Chapter 12 CASE STUDIES

The following projects A, B, C and D are on-going projects or projects that were recently completed. These developments use prefabricated systems like precast structural steel or a hybrid system using steel column and flat plate system and light gauge steel frame. The projects have demonstrated a construction-efficient design with better quality and improved site productivity.

The subsequent projects E, F and G are completed projects using conventional cast-in-situ system. The project teams reviewed the possibilities of using a prefabricated system in these projects. It was found that a change to a more buildable precast system was possible with no major changes to the elevation or the interior layouts.

12.1 PROJECT A - 81 units 3-storey terrace dwelling houses and two semi- detached houses

General Information

Type	**:**	81 units of terrace houses & a pair of semi-detached houses
Storey	**:**	3-storey with a flat roof
Site Area	**:**	2.2 hectares
GFA	**:**	19,920 m^2

Background

The developer has opted for precast construction to achieve better quality, consistency and better buildability. This project is sited along Ang Mo Kio Ave 1 with a site area of approximately 2.2 hectares. The land slopes 18 metres from one end to the other.

Prefabrication solution

The precast system consists of both structural and architectural elements such as party walls, facade walls, floors, staircases, meter compartment and planter boxes. RC pour strips were used at the wall joints and slab joints. The RC pour strips provide for a watertight connection and to minimize cracking at these joints.

To further reduce labour intensive finishing work, the end walls were constructed using facade brick tiles that were precast together with the RC walls.

Issues Encountered

The main challenge to the engineers and architects was the hilly terrain and the staggering site arrangement of the houses. Proper planning with precision in detailing and construction was vital to overcome the physical constraints. Facade design and interior spaces were slightly modified where necessary to adapt the precast system. However, the overall design concept has not been affected.

Project A

Figure 12.1 Erection of precast walls and planks

Figure 12.2 Use of 50-tonne crane for hoisting

Figure 12.3 Minor touching up of finishes

Figure 12.4 Elevation of completed houses

12.2 PROJECT B - A 2-storey semi-detached dwelling house

General Information

Type	:	In-fill semi-detached dwelling house
Storey	:	2-storey and a flat roof
Site Area	:	468 m²
GFA	:	355 m²

Background

The building is a two storey semi-detached dwelling house with a roof terrace. The designers have ensured a safe and economical structure that would fulfill its intended usage.

Prefabrication solution

The building comprised two types of prefabricated components, mainly the structural steel that carried the loads and the precast facade that enveloped the external facade.

The secondary steel universal beams were spaced to support the composite slab such that during casting no additional props were required. The main steel beams supported the secondary beams and transfer loads to the columns. The composite slab with its welded mesh formed horizontal ties and provided lateral restraint to the beams.

The hollow section columns were in-filled with concrete to achieve the minimum half-hour fire resistance.

Precast facade panels were cladded over the structures. Pre-determined groove lines and concrete coloured panels were used. Minimum plastering works were used for the external treatment as most of the labour extensive works were no longer necessary.

Issues Encountered

Prefabrication technology requires greater precision compared to cast in-situ concrete construction. In precast construction, only a +/- 5 mm tolerance is acceptable. Greater amount of accuracy must be achieved early in the design stage. Location of services must be predetermined as well as details for location of windows, skirting etc, must be decided up front to ensure no mis-alignment during construction stage.

Project B

Figure 12.5 Steel decking and prefabricated spiral staircase

Figure 12.6 Elevation

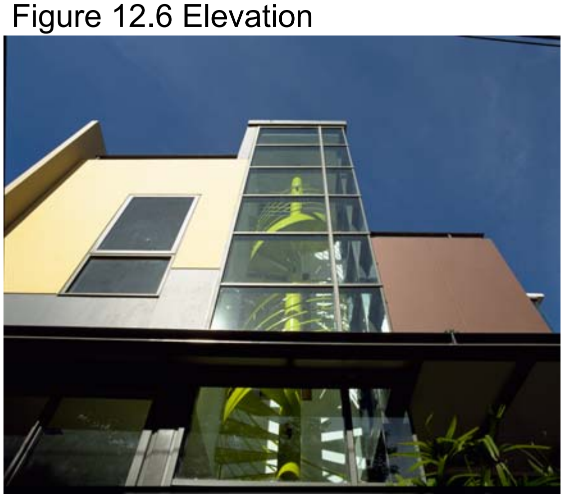


Figure 12.7 Interior layout

12.3 PROJECT C - A 3-storey semi-detached dwelling house

General Information

Type : In-fill semi-detached dwelling house
Storey : 3-storey with a metal pitch roof
GFA : 399 m²

Background

The building is a three storey semi-detached dwelling house with a metal pitch roof along Upper Changi Road East.

Description of a Prefabricated system

(a) Cost Study

A cost estimate study of the project indicated that if the technique was applied on a larger scale, such as 5 houses onwards, the cost savings could be significant. This was due to the high level of prefabrication and mass manufacturing inherent in the process and, of course, to the faster speed of construction. Faster M&E installation, faster architectural finishing work and reduced unskilled labour requirements meant lower costs all round.

The shorter construction period led to greater rental savings as well.

(b) Reduced Pollution

There was also significant reduction in the amount of construction debris generated as many major components were pre-fabricated in factories with very little wet work that required timber formwork, a major source of construction waste. Most components were handled easily without cranes and pulleys. There was also minimal disturbance to neighbours as piling was not required due to the lightweight structure.

(c) Ecological Considerations

The lightweight steel structure also demonstrated that the house could be adapted easily to accommodate ecological considerations such as recycling rainwater, harnessing solar energy and reduced air-conditioning. A 2300 litres tank allowed the owners to have a week supply of recycled rainwater for washing, gardening and koi pond use.

By having a mildly reflective metal roof with large roof airspace gap, good insulation and light cladding materials, it was found that the building retains much less heat compared to conventional RC buildings which tend to retain heat for a longer period. In fact the owners reported that they seldom turned on the air-conditioners during the day.

Issues Encountered

While there are many overseas examples of lightweight steel-framed house available, the architects noted that for various reasons the technique has never been used widely at all in Singapore, especially not for a one-off 3-storey house situation. The main reason for this is probably due to the lack of skilled tradesmen experienced with this method of construction. Secondly, many people dislike the "hollow" sound when they knock on the walls of a typical steel-framed house although they are well aware that the house is just as structurally safe as any conventional RC house.

The first problem cannot be solved easily nor quickly. It is an industry-wide problem that has to be tackled over years. The architects resolved the second problem with the application of denser insulation between fibre cement walls. A foreign visitor to the house noted that in developed countries where this form of housing is common, people do not seem to mind the "hollowness" even though they are typically taller and heavier than locals. It is very much a cultural phenomenon that will ease away when steel frame housing becomes more prevalent.

Hence, a change in the mindset is necessary since this system has proven to greatly improve the site productivity and is a more friendly construction method to the neighbourhood.

Project C

Figure 12.8 Light-gauge Steel Frame

Figure 12.9 External cladding to fibre board walls

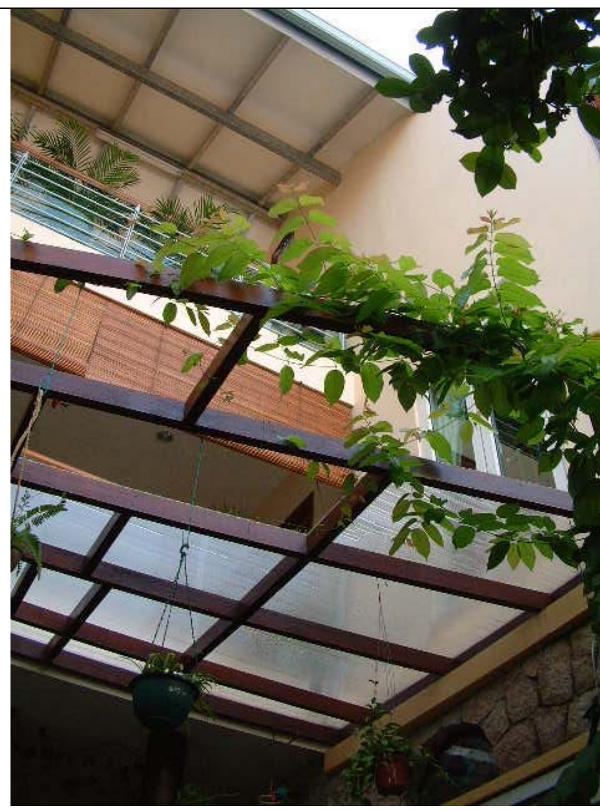


Figure 12.10 A view from the garden

Figure 12.11 Construction of first storey. Only the front panel used CIS construction, all other areas used light gauge steel frames

Figure 12.12 Construction of 2nd storey

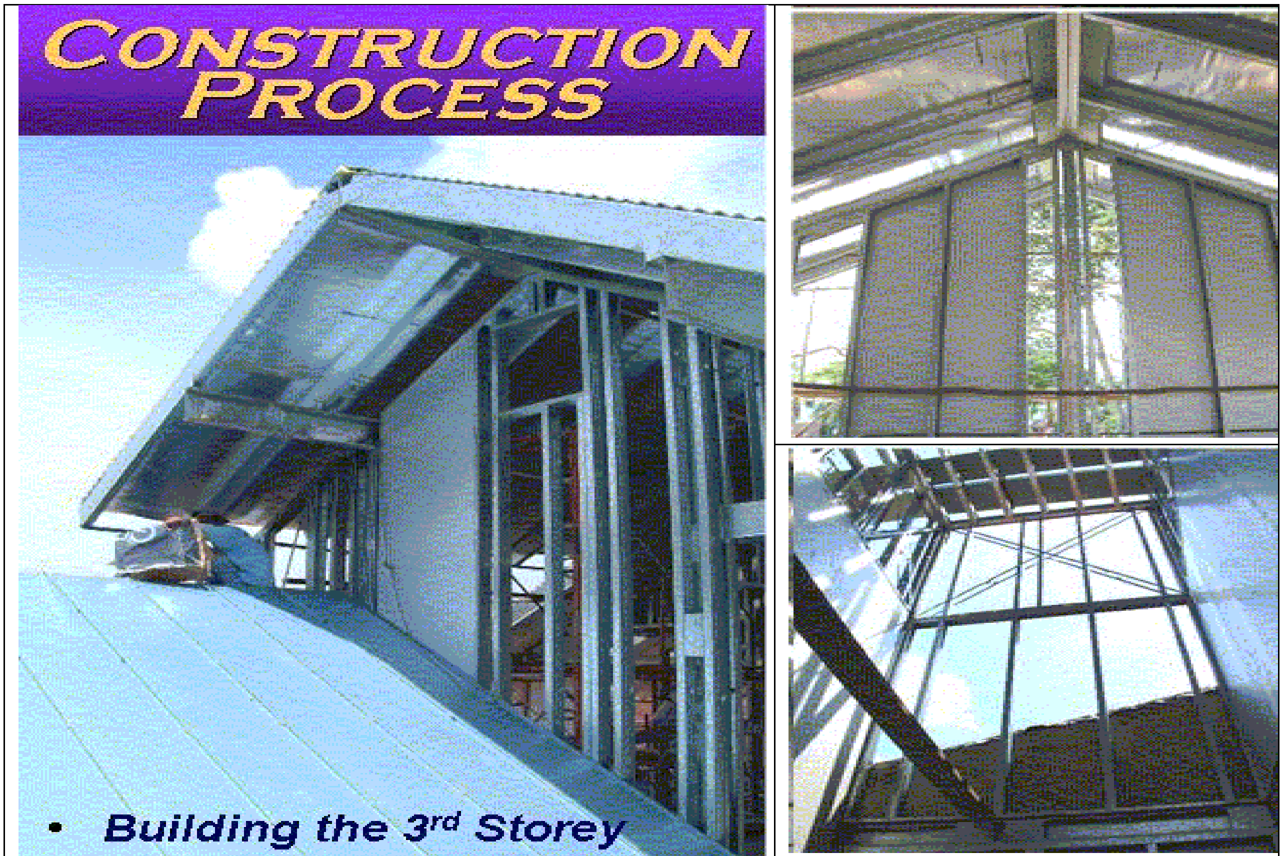


Figure 12.13 Construction of 3rd storey

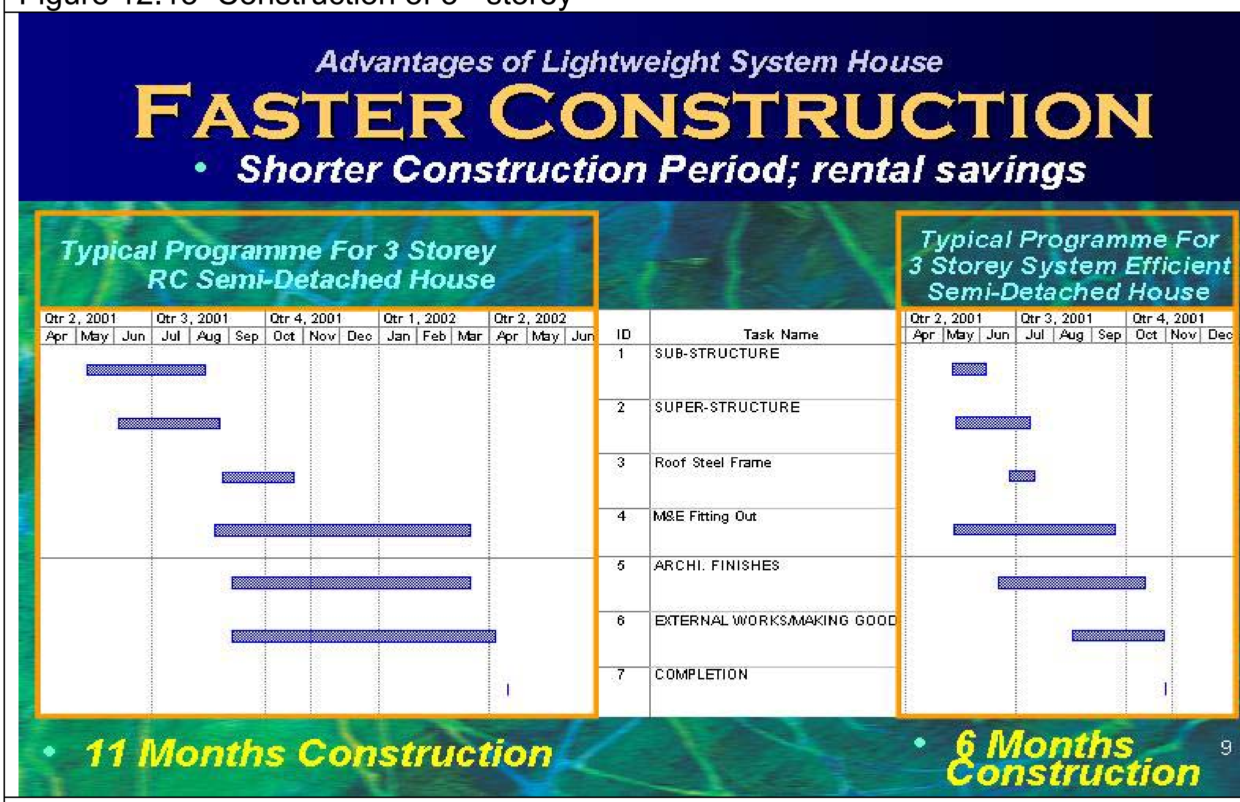


Figure 12.14 Comparison of project construction time between conventional RC system and light gauge steel frame system

12.4 Project D – New Terrace Houses

General Information:

Type	:	Landed Terrace Dwelling Houses
Level	:	3-storey
Site Area	:	66,195.17 m^2
Plot Area	:	220 m^2 (each plot)
GFA	:	218 m^2 (each plot)

Background:

This development comprises 264 units of terrace and semi-detached houses, which are built in 6 phases. So far 3 phases have been completed and phase 4 is in the planning stage. Conventional construction methods have been adopted so far in this development. Some thoughts have been given to explore the possibilities of using precast elements for the typical terrace houses through a case study.

The typical 3-storey units consisting of 5 Bedrooms with Living, Dining, Kitchen and Utility have been designed to conform to local standards. The household shelter shown in the proposal is not part of the original plans. They have been added to meet current building requirement for the purpose of this study. Other elements remain unchanged as in the actual project.

Development of Precast System:

In the new proposal, the overall layout has been maintained with some minor adjustments due to the inclusion of the precast household shelter. The wet areas have been kept at the same side of the plan and as much as possible the toilets have been stacked one above the other. Shower areas and balconies have been provided with 50mm high kerb instead of providing the structural drop to the slabs. Party wall, front/rear wall, boundary wall, staircase & meter box are precast units. In line with the BCA buildability guidelines, the floor to floor heights have been kept repetitive (except 1st storey) in multiples of 175mm (standard staircase riser height). The vertical joints formed at the junctions of the party wall with the front wall panel have been suitably concealed with GRC box-up.

Precast Findings:

1. The case study found that the party walls could be designed as precast shear walls due to the following advantages:

a) For terrace houses, there are no disadvantages to the use of precast shear wall.

b) In party walls, there is no necessity to cater for future openings, e.g. doorways and duct penetrations.

c) Vertical pour-strips between each shear wall panel is necessary to eliminate vertical joint lines.

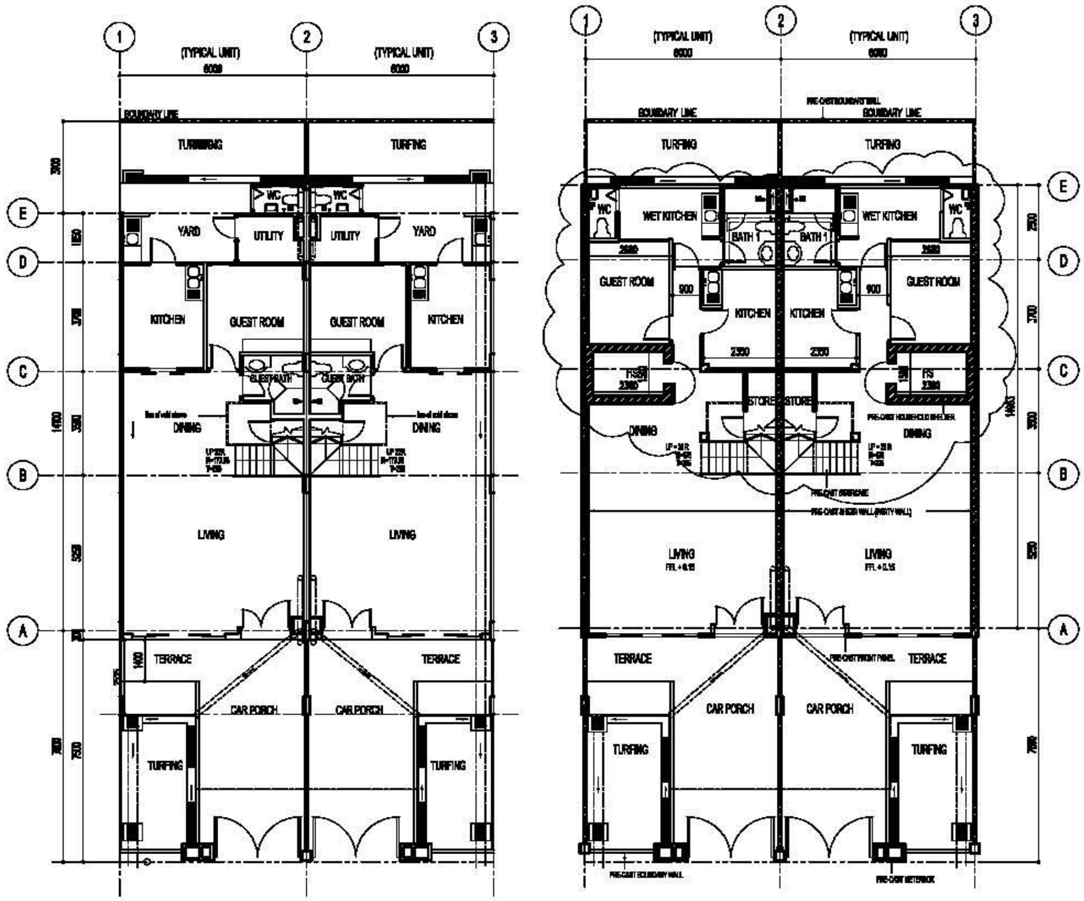
d) Precast columns can be used at the localised staircase/void areas to support the precast slabs.

2. Employing flat roof using precast panels have been found to be economical as against pitched roof where the laying of timber rafters, battens and clay roof tiles are labour intensive activities.

3. As an alternative to the flat roof, the precast panels could be arranged in an inclined manner on to the part walls to make a pitched roof. However clay tiles over the timber battens could not be avoided due to the waterproofing needs.

Conclusion:

The findings of the case study revealed that the precast system can be adopted with very minimum adjustments to the original layout plans.



EXISTING
(CONVENTIONAL CONSTRUCTION)

PROPOSAL
(PRECAST CONSTRUCTION)

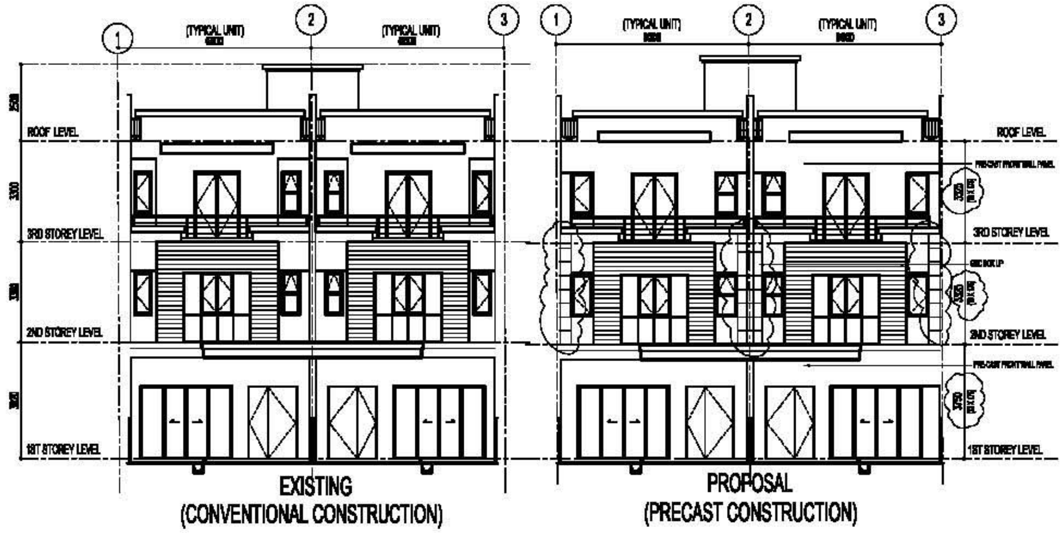
1ST STOREY PLAN

THE NEW PROPOSAL INVOLVES THE FOLLOWING IN THE 1ST STY: -

1. THE OVERALL LAYOUT HAS BEEN MAINTAINED WITH SOME MINOR ADJUSTMENTS.
2. PRECAST HOUSEHOLD SHELTER HAS BEEN INCLUDED.
3. WET AREAS HAVE BEEN KEPT AT ONESIDE TO MINIMISE THE LENGTH OF M&E PIPINGS.
4. PARTYWALL, FRONT/REAR WALL , BOUNDARY WALL, STAIRCASE & METER BOX ARE PRECAST

CASE STUDY - T2 TERRACE HOUSE

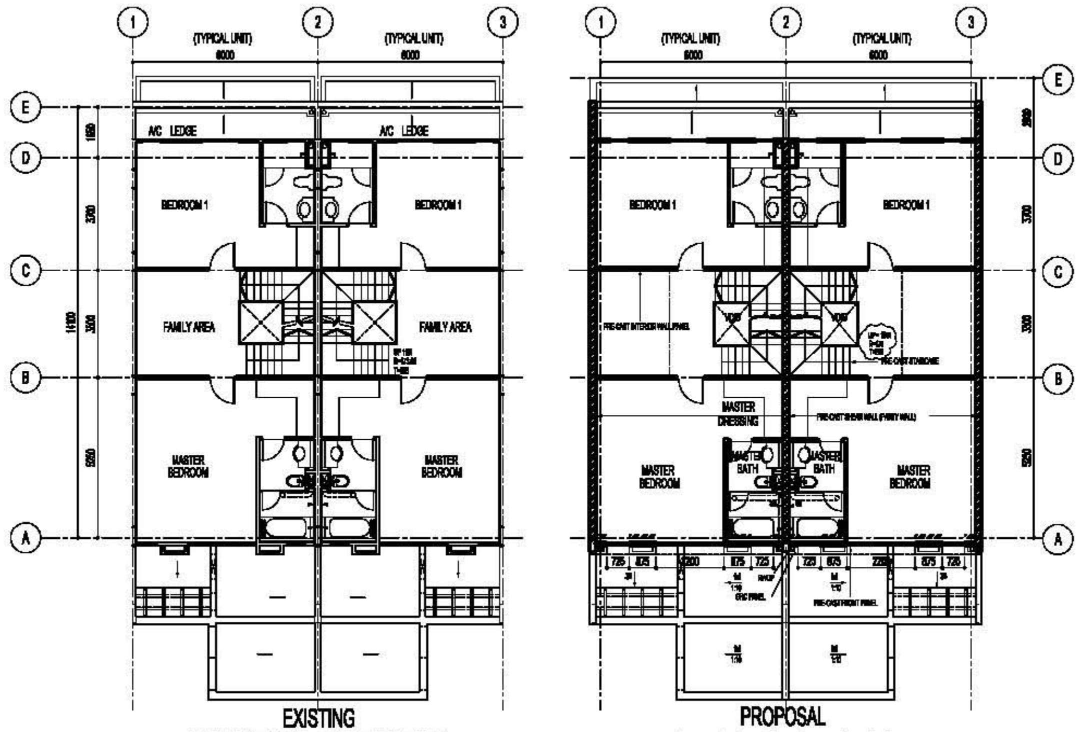
BCA STUDY ON DEVELOPMENT OF PRECAST SYSTEMS FOR LANDED HOUSES



FRONT ELEVATION

THE NEW PROPOSAL INVOLVES THE FOLLOWING IN THE FRONT ELEVATION: -

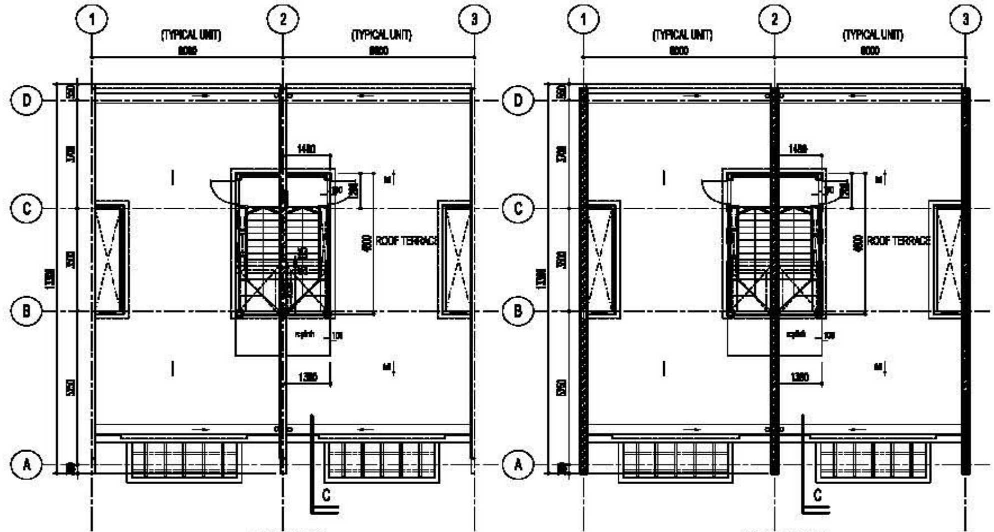
1. IN LINE WITH THE BCA BUILDABILITY DESIGN GUIDELINES THE FLOOR TO FLOOR HEIGHTS HAVE BEEN KEPT REPETITIVE (EXCEPT 1STY) IN MULTIPLES OF 175MM STAIRCASE RISER SIZE.
2. THE VERTICAL JOINTS RESULTED AT THE JUNCTIONS OF THE FRONT WALL PANEL WITH THE PARTYWALL HAVE BEEN SUITABLY CONCEALED WITH GRC BOX UP



2ND STOREY PLAN

CASE STUDY - T2 TERRACE HOUSE

BCA STUDY ON DEVELOPMENT OF PRECAST SYSTEMS FOR LANDED HOUSES



EXISTING
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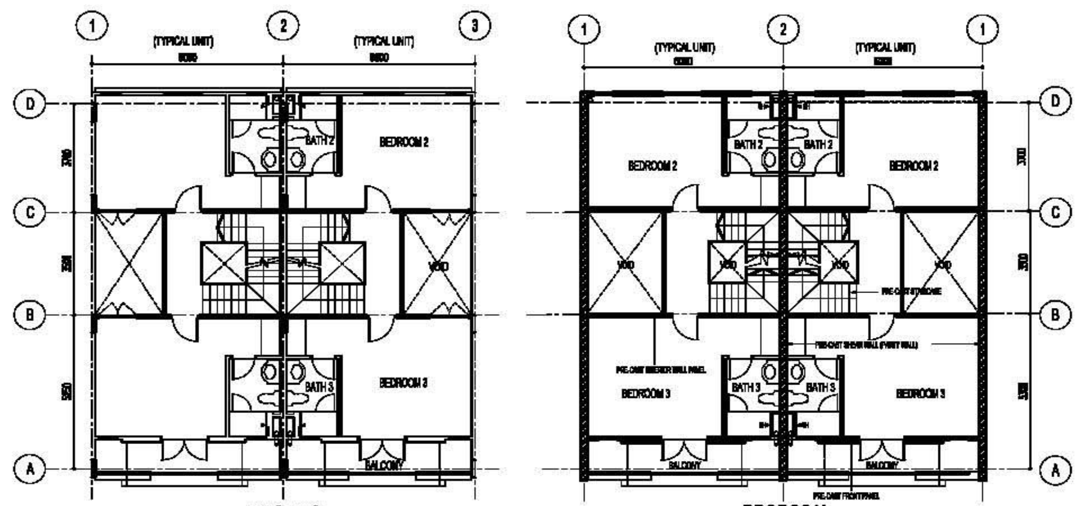
PROPOSAL
(PRECAST CONSTRUCTION)

ROOF PLAN



EXISTING
(CONVENTIONAL CONSTRUCTION)

PROPOSAL
(PRECAST CONSTRUCTION)

3RD STOREY PLAN

CASE STUDY - T2 TERRACE HOUSE

BCA STUDY ON DEVELOPMENT OF PRECAST SYSTEMS FOR LANDED HOUSES

12.5 Project E - In-fill Terrace Houses

General Information:

Type	**:**	A pair of intermediate in-fill terrace houses
Level	**:**	2-storey with an attic floor
Site Area	**:**	143 m^2 (each plot)
GFA	**:**	214 m^2 (each plot)

Background

This case study project is located within an existing housing estate. The brief calls for total reconstruction to two units of intermediate terrace houses for two separate clients. Both houses are 2 storeys with an attic floor and a pitched clay tile roof above. Space requirements are generally quite typical to local standards. Household shelters are not part of the original plans / building. They are added to meet current building requirement for the purpose of this study. Other elements remain unchanged as in the actual project.

As an in-fill project, existing party walls adjoining neighbours on both sides are not disturbed, i.e., the new buildings are structurally independent of their neighbours. New columns and beams are added next to the existing party walls to support the new structures. Conventional construction consisting of cast-in situ RC frames together with brick wall in-fill is used throughout the project.

Precast Findings

The pre-cast system consists of precast RC panel for the front and back walls, pre-cast party wall panels, precast floor with an in-situ topping. Other pre-castable items include staircase and planter boxes.

Issues Encountered

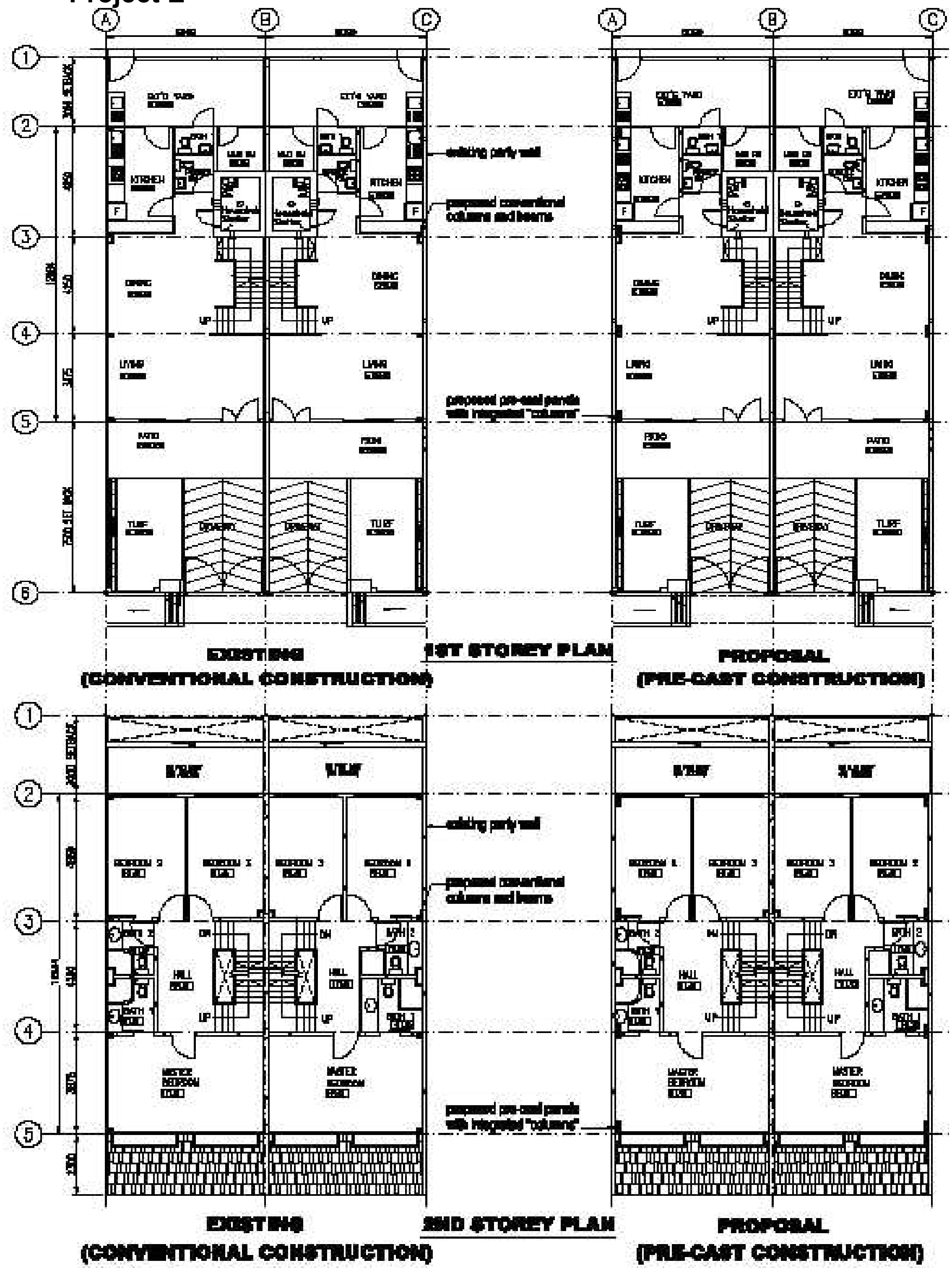
There is a concern with the ability to transport and hoist large pre-cast panels in an existing housing estate. A solution is to break up the front façade into two smaller panels at each floor for ease of transportation. Minor architectural adjustments are needed. Vertical groove lines are deemed acceptable and can be easily treated.

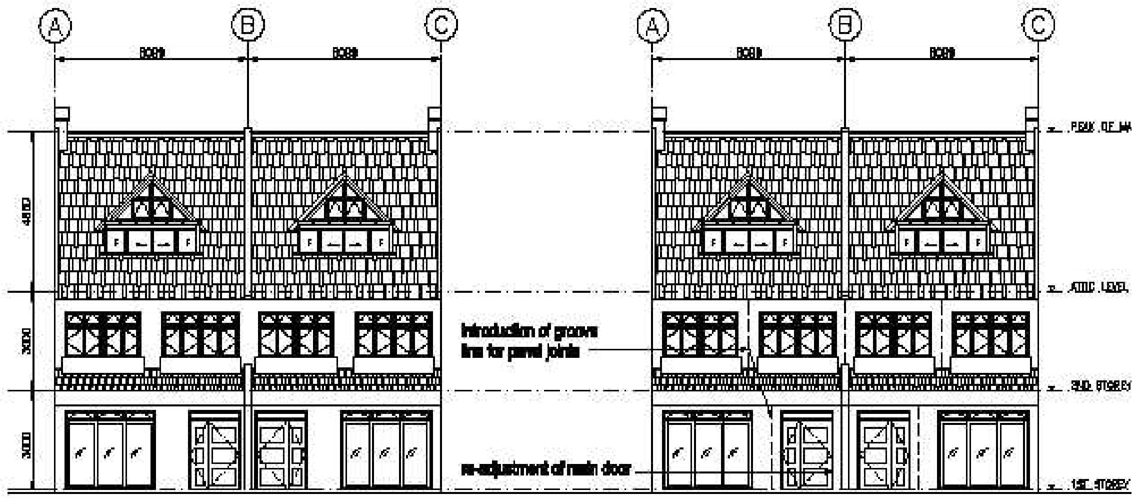
On plan, the new structural columns at party wall are replaced by precast panels with slightly larger footprints. Minor adjustments to toilet layout are needed to suit the structural elements.

Conclusion

This design of the building is such that it is quite easy to precast. Only very minor changes to original design is needed.

Project E

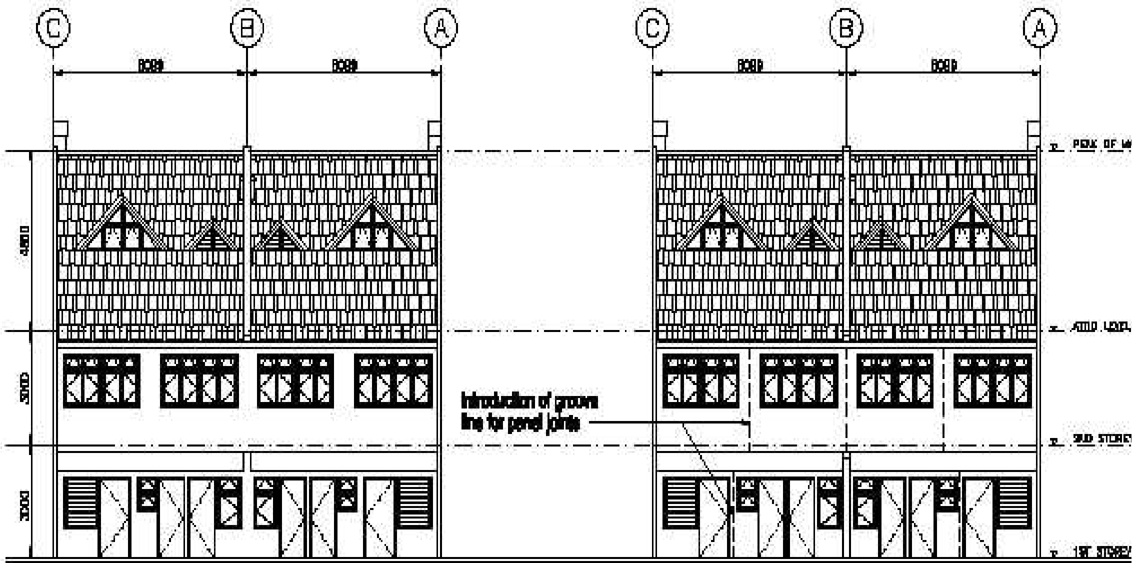




FRONT ELEVATION

EXISTING (CONVENTIONAL CONSTRUCTION)

PROPOSAL (PRE-CAST CONSTRUCTION)



REAR ELEVATION

EXISTING (CONVENTIONAL CONSTRUCTION)

PROPOSAL (PRE-CAST CONSTRUCTION)

12.6 PROJECT F - Semi-Detached Dwelling House

General Information

Type	**:**	In Fill Semi-Detached Dwelling House
Storey	**:**	2-Storey With Attic
Site Area	**:**	390.406m²
GFA	**:**	565.727m²

Background

The project is located within an existing housing estate. The building is a 2-storey semi-detached dwelling with an attic on an elongated site of approximately 31.2 metre depth and 8.6 metre wide. There is a total of 5-bedrooms (inclusive of a guest room at 1st storey). A household shelter is part of the building. Special architectural and design features such as a big foyer and a sculpture pool are added to the 1st storey.

Precast Findings

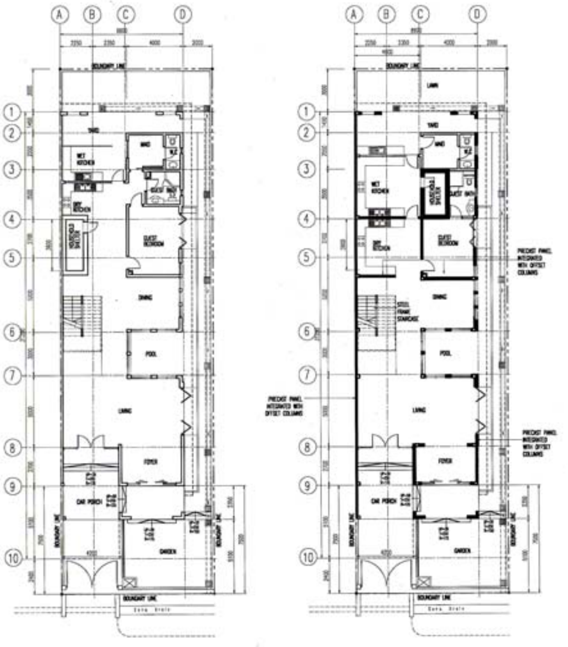
The precast system that is considered for this project is a combination of PC wall panel, precast slab and precast boundary wall. As for the architectural elevation feature, the adjoining wall have been re-designed to reflect the new features of the building as compare to the conventional types of construction.

Issues Encountered

There is no problem with transporting and lifting the large pre-cast panels in the existing site, as the panel walls have been broken up into smaller panels for ease of transportation, hoisting as well as installation. The wall panel could be treated with various finishes. The groove lines, which run vertically and horizontally can be acceptable and it is easily treated.

Conclusion

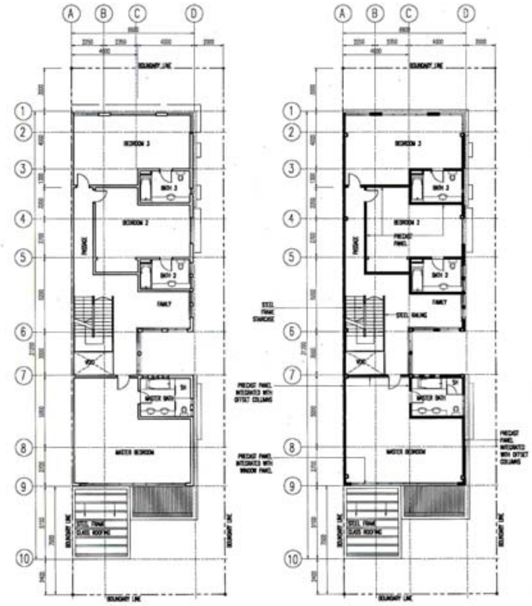
There is not much problem in implementing a pre-cast system for the building as only a minor change to the elevation of the building is expected.



EXISTING (CONVENTIONAL CONSTRUCTION)

PROPOSAL (PRECAST CONSTRUCTION)

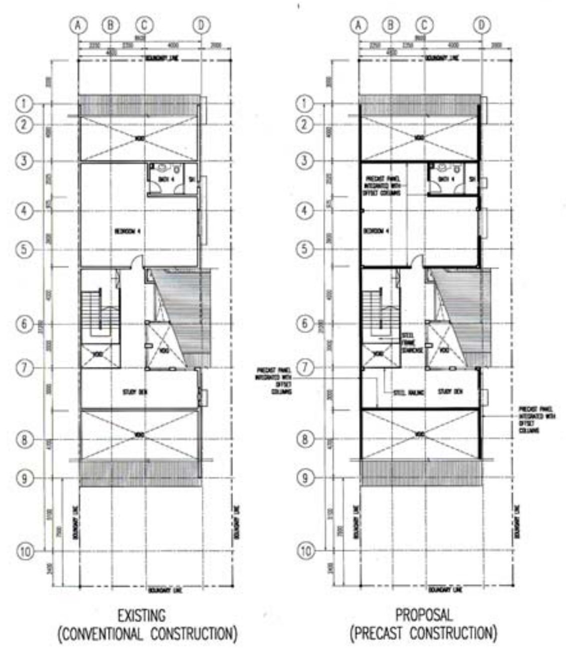
FIRST STOREY PLAN
SCALE 1 : 200



EXISTING (CONVENTIONAL CONSTRUCTION)

PROPOSAL (PRECAST CONSTRUCTION)

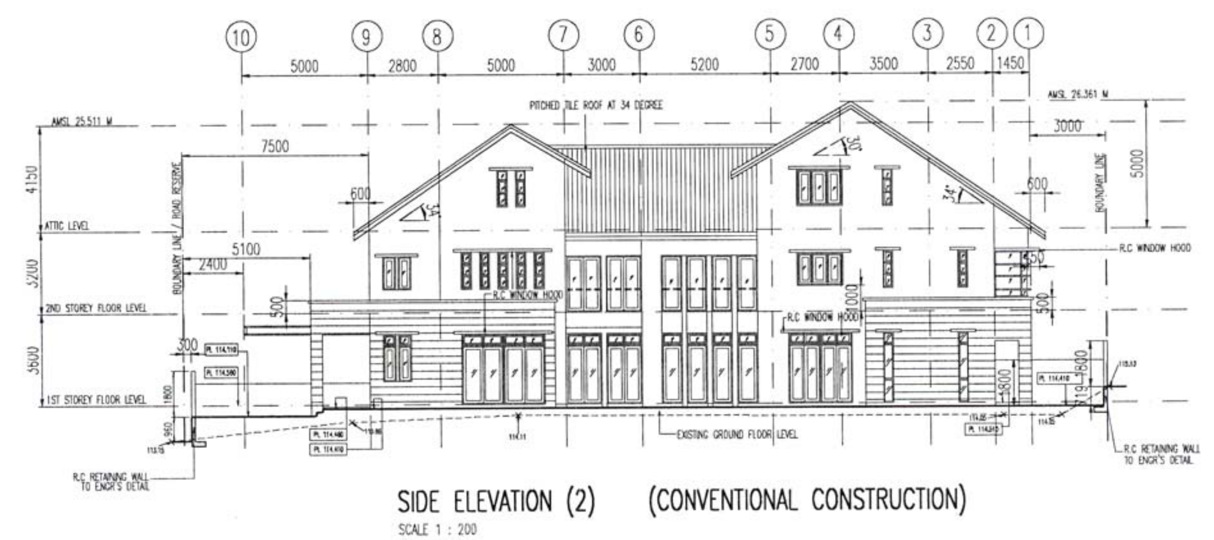
SECOND STOREY PLAN
SCALE 1 : 200



EXISTING (CONVENTIONAL CONSTRUCTION)

PROPOSAL (PRECAST CONSTRUCTION)

ATTIC PLAN
SCALE 1 : 200



Elevation showing conventional construction

Elevation showing design with the use of precast panel