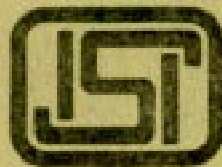


IS : 5499 - 1969

Indian Standard

CODE OF PRACTICE FOR
CONSTRUCTION OF UNDERGROUND
AIR-RAID SHELTERS IN NATURAL SOIL

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CODE OF PRACTICE FOR CONSTRUCTION OF UNDERGROUND AIR-RAID SHELTERS IN NATURAL SOIL

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BDC 12

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Indian Standard

CODE OF PRACTICE FOR CONSTRUCTION OF UNDERGROUND AIR-RAID SHELTERS IN NATURAL SOIL

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 12 December 1969, after the draft finalized by the Functional Requirements in Building Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 In densely populated areas considerable loss of life may be avoided by provision of proper protective air-raid shelters. It is with this view that this standard is being prepared to provide guidance to those engaged in Civil Defence projects.

0.3 This standard is intended for use in construction of shelters in densely populated urban areas with limited open space available. Decisions with regard to actual locations of these shelters, competent authority shall decide where these shelters should be located to suit their particular requirements.

0.4 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard lays down basic requirements of design and materials for the construction of underground air-raid shelters in natural soil for protection of persons against explosion of conventional bombs.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

*Rules for rounding off numerical values (*revised*).

2.1 Air-Raid Shelters — Any premises, structure or excavation used or intended to be used to provide protection against hostile attack from the air.

2.2 Underground Shelter — A shelter the floor of which is below the surrounding ground and the level of the upper surface of its ceiling does not protrude at any point by more than 1 m above the level of the surrounding ground. Shelter whose underground parts of walls are not surrounded by a thickness of earth of at least 3 m, measured horizontally, shall not be considered as underground shelter.

2.3 Rock — Natural solid mineral matter occurring in large masses fragments. For the purpose of this standard, rock shall be designated as a continuous stony layer, the inclination of whose strata does not exceed 45°, and the crushing strength of which, measured on a 70-mm side cube saturated with water, is not less than 100 kg/cm².

2.4 Non-rocky Soil — Any soil other than defined in 2.3 shall be classified as non-rocky soil.

3. MATERIALS

3.1 For the construction of the shelters, cement may comply with the requirements of IS : 269-1967*.

3.2 The design and construction of concrete shall conform to IS : 456-1964†.

3.3 Reinforcement — Reinforcement steel bars shall conform to mild steel Grade I or medium tensile steel bars conforming to IS : 432 (Part I)-1966‡. Steel reinforcement conforming to IS : 1786-1966§ or IS : 1139-1966|| may also be used.

4. LIMITS OF ACCOMMODATION

4.1 Each shelter shall provide accommodation at the rate of 0.4 m² per person.

4.2 The overall net area of the shelter shall not exceed 20 m².

4.3 The minimum height of the shelter shall be 2 m.

*Specification for ordinary, rapid-hardening and low heat Portland cement (*second revision*).

†Code of practice for plain and reinforced concrete (*second revision*).

‡Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement ; Part I Mild steel and medium steel bars (*second revision*).

§Specification for cold twisted steel bars for concrete.

||Specification for hot rolled mild steel and medium tensile steel deformed bars for concrete reinforcements (*revised*).

4.4 Each shelter shall be designed to accommodate a maximum number of 50 persons.

NOTE — The limit, 50 persons, has been specified to reduce the calamity risk.

4.5 As far as possible shelters should be dispersed rather than concentrating in one area or floor. Where owing to lack of space, it is necessary to construct shelters in order to accommodate the maximum number of persons in the minimum space, they should be divided by traverses, zigzags, or doglegs into sections to accommodate not more than 50 persons in each section.

5. ENTRANCES

5.1 Wherever possible, it is desirable to connect shelters one with another, so that, should they be rushed and become overcrowded people may move on to the next unit to leave space for those seeking refuge.

5.2 When trenches are connected, each connecting passageway should be allowed to over sail past the actual corner so as to form a blast pocket to reduce the risk of casualties in the shelter if the bomb falls in the connecting passage. Connecting passages shall meet each other at right angles (see Fig. 1).

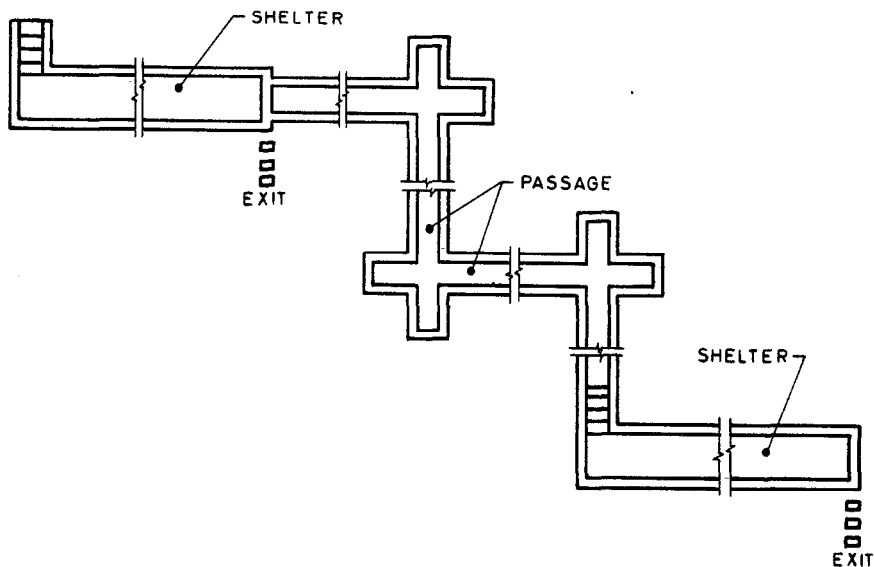
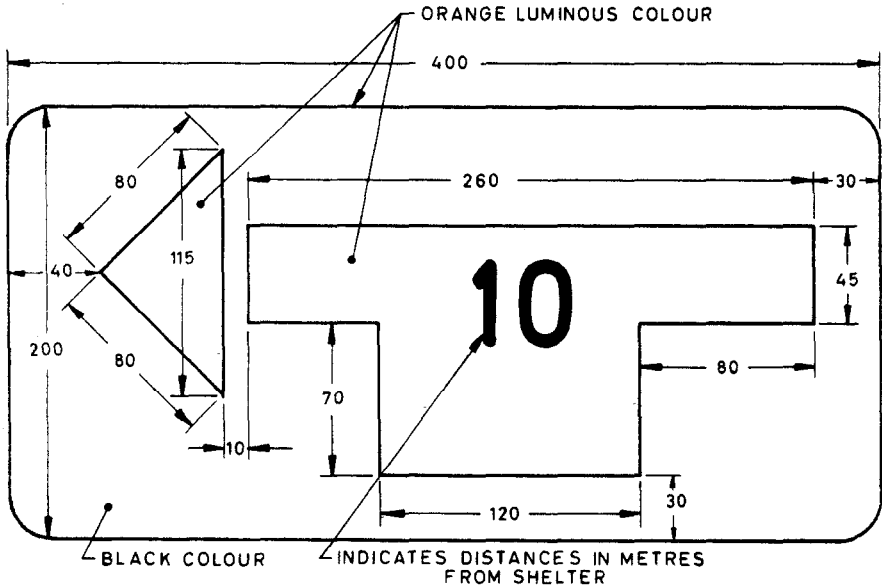


FIG. 1 CONNECTING PASSAGE FOR TWO SHELTERS

5.3 As far as possible, the entrance to the shelter be within the building, with short, easy and direct access from every part of the building. Steps or a slope, the inclination of which does not exceed 1 : 6, shall

lead to the shelter. The entrance to the shelter shall be protected in accordance with 6. The free dimensions of the entrance opening shall not be less than 1.90 m in height and 0.75 m in width.

5.4 The entrance to the shelter shall be marked by a plate on which the following details shall be printed or painted in visible and indelible lettering by means of signs pointing in the direction of the shelter (*see* Fig. 2). The distance of the shelter from the sign shall be indicated in metres on the luminous portion of the sign. The sign may be placed at distances not more than 200 m apart. The nearest sign to the shelter may be placed not less than 10 m away from the shelter.



All dimensions in millimetres.

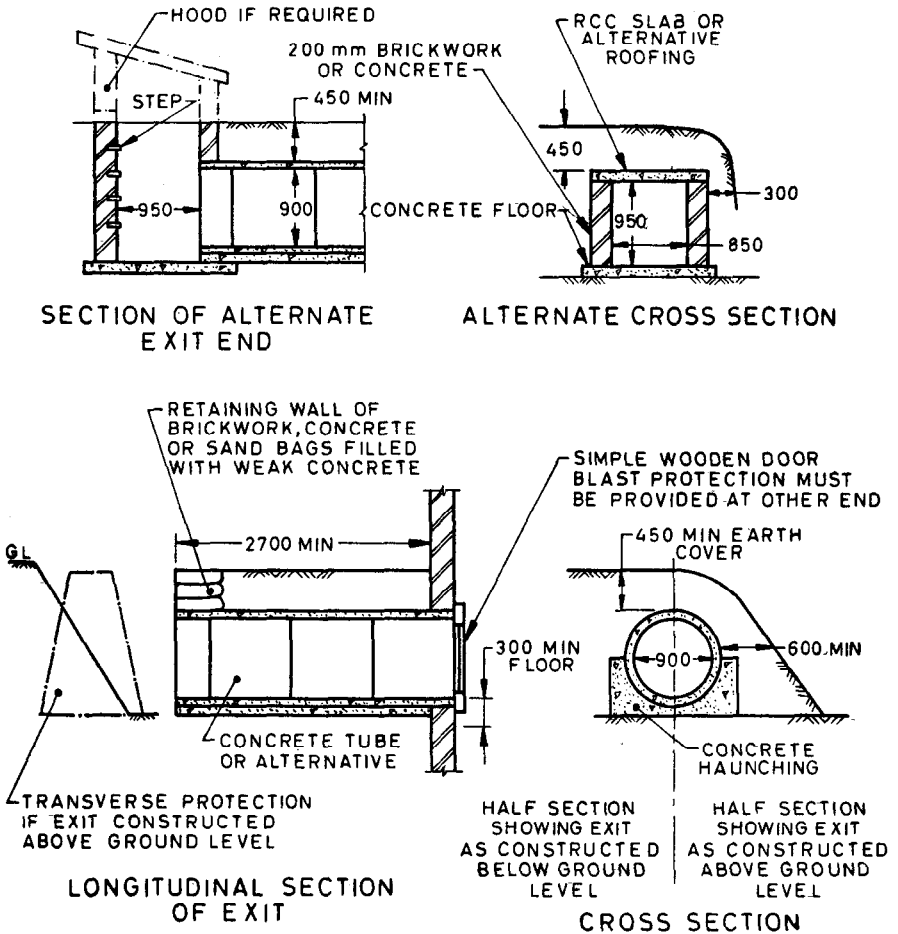
FIG. 2 SIGN FOR AIR-RAID SHELTERS

6. EXIT

6.1 Shelters shall be provided with an emergency exit in the form of a passage. For this purpose a tunnel, tube, staircase, or any other suitable means of egress may be adopted.

6.2 The exit as well as the passage shall be designed in such a way as to avoid direct penetration of blast or splinters. The axis of the passage and the axis of its opening in the shelter, shall not be co-axial.

6.3 The free dimensions of the passage and of its opening in the shelter shall not be less than 0.90×0.70 m. The free dimensions of the outer opening shall not be less than 0.70×0.70 m, and it shall not be closer than 2 m from the external line of the building; it shall be so built as to avoid flooding of the shelter through the passage (see Fig. 3).



All dimensions in millimetres.

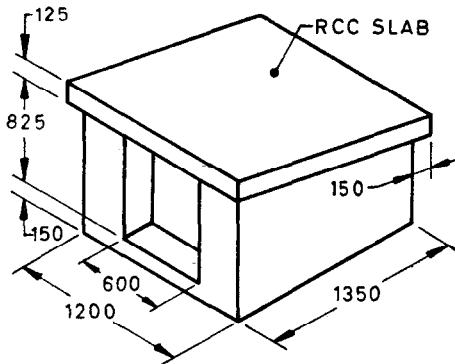
FIG. 3 EXIT PASSAGE FROM UNDERGROUND SHELTERS

6.4 The opening of the shelter into the passage shall be, as far as possible, from the entrance opening and both openings shall not be in the same wall.

6.5 The external opening of the passage shall be fitted with a door which it shall be possible to lock from the inside of the passage; the door shall be a two-leaf door, opening inwards. The leaves of the door shall ensure the ventilation of the shelter. External doors shall also be provided with blast proof walls to minimize the risk in case the explosion occurs in the connecting passage.

6.6 Wherever practicable one exit to the shelter shall give access to the open air and shall be so situated as to be free from the danger of falling debris.

6.7 If the entrance to the shelter is from the open air, it shall be suitably protected (see Fig. 4).



Note — Hood may be constructed of brick or concrete walls with RCC slab or alternative roofing.

ISOMETRIC VIEW OF HOOD

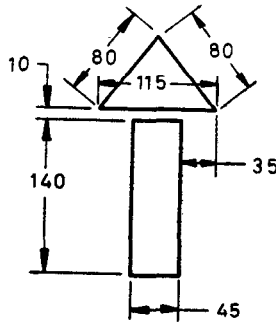
All dimensions in millimetres.

FIG. 4 PROTECTION OF EXITS

6.8 The exit doors inside the shelter shall be prominently marked, for example, with a luminous band painted on top of the exit (see Fig. 5).

7. SHELTERS WITHIN BUILDING LIMITS

7.1 Location — When the shelter is built within the limits of the building, its walls shall not be closer than 2.0 m from the line of the external walls, except in special cases authorized by the competent authority. Where there are basements in the buildings, the shelters shall be constructed in the basements.



All dimensions in millimetres.

FIG. 5 INDICATING DIMENSION OF THE BAND

8. STRUCTURE

8.1 The shelter shall be monolithic, waterproof and damp-proof. All the parts of the shelter shall be firmly bonded to each other and shall be built from reinforced concrete complying with the requirements of 3. Water or gas ducts shall not be contained in any part of the shelter. Care shall be taken to avoid flooding of the shelter in case of floods.

9. WALLS

9.1 The walls of the shelter shall be not less than 30 cm thick; they shall be calculated to resist a load caused by an external uniformly distributed pressure of 10 tons/m². Reinforcement shall be formed by steel bars placed as a mesh, one mesh near each face of the wall. The aperture of the mesh formed by the calculated reinforcement and the distribution bars shall not exceed 15 cm, and the aperture of the additional mesh shall not exceed 20 cm. The diameter of the bars shall not be less than 8 mm; smaller bars may be used for the additional mesh, provided that the total weight of this mesh shall not be less than 4 kg/m² of wall. The volume of steel in the wall, comprising the additional mesh, shall not be less than 0.5 percent of the total volume of the wall (approximately 40 kg/m² of concrete).

9.2 Lateral Protection

9.2.1 Brickwork when used shall be reinforced for affording lateral protection to provide resistance to blast pressures. A minimum reinforcement of a pair of 6 mm ϕ bars per 45 cm run of wall shall be provided.

NOTE — Lime mortar shall not be used for construction of shelters.

9.2.2 Hollow concrete blocks, when used, shall be filled with concrete and reinforced as given in **9.2.1**.

10. ROOF

10.1 The roof slab of the shelter shall not be less than 20 cm thick. The slab shall be calculated to carry, in addition to its own weight, the dead weight of any earth/gravel cover or any slab(s) built or designed to be built above the shelter, that is, a load of 250 kg/m^2 for each slab, in addition to a superimposed load of $1\,000 \text{ kg/m}^2$ and of any concentrated load imposed on different slabs. The calculated reinforcement shall be divided in such a way that the distance between two bars will not exceed 15 cm. The diameter of the bars shall not be less than 8 mm, and the volume of the steel shall not be less than 0.5 percent of the total volume of the slab. If the slab is reinforced in a single direction, the span shall not exceed 4 m, and when the ceiling is crosswise reinforced, the span shall not exceed 6 m.

11. VENTILATION

11.1 Ventilation opening (or openings) shall be provided in the vicinity of the ceiling in order to ensure the exit of the hot air. These openings shall be protected against blast and the penetration of splinters. The hot air shall flow to the exterior of the building or to the staircase, or exit passage. The total area of these openings shall not be less than 0.01 m^2 per each m^3 of volume of the shelter; no opening shall be less than 0.01 m^2 in area, and the least dimension of their cross-section shall not be less than 20 cm.

12. SHELTERS IN CELLARS

12.1 Shelters, the walls of which are at a distance of more than 12 m from the walls of the cellar, shall be considered as overground shelters. The parts of the walls of the cellars at a level below ground shall be surrounded by earth in a thickness, measured horizontally, of not less than 4 m.

13. SHELTERS IN EXISTING CELLARS

13.1 All provisions of the standard except those mentioned in **10.1** are applicable.

13.2 When the ceiling of the existing cellar does not fulfil the requirements of **10**, the walls of the shelter shall be built at a distance of not less than 4 m from the existing walls, and the existing ceiling shall be strutted in such a way that it shall support its own weight and the load specified in **10**. Walls shall be bonded to the ceiling of the cellar.

14. SHELTERS BUILT OUTSIDE THE BUILDINGS

14.1 All provisions except those of **6** and **7** shall apply to shelters built outside the limits of the buildings.

14.2 Emergency exits may not be provided when the distance between the shelter and the walls of the surrounding buildings exceeds one third of the height of the tallest building.

14.3 The roof of the shelter shall be covered by a layer of gravel not less than 30 cm thick.

(Continued from page 1)

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