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Precast building systems in Kuwait housing projects

HUSAIN AL-KHAIAT AND NABIL QADDUMI

Department of Civil Engineering, University of Kuwait, P.O. Box 5969, Safat 13060, Kuwait

ABSTRACT

The present public housing projects in Kuwait cannot cope with the increasing demand for houses. The supply of governmental housing units can be increased by accelerating the construction process. One method of achieving the above target is by employing prefabricated building systems. In this paper, the current building systems used in public housing projects are reviewed and the past experience and problems with prefabricated systems are evaluated. The technical views on the possibility of using prefabricated building systems were ascertained through workshop interviews and questionnaires with experts from precast building companies, consulting offices, contractors, and government officials. Modifications that recipients of public houses made on them were studied. Traditional and precast building systems were evaluated for an existing housing project and a comparison is made for determining the cost and project duration for each system. Final recommendations in addition to the impact of the use of precast building systems in public housing projects in Kuwait are presented.

INTRODUCTION

The problem of government housing in Kuwait stems from the inability to satisfy the housing demand by Kuwaiti families. A waiting list of more than 32,000 applicants exists and is increasing annually (The National Housing Authority 1987). The supply of governmental housing units can be increased by accelerating the construction procedure as well as intensifying the building activities. One method of achieving the above is by employing prefabricated building systems in the National Housing Authority's (NHA) projects.

This paper evaluates the current building systems used in NHA housing as well as identifies and assesses the problems of past NHA prefabricated housing projects. It also investigates alternative building systems and makes recommendations as to which will offer the best performance, based upon certain criteria, in addition to their ability to produce a greater supply of quality houses.

Prefabricated building systems are used widely in many countries. In the neighbouring country of Saudi Arabia, the use of such systems in housing started late. However, it succeeded in constructing projects in shorter periods than traditional building systems. The cost is high but has decreased with the continued use of

prefabricated systems (Kenney 1984). A precast building system is being implemented in Jordan. The precast units can be used to construct 25 different housing units. Construction is fast and simple but the cost is still higher than cast-in-situ systems since the project is in the early stages (Royal Jordanian Scientific Society 1980). Prefabricated plants in Israel were started in the 1950's. In 1975, 60,000 housing units were constructed, and in 1979, the number decreased to 38,000 units. Almost 50% of the social housing is built using prefabricated building systems (Harari 1981).

In general, the use of prefabricated systems has more success cost-wise in Eastern Europe and other socialist countries since the same precast units are used in many projects and for longer periods. Therefore, the cost is lower than traditional systems. In Western Europe and other industrialized countries, the cost of prefabricated projects is equal to or slightly higher than cast-in-situ projects (Lewicki 1976; ACI 1974). However, prefabricated systems are superior in speed and simplicity (Lewicki 1976).

BUILDING SYSTEMS IN HOUSING PROJECTS

Until 1985, buildings of housing projects in Kuwait consisted of reinforced concrete skeletons of beams and columns supporting slabs. Curtain walls of concrete covered with sand-lime bricks were used. Since 1985, flat slab construction is used where beams are eliminated to allow for modifications often made by recipients of these houses. Prefabricated building systems were used in only one project, East Ahmadi Project completed in 1979. It consists of 806 units established for limited-income families. Each unit includes a reception area, living room, kitchen, two bathrooms, three bedrooms, and balcony.

In 1981 a study was made through a questionnaire meant for 404 family recipients of these units (see Al-Khaiat & Qaddumi 1987). The results reflect the opinions

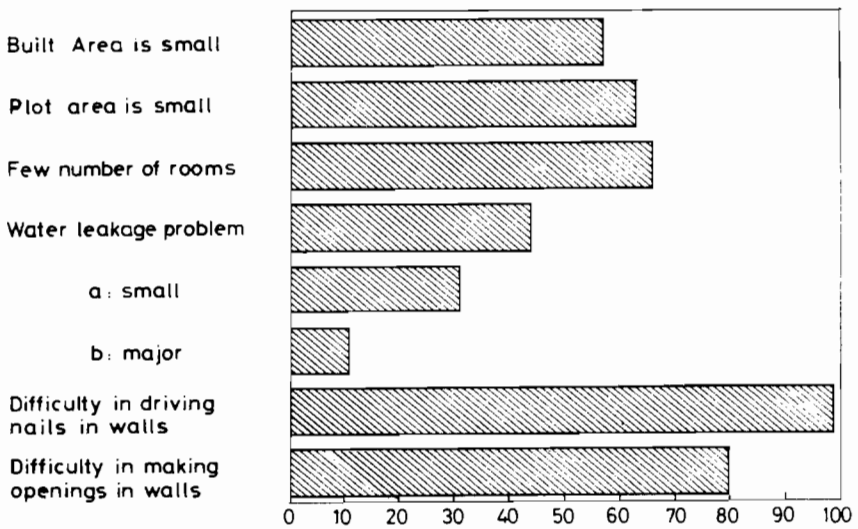

Fig. 1. Views of the East Ahmadi Project occupants.

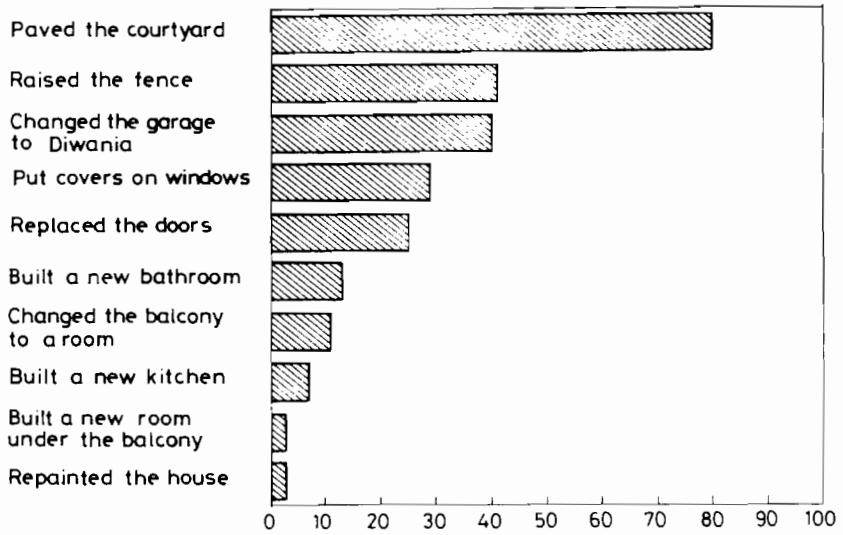

Fig. 2. Types of modifications carried out by occupants (E. Ahmadi).

of the recipients and the modifications made on the houses by them (Figs 1 and 2). Fig. 3 shows the cost of the modifications borne by the families. As a result of these modifications and problems, prefabricated building systems were eliminated in new housing projects. However, the results of the questionnaire revealed that the only significant problems associated with the use of prefabricated building systems in that project were water leakage, difficulty in driving nails in walls, and difficulty in making openings in walls. The second and third problems can be solved by proper architectural design to avoid the need for doing them in future.

It should be noted that the project was the first housing project undertaken by the prefabricated building company in charge. The building company had to interact with 3rd and 4th class sub-contractors usually involved in the NHA projects, whereas previously it had dealt with 1st and 2nd class sub-contractors. Contractors

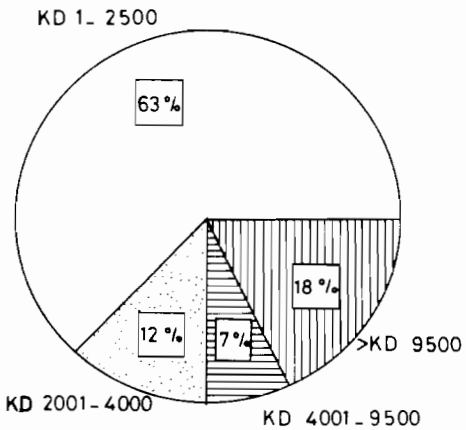

Fig. 3. Cost of modifications carried our by occupants (E. Ahmadi).

in Kuwait are classified into 4 classes; first class contractors are the best. It should be noted that NHA's design was not flexible.

PRECAST COMPANIES

In Kuwait there are six companies which specialize in precast work. They act as main contractors, sub-contractors or they sell units. While they concentrate on the production and erection of precast units, in many situations they also use cast-in-situ concrete construction. These companies produce a wide range of precast elements. Pre-stressing and post-tensioning of structural elements are also used in some of their projects. The companies have a good reputation as fast builders of high quality. They have completed many projects such as parking buildings, office buildings, schools, pedestrian bridges, electric sub-stations, water front and other projects. Since 1980, the National Housing Authority contracted these companies to build all schools within the NHA projects. These companies have the ability to produce about 500,000 m^3 of concrete per year. At present they operate at 40–50% capacity. The companies expressed the ability to construct the following in one year: 35 schools, 10 multi-storey parking buildings, 300 electric sub-stations, 1000 housing units (skeleton type with or without facade wall units, or load-bearing wall type).

In addition, they can continue producing the regular precast elements (e.g. terrazo tiles) and construct private and public buildings such as office buildings, shopping centres, pedestrian by-passes, etc. In many communications with the NHA, the precast companies have repeatedly expressed their interest and willingness to participate in housing projects.

TECHNICAL VIEWS

The technical views on the possibility of using the prefabricated building system in housing projects in Kuwait were ascertained on the basis of a questionnaire discussed at a workshop attended by representatives of various firms. The invitation to attend the workshop was extended to all first and second class contractors, all main engineering firms, all involved government agencies dealing with construction, and all precast companies. Those in attendance and others who belong to the above categories but could not participate in the workshop answered a questionnaire which was developed for this study. The breakdown of the respondents in the questionnaire numbering 82 is as follows:

Owners 6	(7·3%)
Architects 10	(12·2%)
Structural engineers 9	(11·0%)
Designers 15	(18·3%)
Manufacturers 4	(4·9%)
Contractors 32	(39·0%)
Engineering consultants 6	(7·3%)

The questionnaire attempts to draw conclusions as to whether the precast systems to be used in the housing sector are preferred to traditional systems. Prefer-

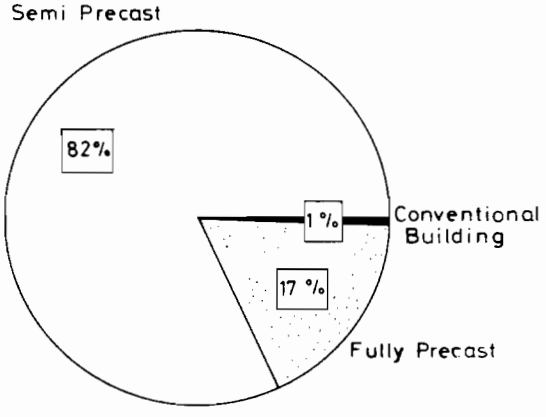

Fig. 4. Technical views about the most suitable precast systems.

ence emerges from several variables. These variables include cost-effectiveness, construction time, design and architectural flexibility, durability, technical feasibility, constructibility, social acceptance (consumer preference), construction management and coordination. General conclusions also were sought from the participants.

Answers allowed us to identify the most significant factors in the use of precast building systems in the order of importance as follows: reduction in project time, ease of management and control, cost effectiveness, quality control, durability, requirement of minimum construction skills, architectural flexibility, and design flexibility.

Even though cast-in-situ contractors constitute about 39% of the questionnaire respondents, 92% support the use of precast systems in housing projects. However, 82% think that a semi-precast system is more suitable for Kuwait (Fig. 4). The answers concerning the type of prefabricated elements to be used are shown in

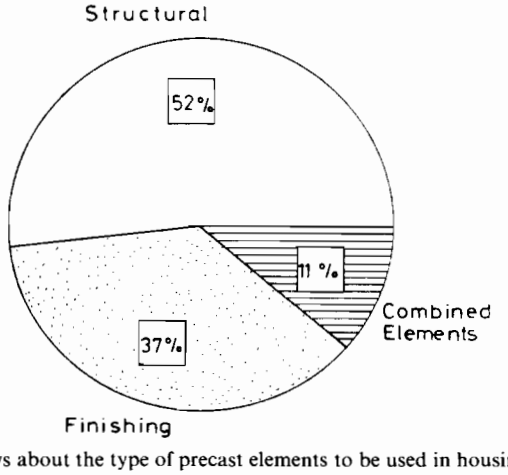

Fig. 5. Technical views about the type of precast elements to be used in housing projects.

Fig. 5. In general, most of the engineers support the use of precast system provided good management, skilled labourers, and flexible designs are ensured.

USER CHOICE

The end user of any housing project should be considered before a decision on the use of precast can be made. Instead of conducting questionnaires for people who have not lived in precast buildings (most have not even entered a precast building) an alternative way was considered. The only problem expected to be faced by the end user is flexibility of the design. Therefore, it was sufficient for the authors to know the previous modifications that the recipients of NHA housing made in order to suggest suitable precast systems. Houses were visited in various projects and all the modifications were noted. The significant modifications include the replacing of the concrete fence, removing of partition walls, partial alterations in external walls and in few cases complete removal of the external walls. Other modifications are either addition, which can be made independent of the kind of building system used, or less frequently, alterations. Therefore, if changes are to be allowed, the following must be considered:

1. Precast units should not be used for the fence, or such fence structure should be developed which is easily removable.
2. Precast units should not be used as partition walls.
3. For external walls.
   (a) If the built-in area occupies most of the plot and expansion is not possible, then precast units can be used in the external walls as load-bearing walls.
   (b) If expansion is possible in one or in two opposite directions, then precast load-bearing units can be used in the other two directions only.
   (c) If expansion is possible in three directions or two non-opposite directions, then precast load-bearing units should not be used in the external walls.

BUILDING SYSTEMS

The objective of the study is to determine whether the usage of precast system can accelerate the construction process and therefore increase the supply of housing units. Hence, the construction time duration of housing projects must be determined for precast building systems and compared to that of traditional building systems. The comparison is made for an actual NHA project in West Fintass, Section B. Cost and duration of the project are determined for the following building systems:

1. Traditional building system: cast-in-situ building.
2. Semi-precast System 1: beams, columns and slabs are precast; the rest of the building is cast-in-situ.
3. Semi-precast System 2: similar to semi-precast system 1; in addition, external walls are also precast.

The cost of the three systems was calculated based on the bills of quantities and cost of materials used in NHA, and cost of precast elements used in the six local precast companies. An extra 15% was added to cover administration costs and contractors' profits. Duration periods were determined using the computer prog-

Table 1. Cost and duration period

	Traditional system	Semi-precast system 1	Semi-precast system 2
Cost (KD)	43,000	45,000	44,000
Period (days)	244	188	107

ramme PROMIS. Table 1 shows the results of the comparison for a housing unit. The cost and duration shown are for the finished house, including all utilities.

The difference in the cost of a house is less than KD 2000 (1 KD = 3·3 US$), i.e. less than 5% of the cost of a traditional building unit. However, the superiority of precast systems is clear in the construction duration.

IMPACT OF PRECAST SYSTEMS' USE

Adoption of a precast systems' policy would produce notable impact on several groups. These impacts are:

A. *The National Housing Authority:*

1. Reduction in the duration period of projects.
2. Increase in the cost (about KD 2000 per house), necessitating development of new more economic prefabricated systems.
3. Change in the supervision mode to include precast factories.
4. Availability of various alternatives for the use of precast units that range from limited use in components of the house to a fully precast house.

B. *Precast building companies:*

1. Increase in production and demand.
2. Increased competition with increased demand; therefore cost should go down.
3. Need to upgrade quality management at the factories.

C. *Recipients:*

1. Better quality housing in a shorter waiting period.
2. Modifications on the house will become dependent on the type of precast building system.

D. *Traditional contractors:*

1. The use of precast building systems affects traditional contractors and importers of building materials.
2. The use of semi-precast building systems, where traditional contractors work with precast building companies, requires the presence of an independent project manager, otherwise the precast company should act as the main contractor.

In addition, the following must be considered when precast building systems are to be used in housing projects:

1. Design of the houses must be flexible to allow for necessary future modification.
2. The aesthetics of the present exterior precast units must be improved to enhance acceptance of precast systems by the recipients.
3. Skilled labourers should be available; they are required for precast systems.
4. The project manager must be capable of managing the various activities of several contractors to avoid delays and the need for storage of precast units at the site.
5. To reduce the cost of precast houses, the number of sizes and shapes of different precast units should be kept at a minimum, but they should be of such configuration as to allow maximum flexibility.
6. The present capability of the six precast companies is 1000 units per year.
7. Precast systems must be used on trial basis at first to assess their use.

CONCLUSIONS

The study shows the possibility of the use of precast building systems in housing projects to increase the supply of good quality houses. The following are the recommendations of the study:

1. The use of precast building systems should complement the present building systems used in housing projects and not replace them. This calls for a closer look at the precast building systems so that ways and means could be suggested to improve the capabilities of the six local precast building companies to meet the rocketing demand for houses.
2. Precast building systems should be used considering their advantages and disadvantages, the significant factors in their use, and the impact of their use, as discussed in this paper.
3. Precast building systems should be used in various degrees ranging from limited use of some precast units to fully precast buildings.
4. To allow for modifications on the house given by the NHA, the following should be considered:
   (i) Precast units should not be used as partition walls.
   (ii) Precast units should not be used as load-bearing walls if expansion is possible in the direction of the wall.
5. Precast building systems should be tried by all the six precast building companies in a sufficient number of housing units before new evaluation is made. Furthermore, each company should be evaluated independent of the other.
6. Modifications done on prefabricated houses by the occupants should be limited and controlled.

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أنظمة البناء الجاهز في المشاريع الإسكانية في الكويت

حسين علي الخياط ونبيل هاني القدومي
قسم الهندسة المدنية بجامعة الكويت ،
ص . ب . ٥٩٦٩ ، الصفاة ١٣٠٦٠ ، الكويت

خلاصة

لا تستطيع مشاريع الاسكان الحالية في الكويت مواكبة الطلبات المتزايدة على السكن الحكومي ، ويمكن زيادة عدد الوحدات السكنية المقدمة عن طريق مضاعفة معدل عملية الانشاء . واستخدام البناء الجاهز في المشاريع الاسكانية يمكن أن يؤدي إلى ذلك . وهذه الدراسة تستعرض نظم البناء الحالية وتجربة استخدام البناء الجاهز في المشاريع الاسكانية السابقة ، كما تأخذ بالآراء الفنية ورغبات المواطنين من خلال التعديلات التي قاموا بها في البيوت الحكومية . وتعرض الدراسة أيضا مقارنة بين البناء التقليدي والبناء الجاهز من حيث وقت وتكلفة إنشاء المساكن . وتقدم الدراسة التوصيات الواجب اتباعها لاستخدام البناء الجاهز وانعكاسات اتباع نظام البناء الجاهز على الجهات العديدة في الكويت .