A method of manufacturing precast concrete units (C), such as prison cells, culverts, lift shaft or staircase sections or the like, employs a main frame (10) to which side and/or end wall panels (87, 52, R & F) are hingedly connected. The wall panels (51, 52, R & F) are cast in the horizontal moulds (20-23) and when the concrete is cured, the moulds (20-23) are raised to a vertical position, where the panels (51, 52, R & F) are supported by internal and external corner forms (13, 14, 24-27), to enable connection and grouting to each other and floor or roof panels (CF). The main frame (10) is retracted and the completed unit (C) is lifted free and the cycle is repeated.
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1

TITLE: "METHOD OF MANUFACTURING PRECAST CONCRETE
UNITS"

BACKGROUND OF THE INVENTION

1. Field of the Invention

THIS INVENTION relates to a method of
manufacturing precast concrete units. The concrete
units include prison cells, lift shafts, stairwells,
culverts and other building structures.

2. Prior Art

Until now, the manufacture of concrete cells
and associated products has been confined to:

(i) in situ poured concrete cells; or
(ii) factory precast cells transported to the
construction site.

With in situ casting, it has always been
difficult to pour concrete vertically into the thin
walls and to fix the reinforcement vertically, and
quality control is difficult to maintain.

With factory precasting, quality control is
improved, but transport is difficult and expensive, and
labour costs for connection of the precast components
together may be high.

In the factory, cast precast cells employ
vertical casting of the walls by using formwork similar
to that used in situ on the construction site.

Attempts have been made to use a form box
which was poured with concrete from the top, the box was
inverted and the box stripped from the cell. The
resultant cell was open on one side. This method
required vertical casting of the walls; doors and
windows were difficult to accommodate; a large crane was
required to lift the form box with the concrete; high
roof clearance in the factory was necessary; and the
method was labour-intensive. Its one advantage was
three-dimensional alignment of the cell.
An alternative method has been to cast the walls horizontally in individual moulds and then bring them together for connection to the floor and/or roof. The panels must be separately lifted from their moulds and located; the panels must not be exposed to any loads before the concrete is cured; and three-dimensional alignment is difficult (if not impossible), being time-consuming and expensive and so not a practical method.

**SUMMARY OF THE INVENTION**

It is an object of the present invention to provide a method which obviates and/or mitigates the disadvantages of the prior art.

It is a preferred object to provide a method which provides factory precasting quality control on the construction site.

It is a further preferred object to provide a method which enables the casting of thick or thin walls horizontally.

It is a further preferred object to provide a method which has a high cycle rate whilst maintaining accuracy, all the components being aligned in all three dimensions when simultaneously raised for assembly.

It is a still further preferred object to provide a method which eliminates difficult vertical reinforcements and castings, and which avoids exposure of the cast components to handling loads.

Other preferred objects will become apparent from the following description.

In one aspect, the present invention resides in a method of manufacturing precast concrete units including the steps of:

(a) erecting a main frame as a datum;
(b) operably connecting one or more side and/or end wall moulds to the main frame, the moulds being movable between respective horizontal and vertical
positions;

(c) casting concrete components, incorporating any reinforcements, in the moulds in their horizontal positions;
(d) raising and supporting the moulds in their vertical positions;
(e) interconnecting the concrete components and any reinforcements;
(f) lowering the moulds to their horizontal positions; and
(g) lifting the assembly of concrete components from the main frame.

BRIEF DESCRIPTION OF THE DRAWINGS
The main frame may include mould means for the casting of a floor section, or be arranged to support a precast roof section lifted onto the main frame for connection to the precast concrete side and/or end walls.

Preferably, the length and/or width of the main frame is selectively adjustable to assist in the assembly being lifted from the main frame.

Preferably, the moulds are hingedly mounted to the base of the main frame and may be simultaneously raised to their vertical positions when lifted by a crane or by hydraulic jacks.

Preferably, all of the moulds are lifted simultaneously.

Preferably, any reinforcing steel is laid in the moulds before the concrete is poured, and the reinforcing may extend from the sides of the moulds to enable operable connection to the reinforcing of adjacent cast components.

Preferably, the moulds are supported in their vertical position by removable internal and/or external corner props.
After the moulds have been lowered and the joints between the concrete components are grouted and allowed to cure, the supports for the moulds are then retracted.

The assembled concrete components, eg. cell, lift shaft section may be lifted from the main frame by a crane.

In a second aspect, the present invention resides in apparatus for manufacturing precast concrete units including:

- a main frame;
- at least one side and/or end wall mould operably connected to the main frame and movable between respective horizontal and vertical positions, concrete (and any reinforcing) being cast in the moulds in the horizontal position;
- means to raise the moulds to their vertical positions;
- means to support the moulds in their vertical positions;
- means to lower the moulds to their horizontal positions; and
- means to lift the assembly of concrete components from the main frame.

To enable the invention to be fully understood, a number of preferred embodiments will now be described with reference to the accompanying drawings, in which:

- FIG 1 is a schematic view showing alignment of the cell relative to three axes;
- FIGS 2 to 8 are schematic views of the cycle for the casting of a cell;
- FIG 9 is a schematic view of the casting of a culvert;
- FIG 10 is a schematic view of the casting of a
lift shaft or stairwell section;

FIG 11 is a plan view of the base frame and side and end wall moulds;
FIG 12 is a side elevational view of a typical side frame;
FIG 13 is a plan view of the top frame;
FIG 14 is a plan view of the side and rear corner hinges;
FIG 15 is a sectional end view of a side wall hinge;
FIG 16 is a sectional end view of a rear wall hinge;
FIG 17 is a sectional end view of the rear wall mould;
FIG 18 is a side view of a typical prop arrangement at a corner of the main frame; and
FIG 19 is a plan view of detail A on FIG 18.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG 1 shows a cell C where accurate alignment is required with three orthogonal axes X, Y, Z. As will be readily apparent to the skilled addressee, even very small misalignments x, y, z on any of the axes X, Y, Z will prevent accurate casting and/or assembly of the cell C and so the present invention is directed to accurate casting and movement of the panels so that when brought together, the panels will be accurately aligned relative to the three axes X, Y, Z.

Referring now to FIGS 2 to 8, the main frame 10 is mounted on supports (to be hereinafter described) to provide an accurate datum, in three axes, for the concrete components being cast. The main frame 10 has a base frame 11, top frame 12, two side frames 13 and two end frames 14, which are adjustable to enable the main frame 10 to be "collapsed" to enable the assembled cell
(see FIG 7) to be lifted therefrom.

In the embodiment illustrated in FIGS 2 to 8, the cell C is to be cast with side walls 51 and 52, a rear wall R, a front wall (with doorway) F, and a roof RF, which will provide the floor and walkway for a similar cell C superimposed on it. Where this cell C is to be used on a lower storey of a two-storey construction, the side, front and rear walls will be anchored to an in situ cast concrete floor. If used as the upper storey, the walls will be anchored to the roof R of the cell C on which it is superimposed. It will be noted in FIG 2 that the doorway and barred window are cast integrally into the front and rear walls F, R.

Internal corner forms 15-18 are moved outwardly into engagement with the top frame 12, supported by adjustable props 19.

Moulds 20-23 are hingedly mounted on the base frame 11 (as hereinafter described) to enable the casting of the side walls S1, S2, front wall F and rear wall R respectively. As shown in FIG 2, they are laid in their respective horizontal positions, suitable reinforcing steel is laid therein and concrete is poured into the moulds.

When the concrete has cured, the moulds are simultaneously brought to the vertical position (lifted by a crane 100). The cast wall panels S1, S2, F and R (see FIG 4) are clipped to the main frame 10 and the moulds 20-23 are returned to their horizontal positions and are prepared for the next casting cycle.

External corner forms 24-27, mounted on adjustable props 28, 29, are brought into place to engage the external corners of the adjacent wall panels (see FIG 5) and the clips 30 are removed.

The roof panel RF, which has been cast simultaneously in a separate mould 31, is lifted into
position (eg. by a crane) (see FIG 6) and is placed on the top support frame 12.

All of the corner joints (between the adjacent wall panels S1, S2, F and R, and the roof panel RF) are grouted and the grout is allowed to cure.

The internal corner frames 15-18 are retracted, the top frame 12 is retracted, and the external corner frames 24-27 are retracted (see FIG 7) to enable the completed cell C to be lifted free (see FIG 8). The cycle is now ready to be repeated.

FIG 9 shows the arrangement for a culvert CU which has side walls S1, S2 and a roof RF only, while FIG 10 shows a lift shaft or stair well section 25 which has side walls S1, S2, front wall F and rear wall R. This section can be superimposed on a similar section and so a lift shaft or stairwell can be erected without the difficulties of in situ casting. As the wall panels are accurately dimensional and aligned, installation of the facilities therein (eg. the lift rails) will be simplified.

Referring to FIG 11, the main frame 10 is shown in plan view with the moulds 20-23 laid horizontally and hingedly mounted on the base frame 11, the hinged interconnection being described hereinafter with reference to FIGS 14-16. The main frame 11 has a perimeter frame formed by parallel side and end beams 11A, 11B interconnected by cross-beams 73 and joists 73A.

As hereinbefore described, the moulds 20-23 (and panels therein) are raised from their horizontal positions shown to their vertical positions in a single lift by crane 100 or by respective hydraulic jacks (not shown) connected to a single hydraulic pump and control unit.

Referring now to FIG 12, a side support frame
13 has a base beam 40 which forms a portion of the perimeter of the base frame 11. A plurality of adjustable props 41 are hingedly mounted on the base beam 40 via suitable hinge assemblies 42, the props 41 incorporating turnbuckle or hydraulic jack assemblies 43 to enable their height to be adjustably set. A top beam 44 which forms a portion of the periphery of top frame 12, is connected to the upper ends of the props 41. The props 41 are braced by horizontal and diagonal braces 45, 46.

Vertical side legs 47, 48 are welded to the base beam 40 and support the assembled cell C when the props 41 are retracted.

Referring now to FIG 13, the top frame 12 is supported on the vertical props 41 of the side frames 13 (and end frames 14) and has side beams 44 and end beams 49 interconnected by respective pairs of adjustable horizontal props 50, 51 (with turnbuckle or hydraulic jack assemblies 52, 53), the props 50, 51 being vertically offset.

A top framing plate 54 is provided at each corner of the top frame 12.

Referring to FIGS 14 to 17, the main frame 10 has its base frame 11 mounted on adjustable legs 55 which may be anchored in (see FIG 13), or bolted to (see FIG 14), suitable concrete footings 56 which have been accurately located. The moulds 20-23 are hingedly mounted on the base frame 11. Each mould has, at each end thereof, a pair of parallel clevis plates 60, 61 interconnected by a pin 62, which passes through the web 63 of respective hinge mounting plates 64 fixed to the beams 11A, 11B of the base frame 11. The pins 62 define accurate axes of rotation of the moulds 20-23 relative to the side and end frames 13, 14 so that the wall panels S1, S2, F and R will be accurately aligned when
the moulds are raised to their vertical positions.

The moulds 20-23 are provided with lifting hooks 66 to enable them to be engaged by suitable cables or chains or a crane, and legs 67, similar to the legs 55 provided to support the moulds horizontally while the concrete is being poured.

Referring now to FIGS 18 and 19, the internal corner forms 15-18 and external corner forms 24-27 support the panels after the moulds 20-23 have been returned to their horizontal positions, and while the joints are grouted and allowed to cure.

Each inner form 15 to 18 has a vertical corner plate 70, of L-section in plan view, faced with a hard rubber panel 71. A horizontal, adjustable prop 72 is hingedly mounted on a beam 73 (or joist 73A) of the base frame 11 and has a turnbuckle or hydraulic jack assembly 74. A diagonal prop 75, also with a turnbuckle or hydraulic jack assembly 76, is hingedly mounted on the beam 73 and is connected to the upper end of the corner plate 70. Both the horizontal and diagonal props 72, 75, have clevises 77 hingedly mounted, via pivot pins 78 to a rearwardly directed web 79 on the corner plate 70 (see FIG 19).

The external corner forms 24-27 also have L-section vertical corner plates 80 faced with hard rubber panels 81 and the adjustable horizontal and diagonal props 82, 83 are connected via clevises 84 and pivot pins 85 to a vertical web 85 on the corner plate 80. Each prop 82, 83 is hingedly mounted on a foot plate 86 which is bolted or otherwise fixed to a footing 87.

By selective adjustment of the props 72, 75 and 82, 83, respectively, the inner and external corner forms 15-18 and 24-27 can be selectively advanced or retracted to release or engage the wall panels S1, S2, F, R. As the panels are under no load, when they are
brought into their vertical positions, they can be cast in very thin sections without difficulty.

Similarly, the adjustment of the props 41, 50 and 51 enable the main frame 10 to be retracted to enable the completed cell C, culvert CU or lift shaft or stairwell section LS to be lifted free of the main frame 10 when completed, the main frame then being "expanded" to enable the casting cycle to be repeated. The cycle time will be dependent on the concrete used (and any accelerators therein), the application of steam, ambient temperature and other factors. It is expected, however, that a cycle rate of 1 cell per day would be easily achieved.

Various changes and modifications may be made to the embodiments described and illustrated without departing from the present invention as defined in the appended claims.
11

CLAIMS:

1. A method of manufacturing precast concrete units including the steps of:
   (a) erecting a main frame as a datum;
   (b) operably connecting one or more side and/or end wall moulds to the main frame, the moulds being movable between respective horizontal and vertical positions;
   (c) casting concrete components, incorporating any reinforcements, in the moulds in their horizontal positions;
   (d) raising and supporting the moulds in their vertical positions;
   (e) interconnecting the concrete components and any reinforcements;
   (f) lowering the moulds to their horizontal positions; and
   (g) lifting the assembly of concrete components from the main frame.

2. A method according to Claim 1 wherein:
   a floor section is cast in mould means at the base of the main frame or a roof section, cast in a separate mould means, is lifted onto, and supported by, the main frame for connection to the side and/or end walls.

3. A method according to Claim 1 or Claim 2 wherein:
   the length and width of the main frame is selectively adjustable to enable inward retraction to enable the assembly to be lifted from the main frame.

4. A method according to any one of Claims 1 to 3 wherein:
   reinforcing steel is laid in the moulds prior to the concrete being cast.

5. A method according to any one of Claims 1 to 4
wherein:

the moulds are supported in their vertical positions by retractable inner and external corner forms.

6. A method according to any one of Claims 1 to 5 wherein:

the moulds are simultaneously raised to their vertical positions by a crane or by hydraulic rams.

7. A method according to Claim 5, and including the further steps:

(fa) grouting the joints between the components and allowing the grout to cure; and

(fb) retracting the inner corner forms from support of the components.

8. Apparatus for manufacturing precast concrete units including:

a main frame;

at least one side and/or end wall mould operably connected to the main frame and movable between respective horizontal and vertical positions, concrete (and any reinforcing) being cast in the moulds in the horizontal position;

means to raise the moulds to their vertical positions;

means to support the moulds in their vertical positions;

means to lower the moulds to their horizontal positions; and

means to lift the assembly of concrete components from the main frame.

9. Apparatus according to Claim 8 wherein:

the main frame has a base frame and the side and end wall moulds are hingedly mounted on the base frame.
10. Apparatus according to Claim 9 wherein:
crane means or hydraulic jacks
simultaneously raise the moulds to their vertical
positions.

11. Apparatus according to any one of Claims 8 to 10 wherein:
the main frame has a top frame mounted on
vertical props of adjustable height, the top frame
having a pair of parallel side members and a pair of
parallel end members interconnected by two or more
horizontal props of adjustable length, the top frame
being retractable to enable the assembly to be lifted
from the main frame.

12. Apparatus according to any one of Claims 8 to 11 wherein:
the means to support the moulds in their
vertical positions include inner corner forms, each
having a corner plate, of L-section in plan view,
mounted on an adjustable horizontal prop and an
adjustable diagonal prop both mounted on a base frame of
the main frame, and movable between an extended position
to support at least one side or end wall panel and a
retracted position to enable the assembly to be lifted
from the main frame.

13. Apparatus according to any one of Claims 8 to 12 wherein:
the means to support the moulds in their
vertical positions include external corner forms, each
having an external corner plate, of L-section in plan
view, mounted on an adjustable horizontal prop and an
adjustable vertical prop both mounted on a foot plate,
and movable between an extended position to support at
least one side or end wall mould and a retracted
position to enable the assembly to be lifted from the
main frame.
14. Apparatus according to any one of Claims 8 to 13 wherein:

a separate roof mould is provided to enable a roof panel to be cast and then lifted onto the main frame and be connected to side and/or wall panels after the side and/or end wall moulds have been returned to their horizontal positions.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

Int. Cl.\(^5\) B28B 7/22

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC B28B 7/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

AU : IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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X Further documents are listed in the continuation of Box C.

See patent family annex.

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document member of the same patent family

Date of the actual completion of the international search: 19 January 1994 (19.01.94)

Date of mailing of the international search report: 28 JAN 1994 (28.01.94)

Name and mailing address of the ISA/AU:

AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION
PO BOX 200
WODEN ACT 2606
AUSTRALIA

Facsimile No. 06 2853929

Authorized officer

R.P. ALLEN

Telephone No. (06) 2832134

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