

**Wall Structure for Civil Defense Shelter and
A Method of Making A Wall Structure and A Civil Defense Shelter**

Field of the Invention

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The present invention relates to a wall structure for a civil defense shelter, and a method of making a wall structure and a civil defense shelter and refers particularly though not exclusively, to such a wall structure, shelter and method using pre-cast concrete sections.

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Background to the Invention

Shelters such as civil defense shelters are being constructed as an integral part of constructions, including multi-storey constructions, be they blocks of apartments, condominiums, or houses. By multi-storey it is meant more than one storey. These shelters provide a refuge for occupants of the apartment, condominium or house in the even of a threatening situation. This maybe an attack (e.g. war); natural disaster such as earthquake or hurricane; or an attempted assault on those persons by thieves, murders or the like.

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Such shelters are normally constructed of reinforced concrete to give the necessary strength. Also for strength reasons they have the side walls (normally four as they are normally square or other rectangular shape) made integrally by a continuous pour of concrete as that is generally seen as providing a stronger structure than a joined structure. As a continuous pour they are either made on site, or made off-site as a pre-cast structure. They are then transported to the site and placed in position by cranes.

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The cranes required for such a task will require a lifting capacity of at least ten tonnes. Many building sites use cranes with a lifting capacity of only five tonnes. In those cases, the shelter must be constructed on site.

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Either way, increased costs, and/or increased construction time, can result.

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It is therefore the principal object of the present invention to provide a civil defense shelter manufactured using a plurality of pre-cast concrete sections.

A final object of the present invention is to provide a pre-cast concrete section for a civil defense shelter that is of reduced weight to assist ease of transport, and lifting by cranes.

5 Summary of the Invention

With the above and other objects in mind, the present invention provides a wall structure for a civil defense shelter to be formed as part of a building; the wall structure comprising a plurality of pre-cast concrete sections which, when joined, form the wall
10 structure.

The sections may be substantially identical and/or generally L-shaped. There may be any number of sections, but preferably there are two sections.

15 Each of the sections has a first end and a second end, each of the first and second ends having a concave indent to form a shear key. The sections may be joined together to form the wall structure using wet joints.

Each section may include a plurality of vertically-extending tubes, each tube being for
20 forming a void, the voids being filled with concrete subsequent to installation of the sections.

The tubes preferably have an outer surface for bonding with the concrete of the sections. This may be, for example, corrugated iron.

25 Reinforcing may be placed in the voids prior to them being filled with concrete, and the tubes may be spaced apart and generally parallel. They preferably extend from an upper edge of the sections to a lower edge of the sections.

30 In another form the present invention provides a wall structure for a civil defense shelter to be formed as part of a building; the wall structure comprising at least one pre-cast concrete wall having a plurality of vertically extending tubes permanently embedded therein, each tube being for forming a void in the wall structure, the voids being filled with concrete subsequent to installation of the wall structure.

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Preferably the tubes have an outer surface for bonding with the concrete of the wall, reinforcing is placed in the voids prior to them being filled with concrete. They preferably extend from an upper edge of the sections to a lower edge of the sections.

- 5 The present invention also extends to a civil defense shelter constructed using a wall structure described above. The building may be a multi-storey building, or may be a single storey building.

10 In a further form, the present invention provides a method of forming a civil defense shelter as part of a building, the method including the steps of:

- a. casting at a site remote from the building a plurality of pre-cast concrete sections which, when joined, form a wall structure;
- b. transporting the plurality of pre-cast concrete sections to a construction site and installing them in the building at a desired location;
- 15 c. joining the plurality of pre-cast concrete sections to form the wall structure; and
- d. casting a roof structure over the wall structure.

20 Preferably, the casting of the roof structure is by placing a pre-cast concrete half slab over the wall structure to form a first part of a roof structure; and casting a remaining part of the roof structure. Alternatively, it may be by casting the roof structure in situ.

The sections may be substantially identical and/or generally L-shaped. There may be any number of sections such as, for example, two sections.

25 Each section may have a first end and a second end, each of the first and second ends having a concave indent for form a shear key. The sections may be joined together to form the wall structure using wet joints.

30 Each section may include a plurality of vertically-extending tubes, each tube being for forming a void, the voids being filled with concrete subsequent to installation of the sections.

The tubes may have an outer surface for bonding with the concrete of the sections.
35 For example, the tubes may be made of corrugated iron. Reinforcing may be placed in the voids prior to them being filled with concrete; and the tubes may be spaced

apart and generally parallel. The tubes preferably extend from an upper edge of the sections to a lower edge of the sections.

In another form, the present inventions provides a method of forming a civil defense shelter as part of a building, the method including the steps of:

- 5 a. casting at a site remote from the building a plurality of pre-cast concrete sections which, when joined, form a wall structure;
- b. the sections including a plurality of vertically extending tubes, each tube forming a void therein;
- 10 c. transporting the plurality of pre-cast concrete sections to a construction site and installing them in the building in a desired location;
- d. joining the plurality of pre-cast concrete sections to form the wall structures;
- e. filling the voids with concrete; and
- f. casting a roof structure over the wall structure.

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Preferably, the casting of the roof structure is by placing a pre-cast concrete half slab over the wall structure to form a first part of a roof structure; and casting a remaining part of the roof structure. Alternatively, it may be by casting the roof structure in situ.

- 20 Preferably the tubes have an outer surface for bonding with the concrete of the sections. For example, the tubes may be made of corrugated iron.

Reinforcing may be placed in the voids prior to them being filled with concrete and/or the tubes are spaced apart and generally parallel.

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Finally, the present invention provides a civil defense shelter as part of a building when built by the method as described above. The building may be a single storey building or a multi-storey building.

30 Description of the Drawings

In order that the present invention may be better understood and readily put into practical effect there shall now be described by way of non-limitative example only preferred embodiments of the present invention, the description being with reference

35 to the accompanying illustrative drawings in which:

Figure 1 is an isometric view from above and the front of a preferred form of a first embodiment;

Figure 2 is a horizontal cross-sectional view along the lines and in the direction of arrows 2-2 on Figure 1;

Figure 3 is an enlarged view of a typical joint of Figures 1 and 2;

Figure 4 is an isometric view corresponding to Figure 1 but of a second embodiment;

Figure 5 is a cross-sectional view along the lines and in the direction of arrows 5-5 on Figure 4; and

Figure 6 is a vertical cross-sectional view along the lines and in the direction of arrows 6-6 on Figure 4.

Description of the Preferred Embodiments

To first refer to Figures 1 to 3, there is shown a shelter having four mutually perpendicular walls 10, 12, 14, and 16. These are a rear wall 10, front wall 12 having a door opening 18, and side walls 14, 16 extending between and joining walls 10, 12. Although the shelter is shown as being rectangular it may be of any shape (in plan view) including, but not limited to, round, elliptical, square, rectangular, pentagon, hexagon, octagon, or other polygonal shape. These shapes may be regular, or irregular. The only basic requirements is for it to be closed-sided when completed, have no glazed windows, and to have a door opening. It may have one or more ventilation openings 70.

The shelter has the four walls 10, 12, 14 and 16 made in two similar sections 20, 22. In this instance the sections 20, 22 are generally L-shaped in plan, but may be of any suitable shape that combine to form an almost complete wall structure. For example, two U or C-shaped sections would work equally as well.

In this case the two sections 20, 22 are substantially identical, apart from door opening 18. However, they may be different, if desired. Each wall 10, 12, 14, 16 may have at least one integrally-formed foot 24 that is sized and located to enable the sections 20, 22 to be able to stand on the feet 24 such that a lower edge 26 of each section 20, 22

is the correct distance above a lower surface with which the shelter is to be integrated. In this way the lower edges 26 of the two sections 20, 22 correctly align, as do the upper edges 28. However, the sections 20, 22 may also be formed without feet 24 if desired or required (see Figure 4).

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From both the upper edges 28 and lower edges 26, reinforcing bars 30 extend and are bent inwardly, so that when a floor and roof are formed they integrate with the wall sections 20, 22.

10 The section 20, 22 require the joints 42 between them to be closed. This is preferably by a wet joint 42, although any other joining technique may be used. Each wall section 20, 22 has a first end 32 and a second end 34 from each of which extend reinforcing bars 36 formed into a loop 40. When second end 34 is placed adjacent first end 32, loops 40 of second end 34 are closely adjacent to and are preferably
15 vertically and/or horizontally aligned with loops 40 of first end 32. Additional, closed loops 38 are placed above and overlapping with loops 40 so that when wet joint 42 is formed, the concrete of wet joint 42 will bond with ends 32, 34, reinforcing bars 36, and loops 38, 40 to thus form a strong, secure joint. Each end 32, 34 may have a concave indent 58 to form a shear key, if desired.

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In this way wall sections 20, 22 can be formed off-site, transported to the construction site to arrive when and as required, be lifted into position using standard cranes, formwork placed in position for the roofs, floors and joints 32, and concrete poured to form the roofs, floors and joints 42 to thus form the complete shelter. For multi-storey
25 structures, the floor of a higher storey forms the roof of the shelter. For multi-storey apartment blocks, the shelters would be vertically aligned so that the floor of one shelter is the roof of the shelter beneath it.

As shown in Figure 6, each floor/roof 44 in a multi-storey structure has one or more
30 pre-cast slabs 46 that rests on upper edge 28 of sections 20, 22 with there being a relatively small area of overlap 48. The remainder portion 50 of floor/roof 44 is cast in situ. In this way, if sections 20, 22 have feet 24, the feet 24 of an upper wall 14a can rest on upper edge 28 of lower wall 14b with both upper and lower reinforcing bars 30 extending inwardly into portion 50 to provide an integrated structure. If sections 20, 22
35 do not have feet 24, the lower edges 26 may rest directly on upper edges 28. Alternatively, a form of separate spacing device (not shown) may be used. The floor/roof 44 may be formed at the same time as joints 42, or may be cast separately.

Alternatively, the floor/roof 44 may be cast in situ without a pre-cast slab 46. The floor/roof 44 may be formed at the same time as joints 42, or may be cast separately.

5 In Figures 4 and 5 there is shown a second embodiment intended to reduce the transported weight of sections 20, 22. Here, in each wall 10, 12, 14, 16 are embedded hollow tubes 50. The tubes 50 are vertically extending spaced apart and generally parallel. Each tube 50 preferably extends from lower edge 26 through to upper edge 28. The walls 10, 12, 14, 16 are cast around tubes 50. The tubes 50 may be of any
10 suitable size, shape or material such that a void 52 is formed within tube 50, and the concrete 54 of walls 10, 12, 14, 16 bonds to the external surface 56 of tubes 50. Preferably, the internal surface of the tubes 50 is also such that concrete will bond to the internal surface. As shown, the tubes 50 are made of corrugated iron. By using corrugated iron the concrete will bond to both the external and internal surfaces. In
15 this way the tubes 50 remain permanently in walls 10, 12, 14, 16 and are not removed to form voids 52. This avoids the tedious, and time consuming, task of remaining formwork used to create voids 52 as has been done in the past. Due to the bonding of the concrete with the internal and external surfaces of tubes 50, there is no loss of strength.

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As the volume of voids 52 is not insubstantial, the transported weight of sections 20, 22 will be considerably reduced even though tubes 50 remain in each sections 20, 22 for the life of the section.

25 When the sections 20, 22 are transported and installed at a desired location of a building on site, appropriate reinforcing 60 is placed in each void in an appropriate manner, and as is required. The reinforcing may include, for example, lapping bars which maybe appropriately connected to similar reinforcing above and/or below sections 20, 22. The tubes can then be filled with concrete in the usual manner. This
30 may be at the same time as forming joints 42, or the concrete may be poured separately.

In this way, the sections 20, 22 as cast are significantly lighter than without the tubes 50. This means they need smaller lifting capacity cranes to lift them at the casting site
- 35 and at the construction site, the vehicles to transport them are of a lower capacity, and they are more easily handled. The strength of a shelter formed using the tubes 50 is

not reduced to any significant extent. As such, the overall cost to the building developer is reduced.

5 Similarly by using the two sections 20, 22 the building developer can have the pre-cast section arrive at the construction site when and as required. This reduces the overall construction cost (and time) for the building developer.

10 Whilst there have been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology that many variations or modifications in details of design or construction may be made without departing from the present invention.

The present invention extends to all features disclosed herein, individually and in all possible combinations and permutations.

The claims:

1. A wall structure for a civil defense shelter to be formed as part of a building the wall structure comprising a plurality of pre-cast concrete sections which, when joined, form the wall structure; each section including a plurality of vertically-extending tubes, each tube being for forming a void, the voids being filled with concrete subsequent to installation of the sections.
2. A wall structure as claimed in claim 1, wherein the sections are substantially identical.
3. A wall structure as claimed in claim 1 or claim 2, wherein the sections are generally L-shaped.
4. A wall structure as claimed in any one of claims 1 to 3, wherein there are two sections.
5. A wall structure as claimed in any one of claims 1 to 4, wherein the sections each has a first end and a second end, each of the first and second ends having a concave indent to form a shear key.
6. A wall structure as claimed in any one of claims 1 to 5, wherein the sections are joined together to form the wall structure using wet joints.
7. A wall structure as claimed in any one of claims 1 to 6, wherein the tubes have an outer surface for bonding with the concrete of the sections.
8. A wall structure as claimed in any one of claims 1 to 7, wherein the tubes have an inner surface for bonding with concrete.
9. A wall structure as claimed in any one of claims 1 to 8, wherein the tubes are made of corrugated iron.
10. A wall structure as claimed in any one of claims 1 to 9, wherein reinforcing is placed in the voids prior to them being filled with concrete.

11. A wall structure as claimed in any one of claims 1 to 10, wherein the tubes are spaced apart and generally parallel.
12. A wall structure as claimed in any one of claims 1 to 11, wherein each of the tubes extends from a lower edge of the section to an upper edge of the section.
13. A wall structure for a civil defense shelter to be formed as part of a building; the wall structure comprising at least one pre-cast concrete wall having a plurality of vertically extending tubes permanently embedded therein, each tube being for forming a void in the wall structure, the voids being filled with concrete subsequent to installation of the wall structure.
14. A wall structure as claimed in claim 13, wherein the tubes have an outer surface for bonding with the concrete of the wall.
15. A wall structure as claimed in either claim 13 or claim 14, wherein the tubes have an inner surface for bonding with concrete.
16. A wall structure as claimed in any one of claims 13 to 15, wherein the tubes are made of corrugated iron.
17. A wall structure as claimed in any one of claims 13 to 16, wherein the tubes are spaced apart and generally parallel.
18. A wall structure as claimed in any one of claims 13 to 17, wherein each of the tubes extends from a lower edge of the section to an upper edge of the section.
19. A wall structure as claimed in any one of claims 13 to 18, wherein reinforcing is placed in the voids prior to them being filled with concrete.
20. A wall structure as claimed in any one of claims 1 to 19, wherein the building is a multi-storey building.
21. A civil defense shelter constructed using a wall structure of any one of claims 1 to 20.

22. A method of forming a civil defense shelter as part of a building, the method including the steps of:
 - (i) casting at a site remote from the building a plurality of pre-cast concrete sections which, when joined, form a wall structure; each section including a plurality of vertically-extending tubes, each tube being for forming a void;
 - (ii) transporting the plurality of pre-cast concrete sections to a construction site;
 - (iii) installing the plurality of pre-cast concrete sections in the building at a desired location;
 - (iv) filling the voids with concrete subsequent to installation of the sections.
 - (v) joining the plurality of pre-cast concrete sections to form the wall structure; and
 - (vi) casting a roof structure over the wall structure.
23. A method as claimed in claim 22, wherein the roof structure is cast in situ.
24. A method as claimed in claim 22, wherein the roof structure is cast by placing a pre-cast concrete half slab over the wall structure to form a first part of a roof structure; and casting a remaining part of the roof structure.
25. A method as claimed in any one of claims 22 to 24, wherein the sections are substantially identical.
26. A method as claimed in any one of claims 22 to 25, wherein the sections are generally L-shaped.
27. A method as claimed in any one of claims 22 to 26, wherein there are two sections.
28. A method as claimed in any one of claims 22 to 27, wherein the sections each has a first end and a second end, each of the first and second ends having a concave indent for form a shear key.

29. A method as claimed in any one of claims 22 to 28, wherein the sections are joined together to form the wall structure using wet joints.
30. A method as claimed in claim 29, wherein the tubes have inner and outer surfaces for bonding with the concrete of the sections.
31. A method as claimed in either claim 29 or claim 30, wherein the tubes are made of corrugated iron.
32. A method as claimed in any one of claims 29 to 31, wherein reinforcing is placed in the voids prior to them being filled with concrete.
33. A method as claimed in any one of claims 29 to 32, wherein the tubes are spaced apart and generally parallel.
34. A method as claimed in any one of claims 29 to 33, wherein each of the tubes extends from a lower edge of the sections to an upper edge of the sections.
35. A method of forming a civil defense shelter as part of a building, the method including the steps of:
 - (i) casting at a site remote from the building a plurality of pre-cast concrete sections which, when joined, form a wall structure; the sections including a plurality of vertically extending tubes, each tube forming a void therein;
 - (ii) transporting the plurality of pre-cast concrete sections to a construction site;
 - (iii) installing the plurality of pre-cast concrete sections in the building at a desired location;
 - (iv) joining the plurality of pre-cast concrete sections to form the wall structure;
 - (v) filling the voids with concrete; and
 - (vi) casting a roof structure over the wall structure.
36. A method as claimed in claim 35, wherein the roof structure is cast in situ.

37. A method as claimed in claim 35, wherein the roof structure is cast by placing a pre-cast concrete half slab over the wall structure to form a first part of a roof structure; and casting a remaining part of the roof structure.
38. A method as claimed in claim 37, wherein the tubes have an inner and an outer surface for bonding with the concrete of the sections.
39. A method as claimed in claim 37 or claim 38, wherein the tubes are made of corrugated iron.
40. A method as claimed in any one of claims 37 to 39, wherein reinforcing is placed in the voids prior to them being filled with concrete.
41. A method as claimed in any one of claims 37 to 40, wherein the tubes are spaced apart and generally parallel.
42. A method as claimed in any one of claims 37 to 41, wherein each of the tubes extends from a lower edge of the sections to an upper edge of the sections.
43. A method as claimed in any one of claims 22 to 42, wherein the building is a multi-storey building.
44. A civil defense shelter as part of a building when built by the method of any one of claims 22 to 43.