, this paper explores the factors contribute to poor workmanship and possible measures to minimise the problem, and also the relationship between measures identified with the factors. A quantitative research was conducted by sending 75 sets of questionnaire to the respondents who experienced in construction projects. The results from 30 sets of completed questionnaire were used for the quantitative analysis. This paper concludes that construction projects suffered from low quality of workmanship produced by the contractors. The most significant factor contributing to poor workmanship is lack of experience and competency of labours. Correlation test result shows that the significant factor can be sovled by providing training and education to the labours, well manpower management and proper design. This paper singles out the factors contributing to poor workmanship and possible measures that can be implemented by contractors. This would help the contractors improve quality performance on their construction projects.

Keywords: Poor Workmanship, Construction Industry.

Introduction

In Malaysia, construction industry can be known as major productive sector since the construction started in the early 1990s with the development of mammoth projects (Abdul Razak *et al*., 2010). Low and Tan (1994) stated that quality development unit (QDU) in Singapore has adopted ISO 8402 defines quality as "*the totality of features and characteristics of a project or service that bear on its ability to satify stated or implied needs"*. In construction context, quality of construction projects can be considered as poor when project objectives cannot be accomplished, customers' needs are not satified and specifications connot met. Usually, quality is one of the constraints in project success and most of the time because of poor workamnship during construction period. As a result, many issues are arised.

Poor quality in construction projects is a common phenomenon in the world. Many disputes happened among clients, house owners and parties involved in construction (especially contractors) on construction defects cases. According to Baiden and Tuuli (2004), *"defects and variations in construction products from standards is persistently a problem of concern in the construction industry in Ghana"*. Kazaz and Birgonul (2005) stated that the satisfaction of quality level in the construction projects has not been achieved and is a serious problem in Turkey. Abdul Razak *et al*. (2010) quoted from Pratt (2000) stated that quality of the certain construction projects in Malaysia are not always meet satisfaction.

Nevertheless, Wai Kiong and Sui Pheng (2005) quoted from the study of Josephson and Hammarlund (1999) found that *"most of the defects due to human factors were caused solely by "forgetfulness and carelessness," 29% by lack of knowledge, and a very small percentage were intentional. As for workmanship defects, lack of motivation dominated the costs, but the presence of risks directly increased the chance of defects"*. On the other hand, through a survey on the 27 building projects which had been done by Andrew (1999), *the "quality related events" would due to "lack of skill", "lack of knowledge" of the* *site operative, "careless", "hard to build" and "unclear project information"* (quoted from Bentley, 1981). All of these causes reflect the low quality of workmanship in construction.

In a research had been done in Singapore, *"the most common defects found were pointing, hollowness in tiles, rough finishing, chip offs, evenness problem, cracks, stains, gap, and alignment out"* during the construction phase and these defects are mainly due to poor quality of workmanship (Wai Kiong and Sui Pheng, 2005).

Hence, it is necessary to identify the source of the problems and then find out the alternative to solve it. By identifying the significant factors, it provided more information about low quality of workmanship on construction projects to the contractors. Therefore, the main objective of this research is to identify the significant factors and measures that have been considered by contractors in construction projects and show the relationship between measures identified with factors contribute to poor workmanship.

General view of Malaysian construction performance

According to Sodangi *et al.* (2010), Malaysian construction industry is vital to improve the Malaysia's development process. Abdul Rahman *et al*. (2006) stated that construction sector contribute a great percentage to the economy in the growing countries, which includes Malaysia. They futher quoted from Department of Standard 2004 mentioned that *"in Malaysia, in the third quarter of 2004, the construction sector contracted by 3.0% compared to a positive growth of 2.4% in the same quarter a year ago. Up to the Asia-crisis average annual growth rate of 14% and budget 2001 allocates 24 billion RM for infrastructure projects (Bank of Malaysia 2001)."* In other words, the construction sector still plays an important role in Malaysian economy although there was economy crisis in the past.

However, Nima *et al*. (2002) pointed out that the construction industry today undergo a lot of problems such as decrease of the standard of quality, rise of cost and delay of construction project.

Abdul Razak *et al*. (2010) quoted from Wong (1991) pointed out that the weak points in the construction sector in Malaysia are lack of efficient training skills in construction field and insufficient status acknowledgement of construction technologists. From a research has been done by Tatiana (2005), who quoted from Morris *et al*. (1989) pointed out that the rate of accomplishment of construction projects was commonly considered as weak because more than 4000 projects were not finished completely among 1959 and 1986.

This can be concluded that construction sector in Malaysia still in high demand and similarly, lots of problems also arise in this sector. These problems will affect the quality performance of the construction projects. Therefore, criteria of quality measurement in construction projects need to be identified prior to the factors and possible measures.

Criteria of quality measurement in construction

Manuel *et al*. (2008) quoted from Abdel-Razek (1998a) highlighted the significant of measurement of quality in the costruction sector. Low and Wee (2001) quoted from Chung (1999) stated that construction quality can be defined as the meet of the requirements of the parties involved – *"meeting contractual requirements of the client, legislative and regulatory requirements of the authorities, social requirements of the public and even cost requirements of the contractor"*. Therefore, construction quality can be measured based on these criteria.

Besides, Tan (2009) quoted from Molenaar et al. (1999) streesed that there are three criteria of measurement of quality in construction, that are the conformity with expectations, administrative restriction and client's/ customers' satisfaction.

Conformity with expectations

According to Robby *et al*. (2001), a construction project success as well as the quality of the project, can be emphasised on the implementation of expectations of those parties involved (quoted from Sanvido *et al*, 1992; Barrett, 2000). These expectations could be the objectives have been created in the early phase of the project, such as "quality or zero defects" objectives.

Administrative restriction

Many construction projects are bonded with the administrative system. Some of the standards and guidelines are enforced in many companies for the purpose to ensure that the products of contruction projects are within the standards of quality. Takim *et al*. (2003) also agree that the approved guidelines and standards is one of the objectives of Quality Assessment System in Construction model which is recently applied by the Construction Industry Development Board of Malaysia (CIDB) to evaluate the quality measurement in construction. He further pointed out that the evaluation of workmanship can be done derived from the approved specificantions.

Clients' or customers' satisfaction

Adnan *et al*. (2000) stated that nowadays the important of quality has expanded to concentrate on the clients' or customers' satisfaction. Tatiana (2005) mentioned that the quality performance of a project is assessed by the client or project owner and also the buyer of the product. According to Takim *et al*. (2003), performance measurements apply to customer satisfactions, requirements, and needs meanwhile the customers may consist of shareholders, buyers and workers. Chinny *et al* (2010) quoted from Liu and Walker (1998) stated that the level of the statisfaction experienced decides the degree of the project success. Clearly, client satisfaction can be considered as common criteria in quality measurement in construction.

Factors contribute to poor workmanship in construction

According to Abdul Rahman *et al*. (1996), workmanship was classified as one of the most frequent non-conformance on construction site. Through literatures, eight variables that related to the causes of poor quality in construction projects had been found out. The variables are:

i. Poor project management
ii. Complicated role of subcontractor
iii. Lack experience and competency of labours
iv. Language barrier to communication and lack of communication
v. Unsuitable construction equipments
vi. Poor weather condition
vii. Limited time
viii. Limited cost

Poor project management

Dai *et al*. (2009) mentioned that ineptitude management is generally recognized as a major factor of poor construction productivity (quoted from BRT 1983; Sanvido 1988). From the research of Dai *et al*. (2009) further stated that the management factors may due to the insufficient of supervision on site. In fact, poor supervision on site contributes to the poor workmanship on construction site and it can be seen at many occasions on the jobsite (Kasun and Janaka, 2006). In addition, the ability of management on the construction site is the primary cause that affects labours' daily productivity (Dai *et al*., 2009). Jha and Chockalingam (2009) stated that the quality of porject manager is one of the causes in affecting project quality (has quoted from Anderson, 1992). Therefore, poor project management is one of the factors contribute to poor workmanship.

Complicated Role of Subcontractor

Khalid *et al*. (2006) agreed that the role of subcontractor is one of the factors contribute to construction deficiency (poor workmanship) and many people are not always focus on this factor. However, in fact, the role of subcontractor is important in construction work. This is because most of the site work is completed by subcontractors and the main contractors just depend on the subcontractors (Khalid *et al*., 2006). Khalid *et al*. (2006) further stated that approximate 90% of the site work is executed by variety of subcontractors whereas main contractor is focus on management and coordination. Besides, Chan *et al*. (2006) also mentioned that labour sub-contracting also arise severe problems in the co-ordination of work and attainment of quality standards (quoted from Shui On, 1991; Fan, 1994). Since there are various types of subcontractor involve in the same construction project, the main contractor is difficult to inspect, supervise and control the works that have been done by the subcontractors. Therefore, complicated role of subcontractor in construction projects can contribute to poor workmanship.

Lack Experience and Competency of Labours

Kasun and Janaka (2006) mentioned that “productivity cannot be achieved by speed and harder work only without adopting better work practices” (quoted from Banik, 1999). Besides, industry stakeholders agreed that insufficient of skilled manpower is the most important matter that they concern about (Jorge et al, 2005). According to Kazaz and Birgonul (2005), some construction companies in Turkey usually prefer to employ short-term unskilled labours and consequently cause the fault in the process of attaining the stability of quality associated issues. Hence, lack of experience and competency of labours must be taken into account as a factor contributes to poor workmanship.

Language Barrier to Communication and Lack of Communication

Different language between the foregin labours and local supervisors causes the communication failure on the jobsite. From a research of Augusto *et al.* (2009), it found that 82% of the respondents in the survey mentioned that the most general trouble faced on the jobsite by the America supervisors is the language obstacle when communicating with the foreign labours. Additionally, from a survey of Kasun and Janaka (2006) showed that exceed 40% of the respondents from the construction site protested about the insufficient of communication. Indeed, language barrier indirectly causes the lack of communication between the supervisors and labours. This consequently causes the misunderstanding by the labours in their work scope and then lead to poor workmanship.

Unsuitable Construction Equipments

Suitability of construction equipments can influence the workmanship quality in construction. Faisal *et al*. (2006) quoted from Adrian (1983) and Al-Hazmi (1987) stated that insufficient of latest information about the obtainable equipments can influence the project quality. In a research of Kazaz and Birgonul (2005), the poor quality of mass housing projects in Turkey mostly because low cost construction techniques which are totally disregarded. Therefore, unsuitable construction equipments can cause low quality of workmanship in construction.

Poor Weather Condition

Dai *et al*. (2009) stated that extreme climate condition is one of the factors that affecting construction labour productivity and workmanship. From the research of Faisal *et al*. (2006) found that the climate of Saudi is hot and severe during summer that causes some of the construction works very hard to carry out, such as concreting. As a result, the quality of workmanship is affected.

Limited Time

Insufficient time caused the construction projects executed to be rushed. According to Andrew (1999), a number of "show houses" on the site were required for many construction projects. Many concurrent works were carried out and inadequate checking had been carried out by the senior managers sequentially caused by the speed of working. As a result, the deficiency of workmanship had been happened. In short, limited time causes low quality of workmanship in construction.

Limited Cost

Insuifficient cost or budget would cause inadequate allocation of cost in construction project. Labour cost is included in construction cost. Proverbs *et al*. (1999) stated that labour element is considered as the most difficult component to price within the reasonable level of accuracy. Obviously, labour costs estimation is considered as uncertainty (Proverbs *et al*., 1999). In addition, contractors who are not preparing sufficient budget for the project will cause the labour cost cut down correspondingly. As a result, the labours supplied are not sufficient to complete a project and construction defects may appear.

Possible measures to minimise workmanship quality problem

There were six possible measures that suggested by researchers in order to minimise workmanship quality problem. The six measures are:

i. Strict supervision
ii. Training and education
iii. Proper communication among parties involved
iv. Proper construction management
v. Proper manpower management
vi. Proper design

Strict supervision

Ghaffar *et al*. (2010) quoted from Howell and Ballard (1998) noted that enhance the quality by strict supervision in construction site is one of the criteria of recent pratices in construction sector. Daily supervision should be carried out by the contractors or subcontractors so that workmanship problem can be identified and the remedy work can be executed immediately. Besides, when executing the supervision, contractor supervisory staff must possess the knowledge, expertise, and capabilities to administer the construction work and superintend the craft worker efficiently (Maloney, 2002).

Training and Education

According to Chan *et al*. (2006), many researchers agreed that appropriate training and enlarging experience is necessary in transfering the quality project. Osama and Khan (2010) added that labour productivity is become significant in construction because of its impact in the process of completing projects. Chan *et al*. (2006) further supported that the construction quality can be enhanced by increasing the capability of site labours.

Proper Communication Among Parties Involved

Proper communication is a necessary in construction. From a research had been done by Augusto *et al*. (2009), 80% of the Hispanic workers in U.S. construction sector mentioned that the communication with the supervisors is vital and need to be improved. Therefore, American supervisors suggested that the training in communication skills is essential to eliminate the language gap among themselves and the foreign labours. Ling *et al.* (2007) stated that effective communication leads the projects complete faster (quoted from Walker, 1998). As Tai *et al*. (2009) mentioned, *"no communications means no* *management"*. Apart from the communication between supervisors and construction labours, proper communication and teamwork are also necessary between contractors and subcontractors. Through a continual communication among parties involved, working relationship among the construction parties can be closer. From a research of Xiao and Proverbs (2002), it found that better quality performance of Japanese construction projects can be attained attribute to steady and durable working relationship between Japanese contractors and subcontractos. Therefore, proper communication is very important to improve the relationship among the construction team and consequently improve the workmanship quality in construction.

Proper Construction Management

Proper construction management would enhance the workmanship quality in construction. Dai *et al*. (2009) quoted from Olson (1982) stated that the capability of construction managers to manage, arrange and lead the work would affect the construction labour productivity. If a construction manager failes to lead and control the construction project, the quality problems may arise. Therefore, a proper construction management is very crucial for every construction project.

Proper Manpower Management

Robby *et al*. (2001) have proposed that manpower management in term of amount and quality of skill workers is an important determinant of contractor performance and extremely prioritised by employers. A construction project which has a well arrangement of manpower will produce a high quality of the project. Besides, Abdulaziz (2010) mentioned that manpower is the sole productive resource; hence construction productivity is essentially relying on human endeavour and performance. Therefore the management of manpower in every construction project should be arranged skillfully.

Proper Design

Wai Kiong and Sui Pheng (2005) found that better design can get rid of workmanship defects and help to avoid the defects. Inadequately worded specifications and uncertain designs always cause the low construction quality (has quoted from Calder, 1997). Wai Kiong *et al*. (2006) quoted from Anand's *et al.* (2003) suggestion also stated that a better design may correct some defects which due to workmanship in masonry work. In addition, Robby *et al*. (2001) stated that well-prepared designs and drawings affect the future works to become easier and the defects can be identified and rectified more effectively.

Research Methodology

The quantitative method was used in this research. Questionnaire surveys had been used in the process of data collection. In order to get high respone rate, the questionnaire surveys were designed in short and did not take much time for respondents to answer. Below shows the sample of questions asked in the questionnaire survey.

Please rate the degree of the effectiveness of the following methods to overcome quality problems.

1 2 3 4 5

Execute Strict Supervision Very Least effective [ ][ ][ ][ ][ ]Highly effective

Training and Education Very Least effective [ ][ ][ ][ ][ ]Highly effective

The respondents in this survey were building surveyor, quantity surveyor, architect, project manager, M&E engineer, C&S engineer and other profession who are involved in Klang Valley construction projects. A set of 75 questionnaires sent to the targeted respondents. Through filtration made from 31 replied questionnaires, 30 sets of questionnaire are useful and valid for analysis, giving a response rate of 40 percent.

The Statistics Package for Social Science (SPSS) software version 17.0 is used for statistical analysis. Ranking analysis was used to rank the degree of importannce of the factors contributing to poor workmanship and the degree of effectiveness of measures to overcome quality problems. Besides, correlation analysis (spearman's rank correlation cofficient) was used to identify the significant relationship between two variables in this research, which were factors contribute to poor workmanship and possible measures to minimise the problem.

Data analysis and discussion

The descriptive analysis was used in analysing data in this study. Table 1 shows the job title of the respondents in Klang Valley construction.

Most of the respondents were C&S engineers and project managers. This is because their scope of work was normally based on the site work; they had their certain experience and expertise in construction. Therefore the reliability of the questionnaire response was accepted. Figure 1 shows types of defect on building elements in the new completed buildings.

From the Figure 1 above, most of the respondents agreed that plaster crack was the most frequent defect in the new completed buildings, with 16.88% of the overall responses. Meanwhile, the least defects found are pointing and settlement, with 2.6% of the overall respinses.

Table 2 shows the ranking of priority based on mean readings for the poor workmanship variables in construction projects. In order to rank the variables, calculation of central tendency using mean was carried out. Five-point Likert scale used in the questionnaire was transformed to mean readings to determine the ranks of each variable.

From the Table 2, it found that lack experience and competency was considered as the most important factor contributes to poor workmanship. Labours cannot perform their works well if they do not own any experience and expertise in the certain field. It is agreed by Chan et al. (2006) mentioned that all the expertise possessed by the construction labours are significant to the quality of construction. However, poor weather condition were rated the least important among all other factors.

Limited cost is the second highest rank for factors affecting workmanship quality. The labours cost is the most difficult component to price within a standard level. It is supported by Proverbs et al. (1999). Usually, for the contractors who do not prepare a sufficient budget to commence a construction project, they may cut down the labour cost and use that budget for other items of the project. As a result, low quality of workmanship produced. Other factors that need to be considered are complicated role of subcontractor, poor project management, limited time, unsuitable of construction equipments and language barrier to communication and lack of communication.

On the other hand, Table 3 shows the ranking of possible variables to minimise workmanship quality problem.

From the table 3, the highest ranked of the measures used in overcoming quality problem is proper communication among parties involved. The parties in one project should communicate in proper way so that a harmony sitution can be existed and help the project goes smoothly, then workmanship quality would reach the acceptable level. It is agreed by Ling et al. (2007) who mentioned that effective communication leads the project to be completed earlier. In contrast, proper manpower management reached the least ranking of the measures.

The second higher ranked is proper construction management. This method is suggested by Dai et al. (2009) who mentioned that the capability of the construction manger to monitor and lead the work on site would give the effect of contrustion labour productivity. The construction management also involves the labour management. Other possible measures that should be taken into account to minimise the workmanship quality problem are strict supervision, proper design and training and education
.
In order to check significance relationship between factors contribute to poor workmanship and possible measures, correlation test using Spearman rank correlation coefficient had been used for the analysis. The results of the correlation test are shown in Table below.

From the results above, it found that lack of experience and competency of labours can be reduced by having training and experience, well manpower management and proper design. It is supported by Ling *et al.* (2007) mentioned that skills of labours can be demonstrated once the training completed.

Besides, poor project management can be solved by conducting proper communication among parties involved, proper construction management and manpower management. It is supported by Tai *et al*. (2009) that there is no management if no communication existed.

In order to minimise language barriers to communication and lack of communication, strict supervision should be conducted; training and education should be given; proper construction management and well manpower management should be executed.

Additionally, proper design would overcome the problem of limited time. Proper design can reduce the probability of variation order from the cilent, therefore no delay on construction and the problem of limited time will not happen.

Conclusion

The objectives of the research had been achieved based on the literature review from articles, journals and books; findings from questionnaire survey; and anaylsis results.

The factors that contribute to poor workmanship are identified based on the literature reviews and questionnaire survey. Based on the literature review, the factors contribute to poor workmanship includes poor project management, complicated role of subcontractor, lack experience and compentency of labours, language barrier to communication and lack of communication, unsuitable of construction equipments, poor weather condition, limited time and limited cost. The factors were ranked based on their degree of importance. It found that lack experience and competency of labours was the most significant factor that contributes to poor workmanship.

Several measures had been suggested by researchers from the literature review, which were strict supervision, training and education, proper communication among parties' invloved, proper construction management, proper manpower management and proper design. The ranking analysis on the effectiveness measures toward workmanship problem was carried out as well. As a result of the ranking analysis, it found that proper communication among parties' invloved was the most effective measure based on the respondents' response.

The relationship between measures identified with factors contribute to poor workmanship was examined by using correlation test-Spearman's rho. Measures identified can be applied to the factors which have significant relationship with them based on the results of correlation test (Spearman rank correlation coefficient) in order to solve the workmanship problem.

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Appendix

Table 1: Number of respondents based on profession

Job Title	Percentage (n=30)
Building Surveyor	13
Quantity Surveyor	7
Architect	10
Project Manager	23
M&E Engineer	3
C&S Engineer	27
Others	17
Total	100

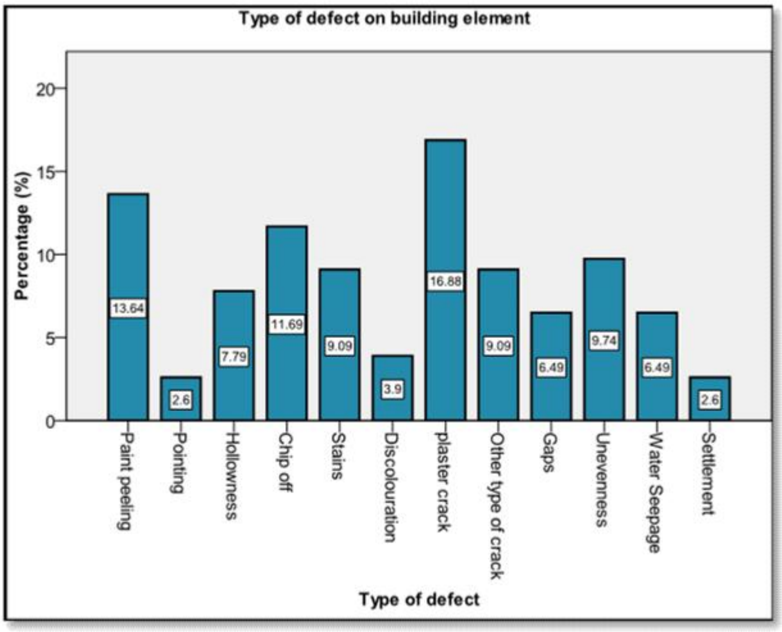

Figure 1: Types of defect on building element

Table 2: Ranking of variables contribute to poor workmanship

Variables	Mean (n=30)	Ranking
Lack experience and competency of labours	4.45	1
Limited cost	4.25	2
Complicated role of subcontractor	4.21	3
Poor project management	4.15	4
Limited time	4.01	5
Unsuitable of construction equipments	3.65	6

Language barrier to communcation and lack of communication	3.20	7
Poor weather condition	2.92	8

Table 3: Ranking of variables to minimise workmanship quality problem

Variables	Mean	Ranking
Proper communication among parties involved	4.32	1
Proper construction management	4.13	2
Strict supervision	4.09	3
Proper design	4.02	4
Training and education	3.76	5
Proper manpower management	3.44	6

Table 4: Relationship between factors contribute to poor workmanship and possible measures

	Strict Supervision	Training and education	Proper communication among parties involved	Proper construction management	Manpower mangement	Proper design
Poor project management	-.014	-.093	.421**	.261**	-.263**	.096
Complicated role of subcontractor	.131	-.222*	-.056	-.246**	-.036	-.133
Lack experience and competency of labours	-.026	.427**	-.017	.177	.409**	.362**
Language barrier to communication and lack of communication	-.346**	.219*	-.115	.205*	.437**	.182
Unsuitable of construction equipments	-.317**	.381**	-.014	.241*	.283**	.385**
Poor weather condition	.134	.504**	.131	.336**	.288**	.133
Limited time	.111	.113	.057	-.097	.040	.200*
Limited cost	.402**	.065	.309**	-.064	-.151	.001

MEASURING INDOOR AIR QUALITY PERFORMANCE IN MALAYSIAN GOVERNMENT KINDERGARTEN

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ABSTRACT

Children require good indoor environment since indoor air quality (IAQ) is very important for their growth and wellbeing. Studies around the world have found that indoor air quality affected these sensitive groups more compared to adults. In IAQ of kindergarten buildings especially in Malaysia is unknown as research on this matter is limited. The failure to identify and establish IAQ status can increase the chance of long-term and short-term health problems. Therefore, the IAQ of two government kindergartens in Malaysia was studied in this research. In these studies, all factors were considered including temperature, relative humidity (RH), airflow rate and the amount of carbon dioxide (CO2), nitrogen dioxide (NO2), formaldehyde and volatile organic compound (VOC). One case study is located in the rural area of Rembau, Negeri Sembilan and the other one is located in the city centre area of Kuala Lumpur. Measurements were taken continuously in a period of three daysin order to establish the IAQ pattern. Furthermore, a comparison with an established benchmark was conducted to identify rooms for improvement. It is anticipated that findings from this research would provide some advancement towards improving existing Malaysian policies and standards. This research could also spur other research activities concerning IAQ.

Keywords: Indoor Air Quality, kindergarten , building performance, environment

Introduction

Nowadays indoor air quality (IAQ) has received great attention from people all over the world (Law et.al, 2001). According to Lee and Chang (2000) , people spend 90% of their daily life inside buildings. Therefore, a clean, healthy and comfortable IAQ is vital in order to avoid health problems. Similarly, a healthy IAQ is vital for the health of children and the aged as they are more sensitive towards indoor air pollutants (Lee and Chang, 2000). For children, it is easy for them to be exposed to contaminated indoor air since they breathe greater volumes of air compared to adults (Torres, 2000). Moreover, according to Torres (2000), it was found that children spent only around 23% of their time indoors such as in kindergartens and schools. Thus, a healthy IAQ is crucial for their growth. This is because, children are susceptible towards poor indoor air quality that can cause health problems that are sometimes difficult to recognize (USEPA, 1996). This is due to the low metabolism level of children, delaying the effects of adolescent health problems until they are older (REF). Besides that, more attention towards IAQ level inside kindergartens needs to be considered seriously because from the study conducted by the Canadian Lung Association CLA (2002), ¼ or 10% of school absenteeism was caused by asthma . In addition, school absenteeism and medication for asthmatic children increase proportionately with the deterioration of the respiratory systemcaused by the high amount of particulate matter inside the schools (Peter et al., 1997).

According to Paul (1994), schools have four times the number of occupants per square foot as office. Therefore, when children breathe high amounts of polluted air, it will produce more polluted air than the fresh air intake. In real conditions, indoor air is 10 times as polluted as the outdoor air (REF). The failure to identify and establish indoor air pollution status can increase the chance of long-term and short-term health problems such as reduction in productivity and learning environment and comfort (ASHRAE, 2001). Due to this fact, an IAQ study was carried out at selected kindergartens in Malaysia. This study is timely as and there is a pressing need to determine the actual IAQ status especially in the schools, where our nation’s so-called future leaders are trained (Ismail et al., 2010).

Indoor Air & Performance in Schools

IAQ refers to the nature of conditioned air that circulates throughout the space or area where we work and live, that is, the air we breathe during most of our lives (Cheng, 2002). IAQ is not only for comfort, which is affected by temperature, humidity and odors but also by harmful biological contaminants and chemicals present in the conditioned space (Cheng, 2002). Most people control the environment in their homes to a certain degree to provide comfort and health. They will not use freshly painted rooms until the smell has gone away. Besides that, according to PDHengineering (2005), IAQ is defined as the characteristic of the indoor air inside a building that consist of pollutants and thermal (which is temperature and relative humidity) concentration that can give effect towards health, comfort and performance of building occupants.

Indoor environment quality (IEQ) is the sum of all environmental factors that effect the occupants including lighting, noise, odors, humidity, temperature, rate of ventilation as well as the rate of exposure to chemical and biological agents (Torres, 2000). IAQ is one of the components that contribute to the quality of the indoor environment in schools (Torres, 2000). On the other hand, indoor air pollutants cause a combined physical, chemical and biological effect on the occupants and limit that adequacy ofventilation systems (REF). Indoor air pollutant comes from the outdoors, mechanical ventilation and air-conditioning (MVAC), building equipment and furnishing as well as human activities (Torres, 2000). Based on a study by Armstrong Laboratory (1992), there are three most frequent causes of unacceptable IAQ firstly, inadequate design or maintenance of heating, ventilation and air-conditioning (HVAC) systems. Secondly, a shortage of fresh air intakes into buildings and finally, a lack of humidity control.

Children and senior citizens have been categorized as sensitive toward indoor air pollution. These sensitive groups are more affected by polluted indoor air rather than ambient atmospheric air (Ismail et al., 2010). Furthermore, overcrowded classrooms will cause poor IAQ resulting in adverse health problems (Lei et al, 2005). This happen because, the metabolic rate per kilogram of body weight of children is much higher than adults (REF) and their respiratory rate is proportionately greater as they breathe in much more air pollution (Yassi et al., 2001). Surprisingly, the number of occupants per square foot in schools is four times that of offices (REF). In addition, schools contain a variety of pollution sources such as lab chemicals, cleaning agents, chalk dust and mold. Furthermore, teachers and students often work more closely in classrooms than people in other types of buildings. According to Tanner (2000), there should be a certain limit to the number of students per square feet or meters in indoor classrooms. Table 1 below shows the result from that research:

There are many factors that can contribute to the indoor air quality problems. Several of researchers carry out with several of factor that causes into IAQ problems. But the various factors are more or less the same for each other. Based on the study done by Armstrong Laboratory (1992), there are three most frequent causes of unacceptable indoor air quality (IAQ). Firstly, there is inadequate design or maintenance of the heating, ventilation, and air-conditioning (HVAC) system. Second, a shortage of fresh air comes inside the building and finally, lack of humidity control.

Material & Methods

For the purpose of this research, two government kindergartens were selected as case studies. They are located in Rembau, Negeri Sembilan (rural location) and Kuala Lumpur (city center location). The rationale behind the selections is that the physical environment and the size of population of each location is different. Below are descriptions of each case study:

i. One unit of government kindergarten which is naturally ventilated and located in the rural area of Rembau, Negeri Sembilan (Abbreviated as TK)

ii. One unit of government kindergarten which is naturally ventilated and located at in the city center of Kuala Lumpur with high population density (Abbreviated as TS)

Six indoor air characteristics were measured by using a MultiRAE meter as well as a Formaldehyde meter. The measurements are more focused on the indoor air rather than outdoor air at both kindergartens. There are six measurement items which are formaldehyde, nitrogen dioxide (NO^2), volatile organic compound (VOC), carbon dioxide, CO^2, relative humidity (RH) and temperature. In order to increase the accuracy of data collection, data collection work was carried out at both kindergartens for three consecutive days. All collected data at certain points inside the kindergartens, were recorded every 30 minutes for 8 hours from 7 am to 3 pm. This is to observe if there were extreme changes in the IAQ. Although class started at 8 am, measurements were taken from 7 am to ensure that readings are stable when kids enter the classroom. Furthermore, measurements were taken beyond the end class of class at noon until 3 pm to observe the indoor air characteristics in the evening. Measurements were gathered and compared with existing benchmarks created by the American Society for Heating, Refrigerating and Air Conditioning Engineers (ASHRAE, 2001, 2007), the Department of Safety and Health (DOSH, 2005), the US Environmental Protection Agency (USEPA, 2008), the Occupational Health and Safety Administration (OSHA, 1999) and the World Health Organization (WHO, 2000).

Results & Discussion

Data analysis between government kindergarten buildings focused more on the performance of their IAQ. Comparisons were made to distinguish which kindergarten holds more of the six hazardous gasses as shown in Figure 1 to 6.

a) *Formaldehyde*

Figure 1 above shows the Formaldehyde concentration between both kindergartens. Based on the graph, it shows that the emission of formaldehyde at TS is higher than at TK especially between 9.30 am until 1.30 pm. It is evident that before 8.30 am there was no formaldehyde emission. However, between 11.30 am to 12.00 pm the rate of emission increased sharply at TS and dropped to zero in the evening. The amount of formaldehyde emission at TK only increased to 0.01 parts per million (ppm) at 9am. At other times, it was 0 ppm.

b) *Nitrogen Dioxide, NO_2*

Figure 2 above indicates the nitrogen dioxide, NO_2 concentration at both TK and TS. From the average reading, both kindergartens show the same data which is 0 ppm.

c) *Volatile Organic Compound, VOCs*

Figure 3 shows the concentration of VOCs at TS which was higher than at TK. This is probably caused by the factors of different locations and surrounding activities. As explain before, TS is located in Kuala Lumpur near a main road. Meanwhile TK is located in rural Rembau, Negeri Sembilan which is not as busy as Kuala Lumpur.

d) *Carbon Dioxide, CO_2*

According to Figure 4, the CO_2 concentration at both TK and TS is very similar throughout the day as the number of occupants is similar. TK has 19 occupants at one time while TS has 15 occupants. The emission of carbon dioxide, CO_2 by kids at both case studies were at a normal stage because the graph did not show huge differences of CO_2 concentrations.

e) *Relative Humidity (RH)*

Figure 5 above shows the RH level at both TK and TS. The level of RH between these two kindergartens was similar. Between 7.00 am to until 9.00 am, the level of RH in both TK and TS kindergarten were between 65% and 75% which were the highest throughout the day.

f) Temperature

Figure 6 indicates the indoor temperature at both TK and TS kindergarten. Measurements showed that the indoor temperature for both TK and TS were similar throughout the measurement period. Between 7.00 am to 9.00 am, temperature increased at both kindergartens from 28 degree Celsius to 29 degree Celsius. Then, from 9.00 am to 12.00 pm the indoor temperature at TK were recorded to be higher than TS's temperature level. This is believe due to students at TK are having more activities and movement which released more heat, thus increase the temperature inside the building.

Comparison with Benchmark

Benchmarking is one of the measures that can be done in order to evaluate IAQ performance. This is important as it will provide the indication of the level of efficiency in terms of indoor environmental level. For this study, result was compared with established benchmarks created by ASHRAE,(2001, 2007), WHO (2000), OSHA (1999) and DOSH (2005). The performance comparisons are presented below.

Figure 7 shows that formaldehyde concentration at both TK and TS did not exceed the maximum standard by OSHA which is 1.00 ppm (OSHA, 1999). Both kindergartens also recorded readings below OSHA's minimum which is 0.04ppm (OSHA, 1999). Therefore, formaldehyde concentration at both kindergartens was acceptable and not harmful. As indicated in Figure 8, the amount of NO_2 at both kindergartens was 0 ppm and below the standard of 1.00 ppm set by WHO (2000). As for VOCs (Figure 9), readings at TS exceed the ASHRAE 2001 standard which is 0.1mg/m3. This is due to the location of TS near to a main road at the city center of Kuala Lumpur. Meanwhile, VOC readings at TK were below the standard at an average of 0.08 mg/m3. This is because TK is located at the rural area that not expose to the many vehicles. CO_2 concentration at TS exceeded the existing benchmark of 1000 ppm at 1005.9 ppm as shown in Figure 10. This is because TS is located inside the grounds of an elementary school (Sekolah Kebangsaan) with, higher number of students compared to TK with only one room of pupils. According to Figure 11, the RH level of both kindergartens did not exceed the maximum standard set by ASHRAE, 2007 which is 65%. This is because Malaysia is located in the tropical region with hot and humid climate which affected the thermal comfort levels of the students. From Figure 12, it can be seen that both kindergartens had temperature readings that exceeded ASHRAE 2007 standards. This scenario happened due to the fact that Malaysia is hot and humid climate as this gives a high temperature and disturbance to the thermal comfort of the children.

In all, the overall IAQ at both kindergartens complied to the selected benchmarks. As for TK, from 6 elements measured, 5 complied to the benchmarks, whereas 1 element (temperature) exceeded the benchmark. Meanwhile, out of 6 elements measured at TS, 3 of them complied to the benchmarks whereas another 3 did not. Only the VOC rate of 0.54 mg/m^3 exceeded the benchmark. Furthermore, CO_2 concentration at TS exceeded the permissible limit of 1000 ppm . Similarly, temperature readings at TS exceeded ASHRAE 2007 standards. Nevertheless, attendance at both TK and TS was 100%.

Conclusion

From the data collection it can be found that the CO_2 concentration at TK and TS is proportional to their indoor temperature. In opposite, the RH rate is inversely proportional to the temperature and CO_2 concentration. Comparisons with benchmarks recognised that the current state of IAQ in both kindergartens showed that overall, the IAQ at both kindergartens complied to the selected benchmarks. Despite the findings from this study, more studies with larger samples of case studies are needed to determine the extent of

IAQ problems in kindergartens in Malaysia. This research evidently shows that at least, VOC, CO_2 and temperature at the selected kindergartens did not meet the minimum benchmarks and this may be related to significant increases in symptoms of health problems among children and teachers at both kindergartens. Therefore programs should be put in place to ensure that all kindergartens provide necessary improvements to tackle the issue of poor IAQ.

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Appendix

Table 1: The number of student in classroom

NO. OF STUDENTS PLUS 1 TEACHER	ELEMTARY SCHOOL (SQFT, M2)	SECONDARY SCHOOL (SQFT, M2)
10	539 (50.13)	704 (65.47)
11	564 (52.45)	768 (71.42)
12	637 (59.24)	832 (77.38)
13	686 (63.80)	896 (83.33)
14	735 (68.36)	960 (89.28)
15	784 (72.91)	1024 (95.23)
16	833 (77.47)	1088 (101.18)
17	882 (82.03)	1152 (107.14)
18	931 (86.58)	1216 (113.09)
19	980 (91.14)	1280 (119.04)
20	1029 (95.70)	1344 4.99)

Source: Tannner (2000)

Table 2: Common factors associated with indoor air pollution

Common Factors Associated With Indoor Air Pollution	
Inadequate ventilation	52%
Contamination from inside the building	16%
Contamination brought in from outside the building	10%
Microbiological contaminants	5%
Building material contamination	4%
Cause not determined	13%

Source: Ambu et al. (2008)

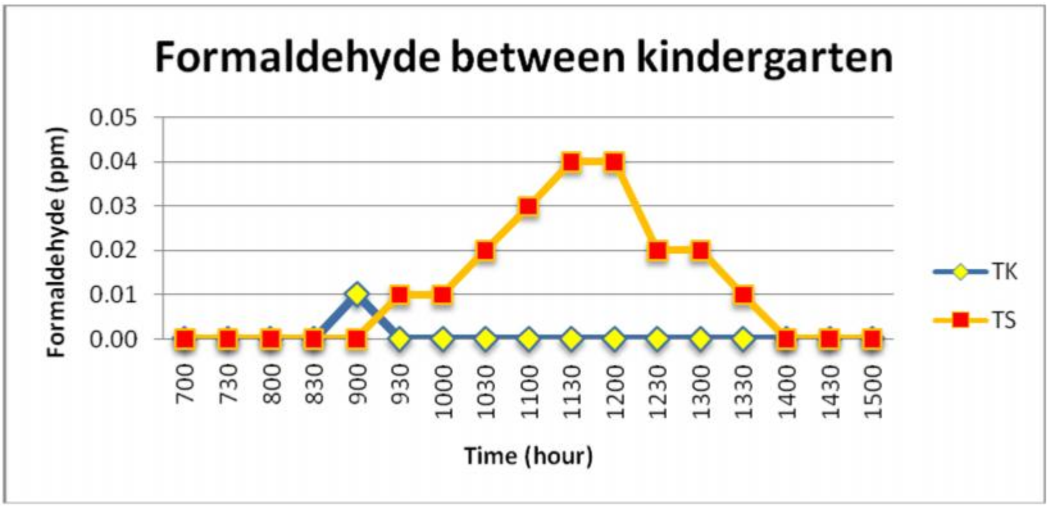

Figure 1: Formaldehyde pattern in two case studies

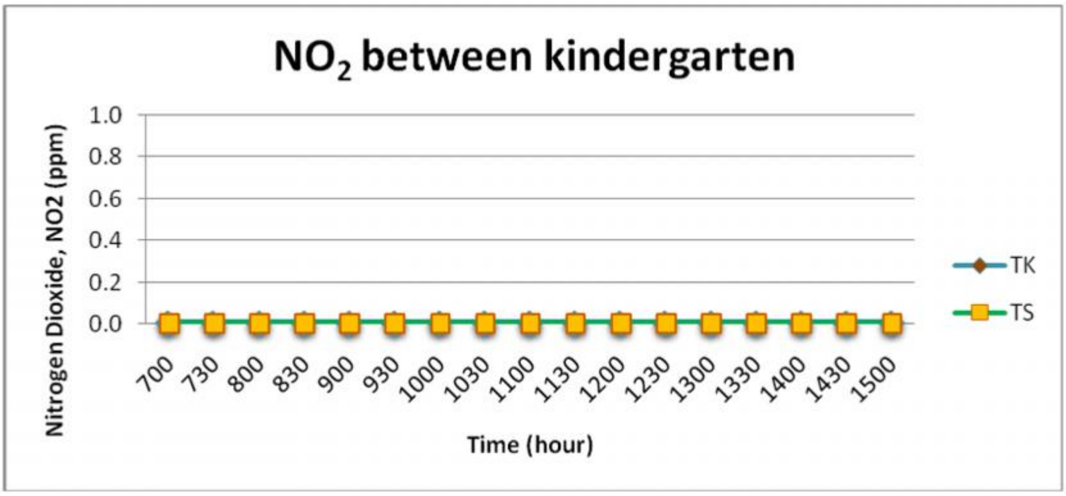

Figure 2: Nitrogen Dioxide pattern in two case studies

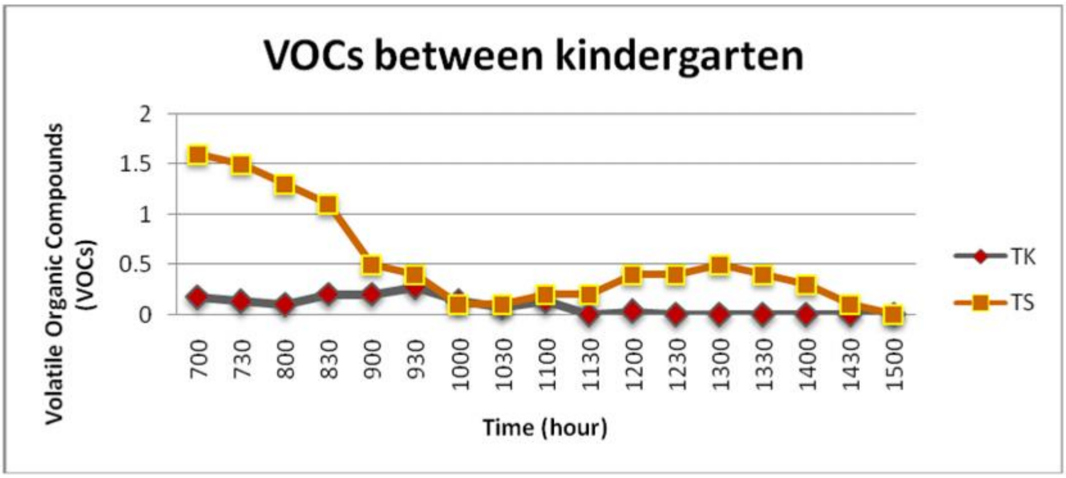

Figure 3: Volatile Organic Compound, VOCs pattern in two case studies

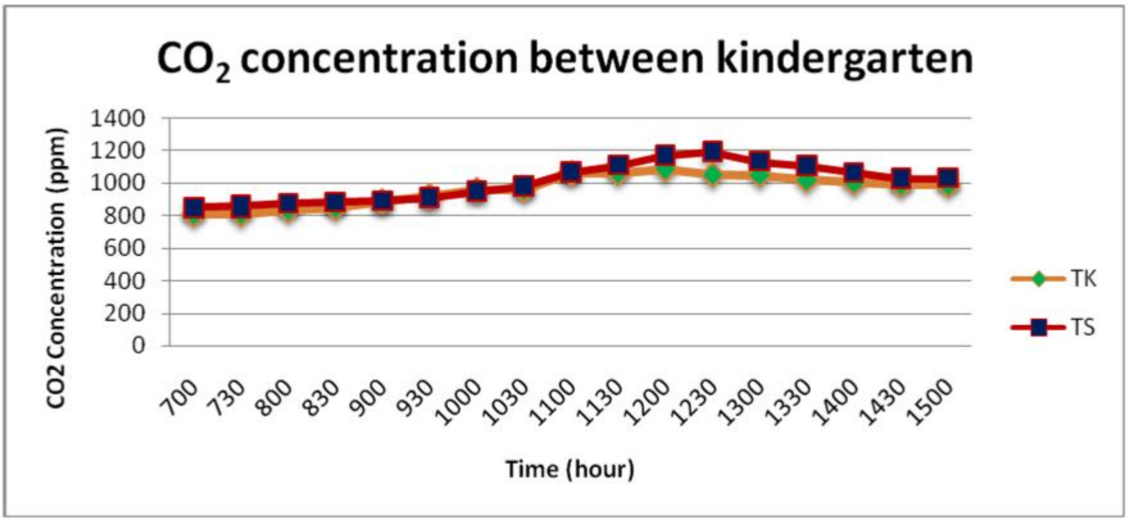

Figure 4: Carbon Dioxide, CO_2 pattern in two case studies

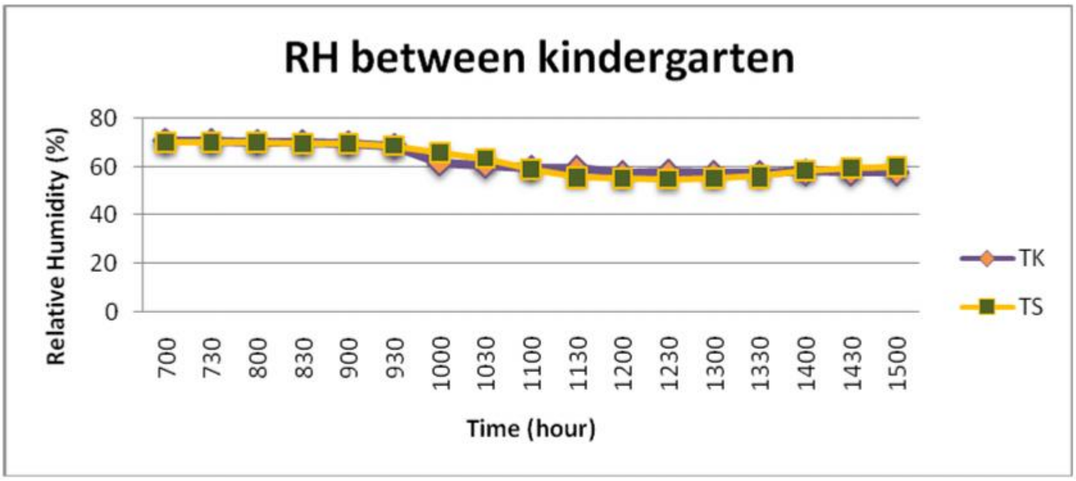

Figure 5: RH pattern in two case studies

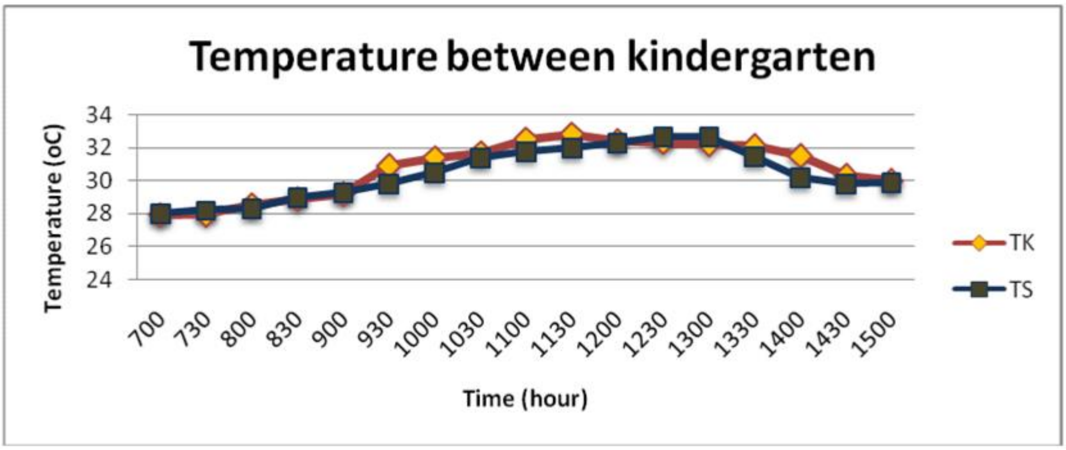

Figure 6: Temperature pattern in two case studies

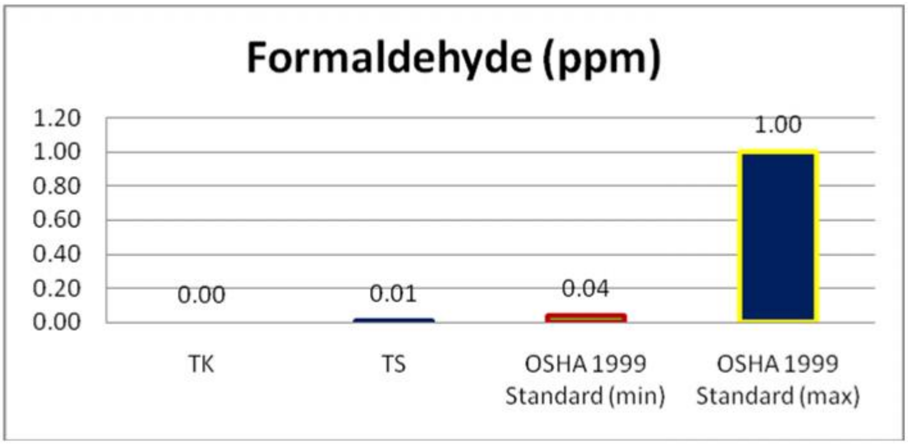

Figure 7: Formaldehyde against OSHA 1990

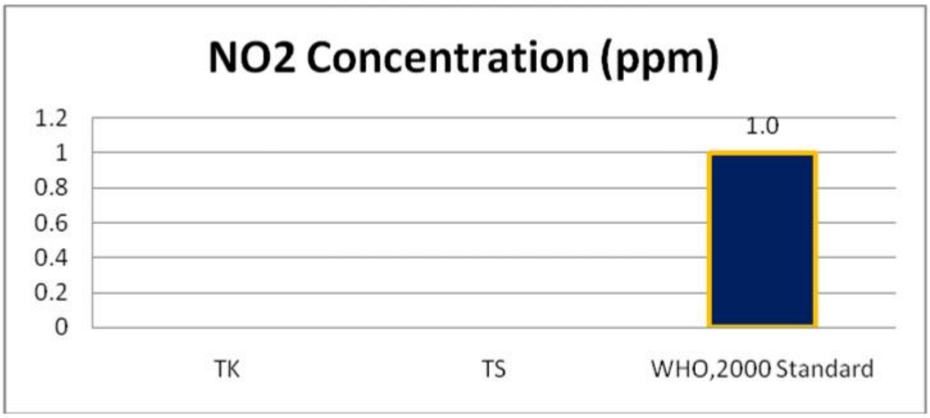

Figure 8: NO_2 Concentration against WHO 2000

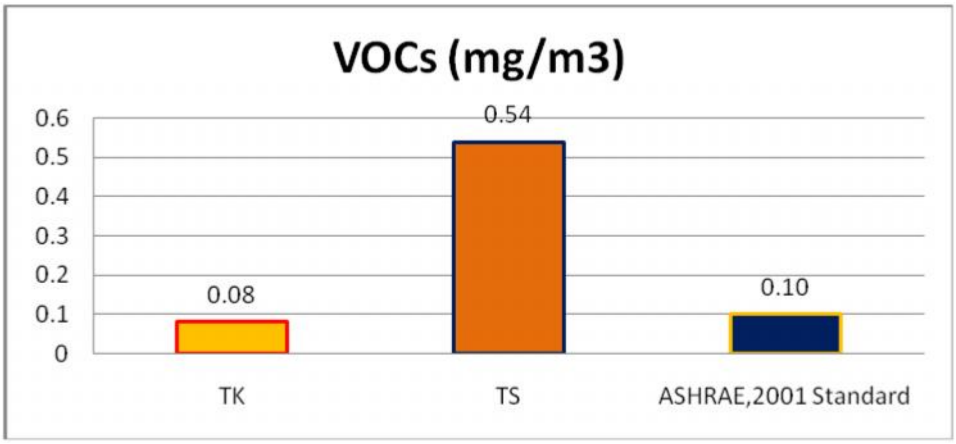

Figure 9: VOCs rate against ASHRAE 2001

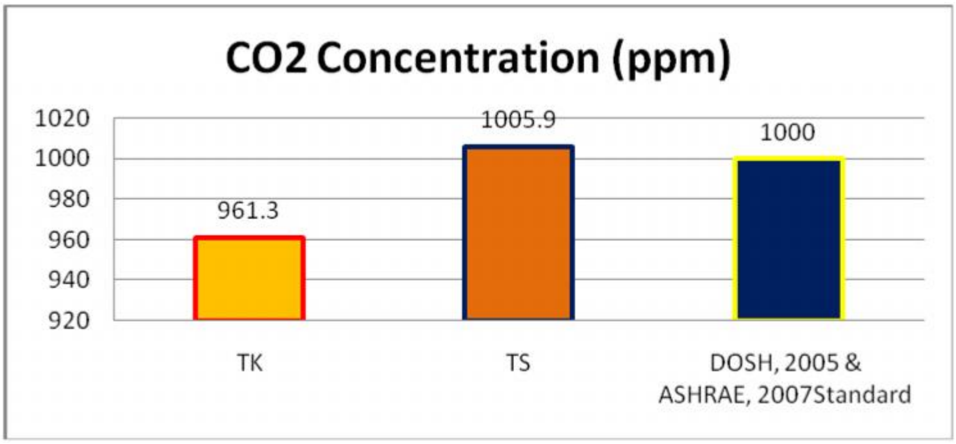

Figure 10: CO_2 concentration against DOSH 2005 & ASHRAE 2007

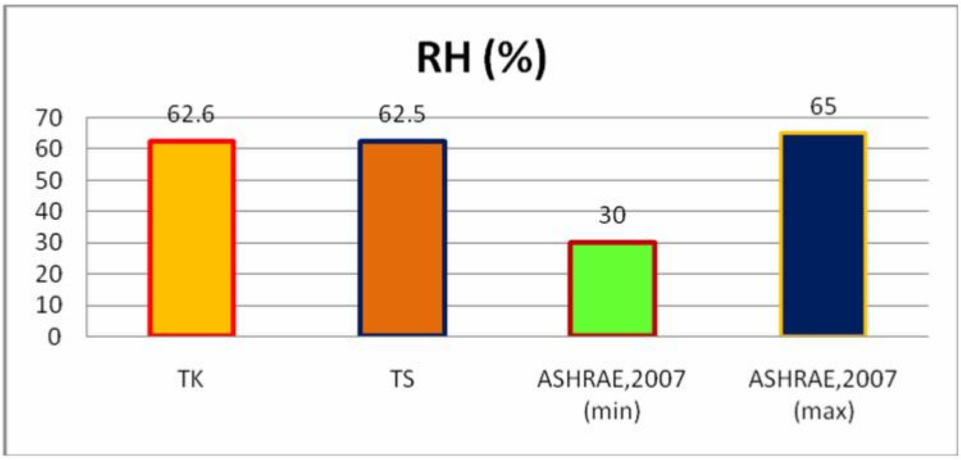

Figure 11: RH rate against ASHRAE 2007

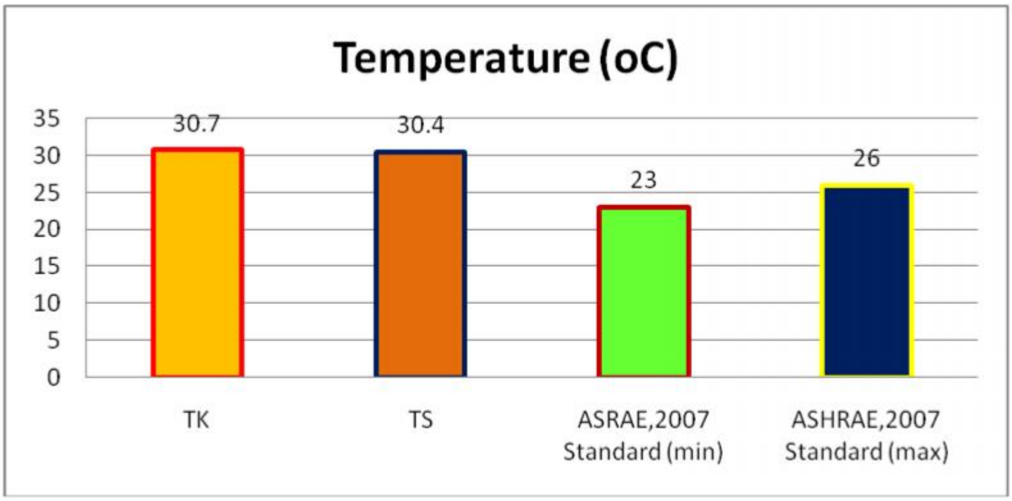

Figure 12: Temperature rate against ASHRAE 2007

KECACATAN BIASA RUANG TANDAS INSTITUSI PENGAJIAN TINGGI: ANALISIS KEADAAN BANGUNAN MENGGUNAKAN MATRIKS CSP1

COMMON TOILET DEFFECT IN HIGHER EDUCATION INSTITUTION: BUILDING CONDITION ANALYSIS USING CSP1 MATRIX

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Abstract

Fasiliti berasaskan tandas atau ruang tandas merupakan satu bentuk fasiliti asas yang sangat penting didalam sesebuah bangunan. Kepentingan fungsi serta kelebihan komponen dan kemudahan bangunan yang terdapat didalam ruang tandas bagi menyokong fungsinya merupakan perbezaan utama ruang tandas berbanding ruang lain. Keunikan ruang tandas dapat dilihat selepas sesuatu bangunan mula diduduki. Pada peringkat ini, isu berkenaan penyenggaraan tandas mula timbul terutama melibatkan bangunan awam termasuk bangunan institusi pengajian. Kadar penggunaan yang kerap berikutan kehadiran pelawat dan jumlah kakitangan yang ramai seringkali mengakibatkan kepincangan berlaku terhadap fungsi ruang tandas seterusnya tahap ketersediaan ruang tandas seringkali dipertikaikan. Aspek kebersihan dan kefungsian merupakan matlamat utama senggaraan ruang tandas. Dalam kitar hayat penyenggaraan, terdapat peringkat kerja-kerja pemeriksaan bangunan yang diperlukan bagi memastikan status fizikal semasa bangunan. Dalam konteks yang lebih luas, teori penilaian bangunan turut menekankan aspek pemeriksaan bangunan berdasarkan tahap dan petunjuk prestasi yang bersesuaian. Kajian ini dijalankan untuk mengenalpasti piawai penilaian bangunan sediada iaitu JKR, ASTM, QLASSIC, CONQUAS, RICS dan SIRIM seterusnya membangunkan rangka-kerja konsep penilaian prestasi bangunan. Pemeriksaan fizikal pula dilakukan bagi menganalisis prestasi semasa ruang tandas di bangunan fakulti. Pemeriksaan keadaan telah dijalankan terhadap 66 ruang ruang tandas di Fakulti 1, Fakulti 2 dana Fakulti 3 di Universiti Kebangsaan Malaysia kampus Bangi, Selangor. Metodologi yang digunakan adalah pemeriksaan visual berdasarkan alat pengukur keadaan bangunan Matriks CSP1. Hasil analisis berdasarkan frekuensi kecacatan mendapati wujud hubung-kait serta faktor kerosakan di antara komponen dan elemen didalam ruang tandas.

Kata Kunci: Ruang Tandas, Matriks CSP1, Kecacatan Bangunan, Pemeriksaan, Penilaian Keadaan, Ukur Bangunan, Indeks Keadaan Bangunan.

Toilet facilities or toilet based facility is a form of basic facilities which is very important in a building. Their functional importance and advantages of building services and components to support its function is the main difference of toilet or washroom compared to another. The uniqueness of the toilet can be seen after the building began to be occupied. At this cycle, the issue of maintenance began to arose, especially involving public buildings, including higher education institutions. Frequent usage due to the presence of visitors and the numbers of staff lead to malfunction occurs to the functioning of the toilet and washroom resulted the serviceability of toilet space are often disputed. Cleanliness and functionality is the main goal of the maintenance. In the life cycle of maintenance, there is the building inspection work required to ensure the physical status of the building. In a wider context, the theory of building assessment also emphasizes on inspection of the building based on the appropriate level and performance indicators. This study was conducted to identify existing building assessment standards namely PWD, ASTM, QLASSIC, CONQUAS, RICS and SIRIM in order to develop a conceptual framework of building performance evaluation. Physical survey was performed to analyze the current performance of the toilet space in the academic building. Inspections of the 66 toilet spaces have been conducted at the Faculty 1, Faculty 2 and Faculty 3 in University Kebangsaan Malaysia main campus Bangi, Selangor. The methodology used is based on visual inspection CSP1 Matrix building condition's rating tool. Revenue based on analysis of the frequency of defect determined the correlation and the factors bearing between the components and elements.

Keyword: Toilet Facility, CSP1 Matrix, Building Defect, Inspection, Condition Evaluation, Building Survey, Building Condition Indexes.

Pengenalan

Penilaian prestasi bangunan semakin berkembang dalam konteks alam bina di Malaysia. Pemeriksaan pula merupakan komponen yang menyokong objektif utama penilaian. Menurut Ahmad (2008), pemeriksaan merupakan satu pengujian terhadap suatu bahan atau produk. Wordworth (2001) pula menyatakan bahawa pemeriksaan adalah proses bagi mengukur kualiti pada suatu produk atau perkhidmatan bagi mencapai piawai yang telah ditetapkan. Pendapat Wordworth (2001) adalah bersesuaian dengan prinsip pemeriksaan bangunan iaitu pemeriksaan pada sesuatu bangunan perlulah dilakukan mengikut piawaian yang telah ditetapkan oleh pihak pemeriksaan bangunan. Menurut Chandler (1995), penilaian keadaan fasiliti adalah proses pemeriksaan kesemua komponen bangunan dan infrastruktur, termasuk kelengkapan mekanikal dan elektrikal, kerangka bangunan, struktur dalaman dan kemasan serta tapak bangunan. Proses pemeriksaan tersebut harus berdasarkan pengurusan strategik dalam menilai prestasi teknikal bangunan bagi memenuhi jangkaan senggaraan jangka masa panjang.

Kriteria pemeriksaan ruang tandas mesti dibangunkan berdasarkan maklumbalas asas pengguna. Keperluan pengguna akan menghasilkan objektif penilaian melalui kriteria penilaian. Seterusnya ukuran prestasi dinilai secara perbandingan dengan kriteria penilaian berdasarkan objektif penilaian. Kesepaduan antara kesemua elemen tersebut membentuk satu kitaran proses sebagai model untuk mengenalpasti kriteria pemeriksaan dan meningkatkan kualiti rekabentuk. Situasi ini disokong oleh Preiser dan Vischer (2005) berdasarkan model sistem maklumbalas asas seperti yang ditunjukkan didalam Rajah 1 dimana peneraju di setiap fasa kitaran hayat bangunan merupakan pemangkin bagi model ini.

Kajian yang dijalankan oleh Bilbo (2009) terhadap amalan pengurusan penyenggaraan fasiliti di sekolah awam di Texas telah membuktikan bahawa majoriti sekolah tersebut telah mempertimbangkan perancangan penyenggaraan sebagai bahagian penting dalam rancangan organisasi secara keseluruhan. Pemeriksaan ruang tandas bangunan institusi pengajian sangat penting bagi menyokong matlamat organisasi dalam menyediakan kemudahan pendidikan berkualiti tinggi dalam persekitaran yang sihat sebagai sokongan terhadap pengajaran, pembelajaran serta penyelidikan (Yussof, 2010). Penyenggaraan reaktif yang menelan kos yang tinggi serta tidak teratur merupakan amalan tipikal di kebanyakan institusi pengajian tinggi. Berdasarkan Taival (2007), tahap prestasi bangunan yang rendah dan tidak cekap boleh memberi impak negatif terhadap institusi pengajian tinggi. Ia bukan sahaja melibatkan peningkatan kos operasi secara pukal, malah turut menyumbang ke arah ketidakselesaan penghuni, masalah kesihatan dan tahap produktiviti yang rendah.

Kriteria Pemeriksaan Ruang Tandas

Kajian literatur intensif telah digunakan dalam membangunkan kriteria pemeriksaan ruang tandas. Sumber bertulis terdiri daripada enam piawai pemeriksaan bangunan sediada telah dijadikan bahan rujukan utama iaitu JKR, ASTM, QLASSIC, CONQUAS, SIRIM dan RICS telah dikaji bagi mengumpul dan mengenalpasti panduan dan kaedah kearah pembangunan kriteria. Kriteria pemeriksaan ruang tandas perlu dibangunkan selaras dengan objektif penilaian prestasi iaitu tahap keberkesanan. Seperti digariskan oleh MALAYSIAN STANDARD (2006), dengan mengetahui objektif pemeriksaan akan membolehkan pemeriksa untuk memanfaatkan masa yang terhad di lokasi pemeriksaan. Menurut Che-Ani et. al (2011), tahap keberkesanan dapat ditentukan berdasarkan objektif yang ingin dicapai. Secara prinsip, objektif yang baik mempunyai lima ciri utama yang turut dikenali sebagai SMART iaitu *specific* (spesifik), *measurable* (boleh diukur), *achievable* (boleh dicapai), *reasonable*/ *reliable* (munasabah) dan *time* (mempunyai tempoh masa).

Dalam konteks objektif pemeriksaan ruang tandas menurut Nasir et al. (2011), hasil analisis bagi piawai penilaian bangunan menunjukkan kebanyakan objektif yang digariskan oleh setiap piawai pemeriksaan tidak mempunyai kesemua ciri yang dinyatakan itu. Hasil analisis jelas menunjukkan bahawa objektif pemeriksaan harus menitikberatkan tahap kebolehkhidmatan dan ketersediaan ruang tandas disamping mengenalpasti kecacatan yang boleh menjejaskan kesihatan, keselamatan, kefungsian, senggaraan dan operasi. Secara tidak langsung ia selaras dengan pendapat Preiser dan Vischer (2005) yang mensintesiskan keperluan pengguna kepada tiga tahap keutamaan iaitu:

i. Prestasi kesihatan, keselamatan dan kawalan;
ii. Prestasi fungsi, efisyen dan aliran kerja;
iii. Psikologi, sosial, budaya dan astetik.

Tahap prestasi merupakan asas dalam memastikan kriteria yang dibangunkan dapat mencapai objektif pemeriksaan. Berdasarkan sintesis kajian, sebanyak lapan kriteria pemeriksaan telah dipilih sebagai set lengkap komponen penilaian iaitu struktur, senibina, mekanikal dan elektrikal, kerja luaran, kemudahan bangunan, kebolehsenggaraan dan operasi, kesihatan dan keselamatan serta kefungsian. Peranan dan skop pemeriksaan tersebut perlu difahami oleh pemeriksa yang terdiri daripada Jurukur Bangunan. Berdasar kajian literatur terhadap enam piawai tersebut, berikut adalah hasil analisis perincian kriteria tahap prestasi seperti yang ditunjukkan didalam Jadual 4.

Mengambil kira pandangan Hollis dan Gibson (2005) serta Hoxley (2002), teknik pemeriksaan secara atas ke bawah mengikut arah putaran jam turut diadaptasikan sebagai prosedur penilaian ruang tandas. Prosedur ini disokong oleh Ramly (2005) dan Noor (2010) bagi membolehkan setiap kriteria pemeriksaan dapat dinilai dengan teliti dan mengelakkan kecuaian semasa mengenalpasti kecacatan. Menurut Nasir et al. (2011), kriteria pemeriksaan ruang tandas dibangunkan dengan melihat kepada objektif utama penilaian. Secara teori, kriteria pemeriksaan perlu menepati keperluan objektif utama, dibangunkan secara padanan kepada piawai penilaian bangunan dan bersifat holistik. Kriteria pemeriksaan merupakan komponen asas yang sangat penting semasa membuat penilaian prestasi keadaan ruang tandas.

Metodologi

Pemeriksaan visual telah dijalankan terhadap ruang tandas di tiga buah fakulti di Universiti Kebangsaan Malaysia (UKM) kampus Bangi, Selangor iaitu Fakulti 1 (F1), Fakulti 2 (F2) dan Fakulti 3 (F3). Tujuan kajian dijalankan adalah untuk menganalisi prestasi semasa ruang tandas di bangunan fakulti seterusnya mengenalpasti kecacatan biasa komponen dan elemen ruang tandas. Berdasarkan bancian awal yang dibuat, didapati terdapat sejumlah 81 ruang disemua aras dan semua jenis pengguna bagi ketiga-tiga fakulti. Namun begitu, sejumlah 15 ruang tandas tidak dapat diperiksa atas pelbagai faktor semasa kajian lapangan dijalankan iaitu masing-masing lapan ruang tandas bagi F1 dan tujuh ruang tandas bagi F2. Di antara faktor tersebut ialah pintu tandas berkunci dan tidak mendapat kebenaran bagi ruang tandas untuk jenis pengguna tertentu. Rujuk Jadual 2.

Berdasarkan kepada pengiraan, Krejcie dan Morgan (1970) telah menyenaraikan sais sampel yang berpadanan dengan sais populasi kajian. Menurut jadual penentuan sais sampel Krejcie dan Morgan (1970), jika populasi bagi suatu kajian ialah dibawah 85 maka bilangan sampel yang diperlukan ialah sebanyak 66 sampel. Penentuan sais sampel ini telah dipatuhi bagi kajian ini iaitu berdasarkan populasi sebanyak 81 ruang tandas,sebanyak 66 ruang tandas telah diperiksa sebagai sampel kajian. Selanjutnya, instrumen yang digunakan dalam kajian ini ialah borang pemeriksaan bagi menjalankan pemerhatian atau pemeriksaan ruang tandas terhadap sampel kajian. Data yang dikumpul telah dianalisis dengan menggunakan perisian SPSS. Menurut Chua (2006) pula, data perlu dianalisis secara kualititatif tidak kira pemerhatian dibuat dengan kaedah pemerhatian sistematik atau peserta. Walaubagaimanapun, data kualititatif boleh dikuantitatifkan untuk memudahkan analisis data. Berdasarkan Chua (2006) juga, penulisan laporan kajian lapangan adalah tidak terhad kepada format tertentu. Namun begitu, catatan, pengekodan dan penghuraian pemerhatian perlu dilakukan secara sistematik dan saintifik. Tujuan utama penulisan laporan adalah untuk memberi maklumat yang sah dan boleh dipercayai tentang hasil kajian dimana ia mestilah penulisan secara logik, sistematik serta penghuraian yang mempunyai bukti yang kukuh daripada pemerhatian.

Pemeriksaan terhadap ruang tandas telah dilakukan di dalam situasi penggunaan harian biasa tanpa mengganggu rutin kepenggunaan ruang tandas tersebut bagi mendapatkan data yang bersifat semulajadi. Peristiwa di bawah kajian lapangan adalah perkara yang benar-benar berlaku dalam keadaan semulajadi secara berterusan. Menurut Tunnell (1977), perkara-perkara tersebut bukan direka, dibina ataupun perkara yang diberhentikan semata-mata untuk tujuan penyelidikan. Disebabkan ciri-ciri ini, kajian lapangan juga dikenali sebagai kajian semulajadi seperti yang dinyatakan oleh Chua (2006). Dalam mengenalpasti tahap penilaian setiap ruang tandas, alat pengukur prestasi bangunan **Matriks CSP1** telah digunakan dalam kajian ini.

Matriks CSP1

Proses menilai tahap prestasi bangunan memerlukan pemerhatian yang teliti, kajian serta pemahaman yang mendalam terhadap subjek dan aspek kajian. Berasaskan matlamat untuk menganalisis prestasi semasa ruang tandas di bangunan akademik serta mengenalpasti kecacatan biasa ruang tandas, kajian ini telah memberi penekanan yang mendalam terhadap penyediaan kriteria penilaian yang sangat penting untuk menilai kecacatan bangunan. Che-Ani et al. (2011) telah memperkenalkan ***Condition Survey Protocol*** **(CSP) 1 Matrix** (Matriks CSP1) sebagai alat pengukur prestasi bangunan yang dibangunkan berdasarkan kesesuaian dan keperluan sistem terkini. Alat pengukur ini merupakan kaedah penilaian bagi prestasi keadaan bangunan berasaskan kaedah pemeriksaan visual.

Matriks CSP1 menggabungkan dua set maklumat penilaian yang saling berhubung-kait iaitu keadaan bangunan diikuti darjah kecacatan tersebut. Analisis terhadap maklumat ini dapat menghasilkan kombinasi indeks terhadap nilai prestasi keseluruhan keadaan bangunan tersebut. Sistem penilaian ini telah disesuaikan untuk menilai prestasi berbagai jenis bangunan walaupun pecahan elemen dan perincian komponen setiap bangunan adalah berbeza. Matlamat utama sistem ini dibangunkan adalah:

i. Membolehkan jurukur untuk mengumpul data pemeriksaan dengan cepat tanpa memerlukan huraian penjelasan yang panjang semasa lawatan pemeriksaan lapangan;

ii. Merekod kecacatan bangunan yang merupakan sumber data utama berdasarkan penilaian keadaan diikuti pengkelasan darjah bagi kecacatan tersebut;

iii. Mendapatkan penilaian keseluruhan bagi keadaan bangunan. Cadangan pembaikan tidak diberi penekanan didalam sistem ini berdasarkan situasi kebiasaan dimana kerja pembaikan tidak dilaksanakan sebaik sahaja penilaian dilakukan atas alasan kekangan kewangan. Walaubagaimanapun, sebarang cadangan kerja pembaikan yang mungkin diperlukan mesti ditentukan kemudian;

iv. Menggunakan penilaian bernombor yang diperoleh semasa kerja penilaian untuk melaksanakan analisis statistik.

Setiap rekod kecacatan diberikan nilai skala keadaan dan keutamaan. Setiap nilai bagi dua set data ini didarabkan bagi mendapatkan jumlah markah bagi setiap kecacatan. Kemudian, jumlah markah dipadankan dengan Matrix seperti yang ditunjukkan didalam Jadual 4. Lingkungan markah adalah bermula daripada 1 sehingga 20. Padanan berwarna hijau, kuning dan merah digunakan bagi membeza tiga parameter berdasarkan jumlah markah iaitu **Penyenggaraan Terancang** (1 hingga 4), **Pemantauan Keadaan** (5 hingga 12) dan **Perhatian Serius** (13 hingga 20) seperti yang ditunjukkan didalam Jadual 5.

Penilaian terhadap setiap kecacatan mesti dikelaskan secara teliti dan berdasarkan kepada piawai penyenggaraan yang setara serta definisi kecacatan yang difahami oleh jurukur dan pelanggan. Proses ini adalah sangat bergantung kepada tahap pengetahuan dan pengalaman jurukur yang menjalankan pemeriksaan tersebut. Penekanan ini akan mengurangkan risiko kesilapan mentafsirkan darjah kecacatan yang didapati terutama sekali kecacatan yang diklasifikasi sebagai kod merah. Adalah penting bagi jurukur untuk mengutamakan kecacatan kod merah tersebut kerana darjah kecacatan ini sangat mempengaruhi penilaian keseluruhan bangunan serta menitik-beratkan kecacatan yang boleh meningkatkan risiko keselamatan kepada pengguna bangunan. Keadaan ini turut membantu jurukur untuk mengenalpasti risiko setiap kerosakan dan memaklumkan pelanggan dengan ringkasan yang berinformasi.

Setelah markah diberi bagi setiap kecacatan, pengiraan bagi penilaian keadaan bangunan secara keseluruhan dilakukan bagi memberikan nilai prestasi bangunan tersebut. Markah bagi setiap kecacatan akan dijumlahkan dan dibahagikan dengan bilangan kecacatan bagi mendapatkan purata keseluruhan. Kemudian, bangunan tersebut akan dinilai samada **Baik**, **Sederhana** atau **Daif** berdasarkan markah purata seperti yang ditunjukkan didalam Jadual 6.

Segala maklumat yang diproses bagi penilaian Matriks CSP1 diperolehi daripada kaedah pemeriksaan terperinci. Bagi mencapai matlamat pembangunan sistem penilaian Matriks CSP1, kajian ini meneruskan usaha untuk mengemaskini teknik pemeriksaan serta kaedah penilaian yang dicadangkan. Kajian ini juga menguji sejauh manakan keberkesan dan kebolehupayaan sistem ini dalam menilai prestasi bangunan dengan cara yang dipermudahkan serta kualiti yang setara atau lebih baik berbanding piawai yang terdahulu.

Perbincangan

Berdasarkan kaedah pemeriksaan yang telah dijalankan, ruang tandas kajian dipecahkan mengikut lokasi yang lebih kecil iaitu sirkulasi dan kubikal. Setiap lokasi pula memiliki pelbagai jenis komponen tertentu yang berbeza sesuai dengan fungsi lokasi tersebut sebagaimana ia direkabentuk. Setiap komponen pula terdiri daripada beberapa elemen yang lebih kecil bagi membentuk fungsi dan kegunaan komponen yang tersebut. Setiap elemen pula mengalami sindrom kecacatan yang berbeza bergantung kepada punca kerosakan yang boleh mempengaruhi prestasi komponen secara langsung.

Hasil pemeriksaan mendapati terdapat 12 komponen utama dalam ruang tandas yang mengalami kecacatan dengan 946 jumlah kecacatan telah direkodkan. Komponen yang mempunyai bilangan kecacatan paling tinggi ialah Sanitari sebanyak 230 (24.3%) bilangan kecacatan manakala komponen yang paling sedikit bilangan kecacatan ialah Pintu Utiliti, Meja Konkrit dan Paip Bekalan. Ketiga-tiga komponen tersebut masing-masing hanya mempunyai satu (0.1%) bilangan kecacatan sahaja. Julat bilangan kecacatan bagi setiap komponen adalah sangat besar iaitu serendah satu kecacatan sahaja sehingga 230 bilangan kecacatan tertinggi dengan nilai purata 79 (8.35%) kecacatan bagi setiap komponen seperti yang ditunjukkan oleh Jadual 7.

Terdapat empat komponen ruang tandas yang paling kritikal dengan jumlah kecacatan melebihi nilai purata iaitu Santari sebanyak 230 (24.3%) kecacatan, Siling sebanyak 138 (14.6%) kecacatan, Dinding sebanyak 177 (18.7%) kecacatan dan Pintu sebanyak 222 (23.5%) kecacatan. Paip Bekalan, Meja Konkrit dan Pintu Utiliti mempunyai bilangan kecacatan yang minimum iaitu masing-masing sebanyak satu kecacatan sahaja dan boleh dianggap sebagai kes terpencil. Manakala komponen selebihnya adalah kecacatan terpencil berdasarkan bilangan kecacatan yang kurang daripada nilai purata. Sehubungan dengan itu, apabila melihat kepada elemen-elemen bagi setiap komponen dalam ruang tandas, majoriti elemen-elemen yang paling banyak mengalami kecacatan adalah elemen yang ada kaitan dengan komponen seperti pintu, dinding, sanitari dan siling. Elemen yang paling tinggi mengalami kecacatan ialah Jubin sebanyak 136 (14.4%) kecacatan, diikuti oleh Papan Siling sebanyak 132 (14.0%) kecacatan, Plaster sebanyak 105 (11.1%) kecacatan, Bingkai sebanyak 99 (10.5%) kecacatan dan Daun Pintu sebanyak 95 (10.0%) kecacatan. Julat perbezaan bilangan kecacatan di antara elemen adalah sangat besar iaitu sebanyak 137 bilangan kecacatan dengan purata setiap elemen mempunyai 34 jumlah kecacatan. Dengan mengandaikan elemen yang mempunyai bilangan kecacatan yang bersamaan dan melebihi 10% daripada jumlah kerosakan sebagai kerosakan yang harus diberikan perhatian serius, maka kelima-lima elemen yang dinyatakan mengalami kadar kecacatan yang paling ketara.. Elemen yang paling sedikit mengalami kecacatan ialah Penutup Pintu, Paip Buangan dan Injap Kawalan. Masing-masing terdapat bilangan kecacatan sebanyak satu (0.1%) kecacatan seperti yang ditunjukkan oleh Jadual 8.

Susulan daripada elemen-elemen yang disenaraikan dalam Jadual 8, terdapat pula pelbagai jenis kecacatan di dalam ruang tandas. Berdasarkan pemeriksaan visual yang telah dilakukan, jenis-jenis kecacatan yang dikenalpasti ialah sebanyak 36 jenis kecacatan seperti retak, kotor, hilang, kesan tompokan air, pecah, bocor dan sebagainya. Jenis kecacatan yang paling tinggi ialah kotor sebanyak 221 (23.36%) kecacatan diikuti oleh retak sebanyak 137 (14.48%) kecacatan serta pecah sebanyak 72 (7.61%). Elemen plaster mengalami keretakan sebanyak 83 kecacatan. Selain daripada sembilan jenis kecacatan utama yang dinyatakan, lain-lain kecacatan pula menyumbangkan sebanyak 266 (28.12%) kecacatan dengan bilangan bagi setiap jenis kecacatan adalah tidak terlalu tinggi seperti yang ditunjukkan oleh Jadual 9.

Hasil analisis menunjukkan setiap jenis elemen yang berbeza bagi setiap komponen yang berbeza mengalami sindrom kecacatan yang turut berbeza. Namun begitu, terdapat juga elemen yang berlainan mengalami sindrom kecacatan yang sama dan sebaliknya. Hal ini berlaku kerana sifat kecacatan yang umum seperti kotor dan retak. Terdapat juga jenis kecacatan yang berpunca daripada bahan buatan sesuatu elemen seperti karat yang berlaku keatas elemen yang mempunyai unsur logam seperti bingkai pintu dan tingkap. Kecacatan sesuatu elemen juga turut berpunca daripada kehilangan sebahagian komponen. Sebagai contoh, pam simbah dianggap mengalami kecacatan jika penutupnya hilang seperti yang ditunjukkan oleh Jadual 10.

Terdapat pelbagai jenis kecacatan berbeza yang berlaku pada setiap elemen yang berlainan. Berdasarkan frekuensi kecacatan melebihi dua peratus bagi setiap kecacatan, dapat diringkaskan 15 kecacatan biasa ruang tandas secara spesifik seperti berikut:

i. Permukaan dan sambungan jubin lantai dan dinding yang kotor akibat kesan lumut, sisa binaan, dan sebagainya yang tidak dibersihkan dengan sempurna;

ii. Retak pada plaster dinding yang terdiri daripada retak kosmetik;

iii. Bingkai pintu dan tingkap yang retak serta renggang pada sambungan dengan dinding;

iv. Daun pintu kotor dengan kesan kulapuk terutamanya pada bahagian bawah;

v. Papan siling tidak selari akibat pemasangan yang tidak sempurna serta kerja-kerja penyenggaraan terdahulu;

vi. Bingkai pintu dan tingkap yang berkarat terutama pada bahagian bawah yang terdedah kepada unsur air secara berterusan;

vii. Papan siling hilang, reput atau pecah serta tidak diganti semula;

viii. Papan siling mempunyai kesan tompokan air akibat kebocoran pada sistem perpaipan dan papak lantai pada aras atas;

ix. Papan siling hampir jatuh yang boleh mendatangkan risiko kecederaan kepada pengguna;

x. Pemegang tisu rosak pada bahagian palang gelungan tisu dan tidak dapat berfungsi sepenuhnya;

xi. Lampu tidak menyala akibat kerosakan komponen;

xii. Cermin muka kotor dengan kesan lumut, contengan vandalisma serta kesan kotoran kekal yang lain;

xiii. Sambungan pada paip agihan terutamanya paip buangan yang bocor;

xiv. Penutup perangkap lantai yang hilang membolehkan sisa pepejal memasuki sistem kumbahan serta mendatangkan risiko kepada pengguna; dan

xv. Lain-lain kecacatan seperti pam simbah tidak berfungsi, cermin muka pecah, set kekunci hilang, daun pintu ketat dan sebagainya.

Kesimpulan Dan Cadangan

Apabila keadaan fizikal bangunan dapat dikenalpasti oleh organisasi pengurusan, keperluan untuk penyenggaraan atau pembaikan akan menjadi lebih jelas. Walaupun kebanyakan institusi pengajian awam mempertimbangkan perancangan penyenggaraan sebagai bahagian penting dalam rancangan organisasi, namun maklumat berkenaan keadaan bangunan masih tidak mencukupi untuk merancang penyenggaraan. Selaras dengan fungsi dan kepentingan tandas sebagai satu bentuk fasiliti sokongan asas, amat penting untuk memastikan ruang tersebut sentiasa berada dalam keadaan bersedia dan berfungsi bagi menjamin perkhidmatan berkualiti dan meningkatkan tahap kepuasan pengguna. Pemeriksaan bukan sahaja memastikan tahap kebolehkhidmatan dapat dicapai malah turut membolehkan ruang tandas tersebut menepati fungsi rekabentuk yang menyumbang kepada kepuasan pengguna.

Secara dasarnya, pemeriksaan terhadap ruang tandas telah mendapati berlakunya kadar kecacatan yang ketara pada komponen dan elemen tertentu mengikut jenis dan tahap yang berbeza. Tindakan susulan perlu diambil berdasarkan hasil pemeriksaan bagi mengelakkan sebarang kecacatan daripada menjadi lebih parah dan mengakibatkan sistem atau kemudahan bangunan menjadi separa lumpuh atau lumpuh sepenuhnya. Walaubagaimanapun, punca kecacatan sebenar termasuk tempoh ketahanan sesuatu komponen dan elemen dalam ruang tandas tidak dapat ditentukan secara spesifik memandangkan kajian ini dilakukan secara pemeriksaan visual dalam tempoh masa yang singkat. Secara tidak langsung, kaedah pembaikan alternatif adalah sukar untuk ditentukan bagi meningkatkan keupayaan dan ketahanan sesuatu komponen. Penilaian keadaan bangunan yang lengkap mampu membekalkan maklumat yang tepat dan gambaran sebenar sesuatu fasiliti. Seharusnya pihak pengurusan mempraktikkan penilaian keadaan bangunan sebagai alat pengurusan strategik dalam menilai prestasi bangunan bagi memenuhi keperluan penyenggaraan jangka masa panjang.

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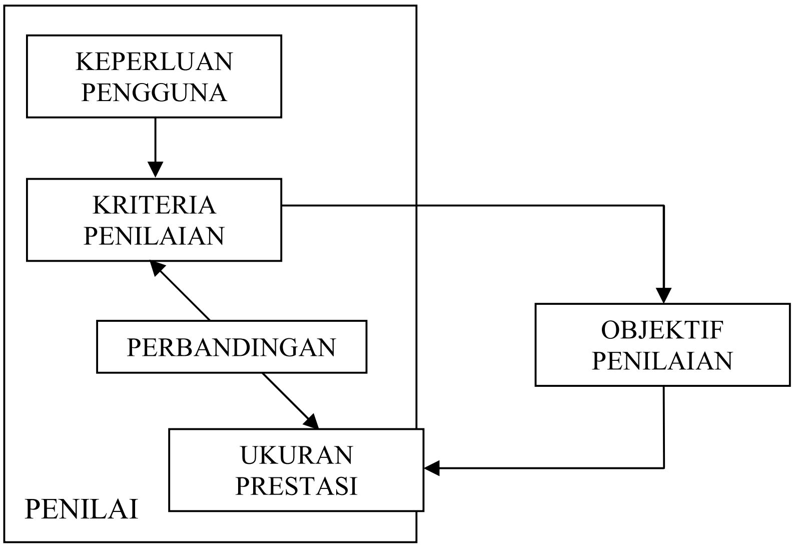
Lampiran



Rajah 1: Sistem maklumbalas asas
Sumber: Preiser dan Vischer (2005)

Jadual 1: Perincian kriteria tahap prestasi berdasarkan piawai pemeriksaan

No.	**Kriteria Pemeriksaan**	**Perincian Tahap Kualiti**	**Fokus**
1	Struktur	Integriti struktur yang mempunyai impak kecacatan serta kos membaik-pulih meliputi struktur konkrit bertetulang, struktur keluli, konkrit pra-tegasan termasuk pelbagai produk struktur pasang-siap (IBS).	Elemen pemeriksaan
2	Senibina	Banyak melibatkan bahan siapan dimana kualiti, kekemasan dan mutu kerja menjadi keutamaan seperti lantai, dinding, siling, pintu & tingkap, bumbung, kelengkapan/ peralatan dan longkang.	
3	M & E	Melibatkan keseimbangan kos dan prestasi bangunan meliputi kerja elektrikal, sistem penyaman udara & pengudaraan mekanikal, perlindungan kebakaran, sanitari & perpaipan serta kelengkapan asas M & E.	
4	Kerja Luaran	Meliputi kerja am luaran seperti laluan, sistem saliran, jalan, parkir, taman permainan, pagar, kolam renang, lanskap kejur & rumah pencawang elektrik.	
5	Kemudahan Bangunan	Kemudahan bangunan yang khusus perlu diperiksa oleh pakar berkenaan yang terlatih. Terhad kepada kemudahan asas seperti bekalan air, pembetungan, sistem perpaipan dan alat pencegah kebakaran.	Aspek pemeriksaan/ penanda aras

6	Keboleh-senggaraan	Mengenalpasti kecacatan yang mempunyai implikasi dan boleh menjejaskan operasi senggaraan di masa akan datang. Semakan terhadap manual dan senarai sistem sebagai dokumen rujukan semasa operasi senggaraan dan pengurusan aset.
7	Kesihatan & Keselamatan	Pematuhan terhadap keperluan khas seperti kehendak menentang kebakaran, keperluan O.K.U, alam sekitar, kawalan pencemaran, kesihatan awam dan lain-lain.
8	Kefungsian	Keupayaan sesuatu komponen, elemen dan sistem menjalankan fungsi khusus sebagaimana direkabentuk dan prestasi umum bagi perkaitan setiap subjek.

Sumber: Nasir et al. (2011)

Jadual 2: Deskriptif data pemeriksaan tandas

No.	**Fakulti**	**Bil. Tandas Diperiksa (Sampel)**	**Bil. Tandas Tidak Diperiksa**	**Jumlah (Populasi)**	**Peratusan (%)**
1.	F1	29	8	37	78.38
2.	F2	26	7	33	78.79
3.	F3	11	0	11	100
	Jumlah	66	15	81	81.48

Jadual 3(a): Keadaan Penilaian

Keadaan	**Nilai Skala**	**Penerangan**
1	Baik	Senggaraan Kecil
2	Sederhana	Pembaikan Kecil
3	Daif	Pembaikan Major/ Penggantian
4	Sangat Daif	Pincang Fungsi
5	Usang	Kerosakan/ Penggantian Bahagian Hilang

Sumber: Che-Ani et al. 2011

Jadual 3(b): Keutamaan Penilaian

Keadaan	**Nilai Skala**	**Penerangan**
1	Normal	Berfungsi; kecacatan kosmetik sahaja
2	Rutin	Kecacatan kecil, tetapi boleh menjadi serius jika dibiarkan
3	Segera	Kerosakan serius, tidak berfungsi pada piawai yang boleh diterima
4	Kecemasan	Elemen/ Struktur tidak berfungsi sama sekali; ATAU Mendatangkan risiko yang boleh membawa kepada kemalangan dan/ atau kecederaan

Sumber: Che-Ani et al. 2011

Jadual 4: Matriks

Skala		**Keutamaan Penilaian**			
		E 4	**U 3**	**R 2**	**N 1**
Penilaian Keadaan	**5**	**20**	**15**	**10**	**5**
	4	**16**	**12**	**8**	**4**
	3	**12**	**9**	**6**	**3**
	2	**8**	**6**	**4**	**2**
	1	**4**	**3**	**2**	**1**

Sumber: Che-Ani et al. 2011

Jadual 5: Nilai deskriptif berdasarkan markah

No	**Matriks**	**Markah**
1	Penyenggaraan Terancang	1 hingga 4
2	Pemantauan Keadaan	5 hingga 12
3	Perhatian Serius	13 hingga 20

Sumber: Che-Ani et al. 2011

Jadual 6: Prestasi keseluruhan bangunan

No	Tahap Bangunan	Skor
1	Baik	1 hingga 4
2	Sederhana	5 hingga 12
3	Daif	13 hingga 20

Sumber: Che-Ani et al. 2011

Jadual 7: Komponen-komponen ruang tandas

Komponen	Bilangan Kecacatan	Peratus (%)
Pintu	**222**	**23.5**
Lantai	63	6.7
Dinding	**177**	**18.7**
Tingkap	32	3.4
Siling	**138**	**14.6**
Sanitari	**230**	**24.3**
Kelengkapan	48	5.1
Paip Buangan	26	2.7
Paip Agihan	7	0.7
Pintu Utiliti	1	0.1
Meja Konkrit	1	0.1
Paip Bekalan	1	0.1
Jumlah	**946**	**100.0**

Jadual 8: Elemen-elemen bagi komponen ruang tandas

Elemen	Bilangan Kecacatan	Peratus (%)
Bingkai	**99**	**10.5**
Jubin	**136**	**14.4**
Daun Tingkap	17	1.8
Papan Siling	**132**	**14.0**
Pemegang Tisu	21	2.2
Lampu	31	3.3
Daun Pintu	**95**	**10.0**

Cermin Muka	33	3.5
Sambungan	26	2.7
Perangkap Lantai	43	4.5
Pam Simbah	69	7.3
Mangkuk Tandas	28	3.0
Injap Kawalan	1	0.1
Plaster	**105**	**11.1**
Rangka Siling	6	0.6
Engsel	13	1.4
Urinal	8	0.8
Set Kekunci	24	2.5
Pengering Tangan	4	0.4
Pili	8	0.8
Sinki	17	1.8
Penutup Pintu	1	0.1
Rangka	7	0.7
Paip	3	0.3
Perangkap S/P	4	0.4
Kipas Ekzos	12	1.3
Pemegang	2	0.2
Paip Buangan	1	0.1
Total	**946**	**100.0**

Jadual 9: Jenis-jenis kecacatan elemen ruang tandas

No.	Jenis Kecacatan	Bilangan	Peratus (%)
1	Kotor	221	23.36
2	Retak	137	14.48
3	Pecah	72	7.61
4	Hilang	53	5.60
5	Rosak	48	5.07
6	Tidak Selari	39	4.12

7	Tidak Berfungsi	39	4.12
8	Bocor	36	3.81
9	Karat	35	3.70
10	Lain-lain	266	28.12
Jumlah		**946**	**100**

Jadual 10: Bilangan kecacatan berdasarkan jenis bagi setiap elemen

Elemen	Jenis Kecacatan	Bilangan	Peratus (%)
Bingkai	Retak	43	4.55
	Karat	20	2.11
Jubin	Kotor	106	11.21
Papan Siling	Hilang	25	2.64
	Kesan Tompokan Air	22	2.33
	Tidak Selari	39	4.12
Pemegang Tisu	Hampir Jatuh	19	2.01
Lampu	Rosak	20	2.11
Daun Pintu	Tidak Menyala	24	2.54
Cermin Muka	Kotor	43	4.55
Sambungan	Kotor	25	2.64
Perangkap Lantai	Bocor	24	2.54
Pam Simbah	Penutup Hilang	21	2.22
Plaster	Tidak Berfungsi	25	2.64
	Retak	83	8.77
Lain-lain		407	43.02
Jumlah		**946**	**100.00**

A COMPARATIVE STUDY OF THE TIME AND COST PERFORMANCE OF LABOUR-ONLY SUBCONTRACTORS IN THE CONSTRUCTION INDUSTRY IN SOUTH WESTERN NIGERIA

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ABSTRACT

The main contractors are continuously involved in a process of transforming inputs (materials, labour and capital) into outputs such as constructed facilities but they are usually accompanied by subcontractors and financial institutions among other firms. This study therefore examined the performance of labour-only subcontractors in the Nigerian construction industry. The principal objective was to find if any significant difference exists between the time and cost performance of these speciality contractors. In achieving this objective, one hundred questionnaires were distributed to each of the four categories of respondents in the Southwestern region of Nigeria. 75, 88, 56 and 42 questionnaires were respectively filled and returned by the main contractors, labour-only subcontractors, clients and consultants in the study area. Descriptive, parametric and non parametric statistical techniques were used for the analysis. Results indicated that significant difference exists between time and cost performance of labour-only subcontractors. Their mean scores were 4.30 and 3.29 respectively. The labour subcontractor performed creditably well in project delivery (time) but there is always cost overruns when compared with the initial estimates of the projects. It was also discovered that subcontractors' time performance is sometimes at the expense of work quality as a result of the speedy execution of work at hand in order to pave way for another engagement. It is therefore suggested that project monitoring and supervision should be given a priority attention if this procurement method is to achieve its expected success.

Keywords: Construction Industry, Cost, Labour-Only, Performance, Subcontractors, Time.

Introduction

Several studies (Ward, 1976; Wahab, 1976; Chua, 1996; Loh and Ofori, 2000 and Adenuga, 2003) have identified the construction industry as one of the main engines of growth in any economy. It provides the infrastructure required for other sectors to flourish, provides housing as the basic human need and it is instrumental in providing national communications network (Palalani, 2000). The construction industry also provides significant employment opportunities at non-skilled and skilled levels.

In Nigeria and globally, different project execution methods had been used and these include Traditional, Design and Build, Project Management, Management Contracting, Direct Labour and Labour-Only Systems. According to Ogunsnami and Iyagba (2003), the downturn in the Nigeria economy from 1985 to 1999 had created recession in the construction industry that makes clients and consultants to think of cheaper ways of achieving constructions. This led to modifications of existing project execution systems in favour of labour-only system. The construction industries of many countries rely heavily on subcontracting. For example, Greenwood (2001) observed that recent publications show a shift in the attitude of main contractors to labour subcontracting in the United Kingdom and this finding is in line with Fagbenle (2006). Ng (1986) also affirmed that subcontracting is common in the industry because of uncertainties in construction demand. He stressed further that main contractors do not employ construction operatives directly, rather, they engage subcontractors. In this way, the main contractors can operate with substantially reduced overheads and ensure economic deployment of labour with greater mobility for the operatives. Wong (1990) submitted that subcontractors could work faster than directly employed labour their profit is only realized if they complete the work with expedition. Subcontractors can also reduce main contractors' construction risks through proper execution of work within a set time frame. Debrah and Ofori (1997) also believed that subcontractors facilitate the work of the main contractors. Fryer (1982) regarded labour as an important resource in construction because it is the one that combines all other resources, namely, materials, plant, equipment and finance in order to produce the various construction products.

Loh and Ofori (2000) also noted that in Singapore, 60-70% of the work is subcontracted. Labour subcontracting has also been the feature of the industry in many other countries, including the United States (Gray and Flanagan, 1989) and Japan (Beardsworth et al. 1988). Hinze and Tracey (1994) who worked on some projects in Europe noted that on many projects, particularly building projects, it is not uncommon for 80-90% of the work to be performed by labour-only subcontractors. The International Labour Organizations (ILO) in its 2003 publication also reported that even in Germany where the construction labour market is still governed by a dense network of domestic regulations, the number of German companies employing more than 500 people have shrunk from about 130 four decades ago to only 50 in 2003.It further gave the instance of Germany, France and Finland where only about 25 per cent of construction workers are employed in firms with more than 100 employees. Advocates of this project execution system had however asserted that it gives cheaper, faster and better quality constructions than any other construction methods. The pertinent questions are: what is the most frequently used procedure for selecting labour-only subcontractors on construction sites?; what are the views of main contractors, clients and consultants on the performance of labour-only subcontractors in relation to time, cost, quality and safety?; what factors influence subcontractors' performance?; is the performance of labour-only subcontractors influenced by project time?; is the performance of labour-only subcontractors influenced by project cost?; does any difference exist between the time and cost performances of labour-only subcontractors on construction sites in the study area?. It is on the account of these claims that the study attempted to compare the performance of labour-only subcontractors in terms of time and cost.

Project Performance and Influencing Factors

Studies into the performance of the construction products have engaged the attention of many researchers (for example, Sidwell, 1983; Sink, 1985; Campbell, 1995 and Chimwaso 2000). Clients of the construction industry have measures for assessing contractors' performance depending on the type of client, projects and other related factors. According to Seeley (1996), the traditional project performance measures of cost, time and quality are frequently used to measure contractors' performance by clients. Sidwell (1983) identified factors influencing project time performance and concluded that client's experience, form of building procurement and project organizational structure are elements of a complex casual factor of project time performance. Several other factors affect project performance. Hatush and Skitmore (1997) grouped the factors affecting the environment of construction project under cultural, economic, political, social, physical, aesthetic, financial, legal, institutional, technology and policy. It was further argued that a project might be delayed because of a seemingly endless list of variables and that all delays usually cost money. Moreover, the neglect of quality has a detrimental effect upon time and cost performances. Other influencing factors identified include other non-traditional measures such as health, safety, material waste and management expertise (Smallwood, 2000), size and scope of project, clients influence with respect to clarity of requirements and avoidance of changes to the design (Akinsola et al. 1997).

Chuachan and Chiang (1989) undertook a survey of 100 building and civil engineering projects in Hong Kong, India, Korea, Singapore, Taiwan and Thailand. Their survey result led them to believe that the performance of a construction management team is influenced by internal and external factors which they classified as project, environment and management related. Ireland (1983)'s early work provided a more useful segregation on management factors from complexity factors. Using a case history approach on 25 high-rise construction projects, Ireland investigated two propositions: "The use of managerial actions can reduce the time taken, reduce their cost incurred and improve the quality produced of high-rise buildings. Ireland's work has made a valuable contribution to the understanding of management related construction time performance. His conclusions relate to how management reacts to environmental factors, though environmental factors are not identified and discussed as independent variables. Dissanayaka and Kumaraswamy (1999) compared contributors to time and cost performance in building projects and concluded that procurement sub-system are less significant than the non-procurement related variables in predicting time and cost performance levels on Hong Kong building projects. Chimwaso (2000) evaluated the cost performance of public projects in Botswana by identifying the factors that influence construction cost overrun. His conclusion revealed that seven out of ten projects investigated had reported cost overruns and that the five influencing factors are incomplete design at the time of tender, technical omissions at design stage, additional work at the client's request, adjustment of prime sum and provisional sum costs as well as contractual claims. Besides the fact that these studies were targeted on Hong Kong, Indian, Taiwan, Thailand and Botswana building sites, they were limited to only two factors/variables of performance measures. Moreover, none of the studies was specific on a particular system of procurement.

At the local scene, Ogunsanmi (2000) comparatively studied the performance of labour-only contracting and direct labour procurement system in three states of Nigeria and concluded that labour-only contracting performed better than the direct labour approach. The management of labour-only contracts in the Nigerian construction industry was investigated by Adenuga (2000) and he concluded that the system is becoming an increasing prominent feature of the construction labour market. Dada (2003) studied the perceptions on measures of contracting/contractors' performance, taking a case study of Lagos States' indigenous contractors. His result indicated that there are no significant differences in the assessment and ratings of the identified measures of contractor's performance. Within the limit of these findings, no literature has addressed the issue of time and cost performance of labour-only subcontractors in Nigeria and this is what this study set to achieve.

Research Methodology

The population of the main contracting firms and labour-only subcontracting firms used for his analysis are those listed in the register of the Federal Ministry of Works and Housing (FMWH), otherwise known as Federal Registration Board of Nigeria. Presently, the Federal Registration Board has four categories of registration which are based on their contract values. Table 1 further shows the contract values for each of these categories.

Based on this, construction firms registered under categories C and D were classified as main contracting firms while subcontracting firms are firms registered under categories A and B. This categorization was also arrived at from the preliminary study of on-gong projects in the study area. A total of eight hundred and eighty (880) construction firms were registered under categories C and D while categories A and B have a total of two thousand, four hundred and sixty (2,460) registered firms. The statistically required sample size is calculated from the following formula (Sediary, 1994).

$$n = n^{1} \Big/ \left\{1 + \left(n^{1} / N\right)\right\}$$

Where,

n = sample size

n^1 = S^2/v^2

n = total estimated population

v = standard error of the sampling population. Total error = 0.1 at a confidence level of 95% and S^2 = (P) + (1-P) = (0.5) x (0.5) = 0.25, where P is the proportion of population element that belong to a defined class.

Four sets of questionnaires A, B, C and D were designed to collect information on the issues raised in the literature review and objective of study. Questionnaire A was designed solely for the main contractors in the building industry while questionnaires B, C, D were designed for labour-only subcontractors, clients and the consultants respectively. A total of one hundred questionnaires were distributed to each of the four categories of the targeted respondents and this covers the southwestern states of Nigeria. The states are Lagos, Oyo, Ogun, Ondo, Osun and Ekiti. From the distribution, 75, 88, 56, and 42 questionnaires were filled and returned by the main contractors, labour-only subcontractors, clients and the consultants respectively.
The mean scores for each of the performance measures (time, cost, quality, frequency of accidents, technical and overall performance) were also computed by using the following formula (Adenuga, 2003).

Mean score (MS) = $\sum\left(\frac{f \times s}{N}\right)$

Where,
S = score given to each factor
F = frequency of responses to each rating
N = total number of responses concerning the factors
The descriptive and inferential statistical techniques were used for the analysis in this study. They include percentages, Kendall's coefficient of concordance, Chi-square test, and the correlation coefficient.

Results and Discussions

In order to know the most frequently used procedure for the selection of labour-only subcontractors on construction sites, questions were asked from the respondent main contractors. The survey (Table 2) showed that the most frequently used procedure for selecting labour-only subcontractors on site is competitive bidding with discretion in selection (60%). This is followed by negotiated selection and price (21.3%), competitive bidding with attached condition (13.3%). A small number used the price quoted by labour-only subcontractors (2.7%). This might not be unconnected with the need to forestall the award of contracts to incompetent subcontractors who might want to use the quoted lower price as a trap for securing contracts. In addition, fifty two of the respondents, representing 69.3%, submitted that contracts are normally awarded based on best price from proven subcontractors. Twelve of the main contractors (16.0%) affirmed that preference is normally given to the lowest negotiated price from labour-only subcontractors when adopting negotiated selection. Regardless of the type of procedures used in this selection, nine of the respondents (12.0%) posited that the subcontract award was based on dividing the yearly work among labour-only subcontractors in order to maintain business relations.

The respondents in each of the four categories were also asked to assess the performance of labour-only subcontractors on their sites. This assessment was based on some identified measures of performance which are time, cost, quality, frequency of accidents (safety), technical and the overall performance. This was rated on a five-point likert scale of 1 to 5 (1-poor, 2 – satisfactory, 3-good, 4- very good, and 5- outstanding).

Kendall's coefficient of concordance test of agreement between the respondents was first performed in this regard. The results (Table 3) indicated significant agreement between the respondents in the ranking of the six factors.

A hypothesis was tested here. The null and the alternative hypotheses are stated thus:

Ho – There is no significant difference in the ranking of the time and cost performance of labour-only subcontractors.

Hi – There is significant difference in the ranking of the time and cost performance of labour-only subcontractors.

Symbolically,

Ho	:	μ_1	$\neq$	μ_2
H1	:	μ_1	$=$	μ_2

The results, which are summarized in Table 4, showed that labour-only subcontractors performed best in project delivery (time) and least in terms of quality performance which of course is associated with cost overrun. The mean scores for time and quality performance are respectively 4.30 and 3.28. Cost performance was rated second from the rear in this circumstance (3.29). The results of the Chi-square test also showed a positive and strong relationship between time and overall performance of labour-only subcontractors. The results were however different in the case of cost performance as it shows no noticeable relationship with the overall performance. Their Chi-square values are 0.040 and 0.624 respectively for time and cost performance. These are summarized in Tables 5 and 6.

Again, the results of the correlation coefficient on the relationship among time, cost, quality and overall performance showed a strong and positive relationship between time and overall performance (0.444). On the other hand, a negative relationship exists between cost and overall performance (-0.081) of these specialty contractors and this is further summarized in Table 7.

From the results in Tables 3-7 and the discussions, the null hypothesis is rejected and the alternative hypothesis is accepted instead. That is, there is significant difference in the ranking of time and cost performance of labour-only subcontractors. The result support the view of Wong (1990) as well as Debrah and Ofori (1992) that labour-only subcontractors could work faster than the directly employed labour and that labour-only subcontractors facilitate the work of the main contractors

Conclusion

The data collected from the four categories of targeted respondents and the results of the statistical techniques have clearly established that significant differences exist in the time and cost performance of labour-only subcontractors on construction sites. Also, labour-only subcontractors performed creditably well in terms of project duration (time) but sometimes at the expense of quality of work. It was further revealed that cost and time overruns are normally involved in the process of upgrading work to the desired quality by the client. In most cases, clients and main contractors tend to be deceived by the time performance of these specialty contactors but there is always cost overrun when compared with the initial cost estimate(s).

It is therefore recommended that for subcontracting to be worthwhile, there must be proper project monitoring and supervision by the main contractor. By this way, the quality of work could be controlled to a very large extent.

This comparison has been made for only time and cost performance of labour-only subcontractors; it will be more desirable if the same comparison could be tested for other performance attributes of labour-only subcontractors. Moreover, comparative analysis with other procurement methods should also be investigated. This is with a view to knowing the cheapest procurement method(s).

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Appendix

Table 1: Categorization of Construction Contractors by the Federal Registration Board of Nigeria

Category	Old Value	New Value
A	Up to ₦50,000	Up to ₦ 2 million
B	₦ 50,000 – ₦ 250,000	Up to ₦25 million
C	₦ 250,000 – ₦ 2 million	Up to ₦ 100 million
D	Over ₦ 2 million	Above ₦ 100 million

Source: Federal Registration Board (2004)

Table 2: Main Contractors' Procedures for Selecting Labour-Only Subcontractors

	Main Procedures			**Sub Procedures**		
	Procedural Type	**Response**	**%**	**Procedural type**	**Response**	**%**
1	Competitive Bidding	10	13.3	Lowest Bidder	2	**2.7**
2	Negotiated Selection and Price	16	21.3	Lowest Negotiated Price	12	**16.0**
3	Negotiated Fixed Unit Price	2	2.7	Best Price from a Proven Subcontractor	52	**69.3**
4	Competitive Bidding with Discretion in Selection	45	60.0	Sharing Work to Maintain Business	9	**12.0**
5	Accept Price Quoted by Labour Subcontractors	2	2.7	Relationship with Subcontractors	0	**0.0**
6	**Others**	**0**	**0.0**	**Others**	**0**	**0.0**

Table 3: Kendall's Coefficient of Concordance Test for Time and Cost Performance

No of cases	**W**	**X^2**	**Df**	**Significant**
30	**162**	**45.508**	**10**	**0.000**

Table 4: Rating of some of the Performance Measures of Labour-Only Subcontractors by the Respondents

		Response rate					**Mean score Rank**	
S/N	**Performance Measures**	**1**	**2**	**3**	**4**	**5**		
1	Time performance	0	6	10	14	45	4.30	**1**
2	Overall performance	3	5	20	43	3	3.47	**2**
3	Technical Performance	0	6	45	14	10	3.37	**3**
4	Frequency of Accident	1	6	38	28	2	3.32	**4**
5	Cost performance	0	7	39	29	0	3.29	**5**
6	**Quality performance**	**0**	**10**	**35**	**29**	**1**	**3.28**	**6**

Table 5: Chi-Square Test Between Time Performance and Overall Performance of Labour-Only Subcontractors.

	Value	df	Assmp. Sig. (2-sided)
Pearson Chi-Square	10.024[a]	4	**.040**
Likelihood ratio	5.935	4	**.204**
Linear-by-Linear association	4.546	1	**.033**
N of valid cases			

Table 6: Chi-Square Test Between Cost Performance and Overall Performance of Labour-Only Subcontractors

	Value	df	Assmp. Sig. (2-sided)
Pearson Chi-Square	1.757[a]	3	**.624**
Likelihood ratio	2.480	3	**.479**
Linear-by-Linear association	0.229	1	**.632**
N of valid cases			

Table 7: Pearson Correlation Coefficients of Assessment of Some Performance Attributes of Labour-Only Subcontractors

	I	II	III	IV
I	1			
II	.035	1		
III	.091	.165	1	
IV	**.444**	**.081**	**.058**	**1**

I – Time performance
II – Cost performance
III – Quality performance
IV – Overall performance