CIVIL DEFENCE.

Air Raid Shelters :
Factories and Commercial Buildings (Amended Code) p. 11.
Standards of Expenditure, p. 24.
Compulsory Area, p. 25.
County Court Rules, p. 26.

Air Raid Shelters.

ORDER, DATED THE 21ST DAY OF AUGUST, 1942, MADE BY THE MINISTRY OF PUBLIC SECURITY UNDER SECTION 11 OF THE CIVIL DEFENCE ACT (NORTHERN IRELAND), 1939.

1942. No. 127.

WHEREAS by the Civil Defence (Approval and Revision of Code) Order (Northern Ireland), 1939, a Code for the guidance of occupiers and owners of factory premises, factories and commercial buildings and other persons concerned in providing air-raid shelter was approved and revised so as to bring the said Code into conformity with the Revised Code set out in the Schedule to the said Order :

AND WHEREAS the said Revised Code was further revised by the Civil Defence (Revision of Code) Order (Northern Ireland), 1940 :

AND WHEREAS it is expedient that the said Revised Code should be further revised :

NOW, THEREFORE, the Ministry of Public Security in exercise of its powers under Section eleven of the Civil Defence Act (Northern Ireland), 1939, and subsequent enactments and of all other powers enabling it in that behalf hereby orders and directs as follows :—

1.—The said Revised Code shall be amended by such revocation and variation of and addition to its provisions as are necessary to bring the said Revised Code into conformity with the Amended Code set out in the Schedule hereto.

2.—The Interpretation Act, 1889, as applied to Northern Ireland by the Interpretation Act, 1921, shall apply for the purpose of the interpretation of this Order as it applies for the purpose of the interpretation of an Act of Parliament.

3.—This Order may be cited as "The Civil Defence (Amendment of Code) Order (Northern Ireland), 1942."

Sealed with the Official Seal of the Ministry of Public Security for Northern Ireland this 21st day of August, One thousand nine hundred and forty-two, in the presence of

(L.S.) *E. W. Scales*,
Secretary.

SCHEDULE.

AMENDED CODE (SECTION 11 OF THE CIVIL DEFENCE ACT (N.I.), 1939) FOR THE GUIDANCE OF OCCUPIERS AND OWNERS OF FACTORY PREMISES, FACTORIES AND COMMERCIAL BUILDINGS, AND OTHER PERSONS CONCERNED.

PART I.

REQUIREMENTS WITH WHICH SHELTER MUST COMPLY.

1. *Definitions.*—For the purposes of this Code the following expressions shall have the meanings hereby respectively assigned to them :—

" Air Raid Shelter " means protection otherwise than by war-like means or by any article of apparel, from hostile attack from the air, and " an air raid shelter " means any premises, structure or excavation used or intended to be used to provide air raid shelter.

" Surface Shelter " means an air raid shelter situated wholly above ground (or on the lowest floor if in a building) constructed as an independent unit to accommodate not more than 50 persons, and designed to the satisfaction of the Ministry in the form of a reinforced box-like structure.

" Trench Shelter " means an air raid shelter in the form of a covered trench or tunnel below or partly below ground level.

" Accommodation " relates to the number of persons to be accommodated in an air raid shelter or in any section or compartment thereof.

" Prescribed stresses " shall mean the maximum permissible working stresses specified,

(*a*) in respect of reinforced concrete, in the " Recommendations for a Code of Practice for the use of Reinforced Concrete in Buildings " of the Reinforced Concrete Structures Committee of the Building Research Board,

(*b*) in respect of steel, in British Standard Specification No. 449-1937 (" The Use of Structural Steelwork in Buildings "),

(*c*) in respect of pressures on load-bearing concrete and masonry (brick and stone), in " Notes on the Use of Materials and Construction in Connection with Steel Structures " appended to B.S.S. 449-1937,

(*d*) in respect of timber, in " Byelaws for the Use of Timber " made by the London County Council on the 30th November, 1937. (*See* Appendix II.)

" Sound brickwork " means brickwork consisting of sound, well-fired clay bricks, or cement concrete bricks, having a crushing strength of not less than 1500 lbs. per square inch when tested in accordance with the methods laid down in the second schedule of Ministry of Health Model Byelaws, Series IV, Buildings, 1939 (see Appendix I), or sand-lime bricks complying with the requirements of British Standard Specification 187-1934 for building bricks Class A, properly bonded and jointed in mortar which is properly set and hardened.

"Brickwork in cement mortar" means brickwork consisting of bricks as described above for sound brickwork, properly bonded and jointed in cement mortar not weaker than one volume of cement to three volumes of sand.

"Sound stonework" means coursed natural or cast stone masonry in sound condition.

"Structural concrete" means concrete of a quality permissible under the recommended Code of Practice for the use of Reinforced Concrete in Buildings of the Reinforced Concrete Structures Committee of the Building Research Board, consisting of not less than 112 lb. of cement, complying with the requirements of British Standard Specification No. 12-1931 or of British Standard Specification No. 146-1932, to 2½ cubic feet of suitable fine aggregate and 5 cubic feet of suitable coarse aggregate.

"Reinforced concrete" means structural concrete as described above, reinforced in accordance with the Code of Practice, such reinforcement amounting in each cubic foot of concrete to not less than 2 lb. of steel total (exclusive of laps and hooks), suitably distributed in the concrete, of which total at least 0.7 lb. is distribution steel at right angles to the main steel.

"Reinforced," in relation to brickwork in cement mortar, or structural concrete means reinforced with steel.

"Steel" means mild steel complying with the requirements of British Standard Specification No. 15-1936.

2. *Lateral and overhead protection.*—An air raid shelter must be of such construction as to give

(*a*) Lateral protection by means of not less than :—
- (i) 1½ in. thickness of mild steel plate or plates,
- (ii) 12 in. thickness of structural concrete,
- (iii) 13½ in. thickness of sound brickwork or sound stonework,
- (iv) 2 ft. thickness of ballast or broken stone,
- (v) 2 ft. 6 in. thickness of earth or sand, or
- (vi) a corresponding aggregate thickness of a proportionate combination of such materials ; and

(*b*) Overhead protection, subject to the requirements of paragraph 3 and 4 for protection from falling debris, by means of not less than :—
- (i) ½ in. thickness of mild steel plate,
- (ii) 6 in. thickness of structural concrete reinforced if and as necessary or otherwise suitably strengthened or effectively supported,
- (iii) structural concrete in the form of precast solid units of not less than 6 in. thickness, reinforced as necessary and adequately supported,
- (iv) 8½ in. thickness of arching in sound brickwork or sound stonework,
- (v) 3 ft. thickness of ballast, broken stone or earth,
- (vi) a corresponding aggregate thickness of a proportionate combination of such materials, or
- (vii) a substantial building overhead consisting of a roof and not less than three floors (including that covering the shelter) where such structure is enclosed with walls of brick, stone or concrete.

Provided that, subject to the approval of the Ministry, other materials of such thickness as it may prescribe, may be used to give protection.

The material affording overhead protection must in all cases be such, or be so secured, as to resist an upward force of 300 lbs. per square foot of horizontal internal surface.

The lateral protection must extend throughout the height of the air raid shelter, except as specially provided hereafter, and similarly the overhead protection must extend over the whole area of the air raid shelter.

Provided that in the case of an air raid shelter formed by the adaptation of existing accommodation, wholly above ground, within a building, where the aggregate area of door and window openings in any one wall of a shelter compartment does not exceed

one-quarter the surface area of such wall and the total width of such openings does not exceed one-third the total length of such wall, it shall suffice if the protection in such openings extends to a height of 6 feet above the floor of the air raid shelter, subject to movable protection being provided to the space above, such protection consisting of timber shutters not less than 2 inches thick or mild steel shutters not less than ¼ inch thick or other approved material; or it shall suffice if the openings are protected by a screen wall or walls giving the lateral protection required under paragraph 2 above, situated not more than 6 feet from the face of the wall of the shelter and extending beyond such openings for a distance sufficient to prevent the entrance of splinters, this latter requirement being deemed to be met where the extent of such screen beyond the opening is not less than its distance from the opening. Where the lateral protection to glazed openings is situated on the outer side of the glass, adequate precautions must be taken against danger from flying splinters of glass by the provision of suitable screens on the inner side.

3. *Protection from falling debris.*—Adequate provision must be made to afford protection from falling loads due to the collapse of any structure over an air raid shelter or within a distance from such air raid shelter equal to one-half the height of such structure, by the provision of a floor or by the strengthening of the existing floor where necessary or by a suitable roof or other construction based on an estimated static loading as representing the effect of impact, to the satisfaction of the Ministry.

Provided that where such falling loads would not include heavy machinery, materials and goods of abnormal weight, nor such constructions as chimney-shafts, towers, heavy colonnades, pediments or cornices, but would comprise only the loads of a normal structure and superimposed loading of ordinary goods or light plant and equipment, it shall suffice if, for purposes of calculation, the falling loads be deemed to be static loads in accordance with the following requirements :—

(*a*) For buildings wherein the loads are carried on load-bearing brickwork or stonework :—

Number of Storeys at a Higher Level than the Top of the Shelter.	Minimum Static Load (in addition to the Floor Load) to be assumed to represent the effect of the Debris. lb. per square foot of Floor Area.
None, 1 or 2	200
3 or 4	300
over 4	400

(*b*) For buildings wherein the whole of the loads are carried on steel or reinforced concrete framing, the effect of the debris load may be assumed to be a static load of 200 lb. per sq. ft. of floor area (in addition to the floor load) irrespective of the number of storeys at a higher level than the top of the shelter.

For the purposes of this clause, the expression " floor load " means the combined dead and superimposed floor load calculated in accordance with the Ministry of Health Model Byelaws, Series IV—Buildings, 1939 (See Appendix I).

External air raid shelters must in all cases be protected from falling debris, projected from a distance, by providing for a static roof loading of not less than 200 lb. per sq. foot.

4. *Stability.*—All new constructions, extensions, additions and alterations in connection with air raid shelters must be so executed that all loading occasioned thereby shall be safely sustained and transmitted to the ground without exceeding the limitations of the prescribed stresses.

Any structure specially erected as an external air raid shelter must be in the form of a surface shelter if wholly above ground, or of a trench shelter if wholly or partly below ground.

In surface shelters, if the lateral protection is provided by brickwork or concrete, this protection must be by brickwork in cement mortar, by structural concrete or by a combination of these materials, and must be reinforced with mild steel vertical rods

of not less than ¾ inch diameter, arranged in two rows, spaced at not greater than 18 inch centres in each row and staggered. These rods must extend 4½ inches upwards into the roof slab and then at right angles a further 1 ft. 3 ins. within the roof slab. The lateral protection of the shelter must also be tied to the floor slab by two rows of mild steel dowel rods of not less than ¾ inch diameter, at approximately 9 inch centres between pairs, extending 1 ft. 9 ins. upwards into the walls and 4½ inches downwards into the floor slab, and then at right angles a further 1 ft. 9 ins. within the floor slab.

The overhead protection to these types of surface shelter must be cast-in-situ structural concrete at least 6 inches thick reinforced as necessary to resist the prescribed debris load. The floor slab must be constructed of cast-in-situ structural concrete at least 6 inches thick, with steel reinforcement having the main rods spaced at not more than 8 inch centres and weighing not less than 2¾ lbs. per sq. yard, and having the longitudinal rods spaced at not more than 18 inch centres and weighing not less than 1 lb. per sq. yard.

The whole structure must be separated from an even consolidated sub-floor by a cleavage plane.

Surface shelters may be constructed in alternative designs and materials, but in all cases the structure must be of a "box-like" form able to suffer severe distortion without collapsing.

All surface shelters must be designed so as to resist a lateral live load of 200 lbs. per foot run of shelter acting at the roof level, in addition to the prescribed debris loading. They must be separated as widely as the site conditions permit, and should not be sited immediately adjoining any other substantial structure.

Except where executed in hard rock, trench shelters must be provided with linings consisting wholly of in-situ structural concrete with continuous reinforcement in walls, floor and roof; such linings must be designed and constructed in accordance with normal engineering principles as a box section, in such manner as safely to resist, in addition to the superimposed load, a lateral load varying in intensity from 200 lbs. per sq. ft. at the roof to 400 lbs. per sq. ft. at the base, or such greater loads as the Ministry may consider it necessary to provide for.

Except in the case of a surface shelter or trench shelter, any air raid shelter provided in a building of a type other than that described in 3 (*b*) above must have the roof supported by a system of strengthening designed in structural steelwork, independent of the existing structure and capable not only of resisting the debris loads specified in para. 3 (*a*) but in addition a horizontal load applied at shelter ceiling level. This load should be assumed as a normal force of 200 lbs. per foot run acting on any side of the shelter, subject to the provision that the total maximum working stresses in the steelwork may exceed the prescribed stresses by not more than 33⅓ % in cases where the excess is due solely to the horizontal loading of 200 lbs. per foot run. All parts of the strengthening system must be kept at least 12 ins. from surrounding walls forming the lateral protection of the shelter.

In the case of air raid shelter provided in framed buildings as described at 3 (*b*) above, if strengthening is necessary this must be carried out by providing an adequate system of structural steel or reinforced concrete intimately connected with the existing structural framework of the building.

5. *Gas-proofing.*—Every air raid shelter providing accommodation for more than twelve persons must be so constructed as to permit of its being rendered gas-proof without structural alteration should the need arise.

6. *Space required in shelters.*—The accommodation of an air raid shelter must, subject to the ultimate limitations specified in paragraph 7, be determined in accordance with the following rules, that is to say :—

(1) (*a*) In the case of a shelter accommodating not more than twelve persons, or (*b*) in the case of a trench shelter having openings at both ends of each section into the open air, or (*c*) in the case of a shelter wholly or partly above ground accommodating not more than 50 persons and freely ventilated by two entrances connecting directly or indirectly with the open air, it must have for every person accommodated not less than 3¾ sq. ft. of floor area. Provided that any such shelter which is used as a dormitory must have for every person so using it not less than 6 square feet of floor area and not less than 50 cubic feet capacity.

(2) In the case of a shelter other than as described in rule (1) above, not intended to be permanently sealed against gas, and ventilated by the entrance and exit or otherwise efficiently ventilated by natural means, or by mechanical means at a rate of not less than 150 cu. ft. of air per hour, per person, it must have, for every person accommodated,

not less than 6 square feet of floor area,
not less than 50 cubic feet capacity,
not less than 25 square feet of surface area of walls, floor and ceiling or roof, excluding from this calculation the surface area of partition walls less than 8½ in. thick.

Provided that the floor area, capacity or internal surface area of any such shelter may be of less extent subject to the following conditions :—

(*a*) That the shelter is ventilated mechanically at a substantially higher rate than the normal (exceeding 450 cubic feet of air per hour for every person in the shelter) and provided that satisfactory arrangements are made for emergency operation of the ventilating plant, when it will be sufficient if there is a floor area of 3¾ sq. ft. for every person in the shelter, or

(*b*) that the shelter being entirely below ground level has abnormally massive construction with dividing walls not less than three feet thick and heavy slabs or vaulting over not less than three feet in thickness at any part inclusive of any solid filling, subject to the authorisation of the Ministry.

(3) In the case of an unventilated shelter accommodating more than twelve persons, intended to be permanently sealed against gas during the whole period of occupation, it must have, for every person accommodated,

not less than 6 square feet of floor area,
not less than 50 cubic feet capacity,
not less than 75 square feet of surface area of walls, floor and ceiling or roof, excluding from this calculation the surface area of partition walls less than 8½ in. thick.

For the purpose of computing the floor area, when there are seats beneath which the floor does not extend (as in a shelter in the form of a horizontal tube), the area of such seats may be deemed to be floor area.

Every trench shelter shall have a horizontal floor and a clear head-room, measured therefrom, of not less than 6 feet extending throughout the length of such shelter or of as much of its length as is intended to provide accommodation. Every other type of shelter must have a clear head-room of not less than 6 ft. 6 inches.

7. *Limits of accommodation.*—Every trench shelter intended to accommodate more than 50 persons must be divided into sections accommodating not more than 50 persons each. In the case of a continuous trench shelter such divisions must be effected by a change in direction through an angle of 80 to 100 degrees and extending in the new direction a distance of not less than 5 feet (measured clear of the width of the trench shelter), subject to such distance being not less than 25 feet in the case of a second change of direction involving a return parallel to and opposite the first section. Every section of a trench shelter must be adequately ventilated by openings at each end.

In the case of shelter (not being a trench shelter) inside an existing building, intended to accommodate more than 200 persons, such shelter must be divided into compartments for the accommodation of not more than 200 persons each, by division walls consisting of either :—

(*a*) A wall of reinforced concrete not less than 24 in. thick, or

(*b*) Two walls each consisting of structural concrete not less than 12 in. thick, or of brickwork in cement mortar or a combination of brickwork in cement mortar and structural concrete not less than 13½ in. thick, reinforced in each case with vertical mild steel reinforcement rods arranged in two rows spaced at not greater than 1 ft. 6 in. centres in each row and staggered, and weighing not less than 2 lbs. per square yard, and with horizontal mild steel reinforcement rods arranged in two rows, spaced at not greater than 1 ft. 6 in. centres and weighing not less than 2 lbs. per square yard.

In order to minimise the number of casualties likely to result from a direct hit, every shelter must, wherever the circumstances of the case make it possible, be

subdivided into compartments for the accommodation of not more than 50 persons each, either by existing walls of sound construction suitably thickened, if necessary, to provide the lateral protection defined in paragraph 2; or by new walls, each of the thickness and construction defined at (*b*) above, of a minimum height of 6 ft. above floor level and separated from an adequate consolidated foundation by a cleavage plane.

8. *Accessibility of air raid shelter.*—Every air raid shelter must be boldly marked and so situated and accessible by day and by night that the persons for whose protection it is intended may pass from the place they work into their shelter within 7 minutes.

In the case of A.R.P. personnel, including persons occupied with essential duties which may not be entirely discontinued during the whole period of a raid (such as boiler-house and switchgear attendants and men in charge of machinery which cannot be shut down at short notice), special provision must be made for the necessary air raid shelter at, or adjacent to, their working positions.

9. *Entrances and exits.*—Every air raid shelter and every compartment of an air raid shelter accommodating more than 50 persons must be provided with an entrance, which shall have a width of not less than 2 ft. 6 in. in the clear; and every air raid shelter or compartment of an air raid shelter accommodating not more than 50 persons must be provided with an entrance, which shall have a width of not less than 2 ft. in the clear.

Every air raid shelter intended to accommodate more than 12 persons must have at least two exits as remote as may be practicable from each other, one of which may be the normal entrance if suitable. One at least of such exits must wherever practicable, give access to the open air and when possible be so situated as to be free from the danger of falling debris. Where the emergency exit gives access to another air raid shelter or to another compartment of an air raid shelter, the opening must not exceed 3 ft. 6 in. in height nor 2 ft. 9 in. in width.

Where the entrances to, or exits from an air raid shelter are in the wall of a building or are situated at a distance from any building or structure, not exceeding one-half the height of such building or structure, all reasonable measures must be taken to afford one of such entrances or exits proper protection from falling debris.

If an entrance or exit of an air raid shelter be from or to the open air and be above the ground level, such entrance or exit must be protected by a door or screen affording a degree of lateral protection not inferior to that specified in paragraph 2 of this code and of such extent as to prevent the entrance of splinters.

10. *Drainage.*—Where necessary, adequate arrangement must be made to keep every air raid shelter free from water.

11. *Sanitary facilities.*—Every air raid shelter must have proper closet facilities at the rate of not less than one seat per 25 persons accommodated, and also such subsidiary buckets and urinals as may be necessary. Such conveniences must, where practicable, be contiguous with the shelter and divided therefrom by a partition or partitions extending the whole height of the shelter, or by partitions and ceiling at a convenient height. Doors or curtains must be provided at entrances to closets.

Provided that where adequate sanitary facilities are afforded (by an existing building or otherwise) in close proximity to the shelter and within ready and easy access, this requirement may be deemed to be complied with.

12. *Lighting.*—Every air raid shelter must be adequately lighted, and a system of independent lighting must be installed sufficient to afford such light as may be necessary in the event of the failure of the normal lighting service. Where generators or large storage batteries are employed for such purpose, they must be isolated and have separate ventilation. Where electric torches, electric battery hand lamps or other portable means of illumination are employed for such purpose, a sufficient supply must be permanently kept in the shelter.

13. *Dangerous pipes, etc.*—Pipes, tanks or containers which might prove a source of danger (such as pipes or containers conveying or holding steam, gas, compressed

air, refrigerants or noxious chemicals) must not be permitted in any air raid shelter, and water pipes connected direct to the mains or to large supply tanks, and gas pipes, must be provided with such valves as may be necessary to permit of their being isolated where they pass through any shelter.

Where water mains or sewers are of such size or in such proximity to an air raid shelter as to be hazardous, such provision must be made as may be necessary to exclude their contents from the shelter in the event of damage.

APPENDICES TO PART I.

APPENDIX I.—REPRINT OF PORTIONS OF THE SCHEDULES IN THE MINISTRY OF HEALTH MODEL BYELAWS, SERIES IV, BUILDINGS, 1939.

PART OF FIRST SCHEDULE.

1.—*Dead Loading.*

For the purpose of calculating the dead loading of a building or any part of a building the weights of the materials shall be assumed to be those set out in British Standard Specification No. 648—1935 (Schedule of Unit Weights of Building Materials), or if not set out in that Specification shall be determined by test.

2.—*Superimposed Loading.*

For the purpose of calculating the superimposed loading on beams, pillars, piers and walls, the minimum superimposed load on each floor and on the roof of a building shall be estimated as equivalent to the dead load specified in the following table for the appropriate type of building, floor or roof :—

Type No.	Description of building, floor or roof.	*Pounds per square foot* of floor area.
1	Rooms of dwelling-houses, flats, hotel buildings and similar residential buildings ; hospital rooms and wards ; corridors, staircases and landings of dwelling-houses and flats.	40
2	Offices—floors above entrance floor.	50
3	Offices—entrance floor and floors below entrance floor.	80
4	Churches, schools, reading rooms, art galleries and similar buildings.	70
5	Retail shops and garages for cars of not more than *two tons* dead weight.	80
6	Assembly halls ; drill halls ; dance halls ; gymnasia ; light workshops ; public spaces in hotels and hospitals ; corridors, staircases and landings for the buildings mentioned in this table other than those described in Type No. 1 above ; cinemas ; restaurants and grand stands.	100
7	Warehouses, book stores, stationery stores and buildings similarly used, and garages for motor vehicles exceeding *two tons* dead weight. Actual load to be calculated but not less than	200
8	Flat roofs and roofs inclined at an angle with the horizontal of not more than *twenty degrees.*	30 (*per square foot* of covered area).
9	Roofs inclined at an angle with the horizontal of more than *twenty degrees.*	10 (*per square foot* of covered area).

3.—*Partitions.*

Where the position of a partition in a building is definitely located in the design, the actual weight of the partition shall be included in the dead floor load.

Where the position of a partition is not definitely located in the design, a uniformly distributed load sufficient to allow for it shall be added to the dead floor load, and for

all such floors used for offices the minimum total allowance for partitions shall be at the rate of *twenty pounds per square foot* of floor area.

PART OF SECOND SCHEDULE.

In determining the maximum permissible pressures on walls constructed of bricks or blocks, the crushing strength of the individual brick or block shall be determined in the following manner :—

Twelve whole bricks or blocks with sides not less than *three inches* long shall be taken. The materials shall be soaked for *twenty-four hours* in water at a temperature between *fifteen degrees* and *twenty degrees* Centigrade. The frogs in bricks shall then be filled with mortar and the top and bottom surfaces of hollow bricks or blocks shall be made plane and parallel with mortar. The mortar shall consist of *one part* (by weight) of cement and *three parts* (by weight) of dry and clean Leighton pit sand, the cement used being either normal Portland cement or rapid-hardening Portland cement. After the application of the mortar to the bricks or blocks, the specimens shall be covered with damp cloths for *six hours*, then immersed in water at a temperature between *fifteen degrees* and *twenty degrees* Centigrade for *twenty-seven days* in the case of normal Portland cement mortar, and for *six days* in the case of rapid-hardening Portland cement mortar, or for such period, being not less than *two days*, at which the mean crushing strength of three cubes each with sides *three inches* long made from the batch of mortar used in the preparation of the bricks or blocks and stored under similar conditions will be between *two thousand* and *four thousand pounds per square inch.*

The test pieces shall finally be crushed between three-ply wood sheets *one-eighth-of-an-inch* thick, the load being applied at a uniform rate of approximately *two thousand pounds per square inch per minute.* The average value of the crushing stress thus obtained for the twelve test pieces, calculated over the gross area of the test pieces, shall be taken as the crushing strength of the individual brick or block.

APPENDIX II.—REPRINT OF EXTRACTS FROM "BYELAWS FOR THE USE OF TIMBER" MADE BY THE LONDON COUNTY COUNCIL ON 30TH NOVEMBER, 1937.

8.—The stresses in timber shall not exceed those set out in Tables II and III following :—

TABLE II.

Nature of stress.	*Maximum stress in lbs. per square inch.* *Non-graded.*	*Grade 1200 lbs. f.*
Extreme fibre stress in bending ...	800	1,200
Shear stress in the direction of the grain	90	100
Compression perpendicular to the grain	165	325
Compression in the direction of the grain in posts and struts having a slenderness ratio not exceeding 10	800	1,000
Tension in the direction of the grain ...	800	1,200
Modulus of elasticity	1,200,000	1,600,000

When a post or strut has a slenderness ratio exceeding 10, the compressive stress in the direction of the grain shall not exceed the maximum pressure set out opposite the slenderness ratio in Table III following :—

TABLE III.

Slenderness ratio.	*Maximum pressure in lbs. per square inch.* *Non-graded.*	*Grade 1200 lbs. f.*
Exceeding 10 but not exceeding 12 ...	785	985
„ 12 „ „ „ 14 ...	775	970
„ 14 „ „ „ 16 ...	755	950
„ 16 „ „ „ 18 ...	725	920
„ 18 „ „ „ 20 ...	690	875
„ 20 „ „ „ 22 ...	635	820
„ 22 „ „ „ 24 ...	565	745
„ 24 „ „ „ 26 ...	485	650

Slenderness ratio.		*Maximum pressure in lbs. per square inch.*	
		Non-graded.	*Grade* 1200 lbs. *f.*
Exceeding 26 but not exceeding 28	...	420	600
„ 28 „ „ „ 30	...	365	485
„ 30 „ „ „ 32	...	320	430
„ 32 „ „ „ 34	...	285	380
„ 34 „ „ „ 36	...	255	340
„ 36 „ „ „ 38	...	225	300
„ 38 „ „ „ 40	...	205	275

9.—The slenderness ratio of any post or strut shall not exceed forty.

10.—When a post or strut is subject to bending action in addition to axial loading, such post or strut shall be of a section sufficient to withstand such bending action in addition to the axial load.

NOTE.—" Slenderness ratio " in relation to a post or strut means the ratio of length to thickness.

PART II.

ADVICE AS TO INCIDENTAL MATTERS AND AS TO METHODS TO BE FOLLOWED IN PROVIDING SHELTERS.

General—Layout of Shelters—Methods of Providing Shelters—Notes on the Construction of Shelters outside Buildings—Notes on the Construction of Shelters within Buildings—Entrances to, and Exits from Shelters—Notes on the Ventilation of Shelters.

General.

No two factories or commercial buildings are alike; they differ in location, in structural design, in layout and equipment; it is not possible, therefore, to specify any one scheme of protection which would be best or even applicable in all cases. Each case must be treated individually, and advice on the best method of treatment should be sought from engineers or architects qualified for such work. When firms have no engineers or architects in their employ, the name of suitable experts may be obtained from the well-known professional institutions.

Layout of Shelters.

Wherever possible, shelters should be spaced at least 25 feet apart, measured in the clear. With trench shelters situated outside buildings this rule should only be departed from in exceptional circumstances where space is very restricted. In water-logged ground or in cases where it is not feasible to erect trench or tunnel type shelters completely below ground the minimum distance between shelters stated above should be increased in proportion to the height of the shelter above ground. In the case of surface shelters this minimum distance should be at least 50 feet except in exceptional circumstances where space is very restricted. With shelters situated within buildings a clear space of 25 feet between shelters should be maintained wherever possible, but it is realised that there will be many cases where it will not be practicable, and it then becomes necessary to divide shelters into compartments with dividing walls of the kind required in paragraph 7, Part I.

In siting shelters, due regard should be given to the nature of existing structures on the site.

It would rarely be economical to site shelters in positions where they might be required to withstand particularly heavy debris loads such as those likely to result from the collapse of heavy cornices, parapets, tanks, large chimney stacks or floors carrying particularly heavy machinery. Sites should also be avoided which might be rapidly flooded from nearby rivers, canals, reservoirs or large water pipes at a higher level than the shelter. The proximity of steam boilers, large refrigerating plants, large furnaces, oil tanks and chemical storage tanks, or quantities of inflammable materials of any kind would also prove a source of danger to the occupants of shelters and should be avoided.

Methods of Providing Shelters.

There are two general methods available for the protection of personnel :—

(1) by the provision of isolated shelters above or below ground, or continuous trench shelters outside the buildings ; or

(2) by providing shelters within the building.

Notes on the Construction of Shelters Outside Buildings.

The choice of the type and position of shelters will nearly always be governed by site conditions.

The required protection may often be obtained by placing shelters on any vacant land adjoining the premises. The land need not necessarily be rendered unsuitable for future building extensions if the shelters are sited with the possibility of such extensions in view. Trench shelters may be so arranged that they come between the rows of stanchion bases or footings of possible building extensions and, by keeping the tops of the trench linings at a suitable depth below the proposed floor level, the shelters need not interfere with the floor layout, or shelters may be so arranged as to form a part of the basement of a future extension. Emergency exits from the shelters would be arranged in the form of manholes or trap-doors set at the level proposed for the new buildings.

It is required in paragraph 8 of Part I that all persons shall be able to reach their places in shelters within a period of 7 minutes. This maximum time has been fixed with a view to meeting difficulties which may exist in exceptional cases, and should not be regarded as a standard as it is of the utmost importance that shelters should be near at hand, so that they can be occupied quickly, with safety, and with the least possible disturbance of production. There is very little likelihood of the shelters being more vulnerable on account of their proximity to buildings, provided they are sufficiently far removed to avoid risk of being buried under debris in the event of collapse, and the advantage of ease of access outweighs any possible disadvantage of greater vulnerability. The shelters should, however, be kept at a safe distance (preferably at least half the height of the structure) from high buildings, chimney-stacks, water-towers, etc., so that in the event of a collapse of any part of these structures the shelters will not be damaged.

Drainage is important, and wherever possible shelters should be constructed on the higher part of the site, or on a slope so that they can be drained naturally. Surface shelters of the type prescribed in the Code afford protection at least equal to that provided by semi-sunk or sub-surface shelters, and this consideration should be borne in mind when deciding upon the type of shelter to be provided, as except in very dry soils, the latter types are subject to dampness or flooding, conditions which are very difficult to remedy once they have occurred.

For trench shelters there should be a clear space between shelters of not less than 25 feet in any direction, but 40 to 50 feet clear space, or as much more as may be possible, is to be preferred where the site permits.

Notes on the Construction of Shelters Within Buildings.

Buildings are often situated in congested areas with no vacant ground available. It then becomes necessary to provide shelters for the personnel inside the building. The buildings are often constructed with masonry walls much cut away by window openings, with cast iron columns, and with beams housed tightly into cast iron caps on the columns. This form of construction is ill adapted to withstand the shock from a near-by explosion, and there is the possibility to be faced that debris loads on shelters in the lower part of the building may be abnormally heavy. The best form of shelter in such a case would be a trench or tunnel under the ground floor of the building, provided the soil conditions would permit of excavation without risk of disturbance of heavily loaded foundations. Where the soil conditions are unfavourable, it will probably be necessary to provide shelter on the ground floor by erecting adequate walls and a roof slab over supported independently of the existing building, and using the most suitable part of the building for the purpose. Generally speaking, the most suitable part would be the corners of the building, as providing ease of access and exit and a degree of dispersal of personnel. Alternatively surface shelters may be erected inside the building, specially designed to withstand the possible heavy debris load.

There are thus three general methods of providing shelter within a building.

(*a*) *Trenches beneath Floors.*

The system of constructing trenches beneath the floors provides good protection, and is suitable for adoption in some buildings where there is no unoccupied ground available or where, owing to the vital character of the work on which the employees are engaged, it is imperative, in order to avoid serious dislocation, that they should have shelter accommodation as near the scene of their normal activities as possible. It offers the advantage that alterations to the structure of the buildings are reduced to a minimum. Cases occur, particularly where buildings are situated on a sloping site and when floor levels vary, where it would be possible to tunnel on one level beneath the concrete floor on a higher level, entrances being formed at either end, one giving access to the floor of the building and the other to the open. The tunnels should be kept well clear of stanchion bases, etc. In peace time, such tunnels could be used as store rooms or cycle-sheds.

The trench shelters should be distributed throughout the building, and should be placed between the lines of stanchions so that they do not interfere with the footings and foundations. They can be placed conveniently between the rows of machines, and must be constructed to have a cover giving the standard overhead protection laid down in Part I, and strong enough to withstand debris from the superstructure. Like trench or tunnel shelters outside buildings they should, wherever possible, be spaced at least 25 feet apart. Access to them should be from the workshop floor, and an emergency exit should be provided clear of the building. As this exit is only for emergency use, it need not be of large dimensions, and a pipe 2 ft. 9 in. in diameter, as a "crawl away," and leading to a manhole, would serve the purpose. The emergency exit would also assist in ventilating the trench.

(*b*) *Shelters provided by adaptation of existing accommodation.*

Where it is proposed to make a shelter within a building, either in a basement or at or above ground level, it is necessary to ensure that the floor over the shelter is adequate to support the fall of debris consequent on the demolition of the superstructure; but where there is not a substantial building structure above the shelter, it is also necessary to ensure that the floor immediately over the shelter provides the minimum overhead protection indicated in Part I. There may be cases where existing floors are sufficiently strong to support the debris loading, but in the majority of buildings it may be expected that some strengthening of floors will be required. The strengthening required should be investigated in each case, but must at least be based on the rules for estimation of debris loads and carried out in accordance with the instructions laid down in Part I of this Code, realising that the rules are arbitrary and that buildings must be treated as special cases where any abnormal features exist.

Care should be exercised in the proper positioning of the struts. This is particularly so in the case of reinforced concrete floors, jack arch floors, etc., since struts incorrectly placed may seriously alter the stress distribution in the various members with the result that the floor may be weakened instead of strengthened.

Care should also be taken to ensure that the walls of the shelter are made to afford the standard of lateral protection indicated in Part I of this Code.

If the building has a reinforced concrete or encased steel frame, with floors designed for heavy loads, and external walls of panel construction supported by the frame, any part of the centre of the building at basement or ground floor level would be very suitable for the provision of a shelter, and it will be necessary only to ensure that the lateral and overhead protection is up to the required standard.

(*c*) *Specially constructed Shelters within the building.*

In some cases it may be found convenient to erect independent surface shelters within the building. Such shelters must conform in all respects with the requirements for surface shelters as laid down in Part I of this Code.

Entrances to and Exits from Shelters.

Entrances to shelters and passages giving access to them, should be constructed with a view to ease of access.

It is estimated that about 50 persons per minute can pass through an opening 2 feet wide, and this basis should be adopted in calculating the provision to be made for the occupation of shelter within a given time. In the case of the larger shelters it is desirable that all the entrances should be at least 2 feet 6 inches wide to permit the convenient passage of a stretcher.

Rules for the provision of emergency exits are laid down in paragraph 9, Part I. The principle which should be observed is that the entrances and exits of shelters should be so constructed as to diminish the likelihood of all being blocked by debris in the event of the collapse of building structures above the shelter. Where it is not practicable to provide emergency exits clear of the area which might be covered by debris it may in some cases be expedient to provide alternative exits in excess of the minimum required in paragraph 9, Part I, and as widely separated as possible. In basement shelters in closely built-up neighbourhoods it may be desirable to form emergency exits into adjacent basements. In such cases the basements on either side of the opening should be cleared of combustible materials. If openings are made in party walls, or fire division walls, they should be protected by self-closing fire-resisting doors to the requirements of the local authority normally controlling building in any locality. Alternatively such openings can be made without any danger of spread of fire between adjoining buildings by forming the openings, inserting suitable lintels over, and blocking each opening with brickwork 13½ inches thick, laid in wet sand with the external joints only pointed in cement mortar. The position of each emergency exit should be clearly marked on both sides of the wall and suitable tools provided in the shelter for breaking through in emergency.

Notes on the Ventilation of Shelters.

Rules are given in Part I for the number of persons who may be accommodated in various kinds of shelter with various conditions of ventilation.

The comfort of the occupants of a shelter depends to a certain extent on the degree of ventilation, *i.e.*, the rate at which the air is removed and replenished, but to a much more important extent on the rate at which the bodily heat of the occupants is removed. Thus a greater degree of discomfort results from a rapid rise in the temperature of the shelter than from the vitiation of the air.

The dissipation of the body heat emanating from the occupants may take place mainly in two ways; by its absorption by the structure of the shelter, and by the removal of the heated air by ventilation.

Where there is not an efficient system of natural or mechanical ventilation (and it must be remembered that when a shelter is "gas-proofed" the natural system is put out of action) conduction must be relied upon to rid the shelter of superfluous heat. For this reason the heat absorption capacity of the walls, floor and roof of a shelter is an important factor in the determination of the permissible accommodation. The trench shelter—with its sides and floor in intimate contact with the earth and with an adequate earth cover—is good in this respect, provided the floor and lining of the trench shelter be constructed of a material which is a good heat conductor such as dense concrete in direct contact with the earth. In the absence of sufficient ventilation, the necessity for the conduction of the internal heat to the earth cannot be over-emphasised and it is rarely advisable to cover the lining and floor with heat-insulating materials. If wood flooring is to be used, it should be in the form of open moveable grids so that the atmosphere can come into direct contact with the cold surface of the concrete below.

There are two main conditions of ventilation for shelters to be considered. The shelters may be entirely sealed for the duration of an air raid against the possible entry of gas, by air-tight doors and with air-locks at the entrances. In such cases it may be useful to provide mechanical ventilation, with some form of manual or pedal operation as an alternative to the normal power supply which might fail in an emergency. With gas-tight, mechanically ventilated shelters, it is important that the incoming air should pass through a filtration unit capable of removing war gases and, as an additional safeguard, the air inlet may be situated at a high level. With sealed shelters, not mechanically ventilated, it is necessary to limit the number of occupants.

In the second condition shelters will not normally be sealed against gas and their entrances and exits will be left open whilst they are occupied. Should gas be released