SECTION 1. IS 456:2000 – PLAIN AND REINFORCED CONCRETE - CODE OF PRACTICE

1.1 Overview of IS 456:2000

IS 456:2000 is the current Indian Standard for the design of reinforced concrete. This is a 97 page document covering all aspects of design of reinforced concrete structures.

The Standard is arranged in the following Sections and all Parts used in the preparation of the design aids in this manual are highlighted:

Section 1 – General

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Part 13. Transporting, Placing, Compaction and Curing
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Section 3 – General Design Considerations

Section 5 – Structural Design (Limit State Method)

1.2 Scope of IS 456:2000

IS 456:2000 deals with the use of plain and reinforced concrete. For the purposes of the Standard plain concrete structures are those where the reinforcement, if provided, is ignored for the determination of strength of the structure. (1.1 and 1.1.1) This is precisely the approach taken for the design of ***mortarless*** walls in axial compression.

There is no Indian reinforced masonry Code at present however it is appropriate to design ***mortarless*** walls in accordance with the provisions of the Concrete Code. There are subtle differences between the reinforced masonry codes and concrete codes in other countries, the main difference being that the minimum reinforcement requirements in the concrete codes are significantly greater as are the design strengths.

When making calculations for the load tables in this manual a small portion of the face shells of the blocks has been taken as acting compositely with the core fill concrete. The design thickness of the wall is the core filled thickness t_d as tabulated in Section 1 of Parts 2a, 2b and 3. It is this thickness also that has been used when calculating slenderness ratios.

The core fill concrete in any wall must be of compressive strength at least equal to the unconfined compression strength of the blocks. For the purposes of the strength calculation in the design aids in this manual however an f_{ck} of at least the strength of the blocks plus 5Mpa has been assumed. This is the minimum grout strength for ***mortarless*** masonry construction designed using the tables and diagrams in this manual.

1.3 Design objectives of IS 456:2000

The stated aim of design to IS 456:2000 is "the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and adequate resistance to the effects of misuse and fire."

1.3.1 Limit state design

IS 456:2000 Clause 18.2.1 states that Limit State Method of design shall normally be used but it also stresses the need for suitable materials, quality control, adequate detailing and good supervision. It states that where Limit State Method cannot be conveniently adopted then Working Stress Method may be used.

Limit state method has been used in the generation of all tables and other design aids in this manual.

1.3.1.1 Loads & Forces

All structures are to be designed for dead loads, imposed loads and wind loads, and for forces such as those caused by earthquake, and the effects due to shrinkage, creep, temperature etc where applicable. (IS 456:2000 19.1)

Imposed loads, wind loads and snow loads shall be assumed in accordance with IS 875 Parts 2, 3 and 4 respectively. (IS 456:2000 19.3)

Earthquake forces shall be calculated in accordance with IS 1893. (IS 456:2000 19.4)

The effects of shrinkage, creep and temperature need to be considered (refer IS 456:2000 Clause 19.5). In ordinary buildings such as low rise dwellings whose lateral dimensions do not exceed 45m the effects of temperature fluctuations as well as shrinkage and creep can be ignored (IS 456:2000 Clause 19.5.1)

The combinations of loads shall be as given in IS 875 Part 5 (IS 456:2000 Clause 19.7)

The symbols used for the various loads are:

DL is the characteristic dead load
EL is the characteristic earthquake load
LL is the characteristic live load or imposed load
WL is the characteristic wind load
W is the characteristic total load

1.3.1.2 Partial safety factors (γ)

The partial safety factors for load (γ_f) are given below for both the ultimate limit state and the serviceability limit state. These are used to account for possible unusual increases in load beyond the characteristic load, inaccurate assessment of the effects of loading, unforeseen stress redistribution, and variations in dimensional accuracy of the built structure.

The design load in Limit State Design is to be the characteristic load multiplied by the appropriate partial safety factor γ_f. (IS 456:2000 Clause 19.9)

IS 456:2000 Clause 36.4.2.1 states that when assessing the strength of a structure or structural member for the limit state of collapse, the values of the partial safety factor, γ_m , should be taken as 1.5 for concrete and 1.15 for steel. It is noted however that these values of γ_m are already incorporated in the equations and the tables in IS 456:2000 for limit state design

The design strength of a material or ancillary component is the characteristic strength divided by the appropriate partial safety factor for the material γ_m .

1.3.1.3 Design loads for Limit State of Collapse

The partial safety factors (γ_f) for each of the characteristic loads vary according to how the load is being combined in order to produce a more severe design load. Where alternative values are shown below, the value that produces a more severe design condition should be selected. (IS 456:2000 Table 18):

a) Dead and imposed load
   i) design dead load γ_f = 0.9 or 1.5
   ii) design imposed load γ_f = 1.5

b) Dead and wind load
   i) design dead load γ_f = 0.9 or 1.5
   ii) design wind load γ_f = 1.5

c) Dead, imposed and wind load
   i) design dead load γ_f = 1.2
   ii) design imposed load γ_f = 1.2
   iii) design wind load γ_f = 1.2

When designing for ultimate limit state, each of the above load combinations should be considered and that which produces the most severe conditions should be adopted.

When considering earthquake effects EL can be substituted for WL in the above load combinations.

When designing for loads from earth pressure it is recommended that a value of 1.5 be adopted for γ_f

1.3.1.4 Design Loads for Limit State of Serviceability

The partial safety factors (γ_f) for each of the characteristic loads vary according to how the load is being combined in order to produce a more severe design load. Where alternative values are shown below, the value that produces a more severe design condition should be selected. (IS 456:2000 Table 18):

a) Dead and imposed load
   - j) design dead load $\gamma_f = 1.0$
   - ii) design imposed load $\gamma_f = 1.0$

b) Dead and wind load
   - j) design dead load $\gamma_f = 1.0$
   - ii) design wind load $\gamma_f = 1.0$

c) Dead, imposed and wind load
   - i) design dead load $\gamma_f = 1.0$
   - ii) design imposed load $\gamma_f = 0.8$
   - iii) design wind load $\gamma_f = 0.8$

Each of the above load combinations should be considered when assessing short term deflections, and the load combination that gives the most severe condition should be adopted.

1.3.2 Stability of the Structure

1.3.2.1 Overturning

The stability of a structure as a whole against overturning shall be ensured .

The restoring moment shall be not less than 1.2 times the maximum overturning moment due to the characteristic dead load plus 1.4 time the maximum overturning moment due to the characteristic imposed load. In cases where the dead load provides a restoring moment only 0.9 times the characteristic dead load shall be used. (IS 456:2000 20.1)

1.3.2.2 Sliding

The structure must have a factor against sliding of 1.4 times the most adverse combination of the applied characteristic forces. Only 0.9 times the characteristic dead load shall be used when checking for sliding.

Structures built with mortarless ***masonry*** load bearing walls fully tied to floor slabs have far greater capacity to cope with accidental damage. Reinforced mortarless ***masonry*** walls with continuity of reinforcement through floor slabs or full anchorage of wall reinforcement into floor slabs act in unison with the slabs to compensate for the accidental removal or localised damage of load bearing elements. Slabs are capable of hanging from walls, and walls and slabs can behave as deep flanged wall beams to span greater distances and transfer loads to undamaged load bearing elements.

1.3.3 Structural properties

1.3.3.1 Characteristic compressive strength of ***mortarless*** masonry, f_{ck}

The adopted value for the compressive strength of the composite masonry unit and the core fill concrete is the characteristic cube compressive strength of the core fill concrete but not greater than 1.25 times the unconfined compressive strength of the masonry face shells. Note that the minimum cube strength of the core fill concrete (grout) is to be 5MPa greater than the unconfined compressive strength of the face shells of the blocks.

IS 456:2000 clause 30.6 states that where hollow blocks are required to contribute to the strength of the member they shall be made of concrete or burnt clay and they shall have a crushing strength of at least 14MPa measured on the net section when axially loaded in the direction of the compressive stress in the slab. This clause is taken in itself to validate the use of part of the block shell in the calculation of the strength of a ***mortarless*** wall and furthermore to validate the use of IS 456:2000 to design ***mortarless*** walls.

1.3.3.2 Characteristic strength of reinforcing steel, f_y

The characteristic strength of the steel reinforcement shall be the yield stress of the bars. Generally Grade 500 hard grade deformed bars shall be used.

1.3.3.3 Elastic Moduli

The elastic modulus of the core fill grout (E_c) is as follows:

E_c **= 22,360** MPa for C20 Grout
E_c **= 25,000** MPa for C25 Grout
E_c **= 27,390** MPa for C30 Grout
E_c **= 31,620** MPa for C40 Grout

The elastic modulus of steel reinforcement E_s **= 200,000** MPa.