Chapter 2 SELECTION AND DESIGN OF HOUSES USING BUILDABLE SYSTEMS

2.1 DESIGN CONSIDERATIONS

The design of any project should suit the purpose of use and the building type, i.e. residential development, institutional development etc. For a project involving any prefabricated system, the designer should seek solutions which maximize the beneficial aspects of the system, resulting in optimum buildability and economy.

Often, designers and developers of landed developments avoided the use of prefabricated components due to the perception that it will result in stereotype designs, costly and involved specialised construction methods unknown to most contractors. Hence, the project team has developed a few possibilities on architectural facade treatments using buildable systems. Three different projects were studied. The following pictures show examples of variations in appearance, which can be achieved for residential projects designed for construction using prefabricated components. The different treatments to the precast facade panels results in variation in the elevations whilst using standardized components.

Project 1 - Option A

- Precast facade walls
- Modular dimension for each panel
- Use of aluminium sun breakers
- Use of aluminium cladding as architectural features

Designed by RSP Architects, Planners & Engineers (Pte) Ltd

Designed by RSP Architects, Planners & Engineers (Pte) Ltd

Project 1 - Option B

- Precast facade walls
- Modular dimension for each panel
- Off-form colour concrete or exposed textured surface using reconstructed concrete
- Full height frameless windows using structural sealant
- Precast horizontal shading devices
- Prefabricated glass canopy at the car porch

Project 1 - Option C

- Precast facade walls
- Modular dimension for each panel
- Off-form colour concrete or exposed textured surface using reconstructed concrete
- Use of metal pitched roof
- Use of timber trellis to enhance the elevation

Project 2 - Option A

- Timber cladding to dry external walls
- Stone cladding to part of elevation
- Metal roofing for pitch roof

Designed by A-Alliance Architects

Designed by A-Alliance Architects

Project 2 - Option B

- Paint finished to dry external walls
- Prefabricated metal louvres
- Skylight for car porch
- Flat roof with metal deck

	Project 3 - Option A • Metal cladding to precast walls or dry walls of covered patio • Groove line expressed along the joints of the precast facade walls • Off-formed groove patterns to rear precast wall • Metal cladding to gable end facade wall
 Project 3 - Option B • Metal cladding to rear precast walls or dry walls • Groove lines expressed along the joints of the precast facade walls	 Project 3 - Option C • Stone cladding to precast walls or dry walls of covered patio • Cantilever metal roof to car porch

The following highlights some of the general details that need to be considered with regard to design:

- Simplify architectural façade treatment and special details
- External cladding can be added to wall board facade or precast concrete walls
- Standardize component shapes and sizes where possible to improve economy
- Consider optimal component size and the transportation capability concurrently especially for large precast concrete panels
- Connection details
- Joints details
- Waterproofing details

2.2 SITE CONSIDERATIONS

As with a conventional cast in-situ construction, a prefabricated construction requires site considerations to be taken into account, in particular, the following:

- Ground conditions for heavy vehicular movement
- Access for mobile cranes - commonly 20 tons, 50 tons or 70 tons mobile cranes with telescopic boom
- Manoeuvring space for over-sized vehicles within the vicinity
- Obstruction to other road users - under the current LTA's requirement, a vehicle having a width of more than 3.2m will require police escort
- Storage area for precast concrete components or prefabricated elements
- Risk to overhead infrastructures and neighbouring properties during handling/lifting of the prefabricated elements

Hence, proper planning and good co-ordination is essential for prefabricated construction. Early involvement of precast contractors or steel erectors during design stage will reduce risk and provide a more friendly construction environment for the site and the neighbourhood.

Figure 2.1 Use of 50-tonne crane for hoisting

Figure 2.2 Hoisting of precast facade

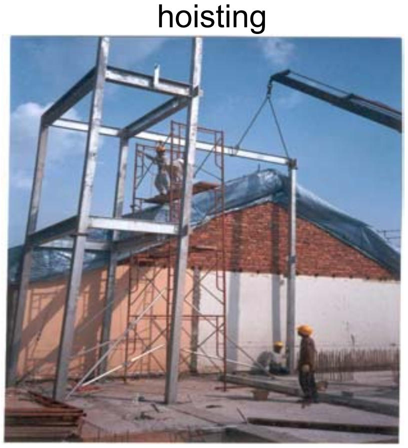

Figure 2.3 Assembly of steel elements in position

Figure 2.4 Use of lorry crane for lifting of steel elements

2.3 COSTING

Construction costs are complex and complicated issues. Although it is a generally accepted fact that the use of repetitive prefabricated components contributes to appreciable cost savings in a high-rise project, it is not clear if such cost advantage applies in a low-rise landed house environment. In the course of investigating the technical feasibility of prefabricated construction for landed houses, one basic and persistent question keeps surfacing – Is prefabricated construction more expensive or cheaper than conventional cast in-situ construction in low-rise houses?

At present, the answer is inconclusive at best. In most cases, we would expect prefabricated construction to cost more than conventional in-situ method. Tender prices from a few recent landed projects, which employ precast construction, seem to indicate a 5-10% cost premium over conventional cast in-situ construction. Because the number of projects involved is limited thus far, this figure should only be taken as a mere indication. However, one contractor who had recently completed a project using structural steel construction, reported that a saving of 5% (of construction cost) was given back to the homeowner.

It is important to note that many factors affect the cost of a project. Apart from direct material costs, factors such as construction time, scale of project, labour components, expected quality, and even external micro economic conditions all affect the overall cost of a project. It is therefore difficult to do a simple direct material cost comparison without also understanding the other affecting factors in the cost analysis.

The cost breakdown for a typical development can be summarised as follows:

	Percentage per house
Land Cost	63%
Construction cost	24%
Other cost	13%

The construction cost may be further broken down into the following:

	Percentage of costing per house
Preliminaries	5 - 10%
Foundation	5 - 10%
Structural works	20 - 30%
Architectural works	40 - 45%
M&E works	10 - 30%
External works	3 - 5%

The project team has reviewed the elemental cost for comparison of precast design with conventional design. The increase in the cost of precast design is found to be minimal as shown below:

**The prices below are indicative only and may differ from time to time and from different contractors and precasters. It is recommended that developers and designers consult precasters and contractors in the actual pricing of the projects.*

**The cost comparison is only on components which were replaced by buildable systems.*

Cost Comparison between Conventional and Buildable Systems for an In-fill Terrace House

Elements	Built-up area (m^2)	Conventional Design ($\$/m^2$) [3]	Precast Design ($\$/m^2$) [3]	Steel System [2] ($\$/m^2$)	Flat plate with Steel Columns [2] ($\$/m^2$)
Party wall	280	35 (Brick walls with plastering)	36 (Structural load bearing wall)		
Structure - floor system	280	90	33	73	73.5
External wall	280	10	12.5		
Staircase	280	8	12.5	2.8	2.8
Household shelter	280	11	16.5		
Others					
Waste disposal	280	14.5	9		
Cranage	280	19.6	29		
Grouting	280	0	7.2		

Typical construction cost of residential properties :

Terrace Houses - $1500 - $1700 / m2

Semi-Detached Houses - $1600 - $1900 /m2

Detached Houses - $2100 - $2800 /m2

Source: DLS Handbook Singapore 2002

[1] The above costing does not include other preliminaries such as scaffold and site overheads. The costs for preliminaries generally range from 6% to 10% of the total project cost.

[2] For the layout and elevation of the different systems (Structural Steel system & Flat Plate system) shown above, please refer to the Appendix.

[3] Cost refers to lump sum cost per square metres of the constructed floor area.

Material costs, of which precast components form a significant part of, cannot and should not be evaluated independently of other cost related factors. Otherwise, the comparison would be misleading. For example, by using more expensive precast construction, direct labour costs are reduced. This is a significant consideration in a market like Singapore where labour cost has been and is expected to continue rising. Time saving is another important factor, and this translates directly to lower preliminaries and faster project turnover. On the other hand, the benefits of improved quality are appreciable but difficult to measure. Better quality means lower subsequent defect rectification costs, but its direct cost benefit is not as easily quantifiable.

The following salient points are also important in cost analysis:

1. **Repetition** – Repetition is the primary key to lower costs in precast construction. The more standardised the precast component is, the lower is its basic cost due to reduction in mould costs, set-up etc. Repetition is quite easily achieved in high-rise construction or for a large development of low-rise houses, but comparatively difficult to attain in small-scale and low-rise development. In other words, without some form of standardisation, there simply isn't enough repetition in a small project to attain economy of scale. With this basic premise in mind, this study sought to achieve repetition and economy of scale through industry-wide standardisation across many developments. Repetition of identical / similar components is therefore an achievable goal when one considers the degree of duplication possible in an industry-wide level rather than in a single project level. Precast component's basic cost can thus be brought down even for small developments.

2. **Standardisation** – By recommending standard sizes, similar methods of construction, and consistent, simple precast components, precasters are able to "spread-out" the basic costs of precast moulds / set-ups over many projects. Much effort has been put into standardisation of construction method and components such as precast flooring system, wall panels, staircases, household shelter, etc. The components have been chosen in a format whereby deviations in component dimensions can be achieved relatively simply. From cost point of view, it is generally agreed among precasters that a minor two-dimensional variation in dimensions (in width or length) can be easily accommodated within an existing mould and set-up. A cost difference in this case is negligible. It is the goal that with good degree of standardisation, contractors can order standard precast components from ready-made stock off the shelf or from catalogues.

3. **Creativity** – Creativity is potentially the opposite of standardisation. It is a fact that architects and designers want to be creative and owners almost always expect their developments / houses to be unique and different from others. Fortunately, in the context of landed houses in Singapore, planning guide lines dictate norms and standards that result in an existing level of standardisation. If a house design is truly unique, which may especially apply

to bungalows and large detached houses or houses sited in unusual land configuration, precast construction is probably not a cost-effective solution. On the other hand, for the majority of terrace houses or semi-detached houses, whether in new development, in-fill development or addition & alteration, the general design will typically fall within a certain fixed framework where precast will be a competitive solution. There is sufficient flexibility in the precast system for architects and engineers to still exercise his imagination and creativity.

4. **Risks & Time Factor** – Part of the reason for the current higher costs in precast construction is due to perceived risk factors applied by contractors. A typical small house contractor is not likely to be as familiar with precast construction as compared to larger contractors. Unknown factors contribute to risks and higher costs. It is fair to assume that with gradual and eventual familiarisation with precast construction methodology, the learning costs for contractors and the unknown risk factors will be reduced over time. This would in the long run lead to lower and more realistic costs for precast construction.

5. **Competition** – There are comparatively few precasters in Singapore because the current demands are not high. When precast construction becomes more acceptable and prevalent in the future, more players will enter the market. This will lead to better competition and lower costs for consumers.