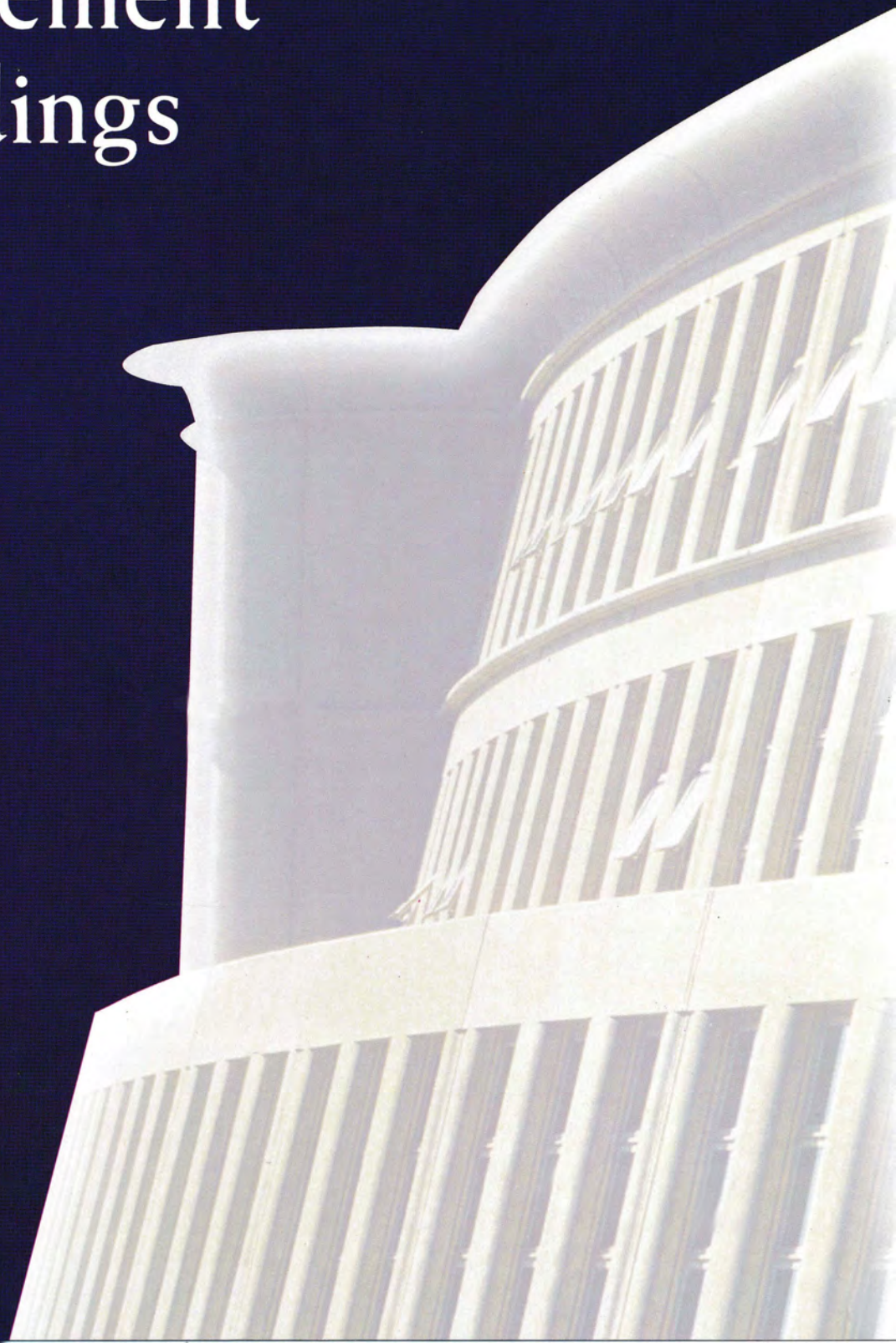
Guide to Precast Concrete and Prefabricated Reinforcement for Buildings



CIDB

Guide to Precast Concrete and Prefabricated Reinforcement for Buildings

The CIDB Guide to Precast Concrete and Prefabricated Reinforcement for Buildings is published by the Productivity Development Unit, Technology Development Division of the Construction Industry Development Board.

FOREWORD

CIDB has promoted buildable design to the construction industry since 1992 as the key to higher productivity and quality. The promotion has been successful in the public sector. Public sector building designs are now much more buildable. Improvements in quality, measured by the CONQUAS system, and higher site productivity, measured in square metres per manday, have been achieved in public sector buildings. The private sector is also becoming aware of the buildable design and a number of good efforts have been made. But a lot more can be done.

Drawing from these experiences, CIDB will be implementing an integrated programme to raise prefabrication levels in the private sector. This includes the standardisation of major building components, improving the infrastructure to facilitate more prefabrication and upgrading the industry's expertise.

This Guide is the first of a series of design tools to help developers, architects and designers increase the buildability of their designs through the wider use of prefabricated components. This industry effort is led by CIDB with representatives from public sector agencies, REDAS, SIA, IES, ACES, SCAL, NUS, NTU, leading design firms, contractors, precasters and reinforcement suppliers.

I wish to thank the chairpersons, in particular Mr Tan Ee Ping, and members of the Steering Committee and Working Committees who helped to produce this Guide. I am confident that it will contribute in an important way to the better understanding and wider application of prefabrication in the construction industry.

DR TAN SWAN BENG
CHAIRMAN
CONSTRUCTION INDUSTRY DEVELOPMENT BOARD

MESSAGE

Prefabrication is one of the key means of increasing buildability. However, precast concrete components and prefabricated reinforcement are still not commonly used in the private sector. This is, to a great extent, due to uncertainties about their cost and their ability to meet the aesthetic and other design requirements of developers.

This Guide aims to familiarise developers and architects with the flexibility and benefits of using precast concrete components and prefabricated reinforcement. Standardisation of sizes of commonly used prefabricated components will encourage wider application and help to make their production more economical. This Guide has therefore incorporated a catalogue of recommended structural building components which would meet the needs of most of our buildings. The recommendations are based on a survey of typical sizes of components used by engineers in the various categories of buildings. Comments and feedback were obtained from developers, architects, engineers, contractors, precasters and steel reinforcement suppliers on the practicality of the recommended preferred dimensions.

I would like to thank members of the Steering Committee and the chairpersons and members of the two Working Committees for sharing their knowledge and their contributions in the preparation of this Guide.

Tan Ee Ping
Chairman of Steering Committee
Guide to Precast Concrete and
Prefabricated Reinforcement for Buildings

ACKNOWLEDGEMENT

The Guide to Precast Concrete and Prefabricated Reinforcement for Buildings was developed with inputs from government agencies, professional institutions and associations, leading consultants, precasters and steel reinforcement suppliers. CIDB would like to thank the chairpersons and members of the Steering Committee and Working Committees for their contributions towards the development of this Guide.

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	Dr Tan Guan	TY Lin South East Asia Pte Ltd

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	Name	*Organisation*
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	Mr Neng Kwei Sung	Construction Industry Development Board

Special thanks are due to ST Architects & Engineers Pte Ltd and LTY Consulting Engineering for their contributions to Section 4.

Our gratitude also goes to all others who have contributed their photographs, drawings, details and materials for this Guide.

CONTENTS

Section Four *Catalogue Of Structural Precast Concrete Components*

Section Five *Use Of Prefabricated Reinforcement*

Appendix

INTRODUCTION

Objective

The objective of this Guide is to promote to developers and architects, greater use of precast components and prefabricated reinforcement in their projects. It provides general guidelines on design, examples of projects which have used prefabrication, types of components and a catalogue of structural components. The aim is to promote the wider use of these components so as to achieve more economical production and therefore lower unit costs.

These recommendations are based on a survey conducted to identify the sizes of building components commonly adopted in various types of building projects. The survey enabled the Working Committee On Precast Components to work out a catalogue of components which can be produced by local precasters. The Working Committee On Prefabricated Reinforcement also compiled information on welded wire fabrics available from the local suppliers.

Principles Of Buildable Design

The shortage of workers, expectation for better quality and demand for shorter construction period require the construction industry to be more efficient. The best way to achieve greater efficiency is to adopt designs which have a high degree of buildability. The CIDB Buildable Design Appraisal System (BDAS) can be used to check the buildability of a design. Buildability is determined by the extent to which the principles **standardisation, simplicity and single integrated elements (the 3S's)** are observed, right from the design stage. Details of Buildable Design Appraisal System can be obtained from CIDB.

Standardisation refers to the repetition of grids, sizes of components and connection details. **Simplicity** means uncomplicated building construction systems and installation details. **Single integrated elements** are those that combine related components together into a single element which may be prefabricated in the factory and installed on site.

A key feature of buildable designs is the use of prefabricated components. Prefabrication has many advantages. It enables projects to achieve a higher level of quality than is possible with cast-in-place construction. It also reduces the need for workers at the site and speeds up construction work.

Developers can play a key role in promoting the use of more buildable designs as their requirements and briefs will influence the design options of Architects and Engineers.

Scope Of The Guide

This Guide includes a catalogue of the preferred standard sizes of precast structural components and prefabricated reinforcements which are available from local suppliers. There are examples of local and overseas projects which have successfully used precast components and prefabricated reinforcement. Illustrations of architectural precast components are shown. Guidelines on precast design and construction considerations are also included.

CIDB hopes that this Guide will be frequently used by Developers and Architects, in planning their projects. For Engineers, this Guide will be supplemented with the CIDB Precast Design Handbook and CIDB Prefabricated Reinforcement Design Handbook.

ADVANTAGES OF PRECAST

Advantages

Better Quality

The most important advantage of precast is the opportunity to achieve consistently high quality end products. In recent years, the increasing shortage of skilled workers in Singapore has threatened to lower the standard of workmanship in many of our building projects. In precast construction, factory-controlled conditions and the use of state-of-the-art manufacturing techniques enable the desired dimensions, shapes, colours and texture of precast concrete to be more easily achieved. Precasting also makes it possible to inspect the surface finish prior to installation.

Design Freedom

Contrary to popular belief, precast concrete does not necessarily restrict design freedom. Diversity of expression and unique buildings can result from custom-made solutions and the intelligent use of industrialised production techniques. A wide variety of forms and shapes are possible with architectural precast concrete. Architects can also select different colours, texture and sizes to fit their aesthetic expressions. Also, precast concrete can harmonise with other building materials.

Economic Advantage

The economy of precast is maximised with high repetition in production. Careful planning can achieve good repetition in the design without sacrificing design freedom. Economic production leading to lower unit costs can be achieved when the recommended preferred sizes of precast components in this Guide are widely used in the industry. Productivity improvement is possible in the factory through design and tooling innovations. Further cost savings can be derived from the speed of construction. Production of components can proceed while foundation and site work is going on. They can then be erected quickly on site. Delays in concreting due to time required for curing, formwork removal and re-erection can be reduced. Financing cost will also be reduced as a result of the shorter overall construction time.

Manpower savings

Another important benefit is the saving of on-site labour. With the elimination of 'wet' trades, the need for skilled workers is also greatly reduced. This is especially important in Singapore due to our shortage of manpower and the rapidly shrinking pool of skilled workers from traditional sources.

Neater and Safer Sites

The use of precast concrete and other prefabricated components will help to reduce material wastage during construction. The elimination of formwork, scaffolding and 'wet' trades means that the site can be cleaner, neater and better organised. This should lead to increased safety.

Maximising The Benefits Through Teamwork

The advantages of precast can be enhanced when the entire design team and the contractor have the opportunity to jointly develop the project from the initial design stage. The time spent in planning and design always pays off in accelerated construction and consequent cost savings. The Architect and Engineer should therefore seek the advice of the Precaster in the early design stage. Maximum economy, optimum utility and high quality can then be achieved through a coordinated team effort.

Examples of Precast Projects

The following pages present examples of projects using precast components.

- *Millenia Tower*
- *The Bayshore*
- *Xpress Print*
- *Republic Plaza*
- *2 Finger Pier Buildings, Passenger Terminal 2, Singapore Changi Airport*
- *Henderson Secondary School*
- *Jurong West N3 C25*
- *Ngee Ann City*
- *CityCab*
- *K.P.M.G. Building, Netherlands*
- *Technical School of Magnanville, France*
- *"Venus 18" Social Housing, France*
- *High Rise Apartments in Yachiyo City, Chiba Prefecture, Japan*

Millenia Tower

MAIN FEATURES

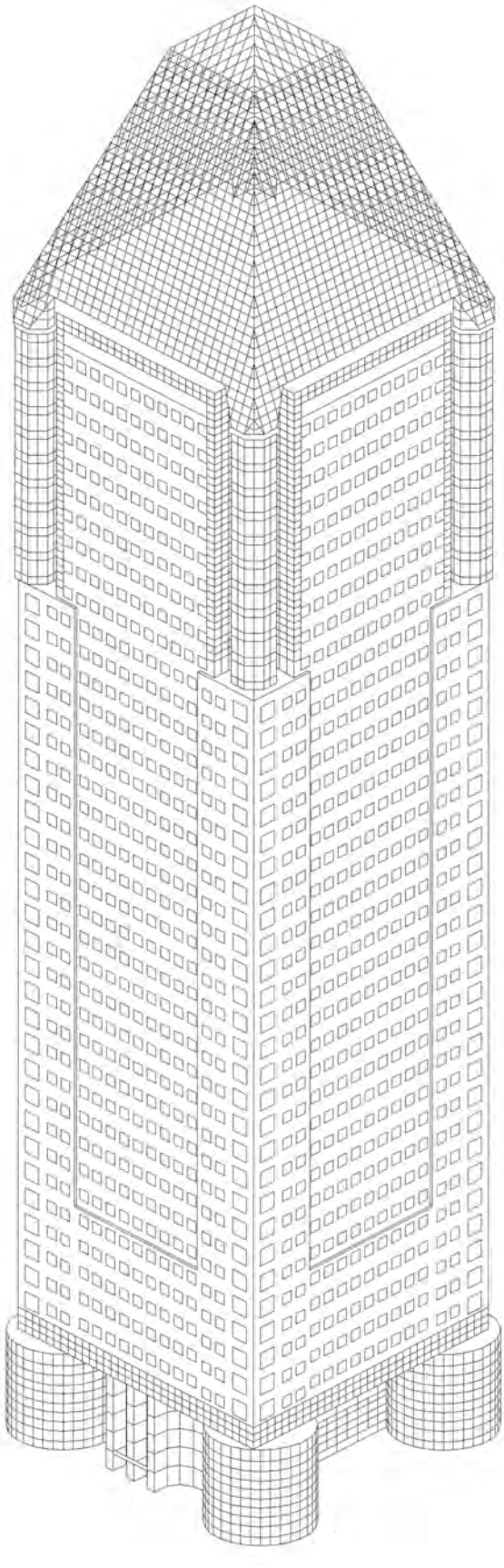
A simple, efficient yet attractive design. Precast post - tensioned beams, precast staircases and prefabricated beam cages were used. A special feature was the design of the external walls as structural walls; this enabled the walls to be cast and completed in one operation, leaving only windows and external skin panels for decorative effect. A climbing formwork system was mobilised for the core wall construction. System formwork was used for all vertical elements such as facades, columns and peripheral beams. The project achieved a 6-day floor cycle compared to the norm of 10-14 days.

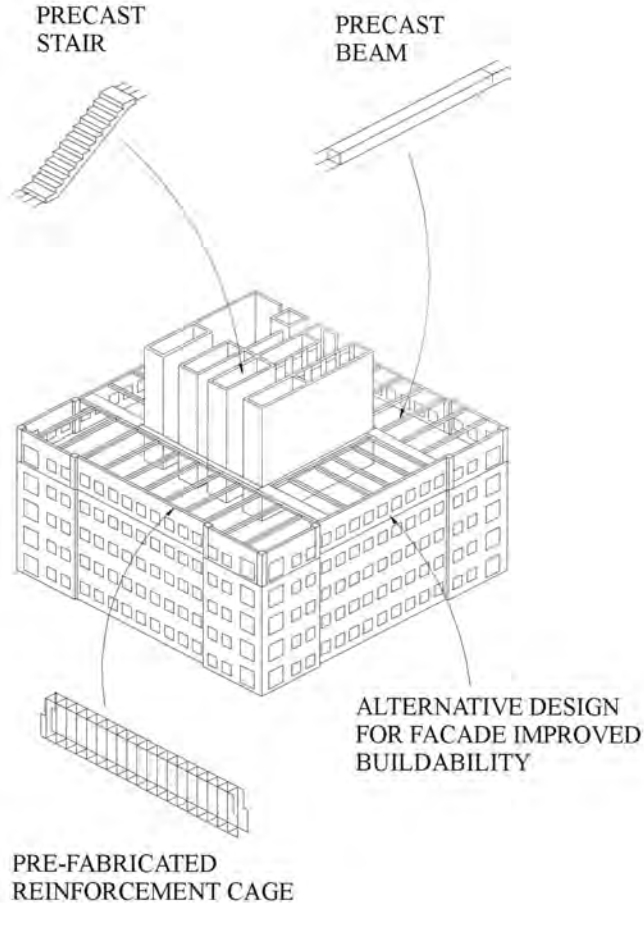
Client : *Pontiac Marina Pte Ltd* • ***Architectural Consultant :*** *DP Architects Pte Ltd, Kevin Roche & John Dinkeloo & Associates*

Structural Consultant : *Meinhardt (S) Pte Ltd* • ***Contractor (Alternative Design) :*** *Dragages Et Travaux Publics Project*

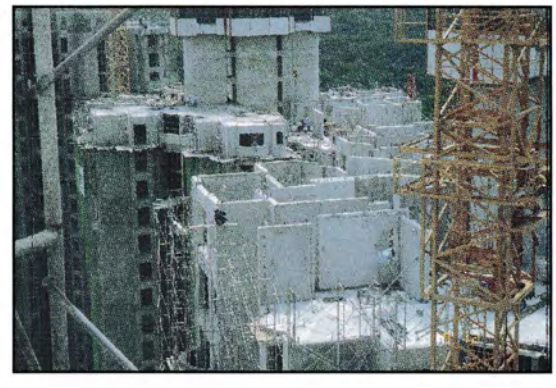
Cost : *$179.57 million*

Project Duration : *34.5 months* • ***Gross Floor Area :*** *78,428.37 m2* • ***No. of Storeys :*** *42*




PRECAST
STAIR
PRECAST
BEAM
ALTERNATIVE DESIGN
FOR FACADE IMPROVED
BUILDABILITY
PRE-FABRICATED
REINFORCEMENT CAGE

The Bayshore



MAIN FEATURES

The use of precast load bearing walls enabled the project to be completed on time. This project called for two precasters to supply the large number of required precast components. Another feature of this project is its cast-in-place flat slab. It highlights that precast and cast-in-place concrete can be used for the same building.

***Client** : Bayshore Park Pte Ltd • **Architectural Consultant:** DP Architects Pte Ltd • **Structural Consultant** : KPT Ho & Partners Consulting Civil & Structural Engineers • **Contractor (Alternative Design)** : Mitsui Construction Co Ltd*

***Project Cost** : $162 million • **Project Duration** : Phase I - 24 months, Phase II - 28 months • **Gross Floor Area** : 112,632 m2*

***No. of Storeys** : 4 no. 30-storey blocks and 2 no. 12-storey blocks*

***Total No. of Units** : 1038*

Xpress Print

MAIN FEATURES

This eight-storey light industry factory adopted several standardised precast concrete structural elements — precast concrete main beams, hollow core slabs, precast planks, precast stairs and precast curve edge beams with balconies.

***Owner** : Xpress Print Pte Ltd • **Architectural Consultant** : Kumpulan Architect • **Structural Consultant** : T H Chuan & Partners*

***Main Contractor** : JDC-Santarli JV*

***Project Duration** : 10 months (including piling) • **Gross Floor Area** : 7670 m2*

Republic Plaza

MAIN FEATURES

The steel framed building was efficiently designed to achieve maximum structural economy in terms of tonnage of steel per square metre of floor area. This, with unitised glass and granite curtain wall, made the building very buildable. Another notable feature was the composite steel decking floor complete with supports /connections for building services. Pre-assembled staircase forms with reinforcement and riser plates were also used.

Client : CDL Properties • Architectural & Structural Consultant : RSP Architects Planners & Engineers

Contractor : Shimizu Corporation • Project Cost : $273 million • Project Duration : 47 months

Gross Floor Area : 102,282 m2 • No. of Storeys : 66

2 Finger Pier Buildings

MAIN FEATURES

Construction of the 2 Finger Pier buildings, each 2-storey high and about 500m long, was to be carried out completely on the air-side which was a very busy operational area in the airport. To minimise disruption to airport operations and to meet very stringent operational and safety requirements, the PWD designed a structural system which enabled a fast and highly mechanised method of construction to be adopted. Standardised precast concrete structural elements comprising precast columns, prestressed precast beams, hollow core slabs and precast stairs were widely used. This reduced on-site activities and labour to a large extent.

Owner : *Civil Aviation Authority of Singapore (CAAS)* • ***Consultant :*** *Public Works Deaprtment (PWD)*

Main Contractor : *Singapore Technologies Construction Pte Ltd* • ***Project Cost :*** *$145 million*

Project Duration : *South East Finger Pier - 15 months , North East Finger Pier - 23 months*

Gross Floor Area : *70,000 m2*

Passenger Terminal 2, Singapore Changi Airport

Henderson Secondary School

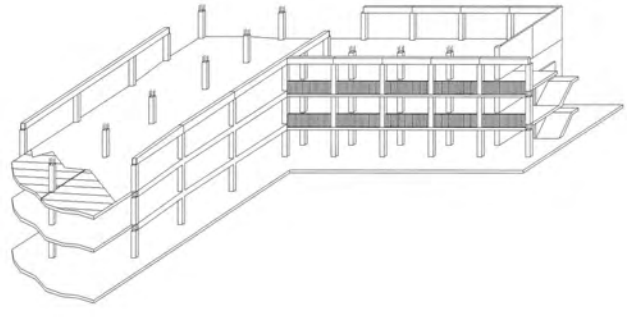
MAIN FEATURES

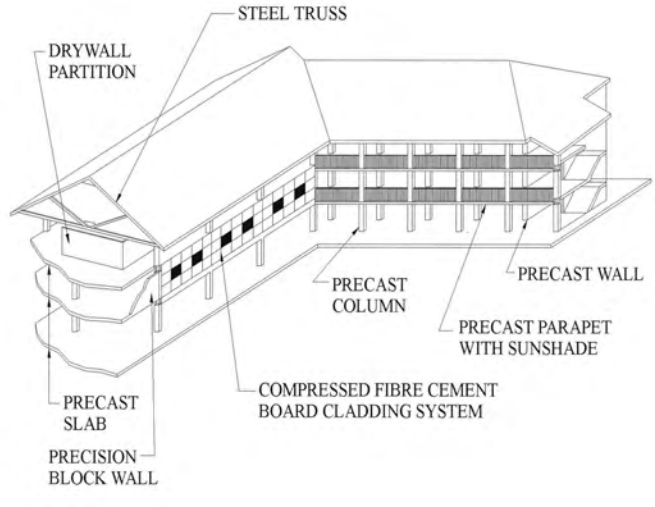
The building adopted a precast structural frame. Precast beams were standardised to three sizes. Some beams had parapets and sunshades integrated to form a single element. Three-storey high precast columns were used together with other precast components such as precast hollow core slabs, shear walls and concrete planks. Modular grids and standardisation of design enabled easy fabrication and installation of both structural and architectural components.

Client : *Public Works Department/Ministry of Education* • ***Architectural Consultant :*** *Kumpulan Akitek*

Structural Consultant : *S. M. Wan* • ***Contractor :*** *Neo Corporation Pte Ltd* • ***Project Cost :*** *$16.2 million*

Project Duration : *19 months* • ***Gross Floor Area :*** *18,400 m2*




STEEL TRUSS
DRYWALL PARTITION
PRECAST COLUMN
PRECAST WALL
PRECAST PARAPET WITH SUNSHADE
COMPRESSED FIBRE CEMENT BOARD CLADDING SYSTEM
PRECAST SLAB
PRECISION BLOCK WALL

Jurong West N3 C25

MAIN FEATURES

The use of prefabricated beam cages, column link cages and welded wire fabric for both walls and slabs eliminated the tedious process of tying reinforcement on site. Architectural precast components for the project included internal lightweight concrete parapets, external concrete facades, gable-end walls and secondary roofing slabs.

The wide application of standardisation and precast components enabled repetitive sequence of work to be carried out. The productivity of the project is almost twice that of private sector's residential projects.

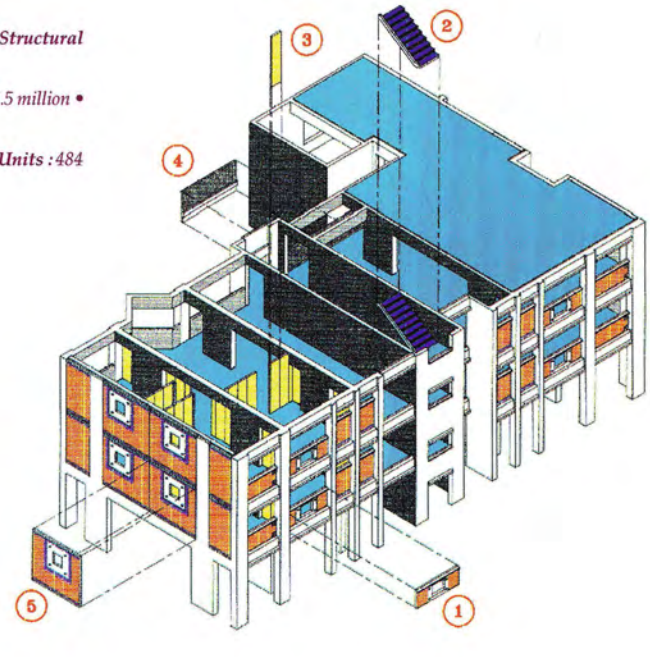
***Client** : Housing & Development Board • **Architectural and Structural Consultant** : Housing & Development Board*

***Contractor** : Tiong Aik Construction Pte Ltd • **Project Cost** : $36.5 million • **Project Duration** : 32 months*

***Gross Floor Area** : 76,771 m2 • **No. of Blocks** : 6 • **Total No. of Units** : 484*

Precast Components:

① Facade
② Staircase
③ Lightweight Partition
④ Parapet
⑤ Gable-End Wall



Ngee Ann City

MAIN FEATURES

Regular column grids for both the podium and tower blocks and the use of standardised column dimensions made the project very buildable. Reinforcement cages for columns and precast staircases were used to reduce on-site work. A prominent feature was the richly hued pre-finished precast wall panels. Each precast panel was cast together with the polished granite and aluminium window frame in one process. This shortened the installation time. A high standard of finish was also achieved.

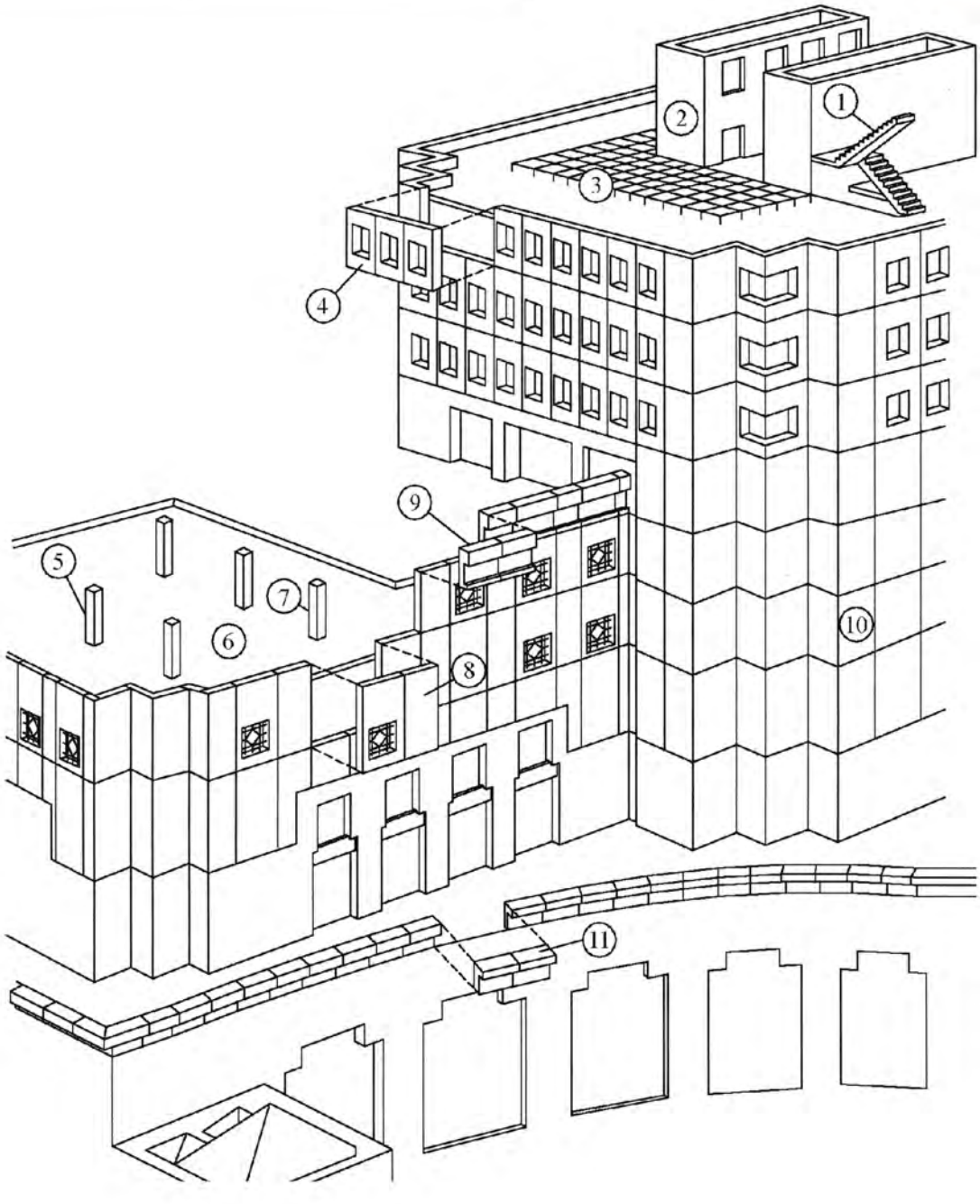
Owner : *Ngee Ann City Pte Ltd & Orchard Square Development Corporation Pte Ltd*
Architectural Consultant : *Raymond Woo & Associates Architects* • ***Structural Consultant :*** *Chong & Lee Consultants*

Contractor (Alternative Design) : *Shimizu Corporation* • ***Specialist Contractor :*** *Shimizu Precon Pte Ltd*

Project Cost : *$391 million (excluding piling)* • ***Project Duration :*** *42 months* • ***Gross Floor Area :*** *258,375 m2*

No. of Storeys : *3-storey basement, 7-storey podium and 28-storey twin towers*

① PC Steps with nosing tile finish
② Slip-form system for lift cores of towers
③ Lightweight concrete access floor system
④ Granite pre-finished external walls including window frames and glass panels
⑤ Prefabricated reinforcement cement cage columns
⑥ Flat plate/table form system
⑦ Standardised column grid
⑧ Granite pre-finished PC external walls with window grilles
⑨ Granite pre-finished PC parapet walls
⑩ Granite pre-finished PC external walls
⑪ Granite pre-finished curved parapet walls



City Cab

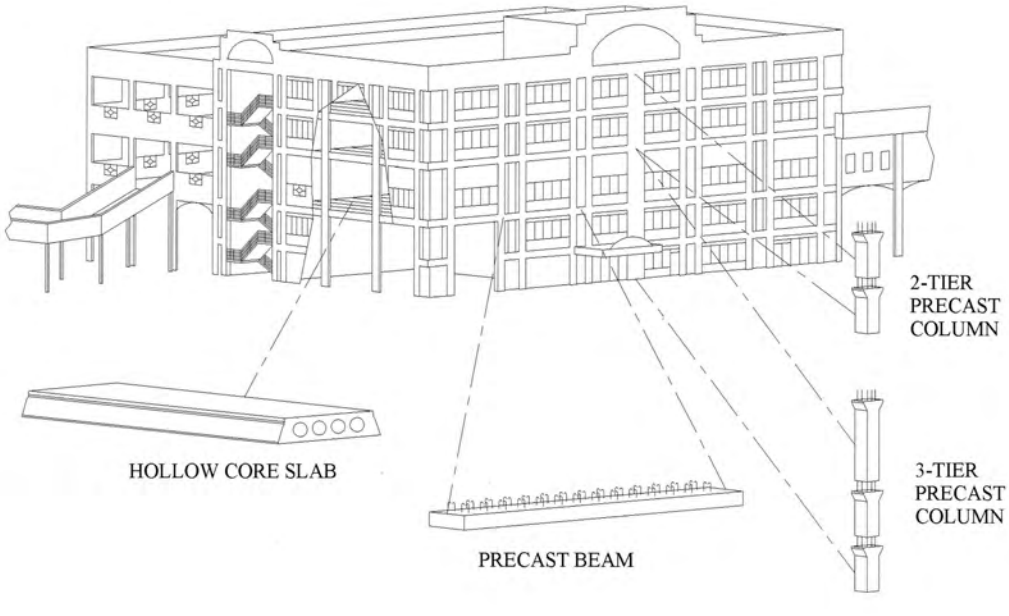
MAIN FEATURES

Precast structural components used for this vehicle and maintenance centre included 12m long standardised columns, beams and hollow core slabs. The use of precast components facilitated fast-track construction, allowing the project to be completed 2 months ahead of schedule. Vertical repetition was incorporated in the design to attain easy construction and economies of scale. In addition, use of standardised windows and dry wall system for internal walls increased the speed of construction.

Owner : *ST Automative Pte Ltd* • ***Architectural and Structural Consultant :*** *ST Architects & Engineers Pte Ltd*

Contractor (Design & Build) : *Singapore Technologies Construction Pte Ltd* • ***Project Cost :*** *$21.8 million*

Project Duration : *13.5 months* • ***Gross Floor Area :*** *25,362 m2* • ***No. of Storeys :*** *4*


2-TIER
PRECAST
COLUMN
HOLLOW CORE SLAB
3-TIER
PRECAST
COLUMN
PRECAST BEAM

K.P.M.G. Building, Netherlands

An entirely precast circular shaped office building.

Architectural Consultant : *Bakker en Verhoeff, Rotterdam*

Technical School of Maganville (France)

Innovative use of precast for curved design.

Architect : *Sade Sarl*

Contractor : *Region Ile De France*

"Venus 18" Social Housing (France)

Classical precast column & elevation treatment add a touch to conventional precast social housing.

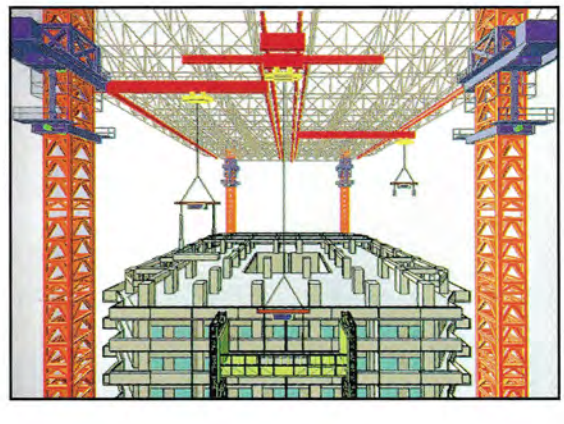
Architect: *Sade Sarl*

Contractor: *Logement Francais*

High-Rise Apartments
Yachiyo City, Chiba Prefecture, Japan

MAIN FEATURES

Obayashi Corporation developed the "Big Canopy" automation system for high-rise building construction. Below the canopy, modular construction materials are moved into place by several hoist cranes. This allows different types of work such as assembly of beams and columns to take place at the same time. This mechanisation and automation of work process increased productivity on site, shortened the construction period of this 26-storey building by 4 months and reduced labour requirement by 60%.



Main Contractor : *Obayashi Corporation*

PRECAST CONSIDERATIONS

The Use Of Precast

It is possible for most buildings of various types such as commercial, residential and industrial to be designed for construction in precast concrete. Buildings with high degree of modular co-ordination and repetitive structural grids are ideal for precast construction. Even buildings with irregular layouts are often suitable for partial precast construction.

It is a common misconception that precast concrete lacks flexibility. With creativity and standardisation of basic precast elements, details and connections, a wide variety of plans, elevations and features can be achieved with precast concrete.

Personnel And Expertise

A good precast building is a joint effort of the Developer, Architect, Engineer, Precaster and Contractor. A good precast building has to begin with a precast design intent at the initial design stage.

At the design stage, the Architect and Engineer should integrate inputs from Precaster and Contractor in order to realise the advantages of precast. These include minimum wastage of material and maximum efficiency in production and erection of precast components.

At the construction stage, the Precaster and Contractor who have taken over the project for construction should work closely with the Architect and Engineer. They should collaborate on the workshop drawing details and refinement, if any, to suit their specific production and erection considerations. This helps to achieve the objective of shorter construction time and better quality.

Planning And Layout

In general, modular co-ordination should be adopted throughout the building. Dimensions between grid lines could be used in modules of 1200mm to facilitate the use of precast components. A modular grid of 300mm is recommended as a basis of design for horizontal dimensions and 100mm for vertical dimensions.

Grids need not be just rectangular. Other geometric shapes can be used. The important point is to achieve regularity so that there is higher repetition of elements and components.

In addition, precast concrete elements should be as large as possible bearing in mind limitations of production, transport, erection and crane lifting capacity. Connections between elements should be as simple as possible.

General Steps In Design

After establishing the design brief with the developer, the following stages are recommended for the design development of a precast building :

Preliminary Design Stage

The Architect and Engineer will develop floor layout plans with grid dimensions, storey heights and building form. This is the critical stage in which modular planning and standardisation of grids and storey heights should be pursued.

In collaboration with the Engineer, the type of precast structural system is then selected. The basic precast structural systems are discussed below. The Architect needs only to consider the possible basic structural systems during the initial design stage.

Section Four of this Guide provides tables for a quick reference on selection of structural precast components for various categories of buildings. Other engineering considerations should be taken up by the Engineer and Precaster at the subsequent design development stage.

Design Development Stage

The Engineer develops detailed design and drawings for the precast structural system established. When necessary, the Precaster should be consulted to achieve practicability and buildability on site.

Selection of Structural Precast Systems

The most common precast structural systems are:

- ***Frame Systems***

Frame structural systems are suitable for buildings which need a high degree of flexibility. Large spans and open spaces can be achieved without interfering walls. This system is particularly suitable for shopping malls, multi-storey carparks, sports facilities, office buildings and industrial buildings.

- ***Load Bearing Walls and Floors***

Precast load bearing walls can appear as walls in shafts and cores, cross-walls and load bearing external walls. Precast wall systems have been used in residential projects. They offer the advantages of fast construction, ready-to-paint surface finishing, acoustic insulation and fire resistance. The slabs between walls can either be precast or in-situ flat plate structure. The aim is to build free open spaces between the load bearing walls and to use light partition walls for the internal layout. This offers flexibility in interior layout.

- ***Cell Systems***

Cell units are feasible for specific uses of a building, for instance, bathrooms and kitchens. The advantage of the system lies in the speed of construction and high productivity in manufacturing since the finishing and fittings (including mechanical and electrical services) of the cells are completely done at the factory. The HDB upgrading programme, for example, uses cell systems.

The above systems may be combined in the same precast building. Precast components are also used in conjunction with in-situ concrete. Structural compatibility should not be a problem. However, stability and robustness should be looked into. The Engineer may refer to the CIDB Precast Design Handbook for engineering considerations.

Site Location

The site location, accessibility and project scale are determining factors in organising precast production, storage and erection. Where practical, some components can be cast at the site.

For congested sites, all elements will have to be delivered by trucks and directly lifted for installation using the 'just-in-time' method. The accessibility of the site and the location of the lifting crane will determine the weight of precast components that can be lifted. Generally, units weighing more than 5 tons may pose lifting problems for tower cranes. Inputs from the Precaster and Contractor should be sought.

Costs

The construction cost of a building using precast components should be assessed in its overall context. The traditional method of costing by material quantities with a fixed factor for labour cost can lead to incorrect estimation. For example, if labour usage is halved, this will more than compensate for a 10 percent material increase.

More importantly, there is savings in time. Also, if properly designed and executed, precast can lead to much better quality work. The overall cost impact of precast has therefore to take all these factors into consideration.

With the rising costs of labour and less assurance of dependable skilled manpower, the trend is that precast construction will become increasingly competitive compared to cast-in-place construction.

M & E Installation

It is important to integrate, at the design stage, M&E services with the use of precast components. Location of openings for ducts and pipes, concealed wirings and fastenings for duct support should be considered at this stage. This will avoid costly rectification work later. Some of the duct work, pipe work and wiring work can be incorporated in precast components. For example, precast walls should include wiring work and cell systems such as prefabricated toilets often come with pipe work and wiring work installed in the factory.

Waterproofing

In precast construction, the effectiveness of watertightness depends on the design of joints and use of appropriate sealants. External joints must be able to resist water leakage due to rain and wind; where feasible, joint design should allow water that has penetrated to drain off. Internally, use of water for cleaning must be expected at certain locations and waterproofing of slabs and wall connections will therefore be necessary. Reference may be made to the CIDB Precast Design Handbook for more information.

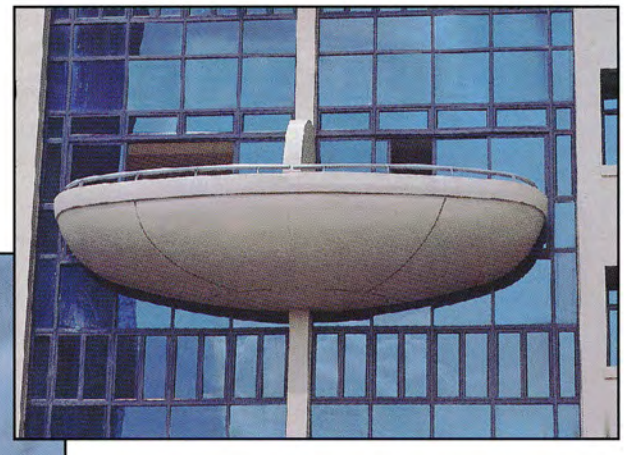
Section Three

ARCHITECTURAL COMPONENTS

Architectural Variety

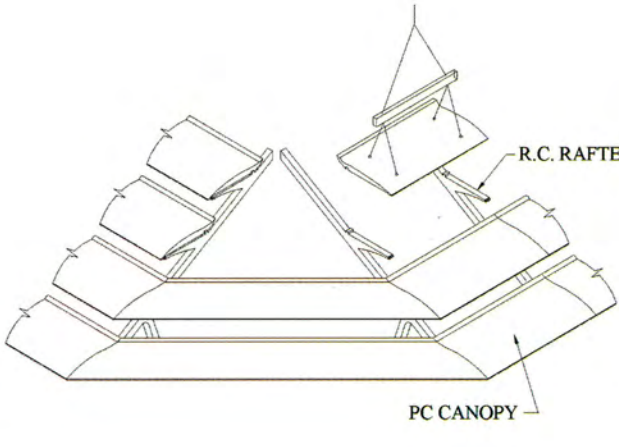
Architectural precast concrete is where creativity and variety can be expressed. Balconies, parapets, gable-end walls, facade walls and other elevation treatments can all be done with precast concrete. Unique shapes and designs and various finished effects (using tiles, granite, spray finish etc) can be achieved. The advantages of precast are higher consistency and quality.

Sizings and dimensions are usually custom made to the project. The only point to note is the need for repetition so as to be economical for production. Internal walls usually come in standard sizes, such as precast lightweight walls and precision blocks. Precision block walls require only 2 to 3 mm skim coat and do away with plastering. The following pages show some of these architectural components.

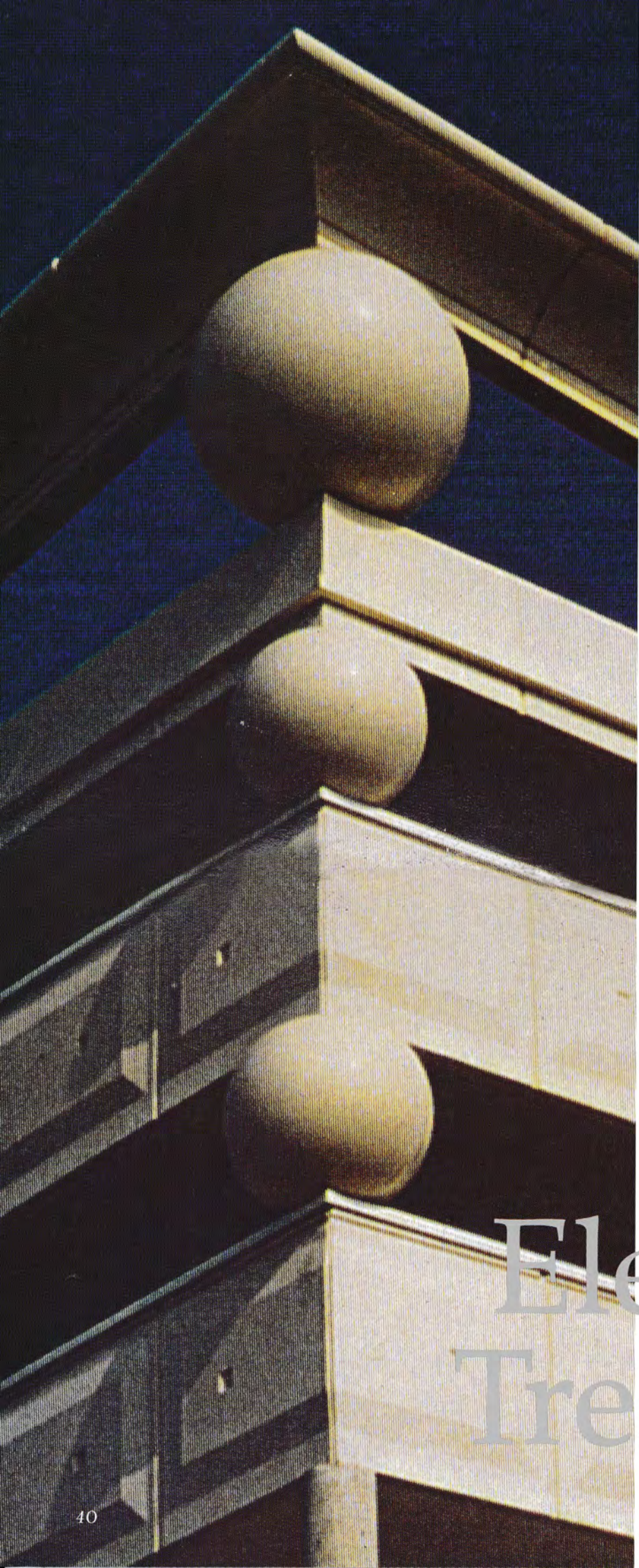


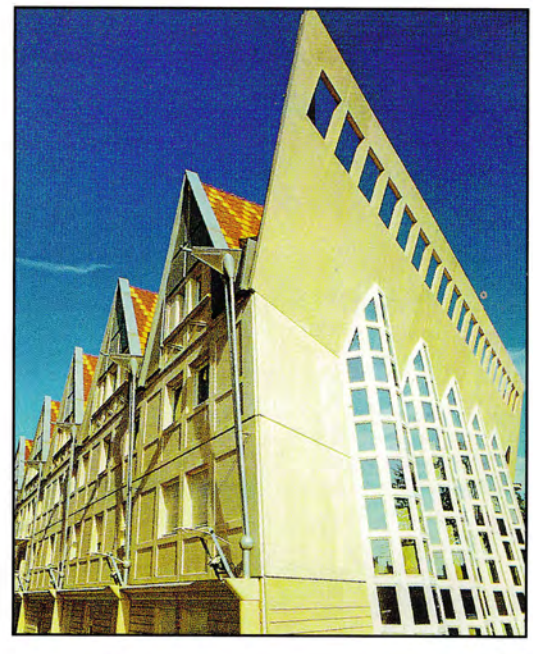
Balcony

Parapet



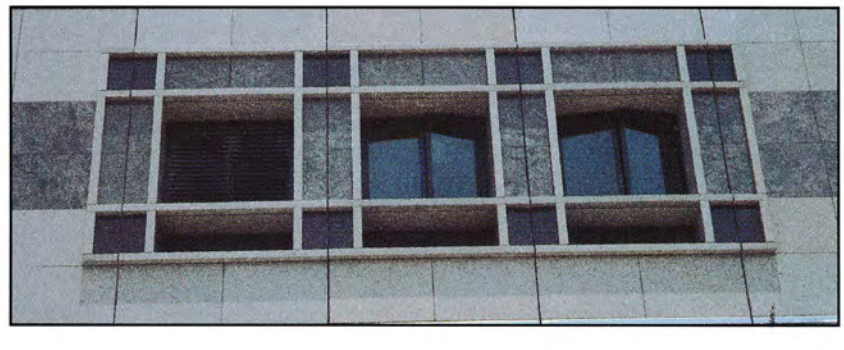
Canopy

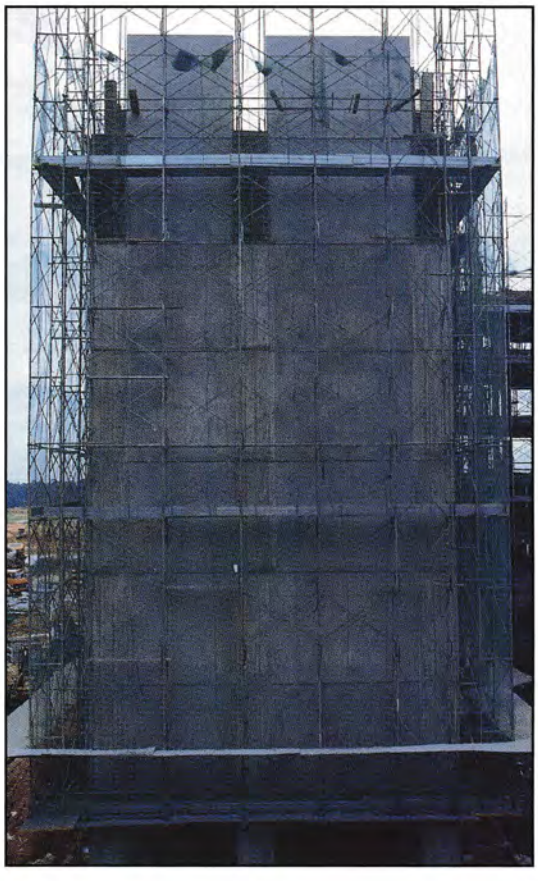


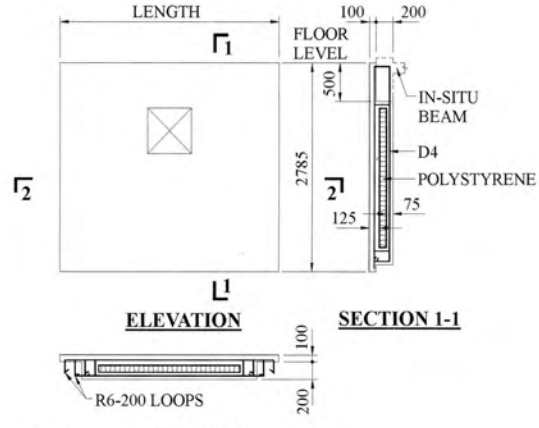


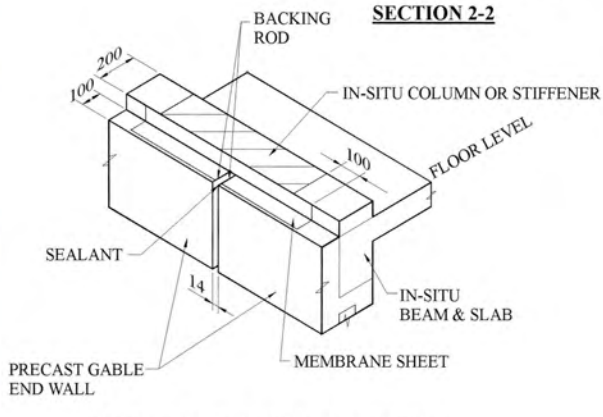
Elevation Treatment

Facade Wall







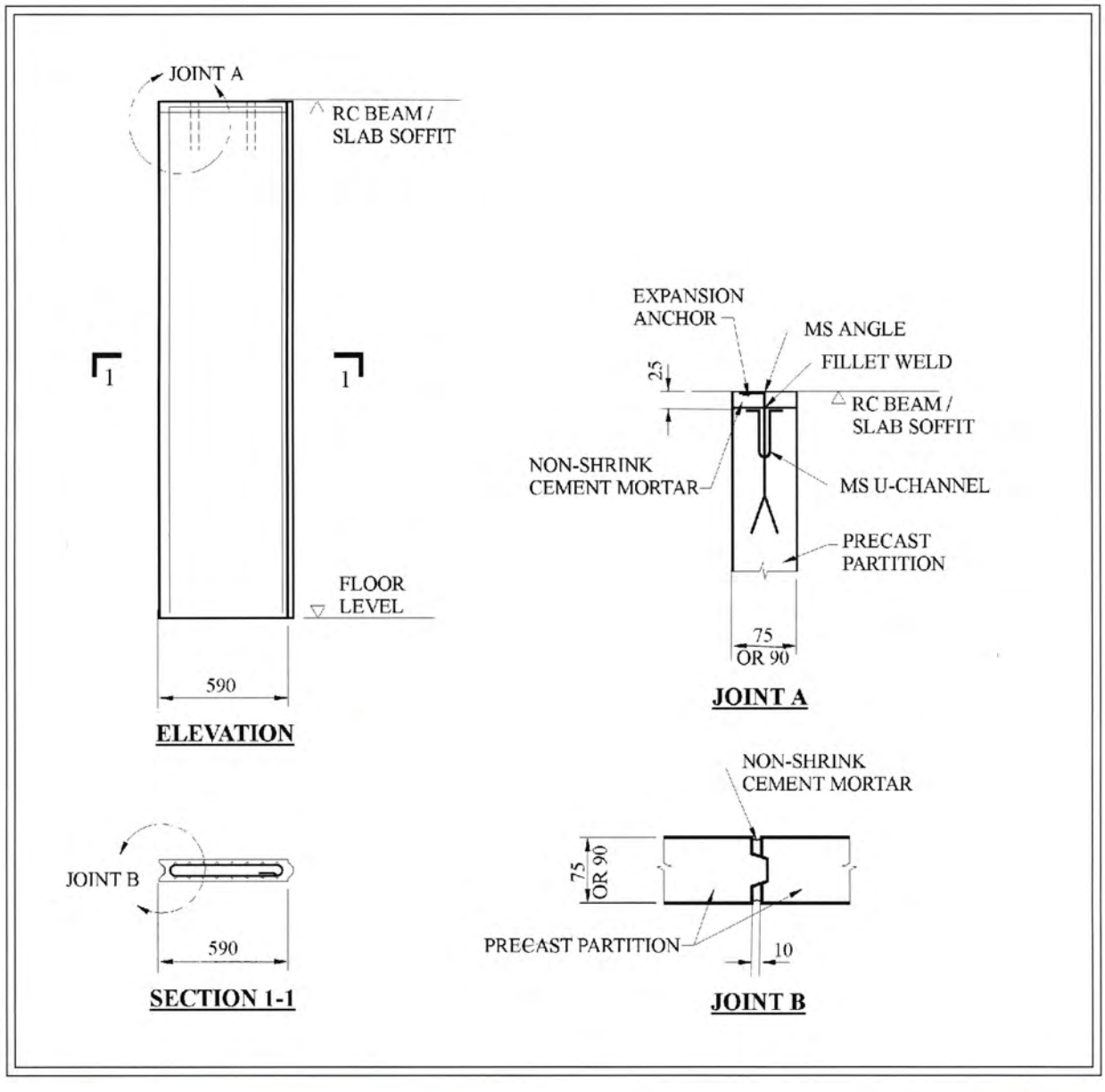


ISOMETRIC VIEW SHOWING TYPICAL WATERPROOFING DETAIL FOR PRECAST GABLE END WALL

Courtesy of HDB
Used with permission

Gable-End Wall

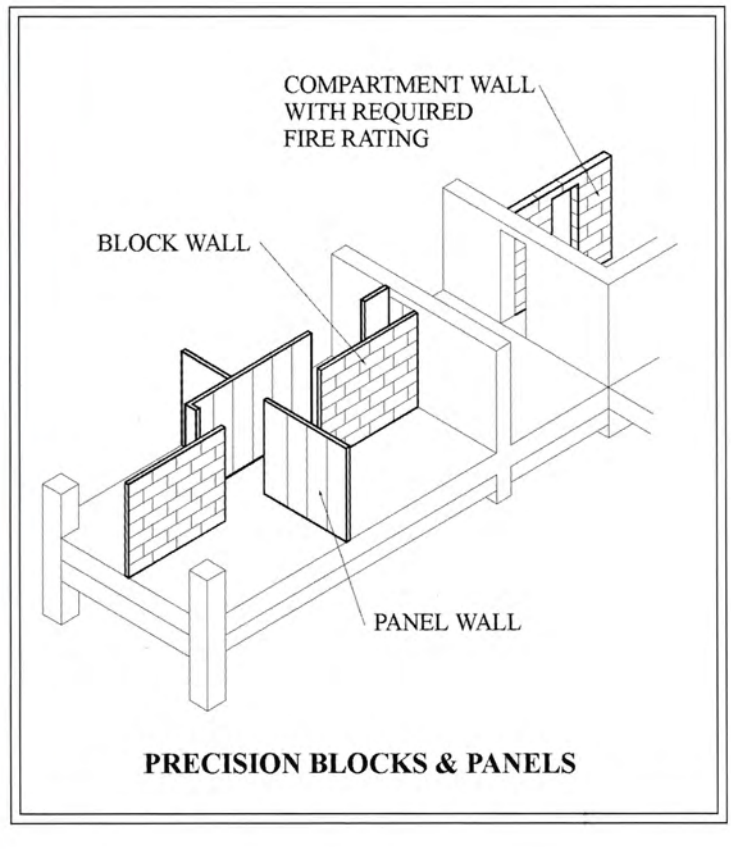
Prefab Bathroom



Courtesy of HDB
Used with permission

Lightweight Partition

Precision Block & Panel



PRECISION BLOCKS & PANELS

Section Four

CATALOGUE OF STRUCTURAL PRECAST CONCRETE COMPONENTS

This section features the industry's first effort to produce a catalogue of structural precast components for framed structure. The catalogue covers 3 categories of buildings :

- Commercial and Institutional
- Residential
- Industrial

The catalogue presented here is primarily to assist Architects in selecting column and beam sizes for given spans, live loads and storey heights. Overall dimensions of beams and columns are therefore emphasised. The supplementary CIDB Precast Design Handbook will provide more detailed dimensions for engineering design and production.

Annotations such as HC (hollow core), PB (precast beam), PC (precast column) are used to enable catalogue development. Over time, this catalogue will be fine tuned and improved through usage and feedback from the industry.

An example on selecting the sizes and the relevant design assumptions are provided at the end of this section.

Table 1A Commercial and Institutional Buildings Recommended Sizes for Precast Slabs and Beams

Structural Beam Span	Design Live Loads	Precast Slab Type (mm) and Overall Beam Size for various Structural Floor Element Span S2(m)					
S1(m)	kN/m2	6.0	7.2	8.4	9.6	10.8	12.0
≤6.0	2.5	PB 40/60	PB 50/60	PB 50/65	PB 60/65	PB 60/70	PB 70/75
	3.0	PB 50/60	PB 50/60	PB 60/65	PB 60/65	PB 60/70	PB 70/75
	4.0	PB 50/60	PB 50/60	PB 60/65	PB 60/70	PB 70/75	PB 70/75
	5.0	PB 50/60	PB 60/60	PB 60/65	PB 70/70	PB 70/75	PB 80/75
>6.0 ; ≤7.2	2.5	PB 50/70	PB 50/70	PB 60/75	PB 60/75	PB 70/80	PB 70/80
	3.0	PB 50/70	PB 50/70	PB 60/75	PB 60/75	PB 70/80	PB 70/80
	4.0	PB 50/70	PB 60/70	PB 60/75	PB 70/80	PB 70/80	PB 80/80
	5.0	PB 50/70	PB 60/70	PB 70/75	PB 70/80	PB 80/80	PB 80/80
>7.2 ; ≤8.4	2.5	PB 50/75	PB 60/75	PB 60/80	PB 70/80	PB 70/85	PB 80/85
	3.0	PB 50/75	PB 60/75	PB 60/80	PB 70/80	PB 70/85	PB 80/90
	4.0	PB 50/75	PB 60/75	PB 70/80	PB 70/85	PB 80/85	PB 80/90
	5.0	PB 60/75	PB 60/75	PB 70/85	PB 80/85	PB 80/85	PB 90/90
>8.4 ; ≤9.6	2.5	PB 50/85	PB 60/85	PB 60/90	PB 70/90	PB 70/95	PB 80/95
	3.0	PB 50/85	PB 60/85	PB 60/90	PB 70/90	PB 80/95	PB 80/100
	4.0	PB 60/85	PB 60/85	PB 70/90	PB 70/95	PB 80/95	PB 90/100
	5.0	PB 60/85	PB 60/85	PB 70/90	PB 80/95	PB 80/95	PB 90/100
>9.6 ; ≤10.8	2.5	PB 50/90	PB 60/90	PB 60/95	PB 70/95	PB 80/100	PB 80/105
	3.0	PB 50/90	PB 60/90	PB 70/100	PB 70/100	PB 80/105	PB 80/105
	4.0	PB 60/95	PB 60/95	PB 70/100	PB 80/105	PB 80/105	PB 90/110
	5.0	PB 60/95	PB 70/95	PB 70/100	PB 80/105	PB 90/105	PB 90/110
>10.8 ; ≤12.0	2.5	PB 50/100	PB 60/100	PB 70/105	PB 70/105	PB 80/110	PB 80/115
	3.0	PB 60/100	PB 60/100	PB 70/105	PB 70/105	PB 80/110	PB 90/115
	4.0	PB 60/100	PB 60/100	PB 70/105	PB 80/110	PB 90/115	PB 90/115
	5.0	PB 60/100	PB 70/100	PB 80/110	PB 80/115	PB 90/115	PB 100/115

Note : 1) PB 50/90 denotes a **precast beam** of width **50cm (500mm)** and overall depth of **90cm (900mm)**. (See Figure 1).

2) The sizes in the above table are recommended sizes. Engineers are to carry out detailed design according to the relevant design code.

3) Refer to Figure 4 for slab sections. Architect and Engineer may wish to check with Precasters for other sizes of hollow core slabs.

215HC 265HC 325HC 360HC 380HC

Table 1B

Commercial and Institutional Buildings
Recommended Sizes for Precast Columns (Table 1B/1)

Structural Beam Span S1(m)	Design Live Loads kN/m2	Square Precast Column for Building Height ≤5 storeys for various Structural Floor Element Span S2 (m)					
		6.0	7.2	8.4	9.6	10.8	12.0
≤ 6.0	2.5	PC 35	PC 40	PC 45	PC 45	PC 50	PC 55
	3.0	PC 35	PC 40	PC 45	PC 50	PC 55	PC 55
	4.0	PC 40	PC 40	PC 45	PC 50	PC 55	PC 60
	5.0	PC 40	PC 45	PC 50	PC 55	PC 60	PC 60
>6.0 ; ≤7.2	2.5	PC 40	PC 45	PC 50	PC 50	PC 55	PC 60
	3.0	PC 40	PC 45	PC 50	PC 55	PC 60	PC 65
	4.0	PC 40	PC 45	PC 50	PC 55	PC 60	PC 65
	5.0	PC 45	PC 50	PC 55	PC 60	PC 65	PC 65
>7.2 ; ≤8.4	2.5	PC 45	PC 45	PC 55	PC 55	PC 60	PC 65
	3.0	PC 45	PC 50	PC 55	PC 60	PC 60	PC 70
	4.0	PC 45	PC 50	PC 55	PC 60	PC 65	PC 70
	5.0	PC 45	PC 50	PC 60	PC 65	PC 70	PC 75
>8.4 ; ≤9.6	2.5	PC 45	PC 50	PC 55	PC 60	PC 65	PC 70
	3.0	PC 45	PC 50	PC 60	PC 60	PC 65	PC 75
	4.0	PC 50	PC 55	PC 60	PC 65	PC 70	PC 75
	5.0	PC 50	PC 55	PC 60	PC 70	PC 75	PC 80
>9.6 ; ≤10.8	2.5	PC 50	PC 55	PC 60	PC 65	PC 70	PC 75
	3.0	PC 50	PC 55	PC 60	PC 65	PC 70	PC 80
	4.0	PC 50	PC 55	PC 65	PC 70	PC 75	PC 80
	5.0	PC 55	PC 60	PC 65	PC 70	PC 80	PC 85
>10.8 ; ≤12.0	2.5	PC 50	PC 55	PC 65	PC 70	PC 75	PC 80
	3.0	PC 55	PC 60	PC 65	PC 70	PC 75	PC 80
	4.0	PC 55	PC 60	PC 65	PC 75	PC 80	PC 85
	5.0	PC 55	PC 65	PC 70	PC 75	PC 85	PC 90

Table 1B

Commercial and Institutional Buildings
Recommended Sizes for Precast Columns (Table 1B/2)

Structural Beam Span S1(m)	Design Live Loads kN/m2	Square Precast Column for Building Height > 5 ; ≤ 10 storeys for various Structural Floor Element Span S2 (m)					
		6.0	7.2	8.4	9.6	10.8	12.0
≤ 6.0	2.5	PC 50	PC 55	PC 60	PC 65	PC 70	PC 75
	3.0	PC 50	PC 55	PC 60	PC 65	PC 70	PC 80
	4.0	PC 50	PC 55	PC 65	PC 70	PC 75	PC 80
	5.0	PC 55	PC 60	PC 65	PC 70	PC 80	PC 85
>6.0 ; ≤7.2	2.5	PC 55	PC 60	PC 65	PC 70	PC 80	PC 85
	3.0	PC 55	PC 60	PC 65	PC 70	PC 80	PC 85
	4.0	PC 55	PC 60	PC 70	PC 75	PC 85	PC 90
	5.0	PC 60	PC 65	PC 70	PC 80	PC 85	PC 90
>7.2 ; ≤8.4	2.5	PC 60	PC 65	PC 70	PC 75	PC 85	PC 90
	3.0	PC 60	PC 65	PC 75	PC 80	PC 85	PC 95
	4.0	PC 60	PC 65	PC 75	PC 85	PC 90	PC 95
	5.0	PC 65	PC 70	PC 75	PC 85	PC 90	PC 100
>8.4 ; ≤9.6	2.5	PC 60	PC 70	PC 75	PC 80	PC 90	PC 100
	3.0	PC 65	PC 70	PC 80	PC 85	PC 90	PC 100
	4.0	PC 65	PC 70	PC 80	PC 90	PC 95	PC 105
	5.0	PC 65	PC 75	PC 80	PC 90	PC 100	PC 105
>9.6 ; ≤10.8	2.5	PC 65	PC 70	PC 80	PC 85	PC 95	PC 105
	3.0	PC 65	PC 75	PC 85	PC 90	PC 95	PC 105
	4.0	PC 70	PC 75	PC 85	PC 95	PC 100	PC 110
	5.0	PC 70	PC 80	PC 90	PC 95	PC 105	PC 110
>10.8 ; ≤12.0	2.5	PC 70	PC 75	PC 85	PC 90	PC 100	PC 110
	3.0	PC 70	PC 80	PC 85	PC 95	PC 105	PC 110
	4.0	PC 75	PC 80	PC 90	PC 100	PC 110	PC 115
	5.0	PC 75	PC 85	PC 95	PC 100	PC 110	PC 120

Table 1B Commercial and Institutional Buildings Recommended Sizes for Precast Columns (Table 1B/3)

Structural Beam Span	Design Live Loads	Square Precast Column Building Height > 10 ; ≤ 15 storeys for various Structural Floor Element Span S2 (m)					
S1(m)	kN/m2	6.0	7.2	8.4	9.6	10.8	12.0
≤ 6.0	2.5	PC 60	PC 65	PC 75	PC 80	PC 85	PC 95
	3.0	PC 60	PC 65	PC 75	PC 80	PC 85	PC 95
	4.0	PC 60	PC 70	PC 75	PC 85	PC 90	PC 100
	5.0	PC 65	PC 70	PC 80	PC 85	PC 95	PC 100
>6.0 ; ≤7.2	2.5	PC 65	PC 70	PC 80	PC 85	PC 95	PC 105
	3.0	PC 65	PC 70	PC 80	PC 85	PC 95	PC 105
	4.0	PC 70	PC 75	PC 85	PC 90	PC 100	PC 105
	5.0	PC 70	PC 75	PC 85	PC 95	PC 105	PC 110
>7.2 ; ≤8.4	2.5	PC 70	PC 75	PC 85	PC 95	PC 100	PC 110
	3.0	PC 70	PC 80	PC 90	PC 95	PC 105	PC 115
	4.0	PC 75	PC 80	PC 90	PC 100	PC 110	PC 115
	5.0	PC 75	PC 85	PC 95	PC 105	PC 110	PC 120
>8.4 ; ≤9.6	2.5	PC 75	PC 80	PC 95	PC 100	PC 110	PC 120
	3.0	PC 75	PC 85	PC 95	PC 100	PC 110	PC 120
	4.0	PC 80	PC 85	PC 95	PC 105	PC 115	PC 125
	5.0	PC 80	PC 90	PC 100	PC 110	PC 120	PC 125
>9.6 ; ≤10.8	2.5	PC 80	PC 85	PC 100	PC 105	PC 115	PC 125
	3.0	PC 80	PC 90	PC 100	PC 105	PC 120	PC 130
	4.0	PC 85	PC 90	PC 105	PC 115	PC 125	PC 130
	5.0	PC 85	PC 95	PC 105	PC 115	PC 125	PC 135
>10.8 ; ≤12.0	2.5	PC 85	PC 90	PC 105	PC 110	PC 125	PC 135
	3.0	PC 85	PC 95	PC 105	PC 115	PC 125	PC 135
	4.0	PC 90	PC 95	PC 110	PC 125	PC 130	PC 140
	5.0	PC 90	PC 100	PC 110	PC 125	PC 135	PC 140

Note for Table 1B:

1) PC 70 denotes a **square precast column** of size **700x700 mm**.

2) The sizes in the above table are recommended sizes. Engineers are to carry out detailed design according to the relevant design code.

3) Rectangular columns of equivalent cross sectional area can be used provided slenderness limits are observed.

Table 2A Residential Buildings
Recommended Sizes for Precast Slabs and Beams

Structural Beam Span	Design Live Loads	Precast Slab Type (mm) and Overall Beam Size for various Structural Floor Element Span S2 (m)				
S1(m)	kN/m2	3.0	3.6	4.8	6.0	7.2
≤3.6	1.5	PB 20/40	PB 20/40	PB 20/40	PB 20/40	PB 20/45
	2.0	PB 20/40	PB 20/40	PB 20/40	PB 20/45	PB 40/50
	3.0	PB 20/40	PB 20/40	PB 20/40	PB 20/45	PB 40/50
>3.6 ; ≤4.8	1.5	PB 20/45	PB 20/45	PB 20/45	PB 20/45	PB 25/50
	2.0	PB 20/45	PB 20/45	PB 20/45	PB 25/50	PB 45/55
	3.0	PB 20/45	PB 20/45	PB 20/50	PB 25/50	PB 45/55
>4.8 ; ≤6.0	1.5	PB 20/50	PB 20/50	PB 20/55	PB 25/55	PB 30/55
	2.0	PB 20/50	PB 20/50	PB 20/55	PB 25/55	PB 45/60
	3.0	PB 20/50	PB 20/50	PB 25/55	PB 30/55	PB 50/60
>6.0 ; ≤7.2	1.5	PB 20/60	PB 20/60	PB 20/65	PB 25/65	PB 30/65
	2.0	PB 20/60	PB 20/60	PB 20/60	PB 25/65	PB 50/70
	3.0	PB 20/60	PB 20/60	PB 25/65	PB 30/65	PB 50/70

Note : 1) PB 20/40 denotes **a precast beam** of width b, **20cm (200mm)** overall depth D, of **40cm(400mm)** (see Figure 1 and 3).

2) The sizes in the above table are recommended sizes. Engineers are to carry out detailed design according to the relevant design code.

3) Refer to Figure 4 for slab sections. Architect and Engineer may wish to check with the Precasters for other sizes of hollow core slabs.

65 Plank 80 Plank 110 Plank 215HC

Table 2B Residential Buildings
Recommended Sizes for Precast Columns (Table 2B/ 1)

Structural Beam Span S1(m)	Design Live Loads kN/m2	Precast Column Size b x h (mm) for Building Height ≤ 5 storey for various Structural Floor Element Span S2 (m)				
		3.0	3.6	4.8	6.0	7.2
≤ 3.6	1.5	-	-	-	PC 25/35	PC 25/35
	2.0	-	-	-	PC 25/35	PC 25/50
	3.0	-	-	-	PC 25/35	PC 25/50
>3.6 ; ≤4.8	1.5	-	-	PC 25/35	PC 25/50	PC 25/50
	2.0	-	-	PC 25/35	PC 25/50	PC 25/65
	3.0	-	-	PC 25/35	PC 25/50	PC 25/65
>4.8 ; ≤6.0	1.5	-	PC 25/35	PC 25/50	PC 25/50	PC 30/55
	2.0	-	PC 25/35	PC 25/50	PC 25/65	PC 25/80
	3.0	PC 25/35	PC 25/35	PC 25/50	PC 25/65	PC 30/70
>6.0 ; ≤7.2	1.5	PC 25/35	PC 25/35	PC 25/50	PC 25/65	PC 30/70
	2.0	PC 25/35	PC 25/35	PC 25/50	PC 25/80	PC 30/70
	3.0	PC 25/35	PC 25/50	PC 25/65	PC 30/70	PC 30/80

Table 2B Residential Buildings
Recommended Sizes for Precast Columns (Table 2B/ 2)

Structural Beam Span S1(m)	Design Live Loads kN/m2	Precast Column Size b x h (mm) for Building Height > 5 ; ≤ 10 storey for various Structural Floor Element Span S2 (m)				
		3.0	3.6	4.8	6.0	7.2
≤ 3.6	1.5	-	PC 25/35	PC 25/50	PC 25/65	PC 25/80
	2.0	-	PC 25/35	PC 25/50	PC 25/65	PC 25/80
	3.0	PC 25/35	PC 25/35	PC 25/50	PC 25/65	PC 25/80
>3.6 ; ≤4.8	1.5	PC 25/35	PC 25/50	PC 25/65	PC 25/80	PC 25/100
	2.0	PC 25/35	PC 25/50	PC 25/65	PC 25/80	PC 25/100
	3.0	PC 25/35	PC 25/50	PC 25/65	PC 25/100	PC 25/120
>4.8 ; ≤6.0	1.5	PC 25/50	PC 25/50	PC 25/80	PC 25/100	PC 30/100
	2.0	PC 25/50	PC 25/65	PC 25/80	PC 25/100	PC 25/120
	3.0	PC 25/50	PC 25/65	PC 25/80	PC 25/120	PC 30/120
>6.0 ; ≤7.2	1.5	PC 25/50	PC 25/65	PC 25/100	PC 25/120	PC 30/120
	2.0	PC 25/65	PC 25/65	PC 25/100	PC 25/120	PC 30/140
	3.0	PC 25/65	PC 25/80	PC 25/100	PC 30/120	PC 30/140

Table 2B Residential Buildings
Recommended Sizes for Precast Columns (Table 2B/ 3)

Structural Beam Span S1(m)	Design Live Loads kN/m2	Precast Column Size b x h (mm) for Building Height > 10 ; ≤ 15 storey for various Structural Floor Element Span S2 (m)				
		3.0	3.6	4.8	6.0	7.2
≤ 3.6	1.5	PC 25/35	PC 25/50	PC 25/65	PC 25/80	PC 25/100
	2.0	PC 25/35	PC 25/50	PC 25/65	PC 25/80	PC 25/120
	3.0	PC 25/50	PC 25/50	PC 25/80	PC 25/100	PC 25/120
>3.6 ; ≤4.8	1.5	PC 25/50	PC 25/65	PC 25/80	PC 25/100	PC 25/145
	2.0	PC 25/50	PC 25/65	PC 25/100	PC 25/120	PC 25/145
	3.0	PC 25/50	PC 25/65	PC 25/100	PC 25/120	PC 25/170
>4.8 ; ≤6.0	1.5	PC 25/65	PC 25/80	PC 25/120	PC 25/145	PC 30/140
	2.0	PC 25/65	PC 25/80	PC 25/120	PC 25/170	PC 25/195
	3.0	PC 25/80	PC 25/80	PC 25/120	PC 25/170	PC 30/160
>6.0 ; ≤7.2	1.5	PC 25/80	PC 25/100	PC 25/145	PC 25/170	PC 30/185
	2.0	PC 25/80	PC 25/100	PC 25/145	PC 25/195	PC 30/185
	3.0	PC 25/80	PC 25/100	PC 25/145	PC 30/160	PC 35/185

Note: 1) PC 25/35 denotes a rectangular precast column of size **25cm(250mm) x 35cm(350mm).**
2) The sizes in the above table are recommended sizes. Engineers are to carry out detailed design according to the relevant design code.

Table 2B Residential Buildings
Recommended Sizes for Precast Columns (Table 2B/ 4)

Structural Beam Span S1(m)	Design Live Loads kN/m2	Precast Column Size b x h (mm) for Building Height >15 ; ≤ 20 storeys for various Structural Floor Element Span S2 (m)				
		3.0	3.6	4.8	6.0	7.2
≤ 3.6	1.5	PC 25/50	PC 25/65	PC 25/80	PC 25/120	PC 25/145
	2.0	PC 25/50	PC 25/65	PC 25/100	PC 25/120	PC 25/145
	3.0	PC 25/65	PC 25/65	PC 25/100	PC 25/145	PC 25/170
>3.6 ; ≤4.8	1.5	PC 25/65	PC 25/80	PC 25/120	PC 25/145	PC 25/195
	2.0	PC 25/65	PC 25/80	PC 25/120	PC 25/170	PC 25/195
	3.0	PC 25/80	PC 25/100	PC 25/120	PC 25/170	PC 30/185
>4.8 ; ≤6.0	1.5	PC 25/80	PC 25/100	PC 25/145	PC 25/195	PC 35/185
	2.0	PC 25/100	PC 25/100	PC 25/145	PC 25/195	PC 35/185
	3.0	PC 25/100	PC 25/120	PC 25/170	PC 30/185	PC 35/185
>6.0 ; ≤7.2	1.5	PC 25/100	PC 25/120	PC 25/170	PC 30/185	PC 35/200
	2.0	PC 25/100	PC 25/120	PC 25/195	PC 35/185	PC 40/200
	3.0	PC 25/120	PC 25/145	PC 25/195	PC 35/185	PC 40/200

Table 2B Residential Buildings
Recommended Sizes for Precast Columns (Table 2B/ 5)

Structural Beam Span S1(m)	Design Live Loads kN/m2	Precast Column Size b x h (mm) for Building Height > 20 ; ≤ 25 storeys for various Structural Floor Element Span S2 (m)				
		3.0	3.6	4.8	6.0	7.2
≤ 3.6	1.5	PC 25/65	PC 25/80	PC 25/100	PC 25/145	PC 25/170
	2.0	PC 25/65	PC 25/80	PC 25/120	PC 25/145	PC 25/195
	3.0	PC 25/80	PC 25/80	PC 25/120	PC 25/170	PC 25/195
>3.6 ; ≤4.8	1.5	PC 25/80	PC 25/100	PC 25/145	PC 25/195	PC 25/195
	2.0	PC 25/100	PC 25/100	PC 25/145	PC 25/195	PC 35/185
	3.0	PC 25/100	PC 25/120	PC 25/170	PC 30/185	PC 35/185
>4.8 ; ≤6.0	1.5	PC 25/100	PC 25/120	PC 25/195	PC 30/185	PC 35/200
	2.0	PC 25/120	PC 25/145	PC 25/195	PC 35/200	PC 40/200
	3.0	PC 25/120	PC 25/145	PC 25/195	PC 35/200	PC 40/200
>6.0 ; ≤7.2	1.5	PC 25/120	PC 25/170	PC 30/185	PC 35/200	PC 45/200
	2.0	PC 25/145	PC 25/170	PC 30/185	PC 40/200	PC 50/200
	3.0	PC 25/145	PC 25/170	PC 35/185	PC 40/200	PC 50/200

Table 2B Residential Buildings
Recommended Sizes for Precast Columns (Table 2B/ 6)

Structural Beam Span S1(m)	Design Live Loads kN/m2	Precast Column Size b x h (mm) for Building Height >25 ; ≤30 storeys for various Structural Floor Element Span S2 (m)				
		3.0	3.6	4.8	6.0	7.2
≤ 3.6	1.5	PC 25/80	PC 25/100	PC 25/120	PC 25/170	PC 30/185
	2.0	PC 25/80	PC 25/100	PC 25/145	PC 25/195	PC 30/185
	3.0	PC 25/80	PC 25/100	PC 25/145	PC 25/195	PC 35/185
>3.6 ;≤4.8	1.5	PC 25/100	PC 25/120	PC 25/170	PC 30/185	PC 35/200
	2.0	PC 25/100	PC 25/120	PC 25/170	PC 35/185	PC 35/200
	3.0	PC 25/120	PC 25/145	PC 25/195	PC 35/185	PC 40/200
>4.8 ; ≤6.0	1.5	PC 25/120	PC 25/145	PC 30/185	PC 35/200	PC 45/200
	2.0	PC 25/145	PC 25/170	PC 30/185	PC 40/200	PC 50/200
	3.0	PC 25/145	PC 25/170	PC 35/185	PC 40/200	PC 50/200
>6.0 ; ≤7.2	1.5	PC 25/145	PC 25/195	PC 35/185	PC 40/200	PC 55/200
	2.0	PC 25/170	PC 25/195	PC 35/185	PC 45/200	PC 55/200
	3.0	PC 25/170	PC 25/195	PC 35/200	PC 50/200	PC 60/200

Note: 1) PC 25/35 denotes a rectangular precast column of size 25cm(250mm) x 35cm(350mm).
2) The sizes in the above table are recommended sizes. Engineers are to carry out detailed design according to the relevant design code.

Table 2C Residential Buildings
Recommended Thickness for Load Bearing Walls

Total number of floors (n) supported by the wall	Design Live Load (kN/m2)	Wall thickness (mm) supporting statically loaded spans (m)						
		≤ 3.6	3.6 - 4.2	4.2 - 4.8	4.8 - 5.4	5.4 - 6.0	6.0 - 6.6	6.6 - 7.2
n ≤ 5	1.5	150	150	150	150	150	150	150
	2.0	150	150	150	150	150	150	150
5 < n ≤ 10	1.5	150	150	175	175	175	175	200
	2.0	150	150	175	175	175	200	200
10 < n ≤ 15	1.5	175	175	175	200	200	225	225
	2.0	175	175	200	200	225	225	225
15 < n ≤ 20	1.5	175	200	200	225	225	225	275
	2.0	175	200	225	225	225	250	300
20 < n ≤ 25	1.5	200	200	225	225	275	300	300
	2.0	200	225	225	250	275	300	300
25 < n ≤ 30	1.5	200	225	225	275	300	300	300
	2.0	225	225	250	275	300	300	300
30 < n ≤ 35	1.5	225	225	275	300	300	300	300
	2.0	225	250	300	300	300	300	300

Grade 30 Concrete
Grade 35 Concrete
Grade 40 Concrete
Grade 45 Concrete
Grade 50 Concrete

Table 3A Industrial Buildings Recommended Sizes for Precast Slabs and Beams

Structural Beam Span	Design Live Loads	Precast Slab Type (mm) and Overall Beam Size for various Structural Floor Element Span S2 (m)				
S1(m)	kN/m2	7.2	8.4	9.6	10.8	12.0
≤7.2	5.0	PB 60/75	PB 60/75	PB 70/80	PB 70/80	PB 80/80
	7.5	PB 60/75	PB 70/75	PB 80/80	PB 80/80	PB 90/85
						240X80DTB
	12.5	PB 80/75	PB 80/80	PB 90/80	PB 100/85	PB 110/90
						240X90DTB
	15.0	PB 80/80	PB 90/85	PB 100/85	PB 100/90	PB 110/100
					240X100DTB	240X120DTB
	20.0	PB 90/80	PB 110/80	PB 110/85	PB 110/110	PB 110/130
>7.2 ; ≤8.4	5.0	PB 60/85	PB 70/80	PB 70/85	PB 80/85	PB 80/90
	7.5	PB 70/80	PB 80/80	PB 80/85	PB 90/90	PB 100/90
						240X80DTB
	12.5	PB 80/80	PB 90/85	PB 100/90	PB 100/95	PB 120/90
						240X90DTB
	15.0	PB 90/85	PB 100/90	PB 110/90	PB 110/95	PB 120/100
					240X100DTB	240X120DTB
	20.0	PB 100/90	PB 110/90	PB 120/95	PB 130/110	PB 130/130
>8.4 ; ≤9.6	5.0	PB 60/90	PB 70/90	PB 70/95	PB 80/95	PB 90/95
	7.5	PB 70/90	PB 80/90	PB 80/95	PB 90/100	PB 100/100
						240X80DTB
	12.5	PB 90/90	PB 90/95	PB 100/100	PB 110/105	PB 120/100
						240X90DTB
	15.0	PB 90/95	PB 100/100	PB 110/105	PB 120/105	PB 130/105
					240X100DTB	240X120DTB
	20.0	PB 100/100	PB 120/100	PB 130/105	PB 140/110	PB 140/130
>9.6 ; ≤10.8	5.0	PB 60/100	PB 70/100	PB 80/105	PB 80/105	PB 90/105
	7.5	PB 70/100	PB 80/100	PB 90/105	PB 90/105	PB 100/110
						240X80DTB
	12.5	PB 90/100	PB 100/105	PB 110/110	PB 110/110	PB 130/110
						240X90DTB
	15.0	PB 90/105	PB 100/110	PB 120/110	PB 120/115	PB 130/115
					240X100DTB	240X120DTB
	20.0	PB 110/110	PB 120/110	PB 130/115	PB 140/120	PB 140/130
>10.8 ; ≤12.0	5.0	PB 60/110	PB 70/110	PB 80/115	PB 90/115	PB 90/115
	7.5	PB 70/110	PB 80/110	PB 90/115	PB 100/115	PB 100/120
						240X80DTB
	12.5	PB 90/110	PB 100/115	PB 110/115	PB 120/120	PB 130/120
						240X90DTB
	15.0	PB 100/115	PB 110/120	PB 120/120	PB 130/125	PB 140/125
					240X100DTB	240X120DTB
	20.0	PB 110/115	PB 120/115	PB 130/120	PB 140/130	PB 150/135

Note : 1) PB 50/90 denotes a **precast beam** of width **50cm (500mm)** and overall depth of **90cm (900mm)**. See Figure 1 and 2.
2) The sizes in the above table are recommended sizes. Engineers are to carry out detailed design according to the relevant design code.
3) DTB denotes **Double Tee Beam.**
4) Refer to Figure 4 for slab sections. Architect and Engineer may wish to check with the Precasters for other sizes of hollow core slabs.

Table 3B Industrial Buildings
Recommended Sizes for Precast Columns (Table 3B/ 1)

Structural Beam Span	Design Live Loads	Precast Column Size b x h (mm) for Building Height ≤ 5 storeys for various Structural Floor Element Span S2 (m)				
S1(m)	kN/m2	7.2	8.4	9.6	10.8	12.0
≤7.2	5.0	PC 50	PC 55	PC 60	PC 65	PC 70
	7.5	PC 55	PC 60	PC 65	PC 70	PC 75
	12.5	PC 60	PC 70	PC 75	PC 80	PC 80
	15.0	PC 65	PC 70	PC 80	PC 85	PC 85
	20.0	PC 75	PC 80	PC 85	PC 90	PC 95
>7.2 ; ≤8.4	5.0	PC 55	PC 60	PC 65	PC 70	PC 75
	7.5	PC 60	PC 65	PC 70	PC 75	PC 80
	12.5	PC 65	PC 75	PC 80	PC 85	PC 85
	15.0	PC 70	PC 80	PC 85	PC 90	PC 90
	20.0	PC 80	PC 85	PC 90	PC 95	PC 100
>8.4 ; ≤9.6	5.0	PC 60	PC 60	PC 70	PC 75	PC 80
	7.5	PC 65	PC 70	PC 75	PC 80	PC 85
	12.5	PC 70	PC 80	PC 85	PC 90	PC 95
	15.0	PC 75	PC 85	PC 90	PC 95	PC 100
	20.0	PC 85	PC 90	PC 100	PC 105	PC 110
>9.6 ; ≤10.8	5.0	PC 60	PC 65	PC 75	PC 80	PC 85
	7.5	PC 65	PC 70	PC 80	PC 85	PC 90
	12.5	PC 75	PC 85	PC 90	PC 95	PC 100
	15.0	PC 80	PC 90	PC 95	PC 100	PC 105
	20.0	PC 90	PC 95	PC 105	PC 110	PC 115
>10.8 ; ≤12.0	5.0	PC 65	PC 70	PC 75	PC 80	PC 85
	7.5	PC 70	PC 75	PC 85	PC 90	PC 95
	12.5	PC 80	PC 90	PC 95	PC 100	PC 105
	15.0	PC 85	PC 95	PC 100	PC 110	PC 110
	20.0	PC 95	PC 105	PC 110	PC 115	PC 120

Table 3B Industrial Buildings
Recommended Sizes for Precast Columns (Table 3B/ 2)

Structural Beam Span	Design Live Loads	Precast Column Size b x h (mm) for Building Height > 5 ; ≤ 8 storeys for various Structural Floor Element Span S2 (m)				
S1(m)	kN/m2	7.2	8.4	9.6	10.8	12.0
≤7.2	5.0	PC 60	PC 65	PC 70	PC 75	PC 80
	7.5	PC 65	PC 70	PC 75	PC 80	PC 85
	12.5	PC 70	PC 80	PC 85	PC 90	PC 90
	15.0	PC 75	PC 80	PC 90	PC 95	PC 95
	20.0	PC 80	PC 90	PC 95	PC 100	PC 105
>7.2 ; ≤8.4	5.0	PC 65	PC 70	PC 75	PC 80	PC 90
	7.5	PC 70	PC 75	PC 80	PC 90	PC 95
	12.5	PC 75	PC 85	PC 90	PC 95	PC 100
	15.0	PC 80	PC 90	PC 95	PC 100	PC 105
	20.0	PC 90	PC 95	PC 100	PC 105	PC 110
>8.4 ; ≤9.6	5.0	PC 70	PC 75	PC 80	PC 85	PC 95
	7.5	PC 75	PC 80	PC 85	PC 95	PC 100
	12.5	PC 80	PC 90	PC 100	PC 105	PC 105
	15.0	PC 85	PC 95	PC 100	PC 110	PC 110
	20.0	PC 95	PC 100	PC 110	PC 115	PC 120
>9.6 ; ≤10.8	5.0	PC 75	PC 80	PC 85	PC 95	PC 100
	7.5	PC 80	PC 85	PC 90	PC 100	PC 105
	12.5	PC 85	PC 95	PC 105	PC 110	PC 110
	15.0	PC 90	PC 100	PC 110	PC 115	PC 115
	20.0	PC 100	PC 110	PC 115	PC 120	PC 130
>10.8 ; ≤12.0	5.0	PC 75	PC 85	PC 90	PC 100	PC 105
	7.5	PC 80	PC 90	PC 100	PC 105	PC 110
	12.5	PC 90	PC 100	PC 110	PC 115	PC 120
	15.0	PC 95	PC 105	PC 115	PC 120	PC 125
	20.0	PC 105	PC 115	PC 125	PC 130	PC 135

Note : 1) PC 50 denotes a **Square Precast Column** of size **50cm (500mm)x50cm(500mm).**

2) The sizes in the above table are recommended sizes. Engineers are to carry out detailed design according to the relevant design code.

3) Column size in Red indicates column self-weight > 25 tons.

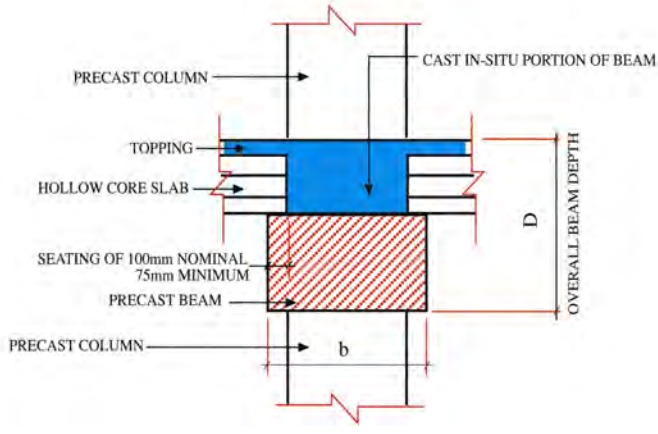


FIGURE 1 HOLLOW CORE SLAB ON PRECAST BEAM

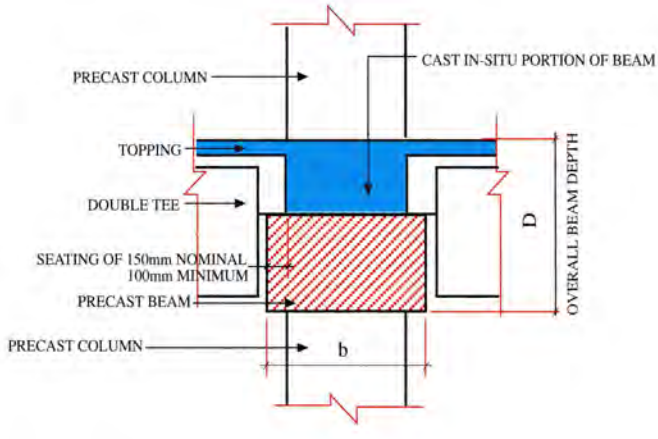


FIGURE 2 DOUBLE TEE BEAM-SLAB ON PRECAST BEAM

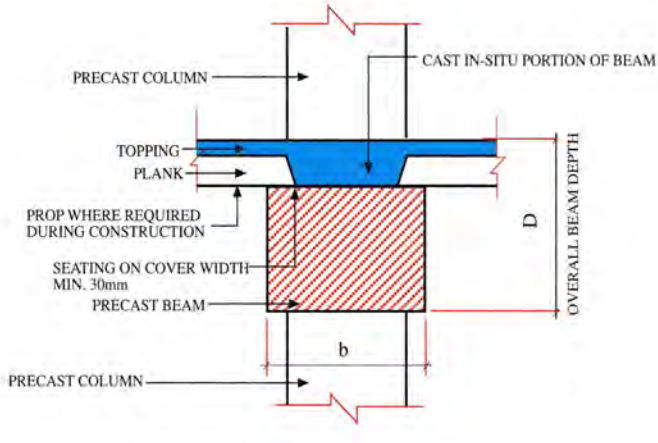
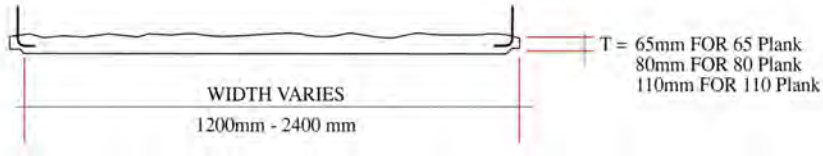
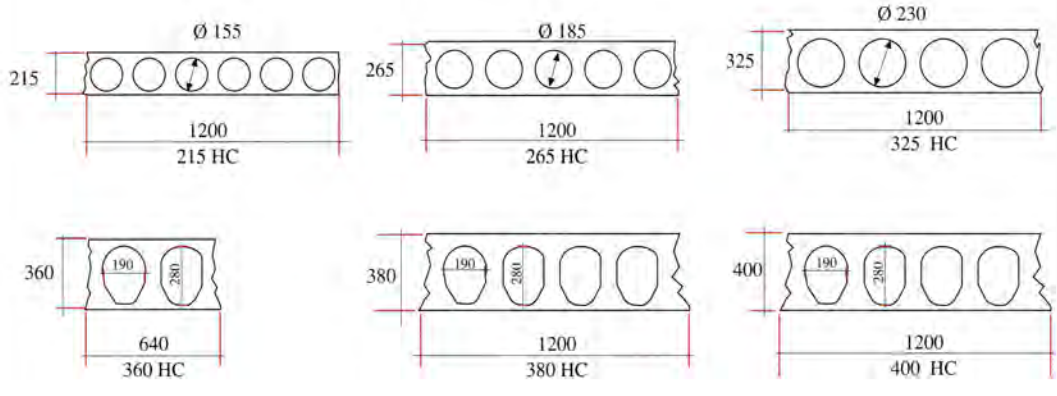


FIGURE 3 PLANKS ON PRECAST BEAM

PLANKS



HOLLOW CORE SLABS



DOUBLE TEE BEAM-SLABS

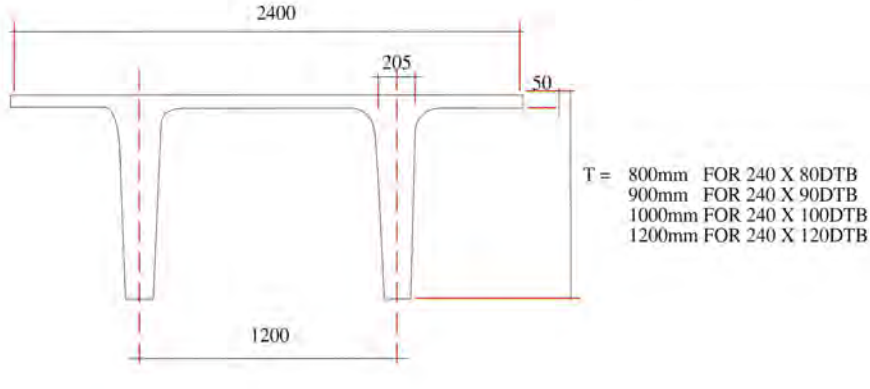


FIGURE 4 TYPICAL SECTION OF VARIOUS PRECAST SLAB ELEMENTS

Design Assumptions and Notes

1. Fire resistance = 2 hrs Commercial/Institutional/Industrial Buildings
   = 1.5 hrs Residential Buildings

2. Superimposed dead loads = 2.7 kN/m2

   Commercial/Institutional/Industrial Buildings 1.2 for finishes, 1.0 for partition, 0.5 for services
   Residential Buildings 1.2 for finishes, 1.5 for partition

3. For column sizing the following apply:-

   a. only total vertical dead and live loads are considered;
   b. imposed live load reduction is applied;
   c. nominal 2% steel content assumed;
   d. floor to floor height assumed;
      4.2m for Commercial and Institutional Buildings
      6.0m for Industrial Buildings
      3.5m for Residential Buildings
   e. minimum dimensions of rectangular column shown are based on fire resistance requirement and the slenderness limit of braced short column of nominal floor to floor height;
   f. limits on slenderness for unbraced short column are more stringent. If in doubt, competent advice should be sought;
   g. if smaller dimensions less than that given in the tables are to be used, slender column considerations apply and additional checks are required;
   h. reduction of column size at upper floors for tall building should be considered and reduced sizes can be obtained by the use of tables for building of lower height; and
   i. cranage, access and connection considerations may preclude the use of precast columns.

4. For beam sizing the following apply:-

   a. precast beam is normal reinforced precast beam;
   b. reduction of overall beam depth may be achieved by use of prestressed precast beams or precast inverted tee beams; and
   c. cranage and access considerations may preclude the use of precast beams.

5. Concrete grades assumed:-

Components	Concrete Grade (N/mm2)	Types of Buildings
hollow core slabs	50	All Buildings
prestressed planks	40	All Buildings
double tee beam-slabs	35	All Buildings
precast beams and columns	35	Commercial/Institutional/Industrial Buildings
	30	Residential Buildings
cast-insitu portion of beams (including topping)	35	Commercial/Institutional/Industrial Buildings
	30	Residential Buildings

6. Considerations for robustness and stability under lateral loads have to be separately assessed.

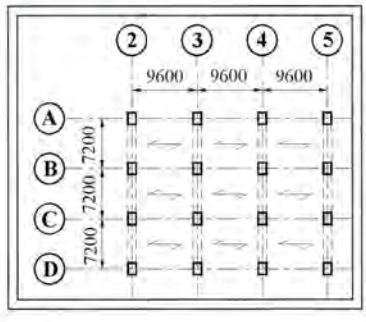
7. Thickness of topping:- 65mm at supports; 50mm at mid-span for 215HC.
75mm at supports; 50mm at mid-span for all other HC.
50mm for DTB.
60mm for 65Plank; 70mm for 80Plank, 110Plank.

8. Design Assumptions for Load Bearing Plain Wall in Residential Buildings

a. Fire Resistance = 1.5 hrs
b. Superimposed dead load assumed = 1.2 kN/m2 for finishes
= 1.0 kN/m2 for partition
c. Walls are assumed pinned at each floor and braced by cross walls.
d. Maximum floor height at 3.5m is assumed.
e. All walls assumed minimum reinforcement for shrinkage cracking control i.e. 0.13% of A_c (A_c denotes area of concrete section).
f. Live load reduction is not used. However for live load greater than 2.0 kN/m2, live load reduction should be used for more economical wall design.

Example: Preliminary sizing of precast slab, precast beam and precast column

Consider the typical floor layout as shown for an Office Building:-



Design criteria:-

1.	Design live load		= 4.0 kN/m2
2.	Design imposed dead loads :	services	= 0.5 kN/m2
		partition	= 1.0 kN/m2
		finishes	= 1.2 kN/m2
3.	Roof :	design live load	= 1.5 kN/m2
		design imposed dead loads	= 2.0 kN/m2
4.	Building is 7-storey with floor to floor height of 4.5m.		
5.	Structural stability is provided by shear cores at other location.		
6.	Headroom to be minimum 3.6m.		
7.	Concrete grade 35.		

Preliminary sizing using the tabulation of recommended sizes for precast elements:-

Step 1. **Provide for precast slab to span parallel to the alphabetical grid and precast beam to span parallel to the numeric grid.**

Step 2. **Consider structures between Grid 3 to 5 and Grid A to C.**
Hence,

(i)	precast beam span, S1	= 7.2m
(ii)	precast slab span, S2	= 9.6m
(iii)	design live load	= 4.0 kN/m2

Step 3. **Precast slab and beam:-**
Refer to Table 1A and with structural span S1 being >6.0, ≤7.2m,
design live load = 4.0 kN/m2 and
structural floor element span S2 = 9.6m,
hence,

(i)	precast slab	= 325 HC
(ii)	precast beam	= PB70/80 (b=700mm ,D=800mm)

Step 4. **Column size:-**
Refer to Table 1B/2 and with building height of 7-storey within the range of >5, ≤10 storey, structural span S1 being >6.0, ≤7.2m,
design live load = 4.0 kN/m2 and
structural floor element span S2 = 9.6m,
hence, square column = PC75 (750mm x750mm)

Other Structural Components

Precast Staircase

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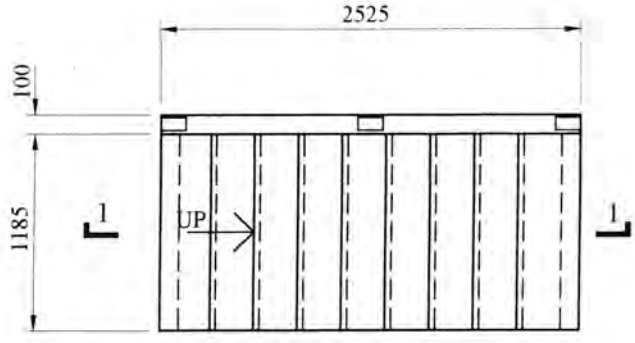
Precast staircase offers consistent step dimensions and good surface finish. Natural granite or coloured tile finish can also be incorporated with the precast unit.

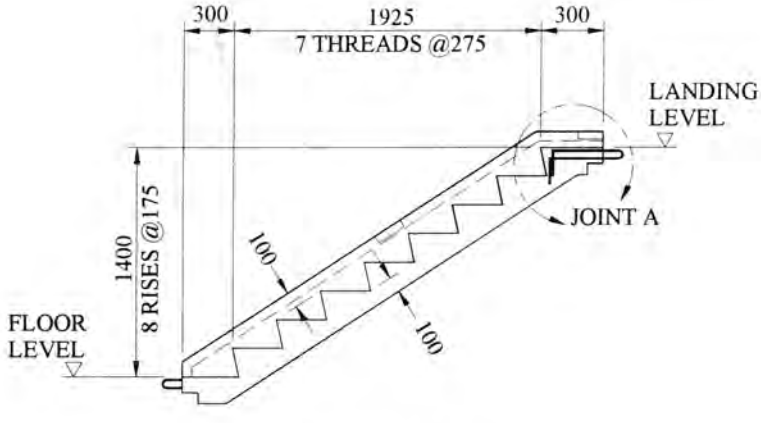
A range of precast staircase types is shown in the table below.

Type	Description	Suitable for buildings with floor-to-floor height of (mm)
1	8 risers @ 175mm = 1400mm	2800
2	9 risers @ 175mm = 1575mm	3150
3	10 risers @ 175mm = 1750mm	3500
4	10 risers @ 160mm = 1600mm	3200
5	10 risers @ 165mm = 1650mm	3300
6	12 risers @ 150mm = 1800mm	3600

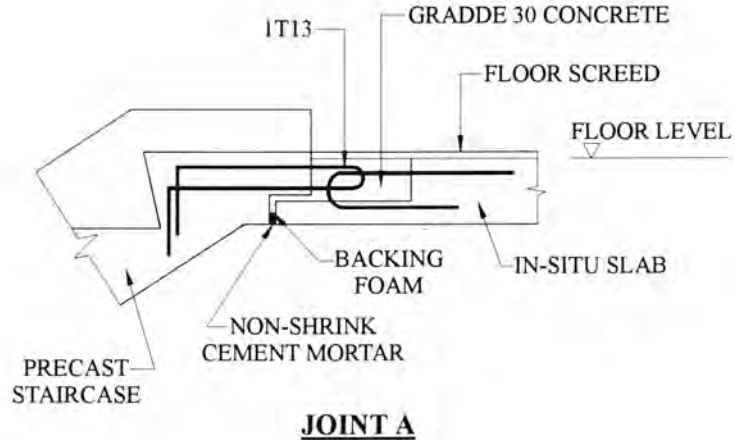
Precast Staircase (Type 1)



PLAN



SECTION 1-1



JOINT A

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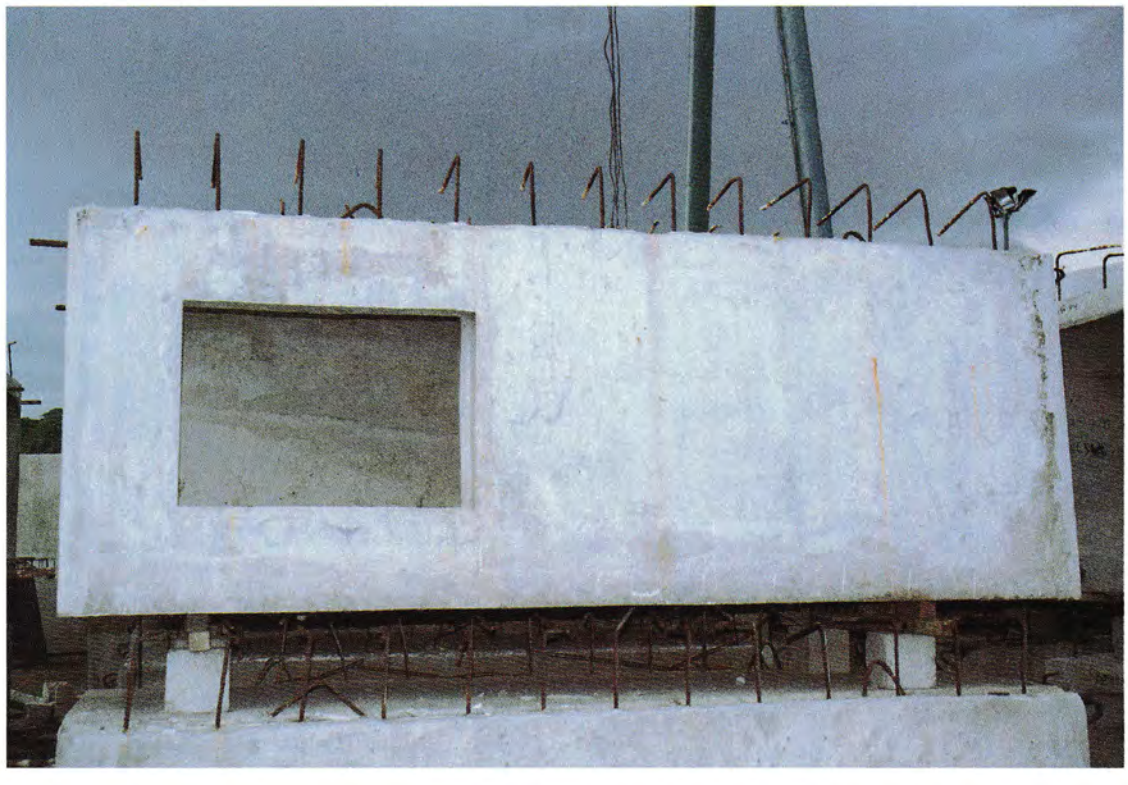
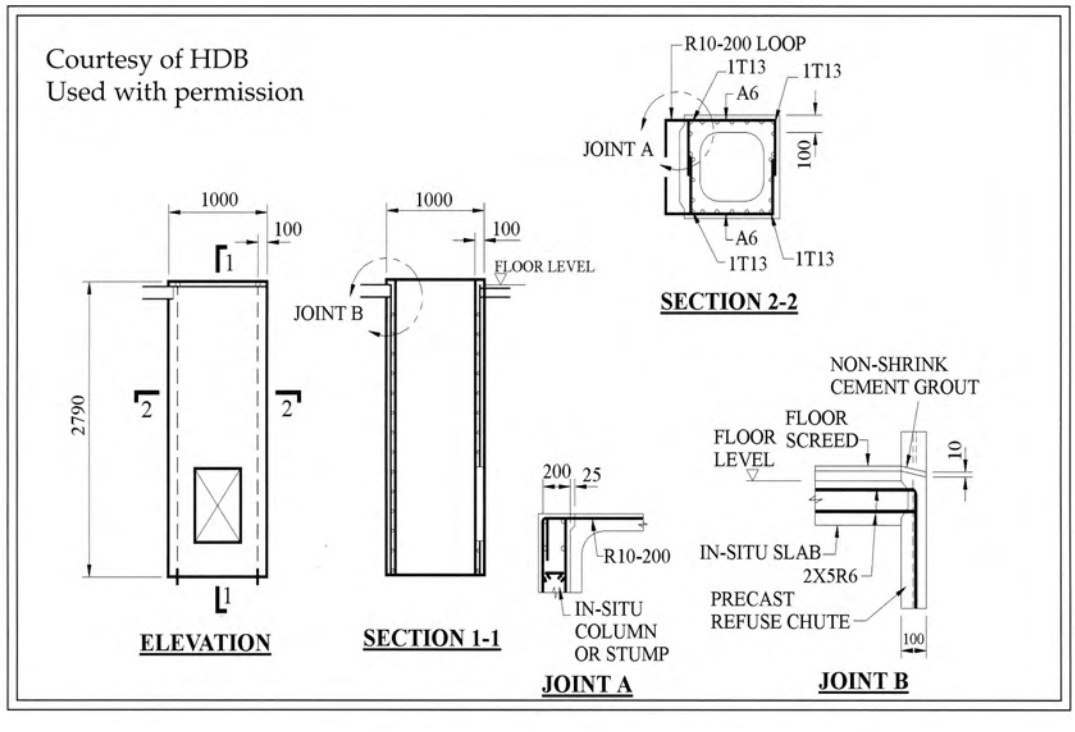
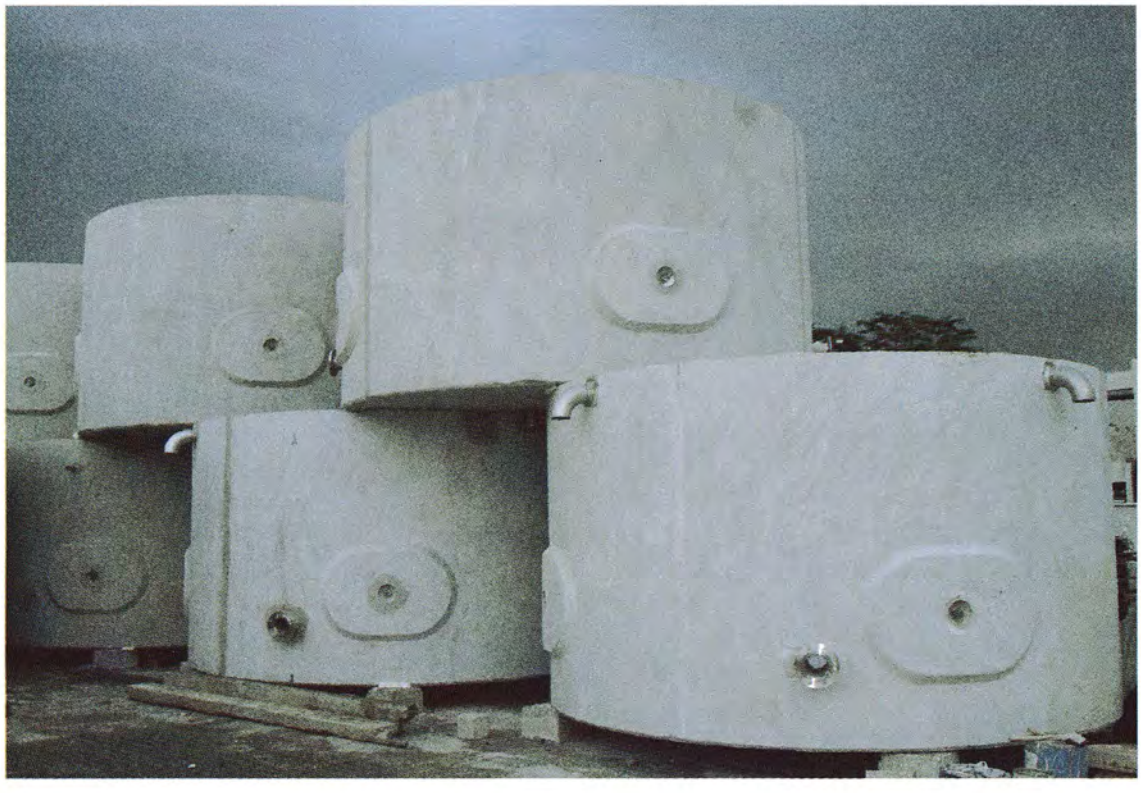
Refuse Chute



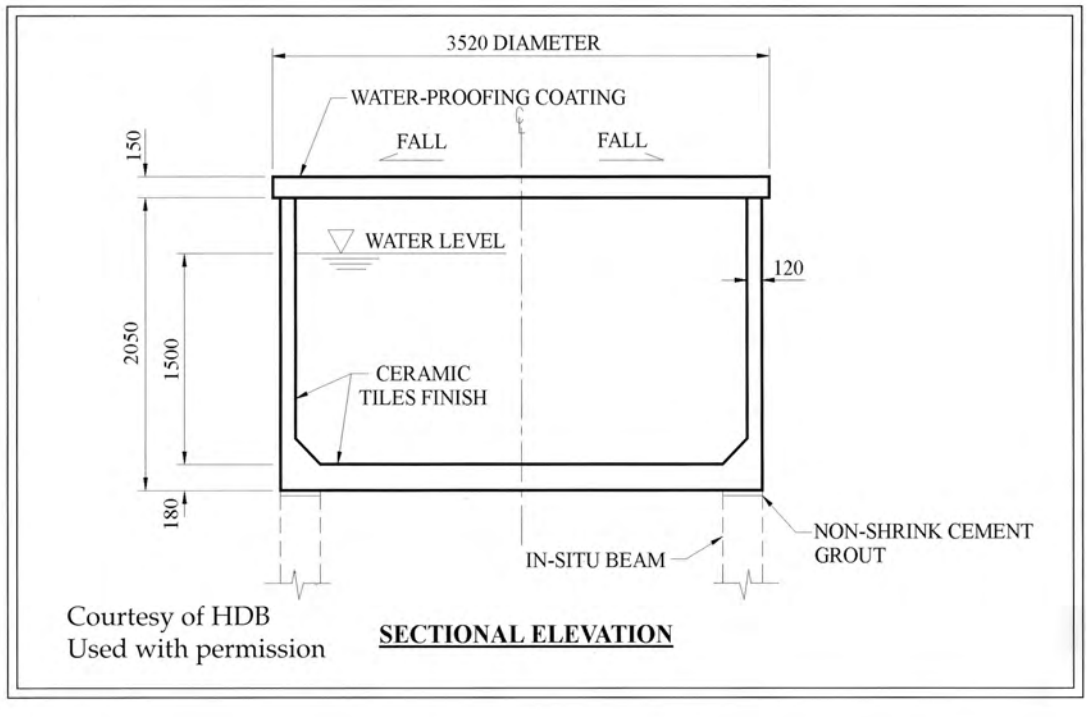
The precast refuse chute is designed as load bearing component. It offers better surface finish and is durable against corrosive refuse. It is anchored to adjacent beams, walls and slabs at each floor by its loop bars.



Water Tank



The precast water tank can be installed easily. It is cheaper and more durable than steel and fibre reinforced plastic water tank.



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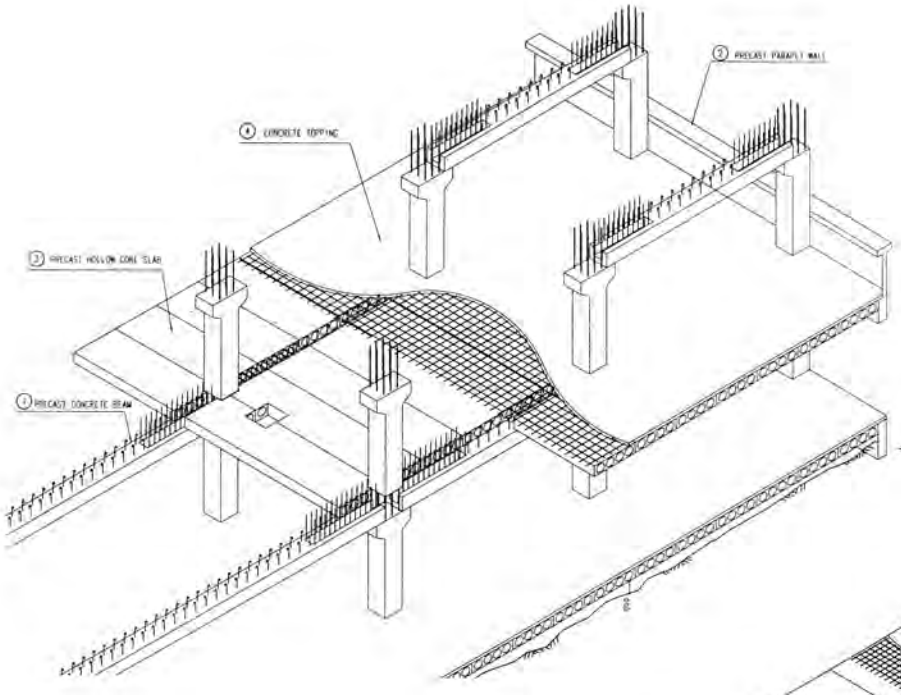
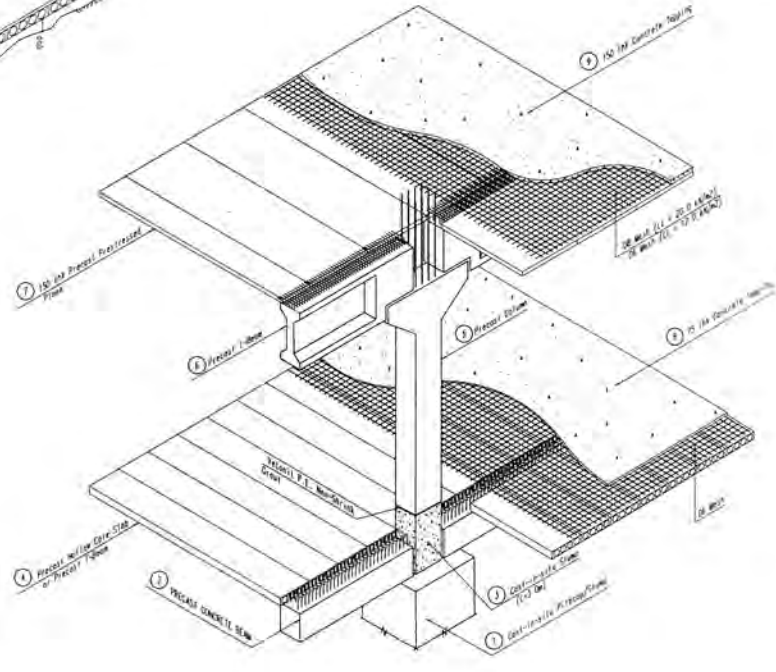
SECTIONAL ELEVATION

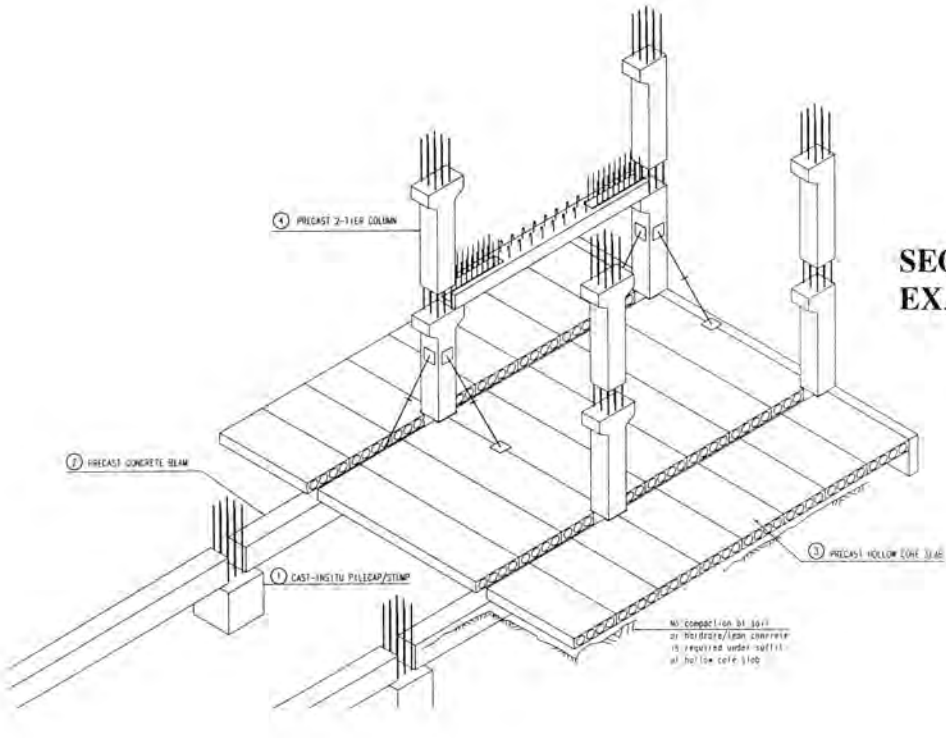
Assembly of Precast Components



SEQUENCE OF ERECTION
EXAMPLE 1



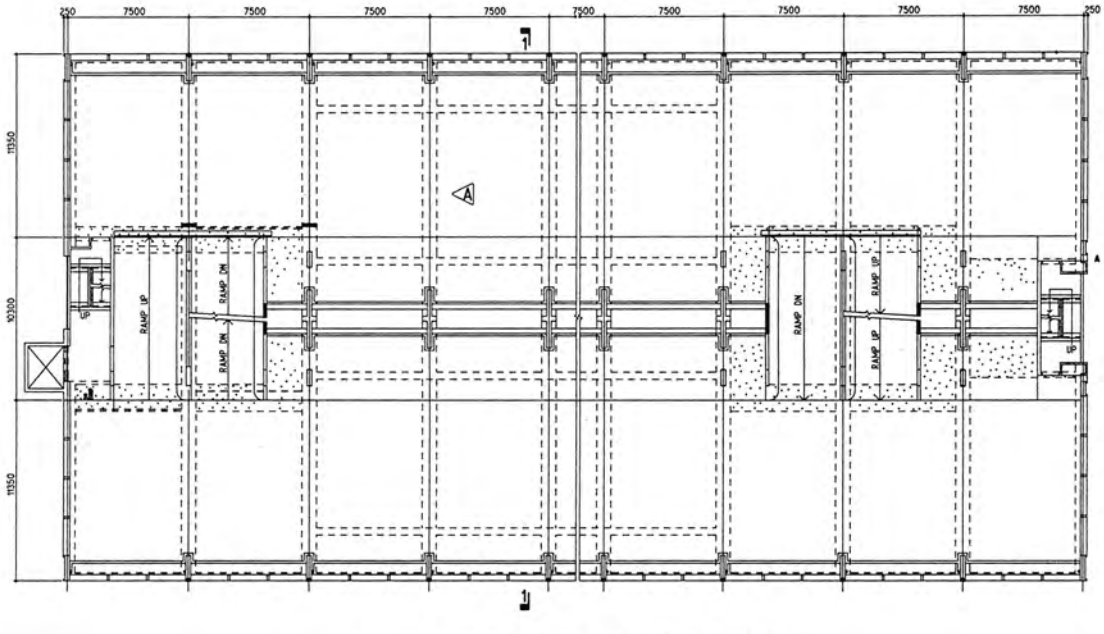
SEQUENCE OF ERECTION
EXAMPLE 2



SEQUENCE OF ERECTION
EXAMPLE 3

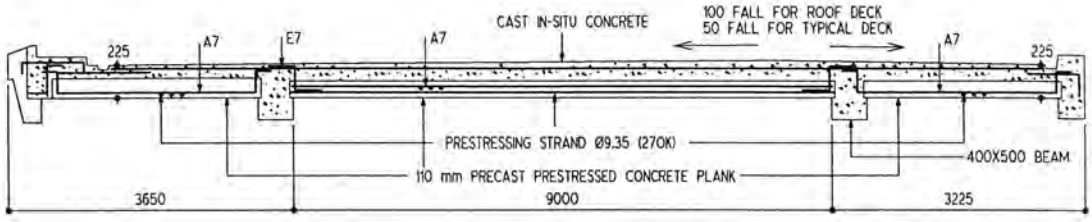
Multi-storey Carpark

The large scale of standardisation in multi-storey carparks enables them to be constructed using prefabricated components. The precast components used range from precast slabs to vehicular crash barriers. Precast frame and skeletal systems with double-T or hollow core slabs for floor are used to obtain large open space for parking. Adoption of precast method for construction of multi-storey carparks has been proven to give a shorter construction time. The following pages show a typical precast multi-storey carpark designed by HDB.

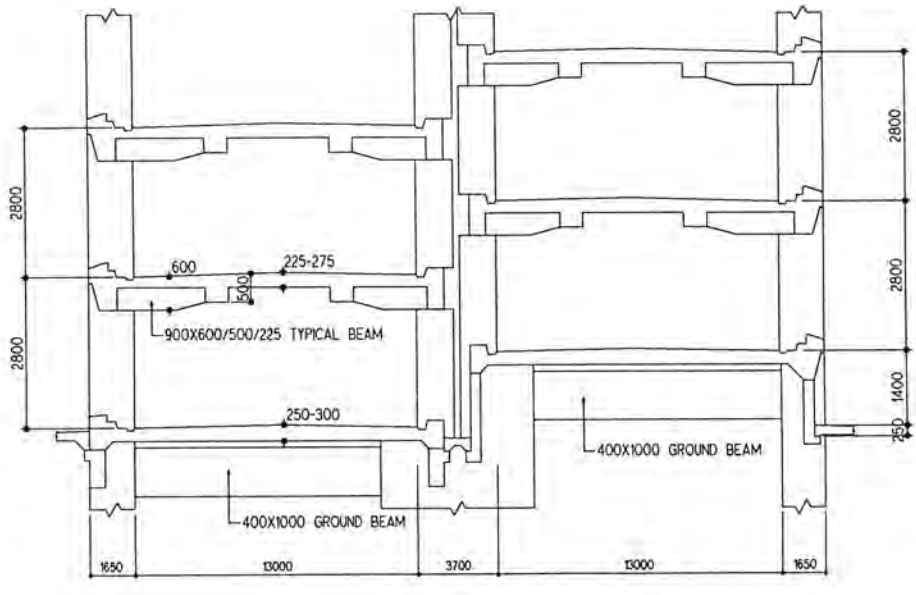


UPPER STOREY FLOOR PLAN

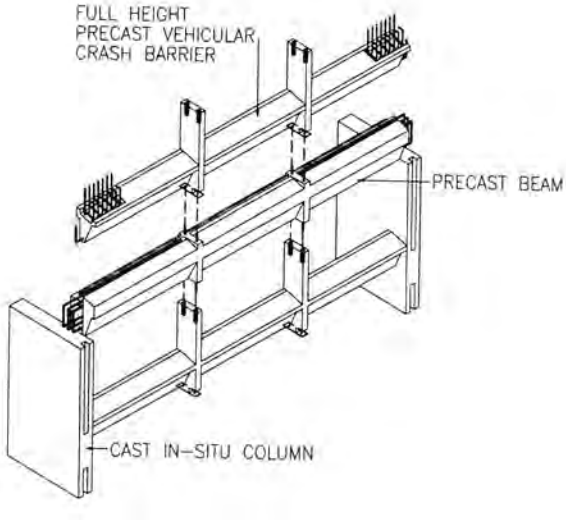
Courtesy of HDB
Used with permission



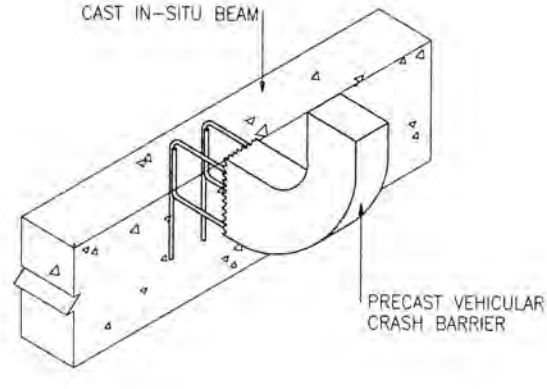
110mm THICK PRECAST PRESTRESSED CONCRETE FLOOR PLANK SECTION 1-1



STRUCTURAL FRAME VIEW A



PERIPHERAL PRECAST BEAM AND FULL HEIGHT PRECAST VEHICULAR CRASH BARRIER



CURVED PRECAST VEHICULAR CRASH BARRIER AT ROOF DECK

Courtesy of HDB
Used with permission

Precast Concrete Components

① Precast Prestressed Concrete Floor Plank For Upper Deck

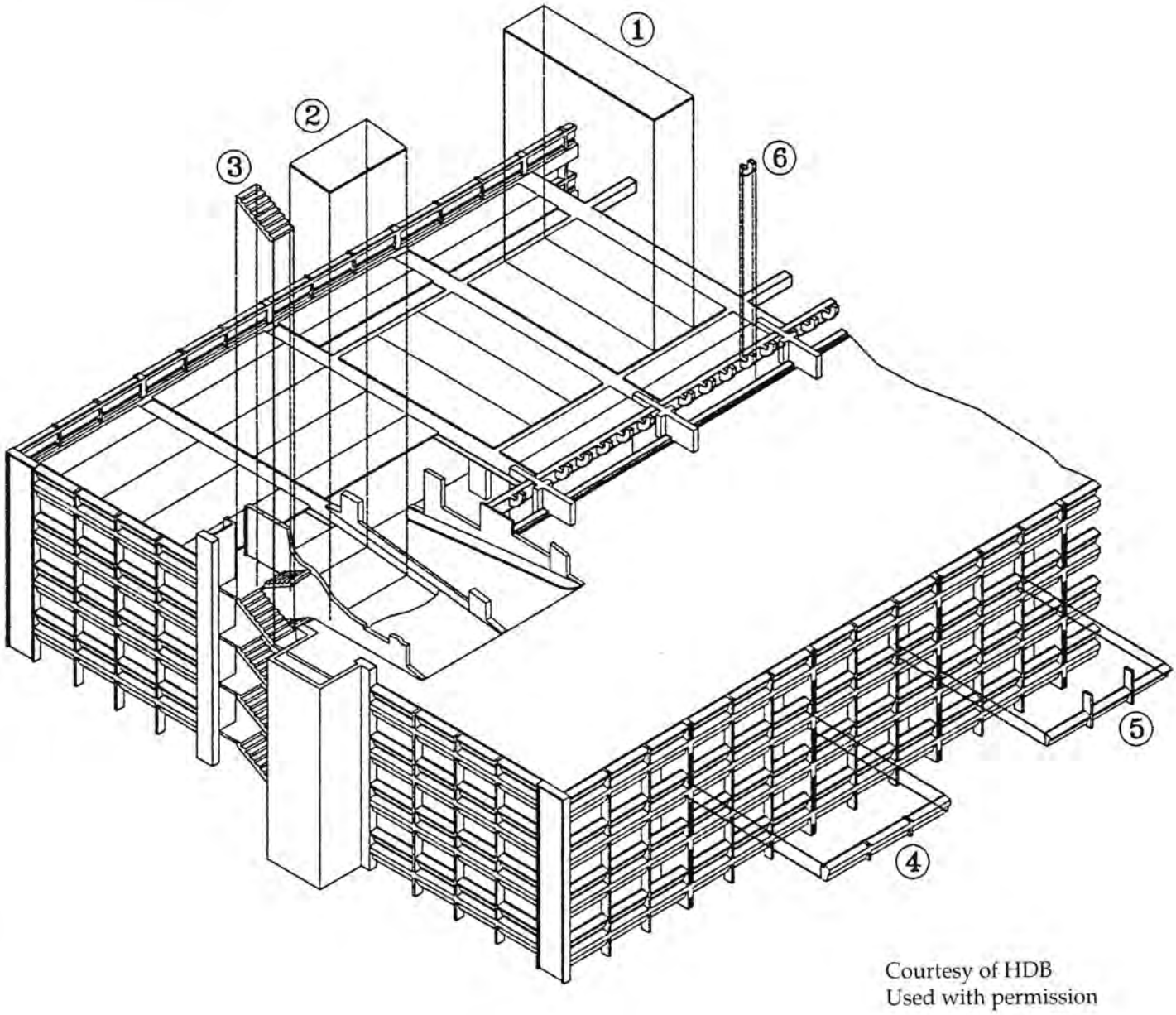
② Precast Prestressed Concrete Floor Plank For Ramp

③ Precast Staircase

④ Peripheral Precast beam

⑤ Precast Vehicular Crash Barrier

⑥ Curved Precast Vehicular Crash Barrier At Roof Deck



Courtesy of HDB
Used with permission

USE OF PREFABRICATED REINFORCEMENT

Advantages

To improve buildability, the use of prefabricated reinforcement should be considered in situations where the use of precast concrete is not feasible. Time for reinforcement laying and site labour can be reduced considerably with the use of prefabricated reinforcement. Prefabrication under well-controlled factory conditions also ensures better quality in dimensional accuracies.

Prefabricated reinforcement includes welded wire fabric, prefabricated link cages and prefabricated full cages (links and main bars). The Housing and Development Board (HDB) uses welded wire fabric and prefabricated link cages extensively in their projects. Many commercial projects use partial or full prefabricated cages to speed up reinforcement placement. Designers should approach steel reinforcement suppliers for catalogues on use of prefabricated reinforcement.

Welded Wire Fabric

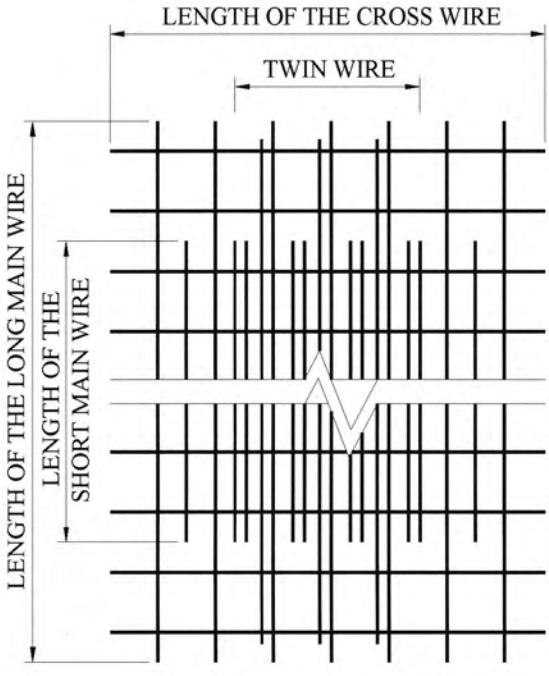
So far, only plain bars have been used in welded wire fabric (WWF) in Singapore. The plain bars, produced according to Singapore Standard 18, are welded together to form WWF according to the specifications in Singapore Standard 32. Recent developments points to the increasing use of deformed bars in WWF, particularly in Germany. In the near future, welded wire fabric using deformed bars are expected to be produced in Singapore, once the Singapore Standard 18 has been revised to include the relevant specifications. Table A,B and C are design aids on the use of WWF. Variations of WWF include :

Double Wire Fabric

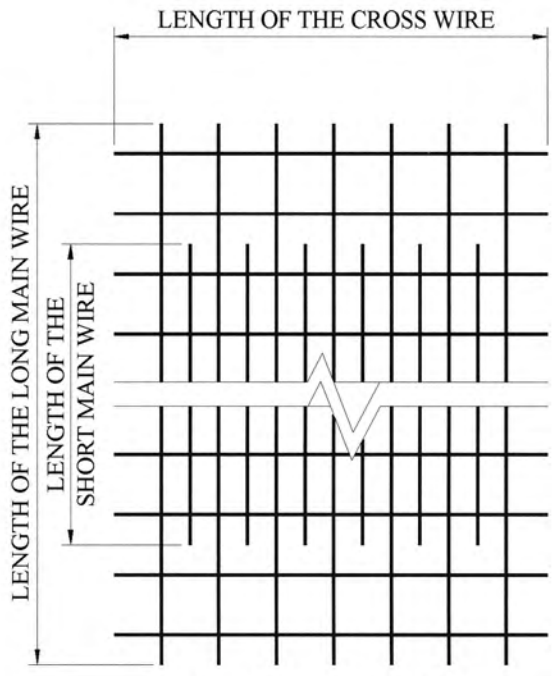
For slab areas where heavy reinforcement are required, double wire fabric may be specified. Two wires are arranged together to form a single main line at regular spacings of 100mm, 150mm or 200mm.

Staggered Fabric

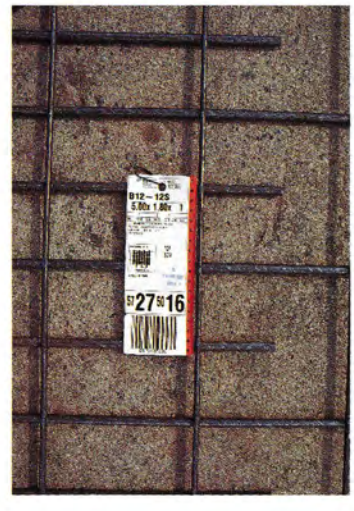
Where there is curtailment of bars, staggered fabric may be specified. Typical use of staggered fabric can be seen in structural slabs as top reinforcement spanning across a beam.



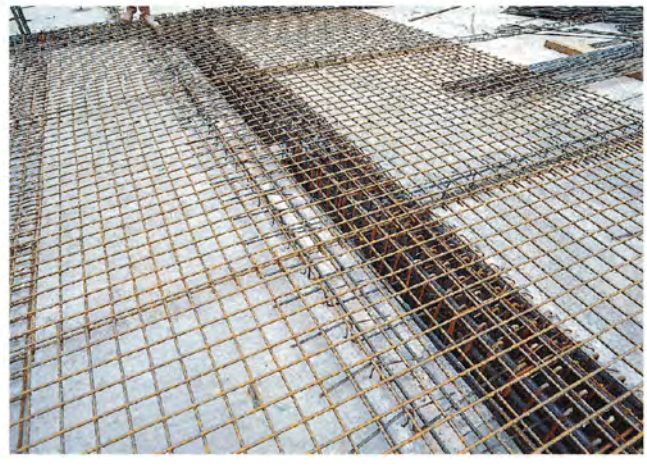
DOUBLE WIRE FABRIC



STAGGERED FABRIC



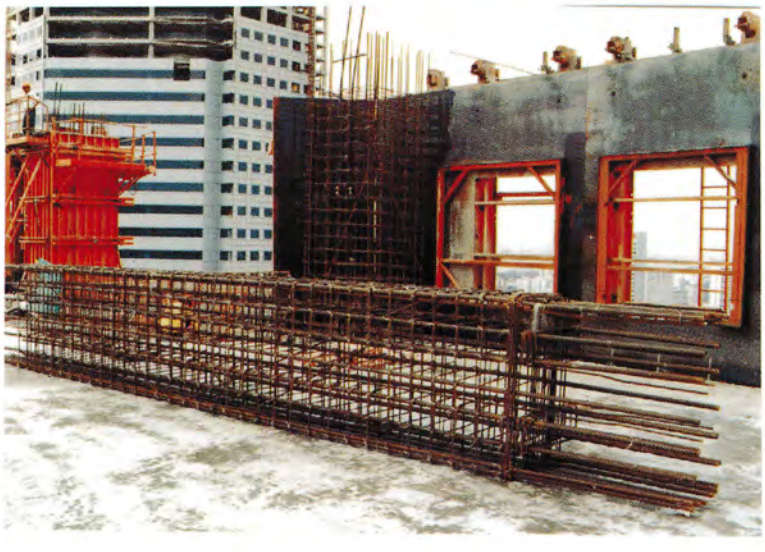
Prefabricated Rei Cages



Designers should take note of the following production limitations:

	Minimum Width (mm)	Maximum Depth (mm)
Beam Cages	150	2000
Column Cages	90	1500
Standard Link Spacing (mm)	75,100,125,150, 200, 250, 300	

nforcement



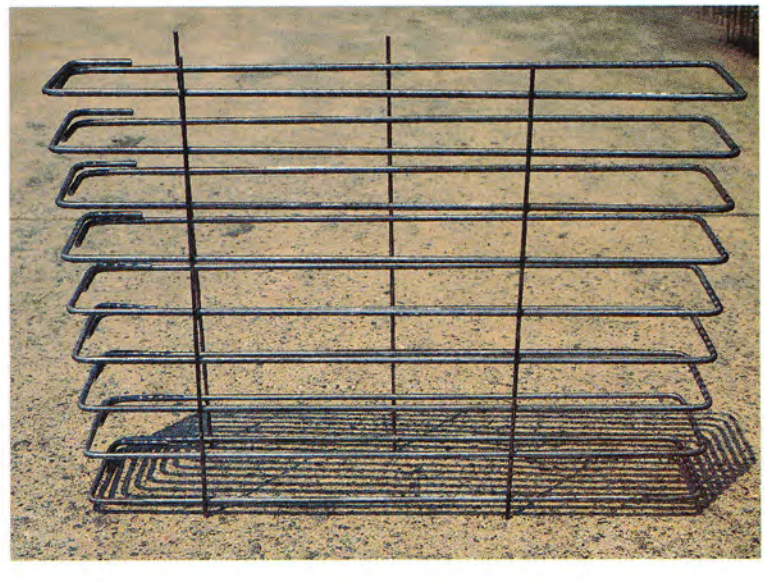


TABLE A SPECIFICATION FOR WELDED WIRE FABRIC

STANDARD SPECIFICATIONS - SHEETS

		Main Wire		Cross Wire		Cross Sectional		Area Mass Per
SS32 Ref. No.	BS4483 Ref. No.	Size (mm)	Spacing (mm)	Size (mm)	Spacing (mm)	Main mm^2/m	Cross mm^2/m	Unite Area kg/m^2
SQUARE MESHES								
A 13	-	13	200	13	200	664	664	10.42
A 12	-	12	200	12	200	566	566	8.89
A 11	-	11	200	11	200	475	475	7.46
A 10	A 393	10	200	10	200	393	393	6.16
A 9	-	9	200	9	200	318	318	4.99
A 8	A 252	8	200	8	200	252	252	3.95
A 7	A 193	7	200	7	200	193	193	3.03
A 6	A 142	6	200	6	200	142	142	2.22
A 5	A 98	5	200	5	200	98	98	1.54
D 13	-	13	100	13	100	1327	1327	20.83
D 12	-	12	100	12	100	1131	1131	17.76
D 11	-	11	100	11	100	950	950	14.91
D 10	-	10	100	10	100	785	785	12.32
D 9	-	9	100	9	100	636	636	9.98
D 8	-	8	100	8	100	503	503	7.90
D 7	-	7	100	7	100	385	385	6.04
D 6	-	6	100	6	100	283	283	4.44
D 5	-	5	100	5	100	196	196	3.08
RECTANGULAR MESHES								
B 13	-	13	100	10	200	1327	393	13.50
B 12	B 1131	12	100	8	200	1131	252	10.90
B 11	-	11	100	8	200	950	252	9.43
B 10	B 785	10	100	8	200	785	252	8.14
B 9		9	100	8	200	636	252	6.97
B 8	B 503	8	100	8	200	503	252	5.93
B 8A	-	8	150	7	200	335	193	4.14
B 7	B 385	7	100	7	200	385	193	4.53
B 6	B 283	6	100	7	200	283	193	3.73
B 5	B 196	5	100	7	200	196	193	3.05
STANDARD SPECIFICATIONS - ROLLS (48X2.4m)								
A 6	A 142	6	200	6	200	142	142	2.22
A 5	A 98	5	200	5	200	98	98	1.54

TABLE B SUBSTITUTION OF FABRIC FOR MILD STEEL BARS

BARS			SUBSTITUTION OF FABRIC FOR MILD STEEL BARS		
DIAMETER (mm)	SPACING (mm)	AREA (mm^2/m)	EQUIVALENT AREA (mm^2/m)	RECOMMENDED FABRIC REF NO. (mm^2/m)	
10	75	1047	540	D9 B9 (636)	
	100	786	405	D8 B8 (503)	
	125	628	324	B8A (335)	A10 (393) B7 (385)
	150	524	270	D6 B6 (283)	A9 (318)
	175	449	231	A8 (252)	
	200	393	203	A8 (252)	
	250	314	162	A7 (193)	D5 B5 (196)
	300	262	135	A6 (142)	
13	75	1770	912	D11 B11 (950)	
	100	1327	684	D10 B10 (785)	
	125	1062	547	D9 B9 (636)	
	150	885	456	D8 B8 (503)	
	175	759	391	A10 (393)	
	200	664	342	D7 B7A B7 (385)	
	250	531	274	D6 B6 (283)	A9 (318)
	300	442	228	A7 (193)	

* Equivalent Area $= \dfrac{As \times fy\ (steel\ bar)}{fy\ (fabric)}$

where As = Area of steel bar

fy (steel bar) = 250 N/mm^2 for mild steel bar

fy (fabric) = 485 N/mm^2 for hard-drawn steel wire

TABLE C SUBSTITUTION OF FABRIC FOR HIGH TENSILE STEEL BARS

BARS			SUBSTITUTION OF FABRIC FOR HIGH TENSILE STEEL		
DIAMETER (mm)	SPACING (mm)	AREA (mm^2/m)	EQUIVALENT AREA (mm^2/m)	RECOMMENDED FABRIC REF NO. (mm^2/m)	
10	75	1047	993	D12 B12 (1131)	
	100	785	745	D10 B10 (785)	
	125	628	596	D9 B9 (636)	
	150	524	497	D8 B8 (503)	
	175	449	426	D8 B8 (503)	
	200	393	373	D7 B7 (385)	A10 (393)
	250	314	298	A9 (318)	B8A (335)
	300	262	248	A8 (252)	D6 B6 (283)
13	75	1770	1679	Nil	
	100	1327	1259	D13 B13 (1328)	
	125	1062	1007	D12 B12 (1131)	
	150	885	839	D11 B11 (950)	
	175	759	720	D10 B10 (785)	
	200	664	630	D9 B9 (636)	
	250	531	504	D8 B8 (503)	
	300	442	419	D8 B8 (503)	
16	75	2681	2543	Nil	
	100	2011	1907	Nil	
	125	1609	1526	Nil	
	150	1341	1272	D13 B13 (1328)	
	175	1149	1090	D12 B12 (1131)	
	200	1005	953	D11 B11 (950)	
	250	804	763	D10 B10 (785)	
	300	670	635	D9 B9 (636)	

$$\text{* Equivalent Area} = \frac{As \times fy\ (\text{steel bar})}{fy\ (\text{fabric})}$$

where As = Area of steel bar

fy (steel bar) = 460 N/mm^2 for high tensile bar

fy (fabric) = 485 N/mm^2 for hard-drawn steel wire

Appendix

Listing of Precasters

		Address:	Tel:	Fax:
1	Balken Piling (S) Pte Ltd	7A Tuas Ave 13, S 638979.	257 6633	758 1694
2	Bolsen Cement Products Pte Ltd	7 Sungei Kadut St 5, S 728954.	269 3822	366 1979
3	Construction Products Pte Ltd	15 Sungei Kadut St 3, S 729146.	365 1922	365 3745
4	Eastern Partek Pte Ltd	15 Sungei Kadut St 2, S 729234.	368 1366	368 2256
5	Econ Piling Pte Ltd	1 Ang Mo Kio St 64, S 569084.	484 2222	484 2221
6	Eng Seng Cement Products (Pte) Ltd	45 Kallang Pudding Building #10-01, S 349317.	746 4333	743 4085
7	Hin Bee Sawmill Co (Pte) Ltd	65 Sungei Kadut St 1, S 729366.	269 1447	368 5604
8	Hong Leong Asia Ltd (Building Products Group)	7A Tuas Avenue 13, S 639407.	862 3501	861 0674
9	Hua Kok Realty Pte Ltd	32 Sungei Kadut Way, S 728787.	362 5667	362 5210
10	KDI Precast Pte Ltd	28 Tuas Crescent, S 638719.	861 3988	861 2284
11	L & M Precast Pte Ltd	3 Gul Road, S 629339.	861 3688	861 6949
12	Lightweight Concrete Pte ltd	11 Kwong Min Road, S 628713.	261 5522	264 4141
13	Nam Kee Cement Products Pte Ltd	11 Sungei Kadut St 5, S 728957.	366 1111	269 2773
14	Poh Cheong Concrete Product Co	65 Sungei Kadut St 1, S 729366.	269 1447	368 5604
15	Prefab Technology Pte Ltd	66 Sungei Kadut St 1, S 729367.	368 3233	365 8038
16	Sembawang Construction Pte Ltd	60 Admiralty Road West, #03-00 Sembawang Building S 759947.	750 6312	756 4591
17	Shimizu Precon Pte Ltd	Lot 113-11, 217 & 1079 Off Admiralty Road West S 750000.	368 3711	368 9587
18	Sin Mah Concrete Product Pte Ltd	22 Defu Lane 6, S 539375.	282 0468	281 3416
19	Contech Trading Pte Ltd	21 Sungei Kadut St 2, S 729238.	362 8810	269 0868
20	Syscon Pte Ltd	17 Tuas Avenue 18, S 638900.	862 3238	861 1439
21	Spandeck Engineering (S) Pte Ltd	5 Tuas Avenue 13, S 638977.	862 3922	861 5389

Listing of Drywall Suppliers

		Address:	Tel:	Fax:
1	Aerocon Technologies Pte Ltd	17 Pioneer Crescent , S 628550.	265 2868	261 0973
2	Celcon Far East Pte Ltd	53A Craig Road , S 089691.	225 9622	225 9633
3	Contech Trading Pte Ltd	21 Sungei Kadut St 21 , S 729238.	366 2551	368 9883
4	CSR S.E.Asia Pte Ltd	8 Tuas Avenue 2 , S 639448.	861 4722	862 3533
5	Gables and Walls Builder Pte Ltd	123 Bukit Merah Lane 1 , #04-118 Alexandra Village S 150123.	276 4711	276 4722
6	Hok Sze Enterprise (Pte) Ltd	18 Enterprise Road , S 629824.	265 2000	265 1313
7	Hong Leong Industries Mfg Ltd	7A Tuas Avenue 13 , S 638979.	862 3501	861 0674
8	James Hardie Building Boards (Asia) Pte Ltd	101 Thomson Road , #15-05 United Square S 307591.	253 2833	253 3113
9	Neo Clad Pte Ltd	1 Irving Road , #07-01 Neo Industrial Building S 369520.	382 3770	382 1763

Listing of Reinforcement Suppliers

		Address:	Tel:	Fax:
1	Asia Steel Welded Mesh Co Ltd	11 Tuas Avenue 3 , S 639410.	861 7333	862 5968
2	Angkasa Marketing(S) Pte Ltd	10 Arumugam Road #09-00 , Lion Industrial Building S 409957.	759 5973	743 7252
3	B.R.C. Weldmesh (S.E.A.) Pte Ltd	350 Jalan Boon Lay , S 619530.	265 2333	266 4728
4	Burwill Trading Pte Ltd	35 Pioneer Road , S 628503.	862 2306	863 2865
5	Eastern Wire Pte Ltd	27 Jalan Buroh , S 619483.	265 0066	261 8562
6	Econ Industries Pte Ltd	2 Ang Mo Kio St 64 , Ang Mo Kio Industrial Park 3 , S 569084.	484 2222	484 2221
7	Legend Building Supplies Pte Ltd	No 4 Kian Teck Drive , S 628821.	265 2857	-
8	LiSteel Singapore Pte Ltd	No 11 Tuas Ave 16 , Jurong , S 638929.	862 2467	-
9	Natsteel Ltd	22 Tanjong Kling Road , S 628048.	265 1233	265 8317
10	Panwah Steel Pte Ltd	116 Middle Road , #08-01 ICB Enterprise House, S 188972.	337 2237	338 8221
11	Viewforth Trading & Engineering Pte Ltd	No 5 Tuas Ave 1 , S 639490.	862 0033	861 6448

Listing of Contractors with Precast Experience
(Based on list of contractors who participate in CIDB productivity survey)

		Address	Telephone	Fax
1	Aoki Corporation	30 Prinsep Street, #08-02 LKN-Prinsep House, S 188647.	3368344	3367152
2	B & C Construction Pte Ltd	100 Jalan Sultan #08-14, Sultan Plaza, S 199001.	2934548	2917833
3	Bestbuild Development Pte Ltd	#04-16 Fu Lu Shou Complex, 149 Rochor Road, S 188425.	3371222	3395401
4	Caravelle Construction & Development Pte Ltd	115 Eunos Ave 3, Eunos Industrial Estate, S 409839.	7411833	7411822
5	Chip Eng Seng Contractors (1988) Pte Ltd	161 Geylang Road #02-01, S 389239.	7498138	7486662
6	Chip Huat Construction Co Pte Ltd	101 Upper Cross Street, #05-24 People's Park Centre, S 058357.	5337544	5343871
7	Chuang Uming Pte Ltd	2 Alexandra Road, # 07-09A Delta House, S 159919.	2752188	2752088
8	CMC Construction (Pte) Ltd	28 Ubi Road 4,Fersina House , S 408614.	7485550	7491461
9	Deenn Engineering Pte Ltd	133 Cecil Street, #18-02/02A/03 Keck Seng Tower, S 069535.	2211120	2220502
10	Dragages et Travaux Publics(Singapore) Pte Ltd	Raffles City, P.O. Box 1723 , S 911758.	3366328	3381013
11	Dumez/GTM-Wan Soon/Woh Hup	Jurong P.O. Box 48, S 916402.	8631981	8631982
12	Durabeau Construction Pte Ltd	No.18 Tuas Ave 6, Jurong Town , S 639305.	8622228	8633170
13	Eng Keong Construction Pte Ltd	179 Thomson Rd, Goldhill Ctr , S 307626.	2554422	2522949
14	Eng Lim Construction Company Pte Ltd	211 Holland Avenue, #04-03 Holland Road Shopping Centre, S 278967.	4668200	4661943
15	Evan Lim & Company Pte Ltd	165A Jalan Jurong Kechil , S 598656.	4672122	4670851
16	Evergreat Construction Co. Pte Ltd	15 Scotts Road, #08-08 Thong Teck Building, S 228218.	7320777	7373636
17	Four Seas Construction Co Pte Ltd	10 Genting Road, The Blue Building, S 349473.	7489951	7442879
18	GTM Entrepose	20 Bideford Road, #03-02 Wellington Building, S 229921.	7380511	7383580
19	Ho Lee Construction Pte Ltd	200 Jalan Sultan #04-25,Textile Centre , S 199018.	2967300	2960678
20	Hock Chew Building Construction Pte Ltd	2A Braddell Road, S 359895.	2891482	3820630
21	Hock Chuan Ann Construction Pte Ltd	BLK 164 Bt Merah Central, #03-3619/3621, S 150164.	2730266	2735737
22	Hock Guan Cheong Builder Pte Ltd	No 53 Kim Keat Road, #04-02 Mun Hean Building, S 328823.	2563206	2561086
23	Housing Construction Pte Ltd	859 Upper Serangoon Road, #01-01 Hougang Court, S 534690.	2847679	2847678
24	Hua Kok Realty (Pte) Ltd	21A/B Opal Crescent, S 328416.	3625667	3625210
25	Hytech Builders Pte Ltd	BLK 165 #05-3685/7/9, Bukit Merah Central , S 150165.	2720802	2736569

26	Hyundai Engineering & Construction Co. Ltd	7 Temasek Boulevard, #40-01 Suntec City Tower One , S 038987.	3371577	3386755
27	JDC Corporation	6 Battery Road #19-02 , S 049909.	2205555	2243575
28	Kajima Overseas Asia Pte Ltd	80 Marine Parade Road, #14-01/03 Parkway Parade, S 449269.	3440066	3443777
29	Khian Heng Construction Pte Ltd	157-B Thomson Road, Goldhill Centre, S 307610.	2557355	2537696
30	Kim Seng Heng Engineering Construction Pte Ltd	39 Senoko Rd, Woodlands East Industrial Est , S 758111.	7582266	7582532
31	Kimly Construction Pte Ltd	3 New Industrial Road, #03-01, Kimly Building , S 536197.	2801755	2802755
32	Kong Siong Construction Co. Pte Ltd	859 Upper Serangoon Rd, #01-01 Hougang Court , S 534690.	2842223	2854577
33	Koon Seng Construction Pte Ltd	149 Rochor Road, #05-02 Fu Lu Shou Complex, S 188425.	3363692	3361129
34	Lean Hin Lee Contractor & Trading (Pte) Ltd	69, Sungei Kadut Drive #04-A/B S 729568	3633422	3664429
35	Lee Service Construction Pte Ltd	31/33 Pioneer Road North, S 628472.	2613333	2623333
36	Lend Lease (S) Pte Ltd	510 Thomson Road, #08-01 SLF Building , S 298135.	2588777	2596677
37	Lian Beng Construction [1988] PL	985 Upper Serangoon Rd, Lian Beng Building , S 534731.	2831468	2809360
38	LKN Construction Pte Ltd	30 Prinsep Street, #11-00 LKN Prinsep House, S 188647.	3343303	3396606
39	Low Boon Leong Construction Pte Ltd	151 Chin Swee Road, #02-04 A, S169876.	7331958	7331952
40	Low Keng Huat Construction Company (s) Pte Ltd	80 Marine Parade Road, #18-05/09 Parkway Parade, S 449269.	3442333	3457841
41	Lum Chang Building Contractors Pte Ltd	38 Kim Tian Road, #03-00 Kim Tian Plaza, S 169262.	2738888	2785072
42	Mitsui Construction Company Ltd	80 Robinson Road, #16-03 , S 068898.	2207166	2229880
43	Nakano Singapore (Pte) Ltd	585 North Bridge Rd, #11-08/10/11 Blanco Court, S 188770.	2969388	2961554
44	Neo Corporation Pte Ltd	No 1 Irving Road #07-01,Neo Ind Bldg, S 369520.	2882822	2880716
45	Obayashi Corporation	6 Shenton Way #16-09,DBS Building Tower Two, S 069536.	2203122	2248425
46	Pillar Construction Pte Ltd	17 Thomson Hill Drive, S 574761.	4532617	4537533
47	Poh Lian Construction Pte Ltd	Poh Lian Building, 95 Kovan Road, S 548181.	2847622	2841353
48	Pyramid Construction Engineering Pte Ltd	67 Rangoon Road #02-00 , S 218357.	2955288	2927856
49	Sato Kogyo Company Ltd	149 Rochor Road, #04-14/15 Fu Lu Shou Complex, S 188425.	3367333	3368853

50	Sembawang Construction Pte Ltd	391A Orchard Road, #16-02 Ngee Ann City Tower A , S 238873.	7506391	7351162
51	Shimizu Corporation	10 Anson Road, #26-01/15/16 International Plaza, S 079903.	2200406	2249890
52	Shung Shing Construction & Engineering Co. Pte Ltd	2 Finlayson Green #08-05A, Asia Insurance Building, S 049247.	2262669	2262282
53	Sim Lian Construction Co Pte Ltd	No 52 Hillview Terrace , S 669271.	7603511	7696617
54	Singa Development Pte Ltd	60A Martin Road, #05-06A , S 239066.	2357171	7372711
55	Singapore Piling & Civil Engineering Pte Ltd	60 Martin Road, #07-38, S 239065.	2355088	7333664
56	Singapore Technologies Construction Pte Ltd	9 Bishan Place, #08-00, S 579837.	3530988	2593323
57	So Say Cheong Pte Ltd	Blk 2 Balestier Road, #04-677 Balestier Hill Shopping Centre, S 320002.	2547049	2532584
58	Spandeck Engineering (S) Pte Ltd	5 Tuas Ave13, S 638977.	8623922	8615389
59	Ssangyong Engineering & Construction Co Ltd	16 Raffles Quay, #12-04 Hong Leong Building, S 048581.	3361255	3399590
60	Straits Construction Co Pte Ltd	Blk 165 Bt Merah Central, #05-3671/3673, S 150165.	2735260	2726469
61	Sum Keong Construction Pte Ltd	No 46 Somme Road , S 207869.	2993370	2997225
62	Sumitomo Construction Co Ltd	No 2 Leng Kee Road, #03-05 Thye Hong Centre , S 159086.	4750079	4756996
63	Taisei Corporation	290 Orchard Road, #05-07 The Paragon, S 238859.	3362224	3362236
64	Takenaka Singapore Pte Ltd	15 Hoe Chiang Rd, #12-04 Euro-Asia Centre, S 089316.	8634039	8634418
65	Tiong Aik Construction Pte Ltd	Tiong Aik Bldg,83 Sungei Kadut Drive, S 729566.	3657688	3655572
66	Tiong Seng Contractors (Pte) Ltd	510 Thomson Road, #19-00 SLF Building , S 298135.	3560822	3560688
67	Tokyu Construction Co. Ltd	585 North Bridge Road, #13-11/13 Blanco Court , S 188770.	2943811	2951991
68	Tong Hup Seng Construction Co. Pte Ltd	1008A Upper Serangoon Road, S 534746.	2846266	2843798
69	W G Prestige Associates Pte Ltd	170 Upper Bukit Timah Road, #10-04 Bt Timah Shopping Ctr, S 588179.	4671008	4668829
70	Wan Soon Construction Pte Ltd	183B Goldhill Centre, Thomson Road, S 307628.	2556833	2535831
71	Yeo Boon Hui Construction Pte Ltd	Blk 203 Hougang St 21, #02-91, S 530203.	2852844	2852846

Summary of Precasters' Product Range

No.	Precasters	Building Structural Components							Building Architectural Components							Other Components			
		Beams	Columns	Hollow Core Slabs	Prestress Plank	Double-T Beam	Staircases	Structural Facade (with built-in beams)	Parapet Walls	Facades (w/o) beams	Claddings	Sunbreakers	Balcony	Gable-End Walls	Internal Partition Walls	Water Tanks	Refuse Chutes	Precast Bathroom	Roofing Slabs
1	Balken Piling (S) Pte Ltd	√	√				√	√	√	√	√	√		√					
2	Bolsen Cement Products Pte Ltd														√				√
3	Construction Products Pte Ltd														√				√
4	Eastern Partek Pte Ltd	√	√	√	√	√	√	√	√	√	√		√	√				√	
5	Econ Piling Pte Ltd	√	√				√	√	√	√			√	√			√		
6	Eng Seng Cement Products (Pte) Ltd			√					√	√	√	√	√	√	√				√
7	Hin Bee Sawmill Co (Pte) Ltd	√	√		√	√	√	√	√	√	√	√		√	√	√	√		√
8	Hong Leong Asia Ltd	√	√		√	√	√	√	√	√	√	√	√	√		√	√	√	√
9	Hua Kok Realty Pte Ltd	√	√				√		√	√	√	√	√	√	√	√	√		√
10	KDI Precast Pte Ltd	√	√		√	√	√	√	√	√	√	√		√	√				
11	L&M Precast Pte Ltd	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
12	Lightweight Concrete Pte Ltd						√	√	√	√	√	√	√	√	√	√	√		
13	Nam Kee Cement Products (Pte) Ltd																		√
14	Poh Cheong Concrete Produc	√	√		√	√	√	√	√	√	√	√		√	√	√	√		√
15	Prefab Technology Pte Ltd	√	√	√			√		√					√		√	√		
16	Sembawang Construction Pte	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
17	Shimizu Precon Pte Ltd	√	√		√		√	√	√	√	√	√	√	√		√	√		√
18	Sin Mah Concrete Products Pte Ltd																√		√
19	Contech Trading Pte Ltd	√	√	√		√	√	√	√	√	√	√	√	√			√	√	
20	Spandeck Engineering (S) Pte	√	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√	
21	Syscon Pte Ltd	√	√		√	√	√	√	√	√	√	√	√	√		√	√	√	√