Al-Azhar University Civil Engineering Research Magazine (CERM)
Vol. (40) No. (4) October, 2018

Major Residential Building Cost Variables in Egypt

Ibrahim Abd El-Rashid[1]; Mohamed Tantawy[2] and Ismael Elharony[3]

1 Professor of Construction Management, Department of Civil Engineering, Faculty of Engineering, Ain Shams University.
2 Assistant Professor, Department of Civil Engineering, Faculty of Engineering, Helwan University, P.O. Box Helwan University.
3 MSc Student, Department of Civil Engineering, Faculty of Engineering, Ain Shams University.

ملخص البحث

يعد أرتفاع أسعار الوحدات السكنية بمعدل متزايد خلال السنوات القليلة الماضية من أهم المشاكل الإقتصادية بجمهورية مصر العربية و بدراسة الأسباب المؤدية لذلك قد يكون ارتفاع تكلفة التشييد و أسعار الأراضى السكنية من أهم الأسباب المؤدية لارتفاع أسعار الوحدات السكنية.و بدراسة تأثير العوامل المؤثرة على تكلفة المبانى و المتعلقة بأعمال التشييد فقط هو الأتجاه السائد بالأبحاث السابقة فى هذا المجال مع إغفال باقى العوامل المتعلقة بتكلفة الوحدة السكنية من تكلفة الأرض السكنية و جميع نفقات المالك ذات التأثير الأعلى على تكلفة الوحدات السكنية. استخراج 73 عامل مؤثر على تكلفة المبانى السكنية تم من خلال مسح لأغلب الأبحاث السابقة و المراجع العلمية المتعلقة بهذا الموضوع.و لدراسة أهمية هذه العوامل المستخرجة تم عمل إستقصاء على عينة مكونة من 126 مشروع من مختلف قطاعات التشييد بجمهورة مصر العربية .و فى النهاية تم عمل ترتيب للعوامل ذات التاثير الأعلى على على تكاليف المبانى السكنية من خلال التحليل الإحصائى باستخدام برنامج "IBM SPSS Statistics".

ABSTRACT

Recently, residential units' prices in Egypt are rapidly increasing in an extraordinary way, although the construction expenses increase is generally in line with overall prices. Although extensive research on the factors influencing the construction cost has been performed, limited research was done to investigate total cost of buildings.

This research thoroughly studies the effect of client budget and construction cost on the total cost per square meter of residential buildings during the planning phase. This research, firstly, identifies 73 cost variables that have a significant influence on both client and construction related expenses. These variables were extracted from literature review and 126 residential projects in Egypt through a pool survey. Statistical analysis is used to rank the top influencing factors. The analysis established the relationship between variables correlation and their corresponding items weights resulting correlation score matrix for ranking variables of residential buildings in Egypt.

Keywords: Cost Variables, Residential Buildings, Total Cost

Introduction

Although extensive research has been under taken the specific factors influencing construction cost, limited international research has been done to investigate the full cost of buildings. A few researches have been conducted inside Egypt investigating the variables affecting residential buildings. These researches are

generally focusing on developing models during final design stages for measuring projects quantities.

(David J Lowe, 2006) investigate the relationship between both construction and client cost as a dependent variables and 41 independent variables classified into three categories namely project strategic, site related and design related variables. Descriptive statistics for the 41 variable were computed in addition tests for normality were conducted. Correlation analysis with both Pearson's product moment and Spearman's rank correlation methods were conducted to investigate the relationship between the ordinal scale independent variables and both the client and construction cost. Means of One-Way Analysis Of Variance (ANOVA) and its equivalent non-parametric test were calculated to measure the differences between subgroups of categorical variables.

(MARGARET W. EMSLEY, 2002) collected the final accounts sum of client and construction cost using (David J Lowe, 2006) investigated variables.19 variables were used to develop 6 regression models. The best fitting model is the log of cost backward using 14 variables resulting a Mean Absolute Percentage Error (MAPE) equals 19.3% and R2 equals .688.Hence the variables were ranked using mean value of T-test then using the number of times appears in the models.

(Christian Stoy, 2007) investigated the cost drivers of residential buildings during the early cost estimates. Data were collected from 290 residential buildings located in Germany. The median building construction cost found to be 806 euro per meter square ranged from 629 to 1013.External wall costs and technological services are the most expensive cost types according to the research. Finally, the research develop 5 regression models concluded that untransformed building construction cost is the best model with a R2 value of .633. The best regression model tested the relationship between 4 dependent variables and Building Construction Costs per m2 Gross External Floor Area.

(Brendon Lim, 2016) investigated residential cost drivers affecting estimation accuracy for small-scale residential construction projects in Australia. Data were collected from two case study projects in South East Queensland, Australia undertaken from the same organization offering a base budgets based on standard designs and materials controlling number of story above, project area, Construction type and duration, followed by interviews conducted with the practitioners involved. The research found that factors affecting large–scale projects are not affecting the small-scale projects with the same significant. The certainty and completeness of project-specific information, suitability of historical cost data, contingency allowances, methods of estimating and the estimator's level of experience are influencing the accuracy of estimation according to the research findings while, cost engineers estimate cost of small-scale residential projects based on pre-established priced bill of quantities as the research consider it to be the most efficient approach for small scale projects.

(JAMES MEIKLE, 2001) reviewed the impact of land prices and construction cost on dwelling prices in Great Britain from 1970 to 1997. The study compares construction and retail indices with dwelling prices measured 40% house price increase every 15 % construction prices increase and 20 % general prices increase. The study results showed that the reason of house prices increase is the land value increase. The study calculated the most influencing non construction element of houses prices as a ratio from dwelling price starting with 5.5 % at year 1970 ending

with 58.3 % at year 1997 which means that construction cost represented small proportion in dwelling prices.

This paper extracted 73 variables as independent variables affected the total cost divided to client cost and building cost as a main groups. Client cost has been classified to land value and others. Building cost has been classified into 11 group element. Building group elements are namely: site mobilization, substructure, super structure, envelope, doors and windows, main entrance finishes, external stair finishes, roofing system, external finishes, internal apartment's finishes and services installations. It is also ranked these variables depending on their significance on total developer cost.

Methodology

Data points were collected from 126 finished residential projects in Egypt, hence a pool survey was used to investigate projects nominal choices affecting cost elements. Variables were extracted in the guidance with reviewing literature, standard text books and standard elemental cost analysis. Pearson's product-moment correlation and Spearman's rho coefficients were used to calculate variables correlation. The top variables affecting elemental cost groups using correlation coefficients have been ranked using score matrix resulting from multiply cost elements percentages with correlation coefficients.

Data Representation

Prior to data entering phase all the ordinal, continuous and nominal variables are transformed to a range starting from 0 to 3 following majority variables range. The ordinal and nominal data with a values more than three and the continuous data are transformed to the required range. Ordinal and nominal data with choices of 0 and 1 are transformed to be 1.5 and 3.

The variables are represented as shown in the Table 1 according to variable representation type where, N = nominal, O = ordinal and S = scale. Nominal variables were numbered based on the available choices from the pool data (e.g., Isolated Footing: 1, Raft Footing: 2, Piles Footing: 3).Ordinal variables were represented the variables that are classified based on its degree of influence on project cost (e.g., Low: 1, Medium: 2, High: 3).Finally variables represented by real numbers were namely scale variables regarding measuring unit.

Table 1: Variables Representation Types

Variable	Description	Type
LOC	Project location	(N)
LNDAREA	Land Area	(S/m2)
LNDSHAPE	Land Shape	(N)
ACCSCNT	Accessibility of major centers of commercial and cultural activity	(O)
AVLSERV	Availability of community services	(S/Number)
ENV LOC	Environmental aspects of the location	(O)
LNDSUPPLY	Supply of land including land services	(O)

Variable	Description	Type
DESQLT	Architect, Structural and Electro-Mechanical Design Quality	(O)
DESFSCAT	Architect, Structural and Electro-Mechanical Consultant's and Design Fees	(N)
LCNFS	Building consent or license fees	(N)
CTYP	Type of Client	(N)
CNTRORTYP	Type of Main Contractor	(N)
DUR	Project Duration	(S/month)
CQLT	Client requirements on quality	(O)
CNTRCTFRM	Contract Form	(N)
PRCRMNT	Method of procurement	(N)
TNDRSTRGY	Tendering strategy	(N)
BARNGMNT	Arrangement of Building	(N)
BSHAPE	Building Shape	(N)
USBLEAREA	Usable floor area	(S/ratio)
STABV	No. storeys above ground	(S/Number)
STBL	Storey below ground	(N)
WLTFLR	Wall-to-Floor ratio	(S/ratio)
NAPRTMNTFL	Number Of Apartments / Floor	(S/Number)
SOILTYP	Soil Type	(N)
FOUNDSYS	Foundation System	(N)
LFCSYS	Lowest Floor Construction	(N)
EXVDPTH	Basement Excavation	(S/depth)
R.WQNT	Retaining walls Quantity	(S/ratio)
SUBWTRPRFN	Substructure Water Proofing Type	(N)
SOGWTRPRFN	Slab On Grad Water Proofing Type	(N)
CLMNSPN	Columns spans	(S/m.l)
UPRFLRSYS	Upper Floors systems	(N)
WLBRCKTYP	Walls Brick Types	(N)
EXTWLFNCH TYP	External Walls Finishing’s Types	(N)
ELS/MFNTYP	Elevation Marble/Slate Types	(N)
ELS/MFNQNT	Elevation Marble/Slate Quantity	(S/ratio)
BLCNRALTYP	Balconies Handrails Type	(N)
BLCNRALQNT	Balconies Handrails Quantity	(S/ratio)
BLCNRALSTLWGT	Balconies Handrails Steel Weight	(S/weight/m.l)
VVFN	Ventilation Void Finishing’s type	(N)
ELCRNCTYP	Elevation Cornice Type	(N)
ELCRNCEQNT	Elevation Cornice Quantity	(S/ratio)
ELOPNFRMTYP	Frames around Opening’s Type	(N)
ELOPNFRMQNT	Frames around Opening’s Quantity	(S/ratio)
ELGGRVQNT	Gypsum Groves Quantity	(S/ratio)
ELDCRNTYP	Architectural Decoration Items Type	(N)
ELDCRNQNT	Architectural Decoration Items	(O)

Variable	Description	Type
	Quantity	
ELEXTNDSTLQNT	Extended Steel Mesh Decoration Items Quantity	(O)
ELPNTILTYP	Elevation Pan Tiles Types	(N)
ELPNTILQNT	Elevation Pan Tiles Quantity	(S/ratio)
APRTMNDOR	Apartments Main Doors Type	(N)
ENTDOR	Entrance Main Door Type	(N)
ELWINSTYP	External Elevations Doors and Windows Type	(N)
ELWINSQNT	External Elevations Doors and Windows Quantity	(S/ratio)
ELFNTYP	Internal Entrance Wall Finishing's Type	(N)
ENTFLORFNTYP	Internal Entrance Floor Finishing's Type	(N)
ENTCEILFNTYP	Internal Entrance Ceiling Finishing's Type	(N)
STRFLORFNTYP	Stair Floor Finishing's Type	(N)
STRWLFNTYP	Stair Wall Finishing's Type	(N)
STRHNDRALHGT	Stair Handrail Height	(N)
STRHNDRALTYP	Stair Handrail Steel Type	(N)
ROFWTRPRF	Roof Water Proofing Type	(N)
ROFTHRMINSL	Roof Thermal Insulation Type	(N)
EXTRFLRTYPE	Side Walks and Pathways Flooring Type	(N)
FNCFNTYP	Front Fence finishes Type	(N)
FNCRALQNT	Front Fence Railings Quantity	(S/ratio)
FNCRALQNTWGHT	Front Fence Railings Steel Weight	(S/weight/m2)
IAPRTMNMRT-ELCT	Internal Mortar and Electrical pipes Existence	(N)
IAPRTMNDORFRM	internal Doors sub-frames Existence	(N)
EXTRELCQLT	External Electrical installations Specification Grade	(O)
EXTRMECHQLT	External Feeding and Drainage specification Grade	(O)
LFTN/TYP	Building lifts Type and Number	(N)

Analysis Results

Correlation analysis using Pearson's product-moment correlation coefficient and Spearman's rho Coefficients are conducted using IBM Statistics 23 SPSS computer software.

A coefficient of positive values represents that two variables are positively correlated while, the negative ones indicated the negative correlation. Values less than .1 indicates a small effect of the variable, .3 medium effect and .5 large effect.

Investigating the relationship between total residential building cost and variables affected it was studied based on multiplying the cost elements percentages (Column No.6) with correlation coefficient results (Columns No.3, 4) as shown in table 2.

No. storeys above ground variable is ranked as the most influencing variable affecting total building cost which is representing the cost decreasing for a larger construction area with an approximate equal average Pearson and Spearman's rho score values.

Type of Client variable is the second variable affecting total building cost not only affects construction costs controlling other important variables such as type of main contractor and client requirements on quality but also, all client costs items are affected by this variable. Low Spearman's rho score value of this variable indicates the cost variability among the same client type. Land value related variable were hence appeared as they affecting the item that achieved the highest percentage of total residential building cost.

Project location with average Pearson and Spearman's rho score values of .52 and .56 respectively is most influencing variable affecting land value. Availability of community services variable with average Pearson and Spearman's rho score values of .33 and .49 respectively is giving the reason of high land value at specific locations.

Client requirements on quality, Type of Main Contractor and Usable floor area are listed as the top ranked variables affecting construction cost. Average Pearson and Spearman's rho score values of .32 and .25 shows the effect of quality on the overall construction cost. Type of Main Contractor variable was achieved a higher Spearman's rho score value of .3 relative to Pearson score value of .19.

Negative score value of usable floor area is the second prove of the negative relationship between construction area and construction cost in addition to No. storeys above ground variable.

Columns spans variable achieved a higher score value comparing to upper floors systems variable as these two variables are affecting the superstructure cost. Columns spans variable achieved average Pearson and Spearman's rho score values of .23 and .19 while, Upper Floors systems variable achieved average Pearson and Spearman's rho score values of .13 and .17.

Among various envelope related variables walls brick types, external walls Finishing's, architectural decoration items type and architectural decoration items quantity achieved the highest score values. Walls brick type variable achieved a lower Pearson score value of .08 comparing to Spearman's rho score value of .13 but, External Walls Finishing's achieved a lower Spearman's rho score value of 0.14 relative to Pearson score value of .07. Architectural decoration Items type and quantity achieved the same average Pearson and Spearman's rho score values equals to .15 and .1 respectively.

Foundation System, Retaining walls quantity and soil type are the top ranked substructure related variable. Foundation system variable achieved a higher average Pearson score value equals to .13 comparing to low average Spearman's rho score value with values equals to .04. Retaining walls quantity variable achieved average Pearson and Spearman's rho score values of .11 and .07 respectively. Soil type achieved the same Pearson and Spearman's rho score value equals to .08.

External electrical installations specification grade, External feeding and drainage specification grade and lifts type and number variables are the most influencing variable affecting service installations cost. The three variables achieved approximate the same Pearson and Spearman's rho score value equals to .08.

External Elevations Doors and Windows are affected by its Type and Quantity. External Elevations Doors and Windows type variable achieved average Pearson and Spearman's rho score values equals to .08 and .07 respectively while, Elevations Doors and Windows quantity variable achieved average Pearson and Spearman's rho score values equals to .05 and .08 respectively.

Lowest Floor Construction Type was appeared as substructure affecting variable with average Pearson and Spearman's rho score values equals to .04 and .11 respectively.

Internal Mortar and Electrical pipes existence variable is appeared as the last important construction related variable with average Pearson and Spearman's rho score values equals to .06 and .05 respectively.

Finally Architect, Structural and Electro-Mechanical Consultant's and Design Fees Category and License Fees existence variables are appeared with equal average Pearson and Spearman's rho score values equals to .03 and .02 respectively. Although client cost excluding land value might achieve a high percentage reach to 14.33% from total building cost, but the high negative correlation between client cost and No. stores above ground variable representing a high client costs for a lower construction area has a more significance on client cost.

Table 2: Top Ranked Variables using Score matrix

RANK	COST INDICATOR	Pearson Correlation	Spearman's rho Coefficient	Corresponding Group Element	Element Percentage	Score Value Pearson	Score Value Spearman
1	STABV	-0.65	-0.664	Total COST	100.00%	-0.65	-0.66
2	CTYPE	0.722	0.319		100.00%	0.72	0.32
3	LOC	0.875	0.942	Land Value	59.14%	0.52	0.56
4	AVLSERV	0.553	0.826		59.14%	0.33	0.49
5	CQLT	0.836	0.648	Building COST	38.86%	0.32	0.25
6	CNTRORTYP	0.492	0.772		38.86%	0.19	0.3
7	USBLEAREA	-0.592	-0.756		38.86%	-0.23	-0.29
8	CLMNSPN	0.562	0.448	Super structure	41.41%	0.23	0.19
9	UPRFLRSYS	0.315	0.419		41.41%	0.13	0.17
10	WLBRCKTYP	0.415	0.653	Envelope	19.58%	0.08	0.13
11	EXTWLFNCH TYP	0.699	0.357		19.58%	0.14	0.07
12	ELDCRNTYP	0.766	0.497		19.58%	0.15	0.1
13	ELDCRNQNT	0.768	0.495		19.58%	0.15	0.1
14	FOUNDSYS	0.747	0.221	Sub structure	17.59%	0.13	0.04
15	R.WQNT	0.647	0.393		17.59%	0.11	0.07
16	SOILTYP	0.47	0.456		17.59%	0.08	0.08
17	EXTRELCQLT	0.688	0.66	Service installations	11.55%	0.08	0.08
18	EXTRMECHQLT	0.688	0.66		11.55%	0.08	0.08
19	LFTN/TYP	0.729	0.79		11.55%	0.08	0.09
20	ELWINSTYP	0.832	0.72	Doors and Windows	9.77%	0.08	0.07
21	ELWINSQNT	0.553	0.819		9.77%	0.05	0.08
22	LFCSYS	0.242	0.542	Sub structure	17.59%	0.04	0.1
23	IAPRTMNM	0.71	0.631	Apartments Finishing	7.97%	0.06	0.05
24	DESFSCAT	0.638	0.335	Client Cost Excluding Land Value	5.24%	0.03	0.02
25	LCNFS	0.638	0.335		5.24%	0.03	0.02

Conclusions

The paper seeks to rank the top influencing variables affecting residential buildings total cost. The significance of 73 cost variables have been verified in the Egyptian real estate market through pool application survey. Client costs including land values and construction costs were collected from 126 residential projects. Data points have been chosen to test medium, large-scale private and governmental sectors.25 variables out of the 73 variables have been ranked using correlation score matrix as the top factors influencing residential buildings total cost in Egypt.

It is found that Type of Client and Number of storeys above ground are the most significant variables affected Total Cost of residential houses. Project location, Availability of community services are the most influential factors affecting land values, while other client costs items were affected by Architect, Structural and Electro-Mechanical Consultant's and Design Fees and License fees Existence.

All-over construction costs have been affected by usable floor area, Type of main contractor and client requirements on quality, however specific items have been affected by columns spans, Upper floors systems, Walls brick types, External walls finishing's types, Architectural decoration items type and quantity, Foundation systems, Retaining walls quantity, soil type, External service installations specification grade, Building lifts type and number, External elevations doors and windows type, external elevations doors and windows quantity, Lowest floor construction, Internal mortar and electrical pipes existence.

References

[1] Kirkham, R. (2007). *Ferry and Brandon's Cost Planning of Buildings, 8th Edition*. John Wiley & Sons.

[2] Ashworth, A. and Perera, S. (2015). *Cost Studies of Buildings*. Florence: Taylor and Francis.

[3] Jim Smith, D M Jaggar, Peter Love. (2007). Second ed. Building Cost Planning for the Design Team. Spon Press.

[4] Field, Andy P. (2005). *Discovering Statistics Using SPSS*. London: Sage Publications.

[5] Lim, B., Nepal, M., Skitmore, M. and Xiong, B. (2016). Drivers of the accuracy of developers' early stage cost estimates in residential construction. *Journal of Financial Management of Property and Construction*, 21(1), pp.4-20.

[6] Emsley, M., Lowe, D., Duff, A., Harding, A. and Hickson, A. (2002). Data modelling and the application of a neural network approach to the prediction of total construction costs. *Construction Management and Economics*, 20(6), pp.465-472.

[7] Lowe, D., Emsley, M. and Harding, A. (2006). Relationships between total construction cost and project strategic, site related and building definition variable. *Journal of Financial Management of Property and Construction*, 11(3), pp.165-180.

[8] Stoy, C., Pollalis, S. and Schalcher, H. (2007). Early estimation of building construction speed in Germany. *International Journal of Project Management*, 25(3), pp.283-289.

[9] Meikle, J. (2001). A review of recent trends in house construction and land prices in Great Britain. *Construction Management and Economics*, 19(3), pp.259-265.