

SPECIFICATION FOR PRECAST CONCRETE WORKS



TABLE OF CONTENT	PAGE
TABLE OF CONTENT.....	i
ABBREVIATION.....	iii
1. GENERAL.....	1
2. DESIGN REQUIREMENTS.....	2
2.1 Design Consideration	
2.2 Joints	
2.3 Ties	
3. ASSEMBLY DRAWING.....	11
4. REINFORCEMENT CAGES.....	11
4.1 Bar Bending	
4.2 Position and Cover	
4.3 Welding of Reinforcement	
5. MOULD/FORMWORK.....	13
5.1 Mould/Formwork Design	
5.2 Dimension and Condition	
5.3 Release Agent	
5.4 Regulatory Requirements	
6. INSTALLATION.....	16
6.1 General	
6.2 Precast Concrete Beam	
6.3 Precast Concrete Column	
6.4 Precast Concrete Half Slab	
6.5 Hollow Core Slab	
6.6 Transportation	
6.7 Lifting and Handling	
6.8 Site Access and Ground Preparation	

6.9	Placement of Precast Concrete Components	
6.10	Erection	
6.11	Alignment	
6.12	Safety Precaution During Installation	
7.	STORAGE.....	24
7.1	Adequate Area	
7.2	Ground Condition	
7.3	Onsite Storage	
7.4	Protection of Precast Component	
8.	CONNECTION.....	25
8.1	Grouting	
8.2	Placement	
8.3	Curing and Protection	
9.	BEARING PAD.....	30
9.1	Natural Rubber	
9.2	Neoprene	
10.	MECHANICAL AND ELECTRICAL SERVICES REQUIREMENTS IN STRUCTURE.....	30
	BIBLIOGRAPHY.....	31
	ACKNOWLEDGEMENT.....	32

ABBREVIATION

HCS	:	Hollow Core Slab
IBS	:	Industrialised Building System
P.D.	:	Project Director

1. GENERAL

This specification includes the basic specification for material, manufacturing requirement from raw materials to delivery, site installation and erection method in addition to the requirements of installation equipment.

This specification outlines the requirements for precast concrete building components including other related items such as joints, connections, bearings and anchorages to ensure that all items act together as an integral structure that is structurally stable under all specified combination of loading conditions.

This section shall apply to the construction of all structures or parts of structures to be composed of concrete with or without steel reinforcement. The work shall be carried out all in accordance with this specification and the lines, levels, grade, dimensions and cross-section shown on the drawings and as required by the S.O./P.D.

The Contractor shall employ manufacturers registered with CIDB to supply or cast on site precast component to the respective project. All precast concrete components to be used in the works shall be approved by the S.O./P.D. prior to installation.

This specification complements the latest JKR Standard Specification for Building Works for all related works and shall be read together.

2. DESIGN REQUIREMENTS

2.1 Design Consideration

2.1.1 General Approach

All design shall comply with the requirements of the latest code of practice. All structural design shall comply with architectural, mechanical and electrical design requirements as stated in the drawings.

Optimum economic benefits are achieved by maximizing the repetition and using modular coordination dimensions of the precast concrete components.

Precast concrete structures shall be designed as discrete components and the continuity of the components shall be achieved through proper connection details.

Weight and length of the components shall be appropriately restricted to comply with the production, transportation, lifting and erection considerations.

Effects of restraint to the changes in volume cause by creep, shrinkage and temperature differences must be considered in every structure.

Precast Beam shall be supported on column corbel or connector and are unpropped (unless otherwise stated) during installation. However, connections using hidden corbel shall be allowed for the exposed area without ceiling.

For wet areas, the contractor is to coordinate the pipes and conduits to be laid within the topping thickness.

2.1.2 Design Principles

The structural framing of the building shall be designed as braced structures. In order to do this, appropriate bracing elements such as shear walls, staircase enclosures, lift cores, triangulated bracing or buttressing designed to resist all lateral forces in the relevant planes shall be provided at the required locations.

Whatever system of resisting horizontal forces is used, reversal of load direction shall be accommodated. The floors shall have adequate strength and be so secured to the structural framework as to transmit all horizontal forces to the points at which such resistance is provided.

In the design of the lifting points, when lifting inserts are used, the inserts shall be designed with minimum factor of safety of 4 at Ultimate Limit State (ULS) against tensile, shear and bonding failures. If reusable lifting hardware or rigging are used, then they shall be designed with minimum factor of safety of 5.

The joint between the stump and the pad footing shall assumed to be pinned to allow for uniform development of earth pressure under the footing.

All structural welding, if required shall be done by qualified welders using equipment and materials compatible to the base material. The work shall be done completely in the factory.

If proprietary connection system is specified, the capacity of the system shall be justified either by calculation or by test results.

Non-load bearing wall shall be properly designed to ensure the safe functioning. Proper attention shall be given to the stability of the wall and appropriate vertical/horizontal wall stiffeners shall be provided

for every 10m² area of wall or a minimum spacing of 3 meters. Lintols, ties, reinforcements and connections shall be used judiciously.

Unless specified otherwise, the minimum grade of concrete shall not be least than grade C30/37

Infill grout strength shall be equal or greater than characteristic strength of precast concrete component.

When precast concrete wall panels are used as cladding, the inherent load carrying capacity of these components may not be neglected.

2.1.3 Industrialized Building System (IBS) Requirements

The calculation shall comply based on the latest version of Manual for Industrialized Building System (IBS) Content Scoring System (IBS Score): Construction Industry Standard, CIS 18 published by the Construction Industry Development Board (CIDB) Malaysia

2.2 Joints

2.2.1 Joints

Movement joints, expansion joint, contraction joints or other permanent structure joints shall be provided in the positions and constructed and sealed with waterproofing materials as detailed in the Drawings and shall be in accordance with the latest JKR Standard Specification for Building Works.

The installation method and the selection, mixing, application and curing of all joint waterproofing materials shall be in accordance with the manufacturer's recommendations. The Contractor may propose

to use alternative joint waterproofing materials by submitting supporting technical information, test reports and samples of the proposed waterproofing materials to the S.O./P. D. for approval.

All waterproofing materials used at public access areas shall be protected with shrinkage compensating grout covering

2.2.2 External Joint

The external joints should be designed as ‘open-drained’ joints, meaning any water in the joint can flow down and discharged out on its own by gravity (see figure 2.1). On the vertical joints, a double barrier consisting of an internal barrier of approved waterproofing materials and an external barrier consisting of approved elastomeric joint such as polyurethane material lay between two panels against a backup string of foam material. Joint width shall be designed according to the sealant movement capability. The movement capability of the sealant and joint width shall be adequate to accommodate the expected movement of the structure element.

Horizontal joint between external walls is waterproofed by means of approved waterproofing materials. In addition, a strip of approved bituminous felt is also laid horizontally at the intersection of vertical and horizontal joints.

Both, vertical and horizontal joints shall then be concealed by installing aluminium strips on top of the grooves and attaching one end of the strip to the wall.

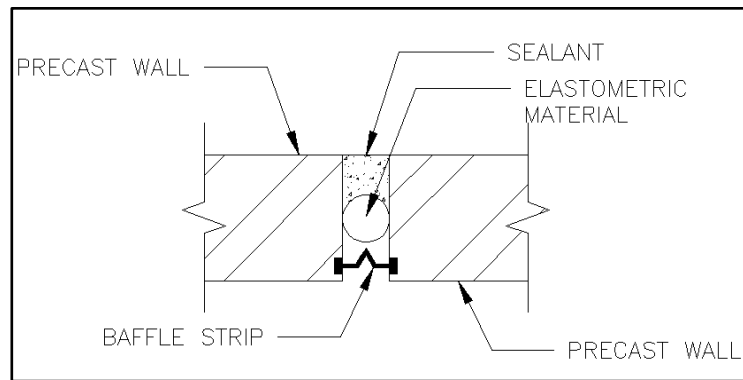


Figure 2.1: Typical Open Drained Joint for External Joint

2.2.3 Internal Joints

In the normally wet area, (e.g. bathrooms, toilets and kitchens), approved waterproofing materials shall be applied over the entire floor area with extra 200mm minimum up the walls and vertical pipes (see figure 2.2). Water proofing admixtures are also introduced in the concrete screeds that are subsequently laid on top of the concrete floor topping, if the screeds are specified. Additives are also added to the concrete placed in the joints to improve workability and reduce shrinkage.

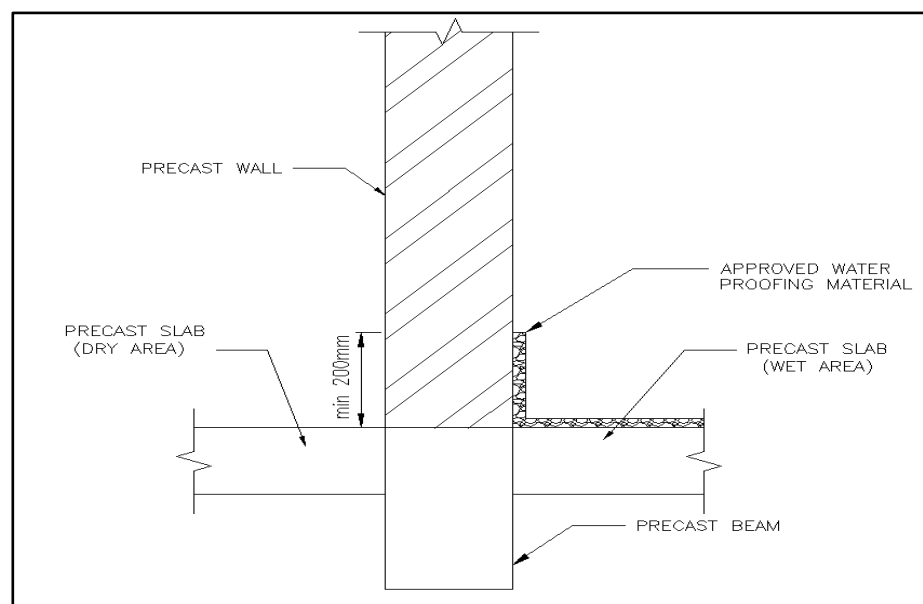


Figure 2.2: Typical Installation of Waterproofing Material on Wet Area

If the concrete topping is designed as structural topping and to act as a composite with precast concrete floor panel, the minimum thickness of the structural concrete topping shall be as per designed or 75 mm for hollow core slab, whichever is greater. Screeds shall also be specified to be laid on top of the finished composite floor panel and water proofing membrane, in addition to the structural topping.

However, specific requirement might differ as per requirements in the drawings.

2.3 Ties

2.3.1 General

Structures which are not designed to withstand accidental actions shall have a suitable tying system, to prevent progressive collapse by providing alternative load paths after local damage. The following simple rules are deemed to satisfy this requirement based on MS EN 1992-1-1.

The following ties shall be provided:

- a. Peripheral ties
- b. Internal ties
- c. Horizontal ties to columns and/or walls
- d. Where required, vertical ties, particularly in panel buildings.

Where a building is divided by expansion joints into structurally independent sections, each section shall have an independent tying system. In the design of the ties the reinforcement may be assumed to be acting at its characteristic strength and capable of carrying tensile forces defined in the following clauses.

Reinforcement provided for other purposes in columns, walls, beams and floors may be regarded as providing part of or the whole of these ties.

2.3.2 Proportioning of Ties

2.3.2.1 General

Ties are intended as a minimum and not as an additional reinforcement to that required by structural analysis.

2.3.2.2 Peripheral Ties

At each floor and roof level an effectively continuous peripheral tie within 1.2 m from the edge shall be provided. The tie may include reinforcement used as part of the internal tie.

The peripheral tie shall be capable of resisting a tensile force.

Structures with internal edges (e.g. atriums, courtyards, etc.) shall have peripheral ties in the same way as external edges which shall be fully anchored.

2.3.2.3 Internal Ties

These ties shall be at each floor and roof level in two directions approximately at right angles. They shall be effectively continuous throughout their length and shall be anchored to the peripheral ties at each end, unless continuing as horizontal ties to columns or walls.

The internal ties may, in whole or in part, be spread evenly in the slabs or may be grouped at or in beams, walls or other appropriate positions.

In walls they shall be within 0.5 m from the top or bottom of floor slabs.

Internal ties shall be connected to peripheral ties such that the transfer of forces is assured.

2.3.2.4 Horizontal Ties to Columns and/or Walls

Edge columns and walls shall be tied horizontally to the structure at each floor and roof level.

The ties shall be capable of resisting a tensile force per metre of the façade. For columns the force need not exceed tensile force per metre of the column.

Corner columns shall be tied in two directions. Steel provided for the peripheral tie may be used as the horizontal tie in this case.

2.3.2.5 Vertical Ties

In panel buildings of 5 storeys or more, vertical ties shall be provided in columns and/or walls to limit the damage of collapse of a floor in the case of accidental loss of the column or wall below. These ties shall form part of a bridging system to span over the damaged area.

Continuous vertical ties shall be provided from the lowest to the highest level, capable of carrying the load in the accidental design situation, acting on the floor above the column/wall accidentally lost. Other solutions based on the diaphragm action of remaining wall elements and/or on membrane action in floors, may be used if equilibrium and sufficient deformation capacity can be verified.

Where a column or wall is supported at its lowest level by an element other than a foundation (e.g. beam or flat slab) accidental loss of this element shall be considered in the design and a suitable alternative load path shall be provided.

2.3.3 Continuity and Anchorage of Ties

Ties in two horizontal directions shall be effectively continuous and anchored at the perimeter of the structure.

Ties may be provided wholly within the in situ concrete topping or at connections of precast members. Where ties are not continuous in one plane, the bending effects resulting from the eccentricities shall be considered.

Ties shall not be lapped in narrow joints between precast units. Mechanical anchorage shall be used in these cases.

The Contractor shall be responsible to ensure the ties are installed according to the drawings.

3. ASSEMBLY DRAWING

All assembly drawing produced by the manufacturer and verified by a Professional Engineer (P.E.) to the S.O./ P.D. for approval before the commencement of the manufacturing of the component. The list of drawings that needs to be endorsed are as below:

- i. Layout drawing
- ii. Section drawing
- iii. Connection details
- iv. Element types
- v. General drawing

Assembly Drawings shall show all necessary details and dimensions to enable assembly of components to proceed.

4. REINFORCEMENT CAGES

All requirement regarding to steel reinforcement shall comply to the latest JKR Standard Specification for Building Works. Additional requirements are as follows:

4.1 Bar Bending

Bar bending shall conform to BS 4449: Steel for the reinforcement of concrete and MS1438: Spec. for scheduling Dimension, bending & cutting of steel reinforcement for concrete, or BS 8666 : Scheduling, dimensioning, bending and cutting of the steel reinforcement for concrete as below:

- i. Carried out in a sheltered environment
- ii. Not be bent if raised to a temperature exceeding 100°C, except with the approval and supervision of the S.O./P.D.
- iii. No allowance to bar bending after fabrication of the cage, except with the approval of the S.O./P.D.

4.2 Position and Cover

4.2.1 The accuracy of the position of bars in the cage shall not be greater than as specified in the BS EN 13670:

- Cover to exposed edges and end: $\pm 5\text{mm}$
- Cover to ends with protection: $\pm 10\text{mm}$
- Distances between stirrups: $\pm 25\text{mm}$

The cover to all bars, including links and secondary bars, but excluding bar provided for handling purposes only, shall be according to the production drawing, given as a nominal cover.

4.2.2 Spacers and chairs shall conform to BS 7973-1: Spacers and chairs for steel reinforcement and their specification.

4.2.3 Product performance requirement shall conform to BS 7973-2: Spacers and chairs fixing and application of spacers and chairs and tying of reinforcement as follows:

- shall not be handmade (e.g. grout, blocks)
- sufficient to achieve and maintain cover to reinforcement
- shall include dimensions, identification, point load strength, permanent deflection after loading, stability and fixity.

4.3 Welding of Reinforcement

4.3.1 Welding of reinforcing steel and welding of reinforcing steel to structure steel in load bearing joints shall conform to BS EN ISO 17660-1: Welding of reinforcing steel-part 1: Load-bearing welded joints; unless otherwise specified.

4.3.2 The processes used are shielded metal arc and gas metal arc. The welding electrode rods for high tensile bar shall be low hydrogen type electrode to cover a wide range of applications for welding carbon manganese and low alloy steel.

- 4.3.3 Spot welding of non-load-bearing bars shall conform to BS EN ISO 17660-2: Welding of reinforcing steel-part 2: Non-load-bearing welded joints.

5. MOULD / FORMWORK

5.1 Mould/Formwork Design

5.1.1 Types

Steel or other suitable forms such as plastic, aluminium, fiberglass or resin based or coated materials or a combination of materials shall be used. The mould/formwork system shall be of good quality, modular, designed for speed and efficiency, minimum wastage in construction, provide high level of working safety and environmentally friendly. The mould/formwork also shall be capable of resisting all loads to which they are subjected to during the manufacture process, including placing, handling and vibrating of concrete. They shall be stiff enough to ensure that the dimensional tolerances specified for the elements are maintained throughout the life of the mould/formwork such that the integrity of the element is not affected. The function, appearance and durability of the elements shall not be impaired or damaged due to the performance of the mould/formwork. Joints shall be sufficiently tight so as to minimise loss of fines.

The selection of mould/formwork materials shall depend on number of usage, required surface finish type and quality, shape complexity of precast elements. Adequate number of braces, ties and struts shall be provided for proper casting and hardening of concrete. A minimum number of demountable parts will help to ensure good maintenance of dimensional accuracy during production, assembly and dismantling. Adjustable mould/formwork shall be used for greater flexibility and variety of precast concrete elements production.

5.1.2 Mould/Formwork Design and Manufacture

The dimensional accuracy of the mould/formwork, shall be determined by the precast manufacturer and the standard tolerances are in accordance with BS 5606.

5.2 Dimension and Condition

5.2.1 Accuracy

The dimensional accuracy of the mould/formwork, shall be determined by the precast manufacture, in accordance with the standard tolerances.

5.3 Release Agent

The separation effect of release agents shall be chemically or physically as follows:

i. Chemically

Additives that react with the alkaline constituents of concrete

ii. Physically

Reduce the interfacial tension between concrete and formwork surface.

The release agents used shall not cause discolouration of concrete surface and shall be easily biodegradable.

5.3.1 Release Agent (Physically)

The mould/formwork shall be treated by brushing or spraying mould/formwork oil based/ solvent based/ water based emulsion oil (release agent) according to BS EN 13670. Applying of mould/formwork release agent using brushing is not advisable

because under or over application of release agent can occur easily. The problems that can be caused from excessive amounts of release agent are discoloration, surface retardation and surface dusting.

The type shall depend on the surface nature of the mould/formwork. Approved release agents for steel and other moulds/formwork include: polymer liquid wax, silicon-calcium spray, natural oil with surfactant, and chemical release agents. For concrete moulds/formwork water based release agents are approved. The dosage, coverage, usage, shelf life, application, etc. shall be according to the supplier's instructions or manufacturers guidelines.

The contractor shall furnish the S.O., the test results of the mould/formwork release agent. In hot weather preparation, the surface of the mould/formwork shall be protected from direct sun rays to prevent absorption of water from fresh concrete. The surface of the mould/formwork shall be protected from rain and no free standing water shall be allowed.

5.4 Regulatory Requirements

The use of mould or formwork system shall comply with BS 5975 and with the regulatory requirements of:

- i. CIDB Act 520
- ii. Occupational Safety and Health Act 1994
- iii. Factories and Machinery Act 1967
- iv. CIS 23: Safety use of Falsework and Formwork
- v. Other regulatories deemed necessary

6. INSTALLATION

6.1 General

The Contractor shall inform the S.O./P.D. at least one month in advance of launching or installation operation and submit the following documents to the S.O. for acceptance:

- a. Method statement including launching systems and transportation
- b. Proposal for traffic diversion, if appropriate
- c. Detailed program of launching and installation operation
- d. Installation operation safety program

Inspection of Precast Unit

The elements shall be inspected for cracking and other defects or damage. The dimensional properties of the components shall be checked in accordance in the drawings.

6.2 Precast Concrete Beam

Before installation of the beam, the dowel bars & bearing pad position on corbel and corrugated ducts in the precast beam shall be free from any blockages. Precast beams shall be hoisted with lifting equipment or any other suitable material of sufficient capacity to minimize handling damages. Precast beams shall be supported on column/wall/beam/corbel/nib or connector and are unpropped (unless otherwise stated in the drawings). The precast beam shall match the setting outline before it's allowed to seat fully on the supporting components. The grouting work for precast beam shall start shortly after the removal of lifting equipment.

Concreting of topping and other imposed construction loads can only be applied after infill concrete have gained sufficient strength.

6.3 Precast Concrete Column

The position of the connection between columns shall be checked before the casting of precast column to ensure the correct position of the connection. The precast columns shall be surveyed and aligned vertically in position.

Before the grout gain sufficient strength, the props shall not be disturbed or removed. For column to column connections, the column/beam connection shall have to be fixed with column's stirrups prior to concreting the in-situ portion of column at beam junction. The values for permitted structural deviations for column and walls are given in Table 6.1 according to BS EN 13670.

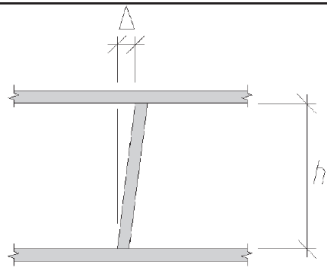
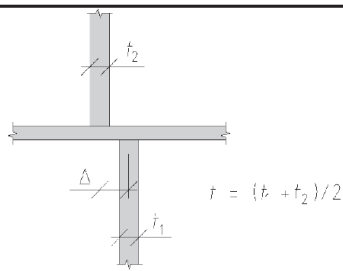
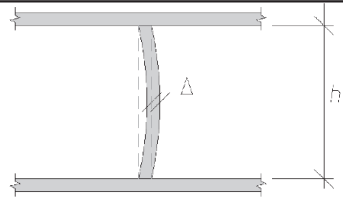
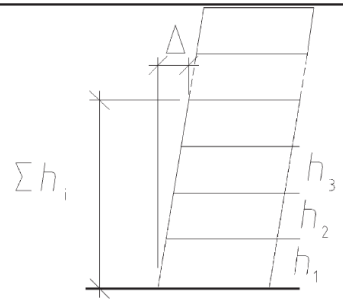
No	Type of deviation	Description	Permitted deviation Δ
			Tolerance Class 1
a	 <p>h - free height</p>	Inclination of a column or wall at any level in a single- or a multi-storey building $h \leq 10 \text{ m}$ $h > 10 \text{ m}$	The larger of 15 mm or $h/400$ 25 mm or $h/600$
b	 <p>$t = (t_1 + t_2) / 2$</p>	Deviation between centres	The larger of $t/30$ or 15 mm but not more than 30 mm
c		Curvature of a column or wall between adjacent storey levels	The larger of $h/300$ or 15 mm but not more than 30 mm
d	 <p>Σh_i - sum of height of storeys considered</p>	Location of a column or a wall at any storey level, from a vertical line through its intended centre at base level in a multi-storey structure n is the number of storeys, where $n > 1$	The smaller of 50 mm or $\Sigma h_i / (200 n^{1/2})$

Table 6.1: Permitted Vertical Deviations for Columns and Walls in Accordance to
BS EN 13670

6.4 Precast Concrete Half Slab

Before installation of the precast half slab, the spacing between supporting components shall be 25mm minimum for the slab to seat on. Bearing strip must be laid on the top surface of the supports for the slab to seat on, unless specified otherwise in the drawings. Precast half slab shall be hoisted with a lifting beam or wire rope with sufficient capacity to minimize handling damages. Precast half slab shall be propped (unless otherwise stated) during installation. Concreting of topping and other imposed construction loads can only be applied after infill concrete have gained sufficient strength.

6.5 Hollow Core Slab

Before installation of the Hollow Core Slab (HCS), the spacing between supporting components shall be 75mm minimum for the slab to seat on. Bearing strip must be laid on the top surface of the supports for the slab to seat on. HCS shall be hoisted by suitable lifting equipment with sufficient capacity to minimize handling damages. HCS shall not be propped (unless otherwise stated) during installation. The shear key grouting shall be commencing after completion of HCS seating

Concreting of topping and other imposed construction loads can only be applied after infill concrete have gained sufficient strength.

6.6 Transportation

The precast concrete components shall be lifted only at points specified in the Drawings and shall be handled and placed without impact. The method of lifting, the type of equipment and transport to be used, and the minimum strength of the components to be handled shall be to the approval of the S.O./P.D.

The Contractor shall obtain the necessary clearances for the transportation of the precast elements and movement of the lifting equipment to the launching site. Contractor's method of transportation shall demonstrate that the elements being transported would not be damaged.

Temporary support for precast concrete components during transportation shall be designed to withstand loads and extra forces during loading, transportation and unloading.

Precast concrete components shall be lifted and supported during manufacturing, stockpiling, transporting and erection operations only at lifting or supporting points, as shown in the fabrication shop drawings, and with approved lifting devices.

A certificate of test of lifting equipment shall be submitted to the S.O./P.D, together with particulars of the experiences of the operator.

The contractor shall ensure the suitability of particular capacity and size of the transporter.

6.7 Lifting and Handling

6.7.1 Method Statement

A lifting method statement shall be prepared by the Contractor and submitted for approval. The method statement shall include and not limiting to stacking ages, types and positions of lifting sockets and rebars, de-moulding and lifting techniques, use of slings and chains, design and function of lifting and spreader beams or other aids (such as tilting frames), turning and tilting, stacking and storage orientations and methods, types and positions of bearers, crane capacity, imposed loads acting on the precast elements.

6.7.2 Lifting Methods

The elements shall be lifted from the mould according to the locations of the lifting devices and instructions on the production drawings, in a manner to avoid cracking and other damage. Lifting beams shall be used where the inclination of the lifting slings or chains will cause cracking of the elements or the safe working load is exceeded. The lifting chains shall be near vertical when attached to the lifting beam. The weight shall be taken gradually without impact. Elements shall be lowered onto the stockyard supports without impact.

Lifting devices, chains and slings shall be tested by a certified testing house and be used according to manufacturer's specifications. The safe working load shall be clearly marked and not exceeded. Elements shall be lifted uniformly from the mould, and not be removed from end-to-end or corner-to-corner. Table 6.2 shows the recommended minimum concrete strength for lifting and handling.

Application	Minimum concrete strength $f_{c,cube}$
Lifting which involves significant impact or high acceleration	15 N/mm ² *
All units where concrete strength for lifting is specified in drawing	2/3 of required design concrete strength
Eccentrically pre-stresses elements (tees, deep flooring units)	25 N/mm ²
* Dependent on anchor length or as recommended by insert manufacturer or otherwise specified	
Note: special care shall be taken with pre-stressed elements to ensure lifting devices are anchored in compression zones, unless covered by specific design	

Table 6.2: Recommended Minimum Concrete Strength for Lifting and Handling

6.8 Site Access and Ground Preparation

The Contractor shall be responsible for providing suitable access to the building, proper drainage and firm, level bearing for the hauling and erection equipments to operate under their own power.

The ground of the launching area shall be prepared at Contractor's own cost to ensure that it is safe to carry the required load during installation or launching operation.

6.9 Placement of Precast Concrete Components

The Contractor shall be responsible for providing true level surfaces on all site placed bearing walls and other site placed supporting members.

The Contractor shall also be responsible of placement and accurate alignment of anchor bolts, plates or dowel in column footings, grade beams and other site placed supporting members.

6.10 Erection

Installation of precast or precast prestressed concrete components shall be performed by competent installer. Precast components shall be lifted by means of suitable lifting devices at points provided by the manufacturer. Temporary shoring, propping or bracing, if necessary shall comply with manufacturer's recommendations and submitted to the S.O. for approval.

The contractor shall ensure the concrete strengths are adequate for the loads that may be required for the inserts or applied by braces, props and their connections.

6.11 Alignment

Precast components shall be properly aligned and levelled as required by the approved fabrication shop drawings. Variations between adjacent components shall be reasonably levelled out by jacking, loading or any other feasible methods as recommended by the manufacturer and approved by the S.O./P.D.

6.12 Safety Precaution During Installation

Utmost precautions shall be taken to eliminate any danger to the workers and general public while launching precast elements. All lifting equipment shall be designed, such that if the primary lifting mechanism fails, a secondary mechanism shall ensure that the precast element shall not fall.

Upon erection, a fail-safe method shall be used to temporarily secure the precast unit until the permanent fixing arrangements shall be implemented.

The securing systems, subject to the S.O./P.D.'s acceptance shall include:

- a. Providing chains between the installed precast concrete components and stable supports
- b. Connecting adjacent precast concrete components with temporary bracings between them
- c. Providing wedges or brackets to the precast concrete components.

The Contractor shall inform the S.O./P.D. and obtain his approval before removing any temporary work but such approval does not relieve the Contractor of his responsibilities for the safety of the work.

7. STORAGE

When the precast concrete components are stored, they shall be firmly supported only at the points as specified in the Drawings. No accumulation of trapped water and deleterious matter shall be allowed in the components. Care shall be taken to avoid rust staining and efflorescence. The precast concrete components shall be stacked in such a manner that their handling can be done in correct order of construction sequence after the concrete components have gained sufficient strength.

7.1 Adequate Area

The area for storage must be easy access and handling of the precast component. The storage area shall preferably be near to the location where the precast component are to be installed to avoid damage by handling, subject to S.O./P.D. approval. The Contractor may proposed alternative location by submitting officially the proposed location and method of transportation/ handling of precast components, and must obtain approval from the S.O./P.D.

7.2 Ground Condition

The contractor shall be responsible for providing suitable hard, firm, level, clean, well drained to avoid any differential ground settlements which may damage the stored component.

7.3 Onsite Storage

Appropriate stacking method shall be used to store the precast concrete component to prevent any undue stresses and damage. The component shall also be stored based on the erection sequence in order to minimize handling.

Horizontal precast such as precast slab, planks, beams and hollow core panel shall be stacked and supported separately using strips of woods or battens across the full width of the designated bearing points as shown in figure 7.1.

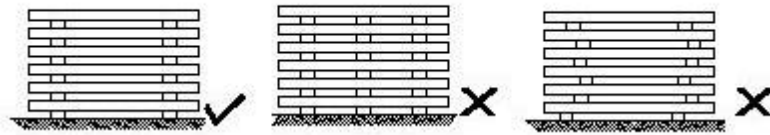


Figure 7.1: Stacking Method of Precast Components

7.4 Protection of Precast Component

Upon installation of precast components, it may be necessary to use boards or plywood or plastic sheets to protect them from dirt, dust, stains, discoloration and fallen debris.

8. CONNECTION

The Contractor shall be responsible to ensure the connection between components (in situ and precast / precast and precast) are properly installed according to the drawings and method statement.

8.1 Grouting

Grout is a cement water mix and admixture (if required) used for infilling at joint and gaps.

8.1.1 Infilling for Joints and Gaps

8.1.1.1 Material

Cement, water and admixture shall comply with the latest JKR Building Specification.

8.1.1.2 Design Mixes

Designed mixes shall be submitted to the S.O./P.D. for approval. The grout shall be of high fluidity and cohesive at plastic and non-shrinkage during hardening.

8.1.1.3 The grout shall be mixed in grout mixer and have a composition of CEM I, water and admixture with approved grout additive. The water/cement ratio shall be between 0.4 to 0.6 or such other proportion as shall be directed by the S.O./P.D.

8.1.1.4 Method Statement

The contractor shall submit all the method statement for mixing, placing and testing the grout for the approval of the S.O./P.D.

8.1.2 Proprietary Products

8.1.2.1 If the contractor chooses to use proprietary product, he shall submit to the S.O./P.D. the name of manufacturer/supplier, type and specification of the product for approval.

8.1.2.2 The grout shall be mixed on site according to the manufacturer's instruction.

8.1.3 Testing

The grout shall be tested in accordance to the following method:

- a) Fluidity Test by using Cone Method (BS EN 445); or
- b) Fluidity Test by using Grout Spread Method (BS EN 445); or
- c) Flowability Test using Flow Cone Method (ASTM C939); and
- d) Compressive Strength Test (BS EN 445).

8.1.3.1 Fluidity Test

The fluidity of the grout during the injection period shall be measured by either one of the methods given in BS EN 445 and the grout shall be compared against the values given in Table 8.1.

Test method given in EN 445		Immediately after mixing	30 min after mixing ¹⁾ or at the time specified by the grout manufacturer
Cone	Time (in s)	$t_0 \leq 25 \text{ s}$	$1,2 t_0 \geq t_{30} \geq 0,8 t_0$ and $t_{30} \leq 25 \text{ s}$
Grout spread	a = average spread (in mm)	$a_0 \geq 140 \text{ mm}$	$1,2 a_0 \geq a_{30} \geq 0,8 a_0$ and $a_{30} \geq 140 \text{ mm}$
¹⁾ Mixing time shall be measured from the time when all materials are in the mixer.			

Table 8.1: Fluidity test requirements

NOTE Fluidity measurements immediately after mixing are denominated t_0 (cone method) a_0 (grout spread method), fluidity measurements made 30 minutes after mixing, i.e. 30 minutes after the first measurements, are denominated t_{30} and a_{30} . Grout shall be kept constantly in motion until sampling for measurement of t_{30} and a_{30}

Fluidity shall not change by more than 20 % from immediately after mixing to 30 min after mixing or any later time specified by the grout manufacturer.

The grout spread test measures the fluidity of thixotropic grouts. The fluidity is measured by the diameter of the circle of grout spread on a smooth plate after a fixed period.

8.1.3.2 Flowability Test

Standard Test Method for the flow of the grout (Flow Cone Method) shall be carried out in accordance to ASTM C939.

8.1.3.3 Compressive Strength Test

8.1.3.3.1 The method of sampling and testing of grout shall be carried out in accordance to BS EN 445.

8.1.3.3.2 The compressive strength shall be determined with reference to BS EN 445 by crushing test on prismatic specimen 40 x 40 mm in cross section and 160 mm in length.

8.1.3.3.3 For each casting day and for each grade of batches, three (3) samples shall be taken. Two (2) specimens shall be cast from each sample for testing at seven (7) and twenty eight (28) days.

8.1.3.3.4 Otherwise specified, the acceptance strength shall be deemed to be satisfied when the average strength is greater than the specified characteristic strength of precast concrete.

8.2 Placement

The grout shall be applied to the location shown in the drawing. If required a formwork box or otherwise a dam shall be formed around the infilling to prevent grout loss.

8.2.1 Vertical Placement (Pressure Grouting)

Grout shall be pumped into each sleeve until grout pours out of the outlet and pumping shall be continued until a pressure of minimum 100 kN/m² is attained. The high pressure cork shall remain closed and in position for a period of one hour after grouting.

8.2.2 Vertical Placement (Gravity Flow)

This method shall only be allowed for shallow sleeve, such as the connection between corbel and precast beam, nib and precast beam. The diameter of corrugated sleeve and the appropriate dowel bar size shall be as shown in Table 8.2.

Corrugated Sleeve Diameter (mm)	Dowel Bar Size (mm)
45	10, 12
55	16, 20, 25
65	25, 32
75	32

Table 8.2: Recommended Corrugated Sleeve Diameter

8.2.3 Horizontal Placement (Gravity Flow Grouting)

Gravity flow grout shall be applied to areas that convenient and easy for grouting works such as, longitudinal joint between precast component. It can be poured by hand directly along the joint and swept into the gap with suitable tools.

8.3 Curing and Protection

After completion of the grouting works, exposed areas shall be thoroughly cured. Method of curing and protection shall comply with the latest JKR Standard Specification for Building Works and shall be submitted to the S.O./P.D. for approval.

9. BEARING PAD**9.1 Natural rubber**

The Contractor shall furnish complete details the functionality, position, specification, working temperature range, application and other technical information to S.O./P.D. for approval.

9.2 Neoprene

The Contractor shall refer to Section D in latest JKR Standard Specification for Building Works for all related works involved.

10. MECHANICAL AND ELECTRICAL SERVICES REQUIREMENTS IN STRUCTURE

10.1 The contractor shall incorporate all mechanical, sanitary and electrical work, to be embedded in the concrete, or openings for pipes or duct work, as shown in the services drawings included in the contract. The contractor shall check with the drawings and confirm with the S.O./P.D. in this regard, and sort out discrepancies, if any, before concreting.

10.2 The Contractor is to submit coordinated shop drawings based on the latest Architectural and M&E construction drawings for S.O.'s/P.D.'s approval before fabrication.

10.3 The contractor shall be responsible for coordinating the implementation of all M&E works with the requirements of the structural component as specified and appoint M&E Services Coordinator based on project cost.

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ACKNOWLEDGEMENT

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A vote of thanks to the chairpersons and members of the organization bodies for their cooperation in commenting and producing this user Guide: Specification for Precast Concrete Works

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**CAWANGAN KEJURUTERAAN AWAM DAN STRUKTUR
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