Construction of pekeliling flats, kuala lumpur

Introduction to Case Study

Pekeliling Flats is situated on the Lebuhraya Mahameru-bound Jalan Tun Razak, Kuala Lumpur. The flats are also known as Tunku Abdul Rahman public flats. Pekeliling flats are one of Kuala Lumpurs earliest public housing projects and were built in 1967. There were 11 residential blocks comprising 2, 969 units.

For the construction of the first pilot project, the Government held a negotiation with a joint venture company Citra/Boon & Cheah which intended to use the French Tracoba System of construction. But the negotiation was unsuccessful and the project was subsequently opened to public tender. The tender was eventually awarded to Gammon/Larsen Nielsen using the Danish System of large panel industrialised prefabricated system.

The construction was then launched in 1968. The scheme at Jalan Pekeliling comprises 4 blocks of 4-storey flats and shops, 7 blocks of 17-storey flats, totaling 3009 units and was completed within 27 month, including the time taken in the construction of the RM 2. 5 million casting yard for the prefabricated elements at 10½ miles Jalan Damansara.

The whole construction of the flat is constructed using the prefabrication of concrete box method which is similar to the “ British Truscon System” whereby a standard through-shaped concrete boxes, which incorporate facade walls made from lightweight materials, ceilings consisting of plaster boarding stapled and as well as internal fittings.

Assembling Method

- The boxes are made by precasting the walls panels with ribs downwards and smoothing down the concrete as it has semi-set. Once the walls have hardened, they are then removed from the moulds by means of an overhead gantry and placed into a jig.
- Foundations pads are cast and on top of these precast concrete beams, inverted “ T” cross section are then laid.
- The boxes are now unloaded directly from the lorry and are placed in position upon these inverted ‘ T’ beams.
- Once the boxes, which form one course from facade to façade have been bolted together along the wall.
- After the boxes are connected together at the structural floor level of two connector plates, which are bolted with bolts to threaded inserts on either side of the joint.
- Once the boxes, which form one course from facade to façade have been bolted together along the wall, where again the cast-in sockets which joined by steel plates and bolts, there only thin vertical joints visible.
- The vertical channels between the adjoining ribs of the end-to-end boxes make rigid cross-walls of remarkable sound insulation.
- Horizontal reinforcement rods are lowered and concrete is cast-in, resulting in the formation of a party wall.

Evaluation and Comparison

Cost

Industrialised prefabricated construction of the Pekeliling project was more expensive than the conventional system. Its cost was 8. 1% higher than a conventional housing project completed around that time.

There are many advantages you can get if you are using precast construction method instead of using in-situ construction method. One of the advantages is the cost implication. Using precast construction method can save money or reduce the cost of construction because:

- Time

Mass production as well as off-site production shortens project timeline, gives earlier return on investment, allowing earlier occupancy and keep in schedule. It is estimated that a precast structure takes up to 20% less time to construct than a similar cast in situ structure. For example, the walls of a building can be manufactured while on-site foundations are being built. If the time is over the schedule or due date, the company needs to pay the damages.

- Durability

Provides long service for high use applications and does not require regular maintenance; save cost in long term.

- Waste Minimization

Fewer materials are required because precise mixture proportions and tighter tolerances are achievable. Less concrete waste is created due to tight control of quantities of constituent materials. Waste materials are more readily recycled because concrete production is in one location. Sand and acids for finishing surfaces are reused. Steel forms and other materials are reused. Reduced requirements for formwork, access scaffolding and less reliance on wet trades. The reduced requirement for site supervision by the main contractor also saves money. Compared to cast in-situ concrete, the following percentages of savings can be expected: 75 per cent in terms of formwork and scaffolding and 90% for wet concrete. Recyclable – precast concrete structures in urban areas can be recycled into fill and road base material at the end of their useful life.

- Fewer trucks and less time are required for construction because concrete is made offsite; particularly beneficial in urban areas where minimal traffic disruption is critical. When fewer trucks are required means lesser the cost needed to rent vehicles.
- The reduction in site labour – which partly offsets a shortage of skilled site workers.

Priced in the $55 – $65 range per linear foot of wall, precast systems are competitive with other foundation walls, particularly when costs are examined as an assembly that includes footings and sub-slab drainage. Precast walls can be installed quickly in any weather. Because the concrete is cured in the factory, precast foundations can be backfilled as soon as the slab is placed and first floor bracing is in place, enhancing jobsite safety and site accessibility. Door and window openings, steel beam pockets, and brick ledges must be cast into the panels, so orders must be customized. The wall sub-base must be compacted and leveled, similar to precision required of footings.

In making cost comparisons between alternative systems, it is imperative that total like for like costs are considered. There are substantial savings to be made using precast construction which are not evident when a direct elemental cost comparison is made with alternative construction methods. To get an accurate like for like cost, whole building costs must be estimated. To accurately assess whole building cost, each of the advantages of precast must be accurately costed.

Savings through factors such as earlier completion dates, inbuilt fireproofing, reduced formwork, scaffolding, reduced wet trades and increased budget control can be significant. Also, fast-track procurement and construction may minimise capital costs by reducing financing costs and securing earlier rental income. The precast frame package typically includes columns, beams, floors, wall panels, stairs, landings, balconies etc., all of which have an inbuilt minimum one-hour fire protection.

Specialist precast frame producers will assist design teams in evaluating the scope for standardised precast components for a particular project. Budget costings and erection programmes can be prepared by the precaster on receipt of outline drawings and a list of performance criteria.

For contractors and specifiers, there is a big difference between price and cost. While price is but one element of cost, it is the initial, most visible and the easier of the two to understand. Focusing on price is not a preferred strategy in any business, especially where high-quality, reliable manufactured goods are concerned. Instead, for precast concrete products, the focus should be on the Total Cost of Ownership (TCO).

How is TCO calculated? The Total Cost of Ownership is equal to the sum of the four cost components: quality, service, delivery and price.

In terms of cost elements, a distinct advantage of precast concrete over cast-in-place (CIP) is speed of delivery and ease of installation, or service. Both contribute directly to lower Total Cost of Ownership. Precast concrete, especially when produced in certified plants, boasts the additional benefit of higher quality. Controlled batch proportions placed under uniform conditions consistently creates a better product than can be cast in place. For illustration purposes, we will use an ordinary precast underground structure.

On the construction site, scheduling is an important, unpredictable and expensive risk. Nature stacks the cost odds against CIP concrete. It is a much quicker and less risky choice to have the precast delivered and installed the same day rather than excavate, form, pour and strip the CIP concrete, cure, damp proof and backfill. Given the cost matrix in Example 1, it could save six days in construction scheduling.

For illustration purposes, consider a typical below-grade structure. For the inside dimensions of a 4-by-8-by-4-foot structure of either precast (6 inches thick) or CIP (8 inches thick), assume these facts:

- CIP requires three separate days to pour the base, walls and top. Curing and stripping adds one day to each step, requiring six days to cast on site.

- Damp proofing adds one day to the CIP process, totaling seven working days of open-hole time.
- Allowing an average $350 per cubic yard for small jobs (ready mix, rebar, mastic, labor and equipment), the 4 cubic yards of CIP required prices out at $1, 400.
- Precast takes only one day to deliver and install, including backfill of the pre-damp proofed unit.
- The precast alternative to produce and truck to the job site prices out at $2, 000.
- Installing the precast requires a four-hour minimum charge of $400 for a 20-ton crane.
- Hardware costs for fittings, embedded items, etc., are identical for precast and CIP.

The TCO of precast is fixed at $2, 400. However, the TCO of CIP is just beginning at $1, 400. That raises the question among doubters as to why a contractor would spend more for precast. But many savvy contractors and specifiers recognize that their costs are actually less with precast.

The six days of additional scheduling are required by the mechanics of pouring and curing concrete on site. The work could be done off site in a quality controlled precast plant while other work on site progresses. Even if a contractor has a concrete crew doing multiple projects on site, the efficiency gained by substituting as much precast as possible cannot be ignored.

A contractor saves money for every minute he or she is ahead of schedule. If a $1 million contract yields a 10 percent profit margin and can be completed in 10 months that equates to $10, 000 per month, or $333 per day in profit.

Saving six days means an additional profit of 6 x $333 or $2, 000. Furthermore, that savings is compounded by the elimination of general conditions costs of about $500 per day for the burden of supervision, insurance, fixed and variable job site costs, etc.

And these are just actual costs. Add to this the avoidance of liquidated damages, and the cost advantage of precast concrete becomes the overwhelming choice. The cost advantages are summarized in Example 2.

Speed

The project took 27 months to complete, inclusive of the time taken in setting up the precasting factories. The construction period was comparable to the fastest conventional construction. Thus industrialised building has the following advantages in terms of time saving.

1. Saving of time and materials involved in the erection of scaffoldings
2. Shorter construction time as a result of well planned and co-ordinated sequence of construction
3. Not affected by weather condition as building components are manufactured in the factory, and there is no on-site concreting.

Labour Requirement

Industrialised prefabricated system enable labour saving of 30%-40% mainly of skilled labour such as brick layers, plasterers and carpenters. In Malaysia, skilled labour in the building industry is scarce so it is expensive. The introduction of industrialised building system can obviously improve the situation.

As we all know, labour can divided into three types. There are unskilled labour, semi-skilled labour and skill labour. Labour productivity is defined as the manhours required to complete the structural element of one unit house. A total of 499 data points were obtained from seven residential projects constructed between January 2003 and April 2004. Analysis of Variance (ANOVA) indicated that the labour productivity was significantly different between four structural building systems for example. The mean labour productivity for conventional building system was 4. 20 manhours followed by cast in-situ table form manhours, cast in-situ half tunnel form 1. 88 manhours and precast concrete system 1. 33 manhours. Furthermore, the analysis of crew size indicated that the mean crew size for conventional building system of 24 workers was significantly different from the IBS of 22 workers. However, the crew size within the IBS was found to be insignificant. The cycle time measured in days per house was found to be significantly different between structural building systems with the conventional building system of 4. 9 days, cast in-situ table form of 3. 9 days, cast in-situ half tunnel form of 2. 9 days and precast concrete system of 2. 3 days.

The labour productivity obtained from this study could be used as a preliminary guideline for client or consultant to identify the most appropriate building system for carrying out a construction project and determining the labour requirement in the construction industry. Further, the comparison of crew size indicated that the conventional building system of 22 workers was significantly different from the IBS of 18 workers. Similarly, the cycle time of 17 days per house for conventional building system was found to be significantly different from the IBS of four days. As a conclusion, using conventional method require more labour to be done on site compare to the pre cast construction or Industrialised Buildiing System (IBS). When using precast, the requirement of labour will reduce because there is less work to be done site. The number of labour also will small compare to the in- situ construction method.

Quality

The finished appearance of the building was of a much higher quality than that achieved in conventionally built low cost housing units. In particular, the finish of interior walls was much better to that achieved using cement-sand hollow blocks. There were serious environmental problems and some stresses were caused as a direct result of the detailing of the system. These problems can be overcome by changes in the detailing.

Productivity

There are many essential elements in construction industry. One of them is construction labour productivity. Its principal applications include construction planning, scheduling, cost estimating, accounting and cost control. As a matter of fact, international labour factors and also suggested ways in which they could subsequently be applied to determine comparative international construction cost and labour requirement are generated by labour productivity rates.

The study on labour productivity for construction industry has been conducted by many researchers. However, the majority of them put their concentration on labour intensive conventional in-situ construction system. Only a fat lot of attention is devoted to perplexing question such as productivity measurement for industrialised building systems (IBS) in despite of the proliferation of the systems in Malaysia. The precast construction system can be termed as industrialised building systems (IBS) also. During the Eighth Malaysia Plan (2001-2005) whereby 600, 000 to 800, 000 houses are expected to be built, the need for huge demand for housing industry results in the development of these IBSs.

The conventional in-situ construction system which is currently being used by the construction industry is incapable to cope with the demand in a stipulated period. The method is labour intensive. Since this method requires a lot of manpower, so it relies heavily on foreign workers. Thus, productivity research attention shall be swerved toward IBS which utilizes the philosophy of assembly activity. For productivity improvement in building industry from craft activity to assembly activity, there is a tremendous potential as depicted in Table 1.

Objectives

Large number of studies focused on labour productivity for single operation such reinforcement bar productivity, productivity of concrete and formwork productivity, whereas, only small effort is devoted towards the combined labour productivity for combination of all the single operation that form the structural element of one unit house. Therefore, this conducted study introduces a standardised data collection methodology for measuring and comparing the conventional and industrialised building systems in aspects of labour productivity and cycle time.

Description of Data

The data for this study were acquired from seven on-going residential projects constructed between January 2003 and April 2004. A sum of 499 data points were observed during that period. The data of projects gross floor area per unit house vary in size in interval between 60m² to 84m². Turnkey contractors were in charged in four projects while the remaining projects were built by a general contractor. In table 2, the project characteristics are presented. (Refer to the Appendix for data)

Carpenter, barbender, concretor and crane operator were in charged in installation and erection of these structural elements. Therefore, the labour productivity of one unit house is calculated as below.

Labour productivity for structural element of one unit houses

= Crew Size carpentry, barbender, concretor and crane operator x work timeBuilding gross floor area (m2)

= Total manhoursBuilding gross floor area (m2)

All data were collected via a standardised data collection form as shown in Table 3. Every day, data collectors were designated to on-going construction sites and 30 minutes were spent per site for observation and record of the crew size, work time and location of work place. Daily observation is recommended because all workers were paid daily. Since workers absenteeism might occur during the construction period and weekly or monthly data variability are too large to enable reliable analyses, weekly or monthly observation is not favorable. Daily observation can also show high degree of variability due to various disturbance project related factors but not as much as other observation. Observation on every hour is also not suggested because it is very expensive and spends a lot of time. Some confidential information was obtained through direct interview with the project managers. Workers’ daily wage is one of the confidential information. Besides that, regular interviews to identify and understand any peculiarities delay and interruption to the projects were essential to carried out.

Rationale for Combining Data Points

The size of the data points has a great effect on the appropriateness, accuracy and reliability of statistical analysis. When a single independent variable is used, small sample with 20 data points is ideal. And yet, a large sample of 1000 data points or more will cause the statistical analysis sensitive and unreliable. Moreover, peculiarities in observations or unusual conditions will bring some inexact data points that cause a baneful effect on the analysis. The rationale for combining the data points from different projects into four structural building systems are as follows:

- All projects are residential projects. They consist of repetitive structural designs. No special formwork system is needed because they do not have any peculiarities architectural features.
- Workers in charged in all operations are semi-skilled and skilled workers. The manual dexterity is about the same.
- The effects of weather and temperature are minimized since all projects are located within 30 km distance.

Result and Discussion

The data analysis and results focus on two specific subjects as described below:

- Labour productivity comparison between structural building systems using analysis of variance (ANOVA).
- Cycle time comparison between structural building systems using analysis of variance (ANOVA).

Comparison of Labour Productivity between Structural Building Systems

This section evaluates the labour productivity comparison between structural building systems. Table 4 presents the descriptive statistic for labour productivity comparison between projects while Table 5 presents the labour productivity comparison between building systems using the average data from the seven projects. Analysis of Variance (ANOVA) results of labour productivity between the four building systems was found to be statistically significant different [ANOVA output, F(3, 498) = 319. 526, P-value = 0. 000] as shown in Table 6. The precast concrete system was the most productive building system with labour productivity of 1. 33 manhours/m^2 followed by cast in-situ half tunnel (1. 88 manhours/m^2), cast in-situ table form (2. 70 manhours/m^2) and conventional building system (4. 20 manhours/m^2). Taking the conventional building system as the benchmark of 100%, the cast in-situ table form system achieved a construction speed of 135% followed by the cast in-situ half tunnel form system of 155% and precast concrete system of 168%.

The result was in tandem with the number of trades for each building system. For example, the conventional building system consisted of four major operations, namely the erection of scaffolding and formwork, installation of reinforcement bars, casting of concrete and dismantling of scaffolding and formwork; hence, it was highly labour intensive. However, only a few construction operations are needed for industrialized building system. For instance, the precast concrete system was pre-assembly in factory, hence reducing on-site labour input. Besides that, no scaffolding is required for cast in-situ tunnel form system to support the slab.

Cycle Time Comparison between Structural Building Systems

This section examines the cycle time measured in days required to complete the structural element of one unit house. Table 7 shows the cycle time for each project while Table 8 shows the average cycle time for four structural building systems.

In Table 9, analysis of variance (ANOVA) results indicated that there was significant different between the four building systems in term of cycle time per house, [F(3, 498)= 161. 416, P-value = 0. 000]. The mean cycle times were 4. 9 days for conventional building system, 3. 9 days for cast in-situ table form, 2. 9 days for cast in-situ half tunnel form and 2. 3 days for precast concrete system. In term of percentage, the conventional building system required 26% more cycle time than cast in-situ table form system, 41% of cast in-situ half tunnel form system, and 53% of precast concrete system.

Summmary

This study has introduced the standardised data collection methodology for measuring and comparing the building structural element of conventional and industrialised building system. Researchers are enabled to combine data points from various projects to produce a larger database if they adopt this methodology. The rational for combining the data point is that the majority of residential projects has a simple structural layout plan and do not have any peculiarities architectural features. A total of 499 labour productivity data points were obtained from seven on-going residential projects. The results and discussion evolves on comparison between structural building systems in terms of labour productivity and cycle time per structural element of one house.

In aspect of labour productivity comparison, the precast concrete system was the most productive building system with labour productivity of 1. 33 manhours/m^2 compare to the conventional building system with labour productivity of 4. 20 manhours/m^2. Besides that, assuming the conventional building system as the benchmark of 100%, precast concrete system achieved a construction speed of 168%. For instance, when the first house constructed using conventional building system is just done, whereas the first house constructed using precast concrete system was done and the second house is constructed about 68% completed.

The comparison of cycle time per house indicated that the two building systems were significantly different. The mean cycle times were 4. 9 days for conventional building system and 2. 3 days for precast concrete system. In term of percentage, the conventional building system required 53% more cycle time than precast concrete system.

Finally, the precast concrete system is preferable compare with conventional building system because the building works can be done faster since it requires less time to construct completely.

Wastage

In the field of structural concrete construction, two basic concepts are generally applied in practice which is precast concrete construction and conventional cast in-situ construction. Wastage can be defined as goods that are damaged, out of date, reduced, or generally unsaleable, which are destined to be thrown away and which are written off as a loss. Construction waste can be divided into three principal categories namely material, labour, and machinery waste. However, material wastage is given more concern because most of the raw materials used in construction industry come from non-renewable resources. The construction industry is a major generator of waste material. Traditionally, construction waste is defined as any material, apart from earth materials, which need to be transported elsewhere from the construction site or used within the construction site itself for the purpose of land filling, incineration, recycling, reusing or composting, other than the intended specific purpose of the project due to material damage, excess, non-use, or non-compliance with the specifications or being a by-product of the construction process.

Material construction waste can be classify as natural waste (unavoidable waste allowed for in the tender), indirect waste (material used for purposes other than that for which it was ordered), and direct waste (material which is encountered for). It is generally known that there is a relatively large portion of the materials being wasted because of poor material control on building sites. The problem of material wastage is not an isolated issue on construction sites. It is also an environmental concern. When construction waste is viewed from an environmental perspective a different type of categorization must be considered. The environmental criteria include the consideration of solid waste. This is divided into four categories: hazardous waste production, non-hazardous waste production, inert waste production, and radioactive waste production.

The construction industry consumes a significant amount of building materials and produces large quantities of building waste. Construction and demolition (C& D) material is a mixture of inert and non-inert materials arising from construction, excavation, renovation, demolition and roadwork. The composition of construction waste is divided into two major categories: inert materials (soft and hard inert materials) and non-inert waste. The soft inert materials (such as soil, earth and slurry) can be reused as fill materials in reclamation and earth filling works. The hard materials (such as rocks and broken concrete) can be reused in reclamation works and/or recycled for construction work as granular materials, drainage bedding layers and concrete application. The non-inert waste (such as metal, timber and packaging waste) can be recycled or disposed of in landfills.

Further, it was shown that there is a noticeable difference in the generation of material waste between pre-cast and in situ. In general, any reduction in on-site concreting leads to waste reduction. Precasting and prefabrication therefore offers significant opportunities for the reduction of waste. In comparison, the wastage in utilizing precast concrete construction method has smaller amount than conventional cast in-situ construction method. The main reason behind this may be due to the negligible wastes arisen during transportation and installation at the site.

The pre-cast concrete elements transported to the site were stored unit wise by manufacturers themselves to avoid damage to the elements. Hence the waste arising during transportation had been minimized and identified as zero. Since pre-cast elements were supplied according to the required length, waste arising during installation of elements was at a minimum level and waste occurring due to over ordering of materials was also eliminated.

Further, the pre-cast elements were produced at factories under proper supervision using steel moulds which can be formed of different sizes. Therefore, the wastage of materials during manufacturing also reduced to a considerable amount.

On the other hand, there have larger amount of wastage due to conventional in-situ construction than precast concrete construction. This large quantity of wastage for conventional in-situ construction was identified due to the lack of supervision, inaccurate mixing methods, inappropriate type of equipment used, poor storage of materials and poor quality workmanship and this led to higher waste of materials in the following ways:

- excess cement being used to accelerate the curing process
- excess concrete being used due to the breaking of form work
- higher waste in transit and handling of metal and sand and
- excess concrete being used in uneven surfaces

The objective of an in-situ method is to eliminate and reduce the traditional site-based trades like traditional timber formwork, brickwork, plastering and to reduce labour content. Conventional cast in situ construction method utilise lightweight prefabricated formwork made of steel, fibre glass or aluminum in order to replace the existing conventional timber formwork. The method is suitable for large numbers of housing units that require repetitive utilisation of formwork. The formwork can be reused as many times as possible with minimal wastage.

There is a noticeable difference between the waste of pre-cast construction and in situ construction. However, because of the significant differences in other material wastes, it can be said that there is a significant reduction of material wastages of pre-cast concrete compared to the material wastages of conventional in-situ concrete. Therefore it can be concluded that there is a significant waste reduction when pre-cast concrete is used.

Conclusion

From the studies that have been done, it can be concluded that the precast method is better than the conventional Cast-In-Situ method in terms of cost, speed, labour, quality, wastage and productivity.