**Duration:** 135 minutes (2 hrs. 15 min.)                                                                                    **MM. :70**
**Design Philosophy:** Limit state method as per IS 456:2000

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**Instructions:**
- In the numerical-type questions, full marks will **NOT** be given if detailed calculation steps are not presented, as required.
- All given loads are to be considered as unfactored/service/working loads, unless mentioned otherwise.

**Q.1** Design a simply supported slab to cover a room with internal dimensions of 4.0 m x 5.0 m and 230 mm thick brick walls all around. In addition to the self-weight, slab is subjected to a live load of 3 $kN/m^2$ and a floor finish load of 1 $kN/m^2$. Use M 20 grade concrete and Fe 415 grade steel. The slab corners are free to lift up. Assume a modification factor of 1.5 for trial calculations. Consider 10 mm dia. bars along both longer and shorter spans. Take mild exposure conditions. Also, sketch the reinforcement details provided in the slab. Check for shear is NOT required.                                                       **[MM. 14]**

**Q.2** Design the reinforcement in a spiral column of 400 mm diameter subjected to a load of 1000 kN. The column has an unsupported length of 3.3 m and is braced against sideway (i.e., take the effective length factor as 0.85). Use M 25 concrete and Fe 415 steel. Assume a clear cover of 40 mm over spirals, and the diameter of spirals as 6 mm. Also, sketch the designed section.                                                       **[MM. 14]**

**Q.3** Design the reinforcements in a rectangular RCC column of size 250 mm x 500 mm for the following two cases:
(a) Column is subjected to an axial load of 1000 kN and a moment of 100 kN-m with respect to the major axis.
(b) Column is subjected to an axial load of 500 kN and a moment of 50 kN-m with respect to the minor axis.
Take M 20 concrete and Fe 415 steel. The reinforcement is equally distributed on four sides. Assume d'/D as 0.1 for both cases. Also, sketch the section designed for each case. Do NOT revise the design for the actual value of d'/D as obtained after detailing the reinforcement in the section.                                                       **[MM. 14]**

**Q.4** Design the staircase slab reinforcements for the staircase shown below. The stairs are simply supported on beams provided at the first riser and at the edge of the upper landing. Take riser as 150 mm, tread as 300 mm, waist/going slab and landing slab thickness as 230 mm. Take the dia. of the main reinforcement as 12 mm and that of distribution steel as 8 mm. In addition to the self-weight, take a live load of 5 $kN/m^2$ and a floor finish load of 0.8 $kN/m^2$. Use M 20 grade concrete and Fe 415 steel. Assume mild exposure conditions. Sketch of reinforcement details and check for shear is NOT required.

                                                       **[MM. 14]**

                                                       **Please Turn Overleaf**
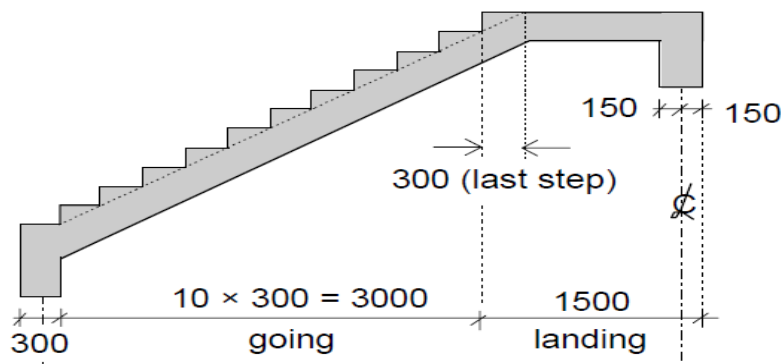
**Q.5** A 850 mm thick isolated footing of size 3.4 m x 2.5 m supports a square column of size 450 mm x 450 mm. The column carries a load of 2300 kN. The effective depth of the reinforcement provided in the footing along the longer direction is 765 mm, and that provided along the shorter direction is 747 mm. The grades of concrete and steel are M 20 and Fe 415, respectively. Calculate the following: **[MM. 14]**

(a) The design one-way shear stress.

(b) The design two-way shear stress.

(c) The design bending moment and the corresponding flexural reinforcement required along the two directions.

A sketch of reinforcement details is NOT required.

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