

**Provisions in NBC 2016 for Use of  
New/Alternate Construction Technologies  
Including those Recommended by BMTPC for  
Mass Housing**

# NATIONAL BUILDING CODE OF INDIA

## PART 6 STRUCTURAL DESIGN

### Section 7 Prefabrication, Systems Building and Mixed/Composite Construction: 7A Prefabricated Concrete

#### 1 SCOPE

This Code (Part 6/Subsection 7A) gives recommendations regarding modular planning, component sizes, prefabrication systems, design considerations, joints and manufacture, storage, transportation and erection of prefabricated concrete elements for use in buildings and such related requirements for prefabricated concrete.

#### 2 TERMINOLOGY

For the purpose of this Subsection, the following definitions shall apply.

**2.1 Authority Having Jurisdiction** — The authority which has been created by a statute and which, for the purpose of administering the Code/Part, may authorize a committee or an official or an agency to act on its behalf; hereinafter called the 'Authority'.

**2.2 Basic Module** — The fundamental module used in modular coordination, the size of which is selected for general application to building and its components.

NOTE — The value of the basic module has been chosen as 100 mm for the maximum flexibility and convenience. The symbol for the basic module is *M*.

**2.3 Cellular Concrete** — The material consisting of an inorganic binder (such as lime or cement or both) in combination with a finely ground material containing siliceous material (such as sand), gas generating material (for example, aluminium powder), water and harmless additives (optional); and/or steam cured under high pressure in autoclaves.

**2.4 Components** — A building product formed as a distinct unit having specified sizes in three dimensions.

**2.5 Composite Members** — Structural members comprising prefabricated structural units of steel, prestressed concrete or reinforced concrete and cast *in-situ* concrete connected together in such a manner that they act monolithically.

**2.6 Diaphragm** — It is a horizontal or nearly horizontal structural system (for example, reinforced concrete floors and horizontal bracing systems), which transmits lateral forces to vertical elements that resist earthquake-induced inertia effects.

**2.7 Increments** — Difference between two homologous dimensions of components of successive sizes.

**2.8 Light-Weight Concrete** — Concrete of substantially lower unit weight than that made from gravel or crushed stone.

**2.9 Module** — A unit of size used in dimensional coordination.

**2.10 Modular Coordination** — Dimensional coordination employing the basic module or a multimodule.

NOTE — The purposes of modular co-ordination are,

- to reduce the variety of component sizes produced, and
- to allow the building designer greater flexibility in the arrangement of components.

**2.11 Modular Grid** — A rectangular coordinate reference system in which the distance between consecutive lines is the basic module or a multimodule. This multimodule may differ for each of the two dimensions of the grid.

**2.12 Multimodule** — A module whose size is a selected multiple of the basic module.

**2.13 Prefabricate** — To fabricate components or assembled units prior to erection or installation in a building.

**2.14 Prefabricated Building** — The partly/fully assembled and erected building, of which the structural parts consist of prefabricated individual units or assemblies using ordinary or controlled materials, including service facilities; and in which the service equipment may be either prefabricated or constructed *in-situ*.

**2.15 Sandwich Concrete Panels** — Panels made by sandwiching an insulation material between two layers of reinforced/prestressed concrete to act as insulation for concrete panels.

**2.16 Self Compacting Concrete** — Concrete that is able to flow under its own weight and completely fill the voids within the formwork, even in the presence of dense reinforcement without any vibration, whilst maintaining homogeneity without segregation.

**2.17 Shear Connectors** — Structural elements, such as anchors, studs, channels, loops and spirals, intended to transmit the shear between the prefabricated member and the cast *in-situ* concrete and also to prevent separation at the interface.

**2.18 System** — It is a particular method of construction of buildings with certain order and discipline using the prefabricated components which are inter-related in functions and are produced based on a set of instructions.

**2.19 Unit** — Building material formed as a simple article with all three dimensions specified, complete in itself but intended to be part of a compound unit or complete building. Examples are brick, block, floor panel, wall panel, etc.

**2.20 Emulative Detailing System** — A connection detailing system for precast concrete structures that has structural performance equivalent to that of a conventionally designed, *cast-in-situ*, monolithic concrete structure

**2.21 Jointed Detailing System** — A connection detailing system for precast concrete structures that has individual precast components separated from each other but connected using special connections such as welded or bolted plates.

### 3 MATERIALS, PLANS AND SPECIFICATIONS

#### 3.1 Materials

Use of materials for plain, reinforced concrete and prestressed concrete shall satisfy the requirements of Part 6 'Structural Design, Section 5 Concrete, Subsection 5A Plain and Reinforced Concrete and Subsection 5B Prestressed Concrete' of the Code. Connections and jointing materials shall be in accordance with 8.3.

**3.1.1** While selecting the materials for prefabrication, the following characteristics shall be considered:

- a) Easy availability;
- b) Light weight for easy handling and transport;
- c) Strength;
- d) Thermal insulation property;
- e) Easy workability;
- f) Water absorption;
- g) Serviceability along with durability;
- h) Non-combustibility/fire resistance rating;
- j) Sound insulation;
- k) Easy assembly and compatibility to form a complete unit;

- m) Economy; and
- n) Any other special requirement in a particular application.

#### 3.2 Plans and Specifications

The detailed plans and specifications shall cover the following:

- a) Such drawings shall describe the elements and the structure and assembly including all required data of physical properties of component materials, material specification, strength of concrete for demoulding, casting/erection tolerance and type of curing to be followed.
- b) Details of connecting joints of prefabricates shall be given to an enlarged scale.
- c) Site or shop location of services, such as installation of piping, wiring or other accessories integral with the total scheme shall be shown separately.
- d) Data sheet indicating the location of the inserts and acceptable tolerances for supporting the prefabricate during erection, location and position of doors/windows/ventilators, etc, if any.
- e) The drawings shall also clearly indicate location of handling arrangements for lifting and handling the prefabricated elements. Sequence of erection with critical check points and measures to avoid stability failure during construction stage of the building.

### 4 MODULAR COORDINATION, ARCHITECTURAL TREATMENT AND FINISHES

#### 4.1 Modular Coordination

The basic module shall be adopted. After adopting this, further work is necessary to outline suitable range of multimodules with greater increments, often referred to as preferred increments. A set of rules as detailed below would be adequate for meeting the requirements of conventional and prefabricated construction.

These rules relate to the following basic elements:

- a) The planning grid in both directions of the horizontal plan shall be:
  - 1) 15 *M* for industrial buildings, and
  - 2) 3 *M* for other buildings.The centre lines of load bearing walls should preferably coincide with the gridlines.
- b) The planning module in the vertical direction shall be 2 *M* for industrial buildings and 1 *M* for other buildings.

## 6 PREFABRICATION SYSTEMS AND STRUCTURAL SCHEMES

6.1 The word 'system' refers to a particular method of construction of buildings using the prefabricated components which are inter-related in functions and are produced to a set of instructions. With certain constraints, several plans are possible, using the same set of components. The degree of flexibility varies from system to system. However, in all the systems there is a certain order and discipline.

6.2 The following aspects, among others, are to be considered in devising a system:

- a) Effective utilization of spaces;
- b) Straight and simple walling scheme;
- c) Limited sizes and numbers of components;
- d) Limited opening in bearing walls;
- e) Regulated locations of partitions;
- f) Standardized service and stair units;
- g) Limited sizes of doors and windows with regulated positions;
- h) Structural clarity and efficiency;
- j) Suitability for adoption in low rise and high rise building;
- k) Ease of manufacturing, storing and transporting;
- m) Speed and ease of erection;
- n) Effective utilization of available equipment, plant and machinery; and
- p) Simple jointing system.

### 6.3 Prefabrication Systems

The system of prefabricated construction depends on the extent of the use of prefabricated components, their materials, sizes and the technique adopted for their manufacture and use in building.

#### 6.3.1 Types of Prefabrication Components

The prefabricated concrete components such as those given below may be used which shall be in accordance with relevant Indian Standards (see Part 5 'Building Materials' of the Code) and the accepted standards [6-7A(1)], where available:

- a) Reinforced/prestressed concrete channel unit,
- b) Reinforced/prestressed concrete slab unit,
- c) Reinforced/prestressed concrete beams,
- d) Reinforced/prestressed concrete columns,
- e) Reinforced/prestressed concrete hollow core slab,
- f) Reinforced concrete waffle slab/shells,
- g) Reinforced/prestressed concrete wall elements,

- h) Hollow/solid concrete blocks and battens,
- j) Precast planks and joists for flooring and roofing,
- k) Precast joists and trussed girders,
- m) Light weight/cellular concrete slabs/wall panels,
- n) Precast lintel and *Chajjas*,
- p) Large panel prefabricates,
- q) Reinforced/prestressed concrete trusses,
- r) Reinforced/prestressed roof purlins,
- s) Precast concrete L-panel unit,
- t) Prefabricated concrete double-T unit,
- u) Prefabricated brick panel unit,
- w) Prefabricated sandwich concrete panels,
- y) Precast concrete foundation, and
- z) Precast concrete staircase.

There may be other types of components which may be used with the approval of the Authority.

NOTE — The elements may be cast at the site or off the site.

#### 6.3.2 Open Prefabrication System

There are two categories of open prefab system depending on the extent of prefabrication used in the construction as given in 6.3.2.1 and 6.3.2.2.

##### 6.3.2.1 Partial prefabrication system

This system basically uses precast roofing and flooring components and other minor elements like lintels, *Chajjas*, kitchen sills in conventional building construction. The structural system could be in the form of *in-situ* framework or load bearing walls.

##### 6.3.2.2 Full prefabrication system

In this system almost all the structural components are prefabricated. The filler walls may be of brick/block masonry or of any other locally available material.

#### 6.3.3 Large Panel Prefabrication System

This system is based on the use of large prefab components. The components used are precast concrete large panels for walls, floors, roofs, balconies, staircases, etc. The casting of the components could be at the site or off the site.

Depending upon the extent of prefabrication, this system can also lend itself to partial prefab system and full prefab system.

Structural scheme with precast large panel walls can be classified as given in 6.3.3.1 to 6.3.3.3.

##### 6.3.3.1 Precast Walls

6.3.3.1.1 Based on the structural functions of the walls, the precast walls may be classified as:

- a) Load bearing walls,
- b) Non-load bearing walls, and
- c) Shear walls.

6.3.3.1.2 Based on construction, the precast walls may be classified as:

- a) *Homogeneous walls* — which could be solid, hollow or ribbed; and
- b) *Non-homogeneous walls* — these could be composite or sandwich panels.

6.3.3.1.3 Based on their locations and functional requirements the precast walls may also be classified as:

- a) External walls, which may be load bearing or non-load bearing depending upon the lay-out; these are usually non-homogeneous walls of sandwiched type to impart better thermal comfort; they can also act as shear walls to resist horizontal loads with appropriate design and
- b) Internal walls providing resistance against vertical loads, horizontal loads, fire, etc; these are normally homogeneous walls.

#### 6.3.3.2 Precast floors

6.3.3.2.1 Depending upon the composition of units, precast flooring units may be classified as:

- a) *Homogeneous floors* — which may be of solid slabs, cored slabs, ribbed or waffle slabs and precast slabs with structural topping (60-75 mm thick) designed as a composite system; and
- b) *Non-homogeneous floors* — which may be of multi-layered units with combinations of light weight concrete or reinforced prestressed concrete, with filler blocks.

6.3.3.2.2 Depending upon the way the loads are transferred, the precast floors may be classified as one way, two way or cantilever systems:

- a) One way system transfers loads to supporting members in one direction only. The precast elements which come under this category are channel slabs, hollow core slabs, channels and ties system, light weight/cellular concrete slabs, etc.
- b) Two way systems transfers loads in both the directions imparting loads on the four edges. The precast elements under this category are room sized panels, two way ribbed or waffle slab systems, etc.
- c) Cantilever components are supported on one

edge or two adjacent edges and other ends without supports.

#### 6.3.3.3 Staircase systems

Staircase system may consist of single flights with in-built risers and treads in the element. The flights are normally unidirectional transferring the loads to supporting landing slabs or load bearing walls.

#### 6.3.4 Box Type Construction

In this system, room size units are prefabricated and erected at site. Toilet and kitchen blocks may also be similarly prefabricated and erected at site.

NOTE — This system derives its stability and stiffness from the box units which are formed by four adjacent walls. Walls are jointed to make rigid connections among themselves. The box unit rests on foundation - conventional or precast.

## 7 DESIGN CONSIDERATIONS AND REQUIREMENTS

### 7.1 Design Considerations

7.1.1 Precast structures could be analyzed either as an emulative systems or as a jointed system. However, emulative analysis is typically preferred where the structure is detailed such that the overall behaviour of the building in its service life will be similar to a RCC building constructed *in-situ*. In emulative approach, the precast structure is analyzed as a monolithic one and the joints in them designed to take the forces of an equivalent discrete system. Resistance to horizontal loading shall be provided by having appropriate moment and shear resisting joints or placing shear walls (in diaphragm braced frame type of construction) in two directions at right angles or otherwise. No account is to be taken of rotational stiffness, if any, of the floor-wall joint in case of precast bearing wall buildings. The individual components shall be designed, taking into consideration the appropriate end conditions and loads at various stages of construction. The components of the structure shall be designed for loads and reactions in accordance with Part 6 'Structural Design, Section 1 Loads, Forces and Effects' of the Code. In addition, members shall be designed for handling, erection and impact loads that might be expected during handling and erection.

NOTE — Rotational stiffness can be accounted for long short term deflection calculations provided that the approach is mutually agreed by the design team and approved by the Authority.

7.1.2 In some conventional forms of construction, experience has shown that structures are capable of safely sustaining abnormal conditions of loading and remaining stable after the removal of primary structural members. It has been shown that some forms of building structure and particularly some industrialized large

# NATIONAL BUILDING CODE OF INDIA

## PART 6 STRUCTURAL DESIGN

### Section 7 Prefabrication, Systems Building and Mixed/Composite Construction: 7B Systems Building and Mixed/Composite Construction

#### 1 SCOPE

This Code (Part 6/Subsection 7B) covers recommendations regarding modular planning, component sizes, joints, manufacture, storage, transport and erection of prefabricated elements for use in buildings and such related requirements for systems building and mixed/composite construction.

#### 2 TERMINOLOGY

For the purpose of this Subsection, the following definitions shall apply.

**2.1 Authority Having Jurisdiction** — The authority which has been created by a statute and which, for the purpose of administering the Code/Part, may authorize a committee or an official or an agency to act on its behalf; hereinafter called the 'Authority'.

**2.2 Basic Module** — The fundamental module used in modular coordination, the size of which is selected for general application to building and its components.

NOTE — The value of the basic module has been chosen as 100 mm for the maximum flexibility and convenience. The symbol for the basic module is *M*.

**2.3 Cellular Concrete** — The material consisting of an inorganic binder (such as lime or cement or both) in combination with a finely ground material containing siliceous acid (such as sand), gas generating material (for example, aluminium powder), water and harmless additives (optional); and steam cured under pressure in autoclaves.

**2.4 Component** — A building product formed as a distinct unit having specified sizes in three dimensions.

**2.5 Composite/Mixed Construction** — Construction involving two or more different kinds of components such as prefabricated structural units of steel, prestressed concrete or reinforced concrete and cast *in-situ* concrete, ferrocement, timber, masonry in brickwork and blockwork, glass and glazing connected together in such a manner that they act integrally.

**2.6 Increments** — Difference between two homologous dimensions of components of successive sizes.

**2.7 Module** — A unit of size used in dimensional coordination.

**2.8 Modular Coordination** — Dimensional coordination employing the basic module or a multimodule.

NOTE — The purposes of modular coordination are

- To reduce the variety of component sizes produced, and
- To allow the building designer greater flexibility in the arrangement of components.

**2.9 Modular Grid** — A rectangular coordinate reference system in which the distance between consecutive lines is the basic module or a multimodule. This multimodule may differ for each of the three orthogonal dimensions of the grid, two in plan and one in vertical direction.

**2.10 Multimodule** — A module whose size is a selected multiple of the basic module.

**2.11 Prefabricate** — Fabrication of components or assembled units prior to erection or installation in a building.

**2.12 Prefabricated Building** — The partly/fully assembled and erected building, of which the structural parts consist of prefabricated individual units or assemblies using ordinary or controlled materials, including service facilities; and in which the service equipment may be either prefabricated or constructed *in-situ*.

**2.13 Sandwich Panels** — Panels made by sandwiching a layer of insulation material between two outer layers of hard durable materials like steel, dense concrete, plastic, cement based sheet, ceramic, etc. The hard coverings on two outer faces may be of same or different materials; the three layers may or may not be bonded with each other to behave as a composite panel.

**2.14 Self-Compacting Concrete** — Concrete that is able to flow under its own weight and completely fill the voids within the formwork, even in the presence of dense reinforcement without any vibration, whilst maintaining homogeneity without segregation.

**2.15 Shear Connectors** — Structural elements, such as anchors, studs, channels, loops and spirals, intended to transmit the shear between the prefabricated member

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and the cast *in-situ* concrete and also to prevent separation at the interface.

**2.16 System** — The method of construction of buildings with certain order and discipline and repetitive operations using the prefabricated components, tunnel form or engineered shuttering, where the work is organized and follows a defined procedure.

**2.17 Unit** — Building material formed as a simple article with all three dimensions specified, complete in itself but intended to be part of a compound unit or complete building. Examples are brick, block, tile, etc.

### 3 MATERIALS, PLANS AND SPECIFICATIONS

#### 3.1 Materials

**3.1.1** Part 6 'Structural Design, Section 7 Prefabrication, Systems Building and Mixed/Composite Construction, Subsection 7A Prefabricated Concrete' of the Code shall be referred for requirements of materials and also for the characteristics to be considered in their selection.

**3.1.2** The materials used in prefabricated components may be many and the modern trend is to use concrete, ferrocement, steel, treated timber, aluminium, cellular concrete, light weight concrete, ceramic products, etc. However, this Subsection pertains to mixed/composite construction.

#### 3.2 Plans and Specifications

This shall be in accordance with Part 6 'Structural Design, Section 7 Prefabrication, Systems Building and Mixed/Composite Construction, Subsection 7A Prefabricated Concrete' of the Code.

### 4 MODULAR COORDINATION, ARCHITECTURAL TREATMENT AND FINISHES

#### 4.1 Modular Coordination

This shall be in accordance with Part 6 'Structural Design, Section 7 Prefabrication, Systems Building and Mixed/Composite Construction, Subsection 7A Prefabricated Concrete' of the Code.

#### 4.2 Architectural Treatment and Finishes

This shall be in accordance with Part 6 'Structural Design, Section 7 Prefabrication, Systems Building and Mixed/Composite Construction, Subsection 7A Prefabricated Concrete' of the Code.

### 5 COMPONENTS

**5.1** The preferred dimensions of precast elements used and their casting tolerances shall be in accordance with

Part 6 'Structural Design, Section 7 Prefabrication, Systems Building and Mixed/Composite Construction, Subsection 7A Prefabricated Concrete' of the Code.

**5.2** The permissible tolerances of timber used shall be in accordance Part 6 'Structural Design, Section 3 Timber and Bamboo, Subsection 3A Timber' of the Code.

**5.3** For permissible tolerances of steel and masonry, reference may be made to relevant Indian Standards.

### 6 FORMWORK SYSTEMS

The formwork systems which are utilized in buildings shall be as given in 6.1 to 6.5.

#### 6.1 Tunnel Form

This is a system which casts walls and slab monolithically in a single pour of concrete. Façade walls are precast or of block masonry to enable removal of tunnel form. All components of the formwork are made up of steel. This produces very rapid construction in a building where the plans are of modular nature suitable for this technology. Accelerated curing, if required, is possible enabling early stripping of formwork.

#### 6.2 Slipform

Slipform is a continuously moving form at such a speed that the concrete when exposed has already achieved enough strength to support the vertical pressure from concrete still in the form as well as to withstand nominal lateral forces. Slipform may be classified as straight slipform, tapering slipform and slipform for special applications. Construction of lift cores and stairwell using slipform technique comes under special applications because of their complex sizes, shapes and loads to be lifted along with the slipform like walkway truss, etc, which is essential for construction. This system uses hydraulic jacks avoiding crane for lifting of assembly during construction operation. This system facilitates rapid construction and continual casting, creating a monolithic structure thereby avoiding construction joints.

#### 6.3 Aluminium Formwork

This system of formwork uses modular aluminium panels, which are light and rust free, in both sheathing and framework. It may be used for a broad range of applications from wall to slab construction panels to more complicated structures involving bay windows, stairs and hoods. Every component is light enough to be handled easily thereby minimizing the need for heavy lifting equipment.

#### 6.4 Large Panel Shuttering System

This is a system, which gives an advantage of combining speed and quality of construction. The vertical load

carrying members are made of steel whereas the horizontal members are of plywood inserted into two wooden beams thereby forming a web flange. All the formwork and support systems shall be designed for the loads coming during the actual execution stage.

### 6.5 Other/New Systems

Any other/new system may be used for systems building after due examination and approval by the Authority.

## 7 SYSTEM AND STRUCTURAL SCHEMES

7.1 Several schemes are possible, with certain constraints, using the same set of components. The degree of flexibility varies from system to system. However, in all the systems there is a certain order and discipline.

7.2 The following aspects, among others, are to be considered in devising a system:

- a) Effective utilization of spaces;
- b) Straight and simple walling scheme;
- c) Limited sizes and numbers of components;
- d) Limited opening in bearing walls;
- e) Regulated locations of partitions;
- f) Standardized service and stair units;
- g) Limited sizes of doors and windows with regulated positions;
- h) Structural clarity and efficiency;
- j) Suitability for adoption in low and high rise building;
- k) Ease of manufacturing, storing and transporting;
- m) Speed and ease of erection;
- n) Optimization of available handling equipment; and
- p) Simple jointing system.

### 7.3 Systems for Mixed/Composite Construction

The system of mixed/composite construction depends on the extent of the use of prefabricated components, their materials, sizes and the technique adopted for their manufacture and use in building.

#### 7.3.1 Combinations of System Components for Mixed/Composite Construction

The following combinations may be used in mixed/composite construction:

- a) Structural steel work and timber roofs on precast frames.
- b) Precast floors onto steel and concrete beams, and masonry walls.
- c) Profiled metal decking on precast beams.

- d) Precast frames onto cast *in-situ* foundations, retaining walls, etc.
- e) Precast frames stabilized by masonry walls, steel bracing, etc.
- f) Precast cladding in steel or cast *in-situ* frames and *vice-versa*.
- g) Glass curtain walling (see Part 6 'Structural Design, Section 8 Glass and Glazing' of the Code), stone cladding or metal sheeting onto precast concrete frames, etc.
- h) Reinforced concrete and structural steel as composite columns and beams.

7.3.1.1 Precast concrete may be combined with cast *in-situ* concrete, often termed hybrid construction. Cast *in-situ* is mostly used to form homogenous connections between precast elements and provide a structural topping for horizontal diaphragm action. In other cases it is used to form the foundations and sub-structure to the building.

7.3.1.2 Structural steel work is largely used in long span prestressed concrete floors supported on rolled and prefabricated steel beams and also as steel roof trusses supported on concrete columns.

7.3.1.3 Timber may be used as long span glue-laminated beams and rafters, with precast concrete. Precast floors may be used in timber frame construction. Similarly, timber frames with precast elements shall be used as a building system.

7.3.1.4 Brick and block masonry may be combined with precast concrete structures and floors. The most common combinations is to use prestressed floors on load bearing walls.

## 8 DESIGN CONSIDERATIONS

8.1 The mixed/composite structures shall be analyzed appropriately and the joints in them designed to take the forces of an equivalent discrete system. Resistance to horizontal loading shall be provided by placing beams, walls and/or bracings in two directions at right angles or otherwise. The individual components shall be designed, taking into consideration appropriate end conditions and loads at various stages of construction. The components of the structure shall be designed for loads in accordance with Part 6 'Structural Design, Section 1 Loads, Forces and Effects' of the Code. In addition, members shall be designed for handling, erection and impact loads that may be expected during handling and erection.

8.2 For mixed and composite construction the following shall be considered:

- a) *Positions of stability cores, walls, bracing, etc* — In high rise buildings, the most



stairway shall be provided in usable condition at all times. This stairway shall be extended upward as each floor is completed. There shall be a handrail on the staircase.

#### 5.3.2.4 Electrical installations

Electrical installations, both permanent and temporary, for construction and demolition sites, including electrical installations for transportable construction buildings (site sheds) shall be in accordance with 12 of Part 8 'Building Services, Section 2 Electrical and Allied Installations' of the Code.

#### 5.3.3 Construction Strategy and Construction Sequence

Construction strategy and construction methods are to be evolved at the planning and design stage specific to the conditions and constraints of the project site and implemented by the site management personnel to ensure ease of construction and smooth flow of construction activities. Sites of high water table conditions with aggressive chemical contents of subsoil needs special design considerations. Buildings with basement in sites of high water table should be planned with dewatering scheme with appropriate construction sequence. Duration of dewatering should continue till sufficient dead loads are achieved to stabilize the buoyancy loads with adequate factor of safety. The construction sequence should be planned taking into consideration the following aspects:

- a) Availability of resources (men, material and equipment);
- b) Construction methods employed including prefabrication;
- c) Planned construction time;
- d) Design requirements and load transfer mechanism;
- e) Stability of ground like in hilly terrain;
- f) Ensuring slope stability with retaining structure before the main construction;
- g) Installation and movement of heavy equipment like cranes and piling equipment;
- h) Effect of weather; and
- j) Minimum time to be spent on working below ground level.

### SECTION 3 CONSTRUCTION PRACTICES

## 6 CONSTRUCTION CONTROL AND PRACTICES

### 6.1 Professional Services and Responsibilities

The responsibility of professionals with regard to planning, designing and supervision of building

construction work, etc and that of the owner shall be in accordance with Part 2 'Administration' of the Code. All applications for permits and issuance of certificates, etc shall be as given in Part 2 'Administration' of the Code. Employment of trained workers shall be encouraged for building construction activity.

### 6.2 Site Preparation

6.2.1 While preparing the site for construction, bush and other wood, debris, etc, shall be removed and promptly disposed of so as to minimise the attendant hazards.

6.2.2 Temporary buildings for construction offices and storage shall be so located as to cause the minimum fire hazards and shall be constructed from non-combustible materials as far as possible.

### 6.3 Habitat for Construction Workers at Site

The habitat and other welfare measures for construction workers shall meet the requirements specified in 14.

### 6.4 Construction of All Elements

6.4.1 Construction of all elements of a building shall be in accordance with good practice [7(15)]. It shall also be ensured that the elements of structure satisfy the appropriate fire resistance requirements as specified in Part 4 'Fire and Life Safety' of the Code, and quality of building materials/components used shall be in accordance with Part 5 'Building Materials' of the Code.

6.4.2 Construction of all accessibility features/elements in a building and its built environment shall be as per the requirements given in 13 of Part 3 'Development Control Rules and General Building Requirements' of the Code.

6.4.3 All mechanical, electrical and plumbing (MEP) and other services in a building shall be installed in accordance with approved designs as per Part 8 'Building Services' of the Code and Part 9 'Plumbing Services including Solid Waste Management' of the Code. Proper sequencing of installation of various services shall be done for ensuring smooth construction activities.

6.4.4 Necessary temporary works required to enable permanent works, shall be executed in accordance with 7.

### 6.5 Low Income Housing

For low income housing, appropriate planning and selection of building materials and techniques of construction have to be judiciously done and applied in practice. Requirements of low income housing specified in Part 3 'Development Control Rules and

General Building Requirements\* of the Code shall be followed. However, all requirements regarding structural safety, health safety and fire safety shall be in accordance with this Part.

#### 6.6 Use of New/Alternative Construction Techniques

The provisions of this Part are not intended to prevent use of any construction techniques including any alternative materials, not specifically prescribed by the Code, provided any such alternative has been approved. The Authority may approve any such alternative, such as, ferrocement construction; stretcher bond in filler slab; glass fibre reinforced gypsum (GFRG) panel system using composite of GFRG panel and reinforced concrete; pre-engineered steel structures with reinforced concrete expanded polystyrene core based panel/other in-fill walls; light gauge steel framed structures with suitable water resistant wall panels like cement bonded particle board, provided it is found that the proposed alternative is satisfactory and conforms to the provisions of relevant parts regarding material, design and construction and that material, method, or work offered is, for the purpose intended, at least equivalent to that prescribed in the Code in quality, strength, compatibility, effectiveness, fire and water resistance, durability and safety.

#### 6.7 Urban Roads/City Roads Planning and Construction

6.7.1 The urban roads, which are commonly known as city roads/streets have been under constant development. The emphasis has been primarily on providing essentially required width of metalled surface for the movement of vehicles (both motorized and non-motorized). Footpaths of various widths and heights are required to be provided.

The space between the buildings and the city roads should be treated as valuable and important space allowing for a comfortable and safe use by the pedestrians, hawkers, cyclists including non-motorized vehicle (NMV) drivers, and adequate space for drainage, utilities, street lighting poles, transformers and trees. Thus, the objective should be to create urban streets/roads that are efficiently planned, safe for vehicles as well as pedestrians, universally user friendly, and sustainable.

The elements required in an efficiently planned street, such as, kerb stones; kerb channels; kerb ramps; tactile ground surface indicators; silt chambers with manhole cover; drain cover slabs; drain manhole covers; service pipes; manhole covers for electrical services; manhole covers for telecom services; cycle tracks (NMV); bollards across pedestrian paths; tree gratings; lighting poles on main roads and service roads; table tops on free left turns; pedestrian paths at intersections/

T-junctions; pedestrian paths on traffic islands; pedestrian paths across central verge; pedestrian paths near rotaries (un-signalized); pedestrian paths below flyovers; signages; traffic signals; cable ducting by discoms; central verge irrigation system; central verge, footpath and traffic islands plantation; street furniture; bus queue shelters; public art, public toilets, etc. should be identified. These elements should be integrated at the planning stage, indicating the methodology of execution, taking care of the following while complying with the relevant rules/regulations:

- a) Road cross-section planning based on land-use with emphasis on smooth vehicular movements.

NOTE — This may be achieved by rationalizing lane widths based on norms laid down by Indian Roads Congress.

- b) Design of road intersections, fixing of geometrics of roads, providing provision of entry and exits from the service roads.
- c) Coordination between the traffic police, transport authorities and the executing agencies to be ensured for efficient location of traffic signals, zebra crossings and the bus queue shelters and the pickup stands for the para-transport.
- d) Standardization of kerb stones, kerb ramps and kerb channels.
- e) Appropriate selection of materials, like, paver blocks, tiles, stone slabs or plain cement concrete for footpaths, plazas, etc, so that they add to aesthetics of buildings and roads.
- f) Standardization of access manhole covers for various utilities.
- g) Providing footpath at one level by adjusting the drain cover slab levels.
- h) Integration of bus queue shelters with the footpath.
- j) Pedestrian friendly access across the roads to the foot-over bridges, subways and public toilets.
- k) Access to gates of residential commercial properties integrated with the road through the footpath in front.
- m) Sharing of NMV with footpath necessary at many locations.
- n) Adequate provision of public conveniences and dust bins.
- p) Street lighting for proper illumination of roads and service roads including modifications of street lighting along with central verge and the service roads blocked by existing trees.
- q) Low height plantation on central verges, avoiding plantation of trees.

