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Reducing the cost of Kuwaiti governmental housing projects by building expandable units

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ABSTRACT

The Government of Kuwait has embarked upon an ambitious plan to provide, for each eligible family, a two-storey housing unit, each on its own plot of land. This scheme is proving to be very expensive and extremely demanding on land. The availability of land for these housing units is now becoming a big problem.

This study presents two alternatives for the current housing systems provided by the Kuwaiti Government for Kuwaitis. In the proposed systems, the housing units would be capable of future expansion when needed. Thus, when the same family members need additional space, they can expand their housing unit instead of demanding another plot of land and house. There would not be the same resentment as there was to high-rise living, since all the family members would be sharing the same house, which has been the traditional Kuwaiti housing system. This system of expansion would reduce the demand for new land, thus reducing the size of the land acquisition problem facing the Government, and also reduce construction costs.

Two alternatives have been studied; in the first one the existing housing unit which is currently provided by the Government has been strengthened to be able to carry a third floor when the need arises, while in the second, a small house would be built initially for the starting family, then—as the family increases—the house would be expanded horizontally and/or vertically according to the increase in family size.

A cost analysis for each alternative has been carried out using the life cycle costing technique to rank them and evaluate quantitatively the corresponding savings. In the first proposal the saving would be in the range 8%–22% over the current cost, and in the second proposal the saving would be in the range 20%–29% over the current cost. The low value is based on a 10% discount rate, while the high value is for a 5% discount rate.

INTRODUCTION

The Kuwaiti Government is currently providing each Kuwaiti family with a heavily subsidized housing unit, which consists of a 400 m^2 plot of land with a two-storey house that has a total built-up area in the vicinity of 350 m^2. The National Housing Authority (NHA) is the governmental agency responsible for building these units. The first stage in construction of such housing projects is to acquire the needed land, then to develop it by providing the needed infrastructure. According to recent studies (Kuwait Society of Engineers 1982; Qaddumi & Tehrani 1985; Saeed 1988) the policy of providing each family with individual plots of land will create a serious problem in the near future (15–20 years from now).

The obvious solution to this problem is to adopt a high-rise building system, rather than the two-storey villa system currently being followed by the NHA. The NHA did, in fact, embark on such a high-rise building in their Al-Sawabar project, but it was met with great resentment from Kuwaitis who are against living permanently in apartments. This resentment forced the NHA to cancel another proposed project of a similar nature in Sulaibikhat. In a recent updating, by the NHA, of requests for governmental housing units, less than 0·6% were willing to live in apartment buildings. This left the NHA with no choice but to continue the original policy of providing villas.

This paper presents two alternatives for the current system. In the first alternative, the current house of 350 m^2 would be strengthened in order to make it possible to add additional floors in the future when needed. In the second alternative, a smaller house (250 m^2) would initially be built, then extended horizontally and/or vertically as needed in the future. A systematic evaluation of each alternative has been carried out using the life cycle costing technique to evaluate the anticipated potential savings due to implementation of each alternative.

EXISTING DESIGN

Currently the NHA offers each Kuwaiti family a house consisting of five bedrooms, three living rooms, three bath-rooms, one kitchen and a dining room. Attached to the house is a small extension to serve as a guest reception area (traditionally called a *Diwaniah*), plus enough space for a live-in maid. The total built-up area comes close to 350 m^2 on a 400 m^2 plot of land.

BASIC PHILOSOPHY OF THE HOUSING UNITS' EXPANDIBILITY AND THE REQUIRED BUILT-UP AREA

The expandibility of the basic housing unit is a function of three criteria, the first of which should satisfy the ratio between the built-up area and the area of the plot, i.e. the total built-up area should not exceed 1·2 of the plot's area. Thus, the maximum area that can be built is 480 m^2.

The second criterion is the growth pattern of the Kuwaiti family. A summary of the relevant information from the latest Kuwaiti Census (1988) is summarized in Table 1. Thus it is assumed, from this data, that the average age of boys when they marry is 22, while for girls it is 18. Furthermore, it is assumed that one child would be added to the family every three years, and the first child would get married and

Table 1. Family growth pattern for Kuwaitis

	Male	Female
Marriage age	22	18
Death age	65	72
Family growth	one child every 3 years	
Average family size	7·8	

start a family at the age of 22. The growth in family size will be assumed based on this pattern.

Thirdly, to maintain the current building space allocation per person, the NHA is currently working on the basis that the house is designed to allow 45 m^2 on average per person. They provide a total of 350 m^2 for a family which is expected to reach 8 persons. Although they are expected to reach this number after 16 years of marriage, the current practice is to provide a house which would accommodate any future growth in family size.

PROPOSED ALTERNATIVES

In the first proposal, the NHA would still provide each family with 350 m^2 of built-up area, but with a structure that is able to support an additional floor area equal to 130 m^2, to be built when the need arises. This would be needed when the first son gets married, presumably at the age of 22. The 130 m^2 would then be added to the house to accommodate the new family rather than providing the new family with a new house. As the new family would grow in size, more members of the original family would leave the house through marriage. Table 2 shows the pattern of the house's use in this proposal. It should also be noted that the first grandchild could utilize the same house and save another house at year 49 of the house's life cycle.

In the second proposal, the NHA would provide each family with a small house (250 m^2) to meet their needs for the following ten years. An extension of 115 m^2 would then be added to the house to accommodate later increases in the family's size. A second extension would be needed when the first son gets married at year 22 of the house's life cycle. Table 2 shows the expected growth in the family and the anticipated requirement for built-up area.

COST OF DIFFERENT ALTERNATIVES

Engineering and building construction cost

In order to calculate the first element of cost, namely the engineering and construction cost, a full set of drawings and specifications of the house currently built by the NHA were obtained. Fig. 1 shows the plans and elevation of a typical NHA house. A photo of NHA houses is provided in Fig. 2. Also, a full quantity survey was carried out for the different components, and the current construction costs from different local sources were obtained. The same procedure was carried out for the two alternatives. An average cost of 100 KD/m^2 was found to be representative of the building cost as of December 1988, and this figure is sufficiently accurate for the purpose of this work. This figure has also been checked against the current cost of various NHA projects for different contractors, and found to be in good agreement with the average bid. It is assumed that the cost of engineering will be similar for the different alternatives; therefore, there is no need for this cost to be included in the analysis.

Land cost and its development

The second cost element is the land. It has two main components: first, the cost of raw land and, second, the cost of providing the required infrastructure, which

Table 2. Number of people using the house throughout its life cycle and the required area for different alternatives

	Existing housing systems			Proposed alternatives			
End of year	Members of the family living in the same house	Total No. of users	Built-up area (m^2)	Members of the family living in the same house	Total No. of users	Built-up area for Alt. 1 (new + old) = total	Built-up area for Alt. 2 (new + old) = total
1	FMC	3	350	FMC	3	350	250
4	FMCC	4		FMCC	4		
7	FMCCC	5		FMCCC	5		(250 + 115) = 365
10	FMCCCC	6		FMCCCC	6		
13	FMCCCCC	7		FMCCCCC	7		
16	FMCCCCCC	8		FMCCCCCC	8		
19	FMCCCCCC	8		FMCCCCCC	8		
22	FMCCCCC	7		FMCCCCCCS	9	(350 + 130) = 480	(365 + 115) = 480
25	FMCCCC	6		FMCCCCCSG	9		
28	FMCCC	5		FMCCCCSGG	9		
31	FMCC	4		FMCCCSGGG	9		
34	FMC	3		FMCCSGGGG	9		
37	FM	2		FMCSGGGGG	9		
40	FM	2		FMCSGGGGGG	10		
43	M	1		MCSGGGGGG	9		
46	M	1		$MCSGGGGGGS_1$	10		
49	M	1		$MCSGGGGGS_1G_1$	10		
52	M	1		$MCSGGGGS_1G_1G_1$	10		
55	M	1		$MCSGGGS_1G_1G_1G_1$	10		
58	0	0		$CS_1GGS_1G_1G_1G_1G_1$	9		
60	0	0		$CS_1GS_1G_1G_1G_1G_1G_1$	9		

F = father, M = mother, C = child, S = child's spouse, G = grandchild, S_1 = grandchild's spouse, G_1 = great grandchild.

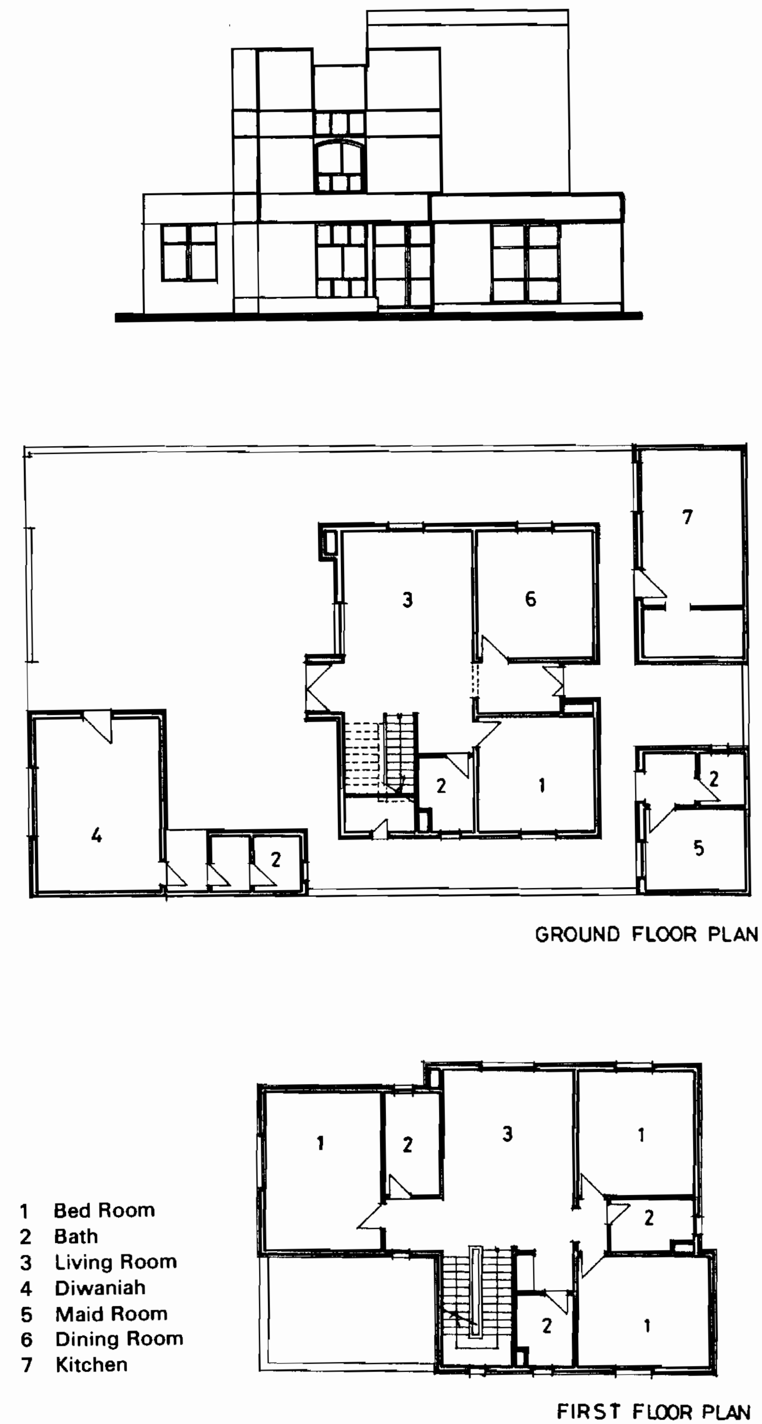

Fig. 1. Elevation and floor plans of the NHA house considered in the present study

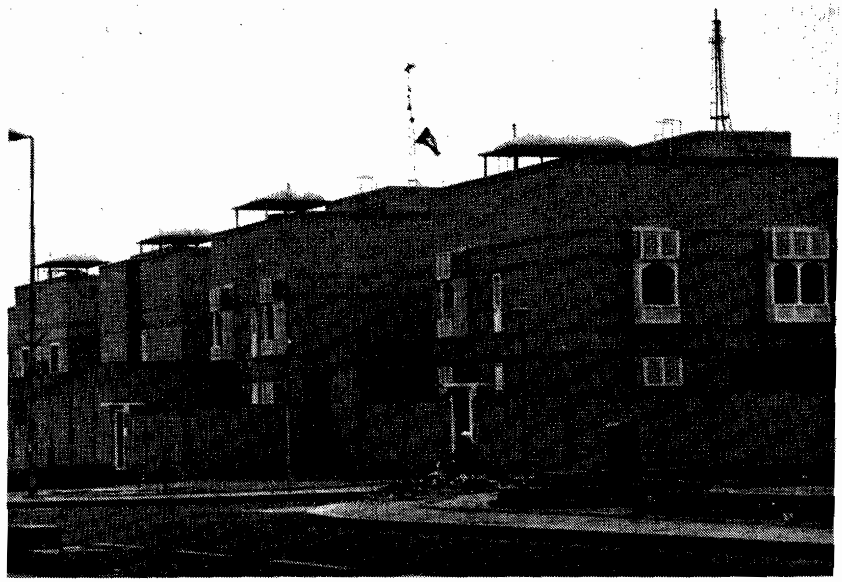

Fig. 2. A typical NHA housing project

includes the cost of storm-sewers, water mains, electricity and road works. It is very difficult to estimate the cost of raw land, since it is supplied to the NHA by the Government at no cost. For the purposes of this research, a value of 6,000 KD/house plot is assumed, based on the market value of a similar plot of land in the private sector. The second component, the infrastructure cost, can easily be obtained from the records of the NHA, which is found to be, on average, 10,000 KD/house. Thus a total cost of land and development is assumed equal to 16,000 KD/house.

Repair, maintenance and operating costs

Regarding repair and maintenance, it is assumed that their cost would be the same for the different alternatives. The only main difference would be the cost of energy, since it is a function of house size. In Kuwait, for seven months of the year, the temperature is above comfort level; consequently, the major part of energy consumed is for space cooling. A considerable amount of work has been done in the eighties by different Kuwaiti institutions to reduce the energy consumption of buildings. Currently all NHA houses have various energy-saving measures, and they are designed to be within the guidelines laid down by Kuwait's Ministry of Electricity and Water (MEW), which limit the allowable load to 65 W/m^2 of the built-up area, in addition to the energy needed for lighting and household appliances.

To estimate the energy consumption of the existing design and the proposed alternatives, a computer program was used for this purpose, where the weather information, building dimensions and properties were used as input to calculate the total energy requirements of the building. This computer program is known commercially as CL4M. It was found that the energy consumption of all the designs is within MEW's guidelines.

The present price of electricity to the Kuwaiti consumer is 2 fils/kWh (U.S. $0·007/kWh), whereas the actual production cost of electricity to the Government is

Table 3. Data required for life cycle estimation

Year	Existing system: Cost in K.D.	Existing system: Type of cost	Alternative 1: Cost in K.D.	Alternative 1: Type of cost	Alternative 2: Cost in K.D.	Alternative 2: Type of cost
1	51,000	Land and construction	52,000	Land and construction	41,000	Land and construction
2 → 10	935	running cost	935	running cost	935	cost
11						
12					12,185	First expansion
12 → 21					1,005	running
22	51,935	Land, construction and running cost	14,935	house expansion running cost	12,505	second expansion and running cost
23 → 46	1,870	running cost				
46	52,870	Land, construction and running cost				
47 → 60	2,805	running cost	1,350	running cost	1,350	running cost

18 fils/kWh. Thus the consumer is paying around one tenth of the actual cost. This is part of the Government's policy of subsidizing the cost of essential commodities. In this study the production cost of energy will be used, since it is more realistic.

Based on these figures, the cost of the different alternatives is shown in Table 3.

ECONOMIC EVALUATION OF DESIGN ALTERNATIVES USING LIFE CYCLE COSTING

Life cycle costing is fundamentally intended to determine the expenses associated with various design alternatives using the concept of equivalent costs. These expenses would include cost of acquisition, yearly operating and maintenance costs, yearly fuel and utility costs, future repairs and alterations, and future replacement of major systems. To compare between the two alternatives, an equivalent uniform annual cost (*EUAC*) should be calculated for each alternative.

The *EUAC* is a constant annual amount which, if paid throughout the assumed

life cycle of the building, equals the discounted total life costs. The $EUAC$ converts an uneven stream of expenditures, occurring over a number of years, into a constant annual amount which simplifies the comparison of alternatives.
Mathematically, the $EUAC$ is expressed as follows:

$$EUAC = CR\{(I)(PV) + \sum_{a=1}^{n} (PV_a) \times (R + O_a E_a + M_a) + S(PV_a)\} \quad (1)$$

where
$EUAC$ = equivalent uniform annual cost
CR = capital recovery factor
I = initial costs of design, development and construction
PV = present value factor, an appropriate factor to bring the cash flow to the initial point in the life cycle analysis.
$\sum_{a=1}^{n}$ = the sum as a varies from $a = 1$ to the end of the building's life cycle, n
R = cost of replacing building components during the building's life cycle
O_a = annual operating cost for the ath year in base year, K.D.
E_a = differential escalator for the ath year to adjust utility cost for future rises in price greater than the general price level. In the absence of strong evidence to the contrary, it is assumed that all general price level changes inflate or deflate at the same rate and therefore need not be included in the analysis
M_a = annual maintenance cost for the ath year in base year, K.D.
S = salvage value of the building and land at the end of the building's assumed life cycle.

As can be seen from the equation, the $EUAC$ is obtained by multiplying the costs of each year of ownership by the present value factor, summing these to reach the present value of the total life cycle cost, and then multiplying this value by the capital recovery factor.

Mathematically, CR is expressed as follows:

$$CR = \frac{i(1+i)^n}{(1+i)^n - 1}$$

where i = discount rate, and n = number of years. The purpose of this capital recovery factor is to convert a one-time cost investment into an equivalent uniform cash flow, at a certain discount rate for a certain period of years.

The mathematical expression for PV is given in Macedo *et al.* (1978) and Dell Isola & Kirk (1981).

The discount rate represents an estimate of the average rate of return on private investments before taxes and after inflation. It is assumed equal to 10%, and also to 5% for comparison. Thus, once the value of the variables given in Equation 1 have been established, the $EUAC$ for the different alternatives can be calculated.

RESULTS OF THE ANALYSIS

Building an expandable housing unit can reduce both the construction cost and the running cost, as can be seen from Table 3 which summarizes the required cost data in Kuwaiti dinars for the life cycle cost analysis. In this analysis, costs that are identical for alternatives are ignored. The only costs included in the analysis are the significant, different costs of alternatives that could influence their ranking. Using

Table 4. Economical comparison of the existing case and the proposed alternatives

	Present NHA house	First alternative	Second alternative
(a) Interest = 5%			
Present worth (KD)	94,592	73,511	67,405
EUAC (KD)	4,997	3,883	3,560
(b) Interest = 10%			
Present worth (KD)	62,937	57,958	50,444
EUAC (KD)	6,314	5,814	5,061

the data in Table 3 to calculate the *EUAC* for the existing design and proposed alternatives, the results are summarized in Table 4.

Table 4 shows that the best economic value is achieved by adopting alternative no. 2, where the saving is found to be 20% for $i = 10\%$, and 29% for $i = 5\%$. Alternative 1 is also more economical than the existing system; adopting this alternative would result in a saving of 8% for $i = 10\%$, and 22% for $i = 5\%$. Moreover, the land shortage problem would be reduced, since less new land would need to be developed, and extra costs for roads, infrastructure, and so on, would be reduced.

CONCLUSIONS

A life cycle costing analysis for two alternatives to the current Kuwaiti Government policy, where a 350 m^2 house built on a 400 m^2 plot of land is allocated to every family, is presented.

1. In the first alternative, the existing house would be strengthened to accommodate an additional storey when needed. This would result in a saving of 8% where the interest rate is 10%, and 22% where the interest rate is 5%.
2. In the second alternative, a smaller (250 m^2) house would be built first, which could later be expanded horizontally and/or vertically as the family size increases. This would result in a saving of 20% over the present system, where the interest rate is 10%, and 29% where the interest rate is 5%.
3. The two proposed systems should relieve the land shortage problem facing the Government, and development costs for new areas would also be reduced. Furthermore, the waiting period to acquire a house could be decreased since more than one family would occupy each house, thus reducing the number of applications for new housing units.

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خفض كلفة مشاريع الإسكان الحكومي
عن طريق بناء وحدات قابلة للتوسعة

حسين الخياط و سامي فريج
قسم الهندسة المدنية بجامعة الكويت
ص . ب . ٥٩٦٩ ، الصفاة ١٣٠٦٠ ، الكويت

خلاصة

تتبع الحكومة الكويتية سياسة طموحة بمقتضاها توفر الحكومة لكل أسرة كويتية مستحقة سكنا خاصا على قطعة مستقلة من الأرض . وهذه الخطة مكلفة خاصة من حيث الطلب على الأراضي . وهذه الدراسة تطرح فكرة بديلة لنظام يقوم على أساس بناء وحدة يمكن توسعتها مستقبلا عند الحاجة . وهذه التوسعة قد تكون أفقية أو رأسية أو كليهما معا . وتتم هذه التوسعة لاستيعاب الزيادة في أفراد الأسرة الواحدة . وبدلا من طلب أرض ومنزل جديد لأحد أفراد الأسرة فإنه يمكن إضافة مساحة البناء المطلوبة للأسرة الجديدة إلى الوحدة الأصلية ، مما ينتج عنه التوفير في الأراضي المطلوبة وفي كلفة البناء . وتقوم الدراسة ببحث تكلفة النظام الحالي مقارنة بالنظام المقترح من خلال دورة حياة المنشأ . ويدخل في هذه التكلفة تكاليف الأرض والصيانة والطاقة . وكذلك يقيم البحث هذه البدائل ، ويحدد بشكل كمي مقدار التوفير المتوقع من اتباع هذا النظام المقترح .

قدمت الدراسة اقتراحين : الأول عن طريق تقوية البناء الحالي ، حتى يمكن تعلية دور عند الحاجة ، وقد انخفضت التكلفة نتيجة هذا الاقتراح بمقدار ٨٪ على أساس نسبة عائد ١٠٪ ، وبمقدار ٢٢٪ على أساس نسبة عائد ٥٪ . والاقتراح الآخر هو بناء وحدة صغيرة مبدئيا ، ثم تتم التوسعة عند الحاجة ، وقد نتج وفر في التكلفة باستعمال هذا الاقتراح مقداره ٢٠٪ على أساس نسبة عائد ١٠٪ ، وبمقدار ٢٩٪ على أساس نسبة عائد ٥٪ .