Building Construction

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Form Work

• concrete when first mixed is a fluid and therefore to form any concrete member the wet concrete must be placed in a suitable mould to retain its shape, size and position as it sets. It is possible with some forms of concrete foundations to use the sides of the excavation as the mould but in most cases when casting concrete members a mould will have to be constructed on site. These moulds are usually called formwork. It is important to appreciate that the actual formwork is the reverse shape of the concrete member which is to be cast.

• Falsework ~ the temporary structure which supports the formwork.

• Principles ~
Typical Simple Beam Formwork Details

75 x 25 cleats at 600°C/c

15 mm thick plywood sides

75 x 32 struts

21 mm thick plywood soffit

75 x 25 cleats at 600°C/c

25 x 50 ties at 600°C/c

75 x 75 crosshead or headtree

100 x 50 crosshead or headtree

100 x 75 crosshead or headtree

Security chain for pin

Collar

Outer tube

Inner tube

Pin

150 x 150 base plate

SINGLE PROP SUPPORT

DOUBLE PROP SUPPORT

Folding wedges

225 x 75 sole piece

150 x 75 props at 1.200°C/c

Wig dogs to both sides

75 x 32 braces
• Beam Formwork ~ this is basically a three sided box supported and propped in the correct position and to the desired level. The beam formwork sides have to retain the wet concrete in the required shape and be able to withstand the initial hydrostatic pressure of the wet concrete whereas the formwork soffit apart from retaining the concrete has to support the initial load of the wet concrete and finally the set concrete until it has gained sufficient strength to be self supporting. It is essential that all joints in the formwork are constructed to prevent the escape of grout which could result in honeycombing and/or feather edging in the cast beam. The removal time for the formwork will vary with air temperature, humidity and consequent curing rate.
Typical Details ~

21mm thick plywood floor soffit formwork

15mm thick plywood edge beam formwork sides

dry beam

75 x 32 strut

21mm thick beam soffit

75 x 32 runner or stringer

100 x 75 crosshead or headtree

adjustable steel props

secondary beam formwork

150 x 50 soffit support joists at 600 c/c

margin support for beam formwork

Typical Formwork Striking Times ~

Beam Sides - 9 to 12 hours
Beam Soffits - 8 to 14 days (props left under)
Beam Props - 15 to 21 days

} Using OPC-air temp 7 to 16°C
• Column Formwork ~ this consists of a vertical mould of the desired shape and size which has to retain the wet concrete and resist the initial hydrostatic pressure caused by the wet concrete. To keep the thickness of the formwork material to a minimum horizontal clamps or yokes are used at equal centres for batch filling and at varying centres for complete filling in one pour. The head of the column formwork can be used to support the incoming beam formwork which gives good top lateral restraint but results in complex formwork. Alternatively the column can be cast to the underside of the beams and at a later stage a collar of formwork can be clamped around the cast column to complete casting and support the incoming beam formwork. Column forms are located at the bottom around a 75 to 100 mm high concrete plinth or kicker which has the dual function of location and preventing grout loss from the bottom of the column formwork.
Typical Details ~

- 21mm thick plywood column formwork sides
- 75 x 32 margin pieces forming support for incoming beam formwork
- 100 x 32 cleats at 600 °C
- 100 x 50 soldiers or studs
- Noggins as required
- Clamps or yokes at spacings to suit anticipated pressures for details see next page
- Lift out access piece to enable formwork to be cleaned out prior to casting

Typical Striking Times
9 to 12 hours using OPC – air temperature 7 to 16°C
Column Yokes ~ these are obtainable as a metal yoke or clamp or they can be purpose made from timber.

Typical Examples ~

![Diagram of a column yoke system]

- **Steel wedge**
- **Column formwork**
- **Security chain or wire**
- **Steel blade or arm with 2 rows of 32 x 8 mm slots**
- **Metal clamp - available in a range of sizes from 300 to 1400 mm**
- **100 x 32 cleats taken beyond width of panel to form rebate**
- **Yoke out of 100 x 75 timber**
- **Plate washer to both ends of bolt**

**SQUARE COLUMN**

- Gangnail or plywood connecting plates to both faces

**Shaped Columns ~**

The basic principles of rectangular or square columns is followed but purpose made...
gangnail or plywood connecting plates to both faces

12 mm min. gap

shaped timber yokes joined to form half yokes

hardboard or similar lining

25 mm thick shaped staves

16 mm diameter bolts

clear

timber yokes out of 200 x 100

column formwork

columns is followed but purpose made shaped yokes are sometimes required. Rebated columns can be formed with blocks or boxing thus —

block or boxing

CIRCULAR COLUMN

REBATED COLUMN
Wall forms

• conventionally made up of plywood sheeting that may be steel, plastic or wood faced for specific concrete finishes. Stability is provided by vertical studs and horizontal walings retained in place by adjustable props. Base location is by a kicker of 50 of 75 mm height of width to suit the wall thickness. Spacing of wall forms is shown on the next page.
Wall formwork principles

- wall thickness
- waling

- coil tie spacer*
- noggin
- plate washer and bolt
- plywood wall form
- vertical stud
- kicker

- raked adjustable steel prop

structural floor slab
• Formwork sides to concrete walls of modest height and load can be positioned with long bolts or threaded dowel bars inserted through the walings on opposing sides. To keep the wall forms apart, tube spacers are placed over the bolts between the forms. For greater load applications, variations include purpose made high tensile steel bolts or dowels. These too are sleeved with plastic tubes and have removable spacer cones inside the forms. Surface voids from the spacers can be made good with strong mortar. Some examples are shown below with the alternative coil tie system. Further applications are shown on pages 255†257.
Bolt
- wall form
- waling
- spacer tube
- strut
- plate washer, nut and bolt or threaded steel dowel

Coil tie
- plastic cone
- washer
- bolt threaded to match coils
- two tie rods welded to coils (left in place)

Tie bolt
- waling plate washer
- wing nut
- tube and cone spacers
- 15 or 20mm standard diameter high tensile steel deformed screw threaded bar
- kicker, 50 to 75mm high x wall width
Steel Roof Trusses

• These are triangulated plane frames which carry purlins to which the roof coverings can be fixed. Steel is stronger than timber and will not spread fire over its surface and for these reasons it is often preferred to timber for medium and long span roofs. The rafters are restrained from spreading by being connected securely at their feet by a tie member. Struts and ties are provided within the basic triangle to give adequate bracing. Angle sections are usually employed for steel truss members since they are economic and accept both tensile and compressive stresses. The members of a steel roof truss are connected together with bolts or by welding to shaped plates called gussets. Steel trusses are usually placed at 3",000 to 4",500 centres which gives an economic purlin size.
Typical Steel Roof Truss Formats

- rafter
- tie
- strut
- tension member
- compression member

- up to 7.500
- up to 10.000
- 12.000
Typical Steel Roof Truss Details ~

100 x 75 x 10.6 kg/m angle purlin site bolted to purlin cleats

100 x 75 x 10.6 kg/m angle rafter

150 x 75 x 17 kg/m angle purlin cleat

50 x 50 x 5.82 kg/m angle strut

50 x 50 x 5.82 kg/m angle strut

8mm thick ms gusset plate

truss symmetrical about centre line

65 x 50 x 6.75 kg/m angle tie

shop bolted connections

NB. all centre lines converge on common points

8mm thick ms gusset plate

65 x 51 x 6.75 fixing cleats to both sides of gusset plate

supporting steel column

65 x 51 x 6.75 kg/m ms angle tie
• Sheet Coverings ~ the basic functions of sheet coverings used in conjunction with steel roof trusses are to:

• 1. Provide resistance to penetration by the elements. 2. Provide restraint to wind and snow loads. 3. Provide a degree of thermal insulation of not less than that set out in Part L of the Building Regulations. 4. Provide resistance to surface spread of flame as set out in Part B of the Building Regulations. 5. Provide any natural daylight required through the roof in accordance with the maximum permitted areas set out in Part L of the Building Regulations. 6. Be of low self weight to give overall design economy. 7. Be durable to keep maintenance needs to a minimum.
• Suitable Materials ~
• Hot-dip galvanised corrugated steel sheets † BS 3083
• Aluminium profiled sheets † BS 4868.
• Asbestos free profiled sheets † various manufacturers whose products are usually based on a mixture of Portland cement, mineral fibres and density modifiers † BS EN 494.
Typical Profiles:

- **Pitch**
- **Net Cover**
- **Lap**
- **Sheet Width**

**Corrugated Sheets**

**Deep Corrugated Sheets**

**Tile Profile Sheets**
Typical Purlin Fixing Details ~

STEEL ANGLE PURLIN
- Roof sheeting
- Insulation
- 8mm diameter hook bolt
- Lining sheet
- Purlin

TIMBER PURLIN
- Roof sheeting
- Insulation
- Drive screw
- Lining sheet
- Purlin

ZED BEAM PURLIN
- Roof sheeting
- Insulation
- 8mm diameter Z type hook bolt
- Lining sheet
- Purlin

STEEL CHANNEL PURLIN
- Roof sheeting
- Insulation
- 8mm diameter square bend hook bolt
- Lining sheet
- Purlin
Flat Top Girders — these are suitable for roof spans ranging from 15,000 to 45,000 and are basically low pitched lattice beams used to carry purlins which support the roof coverings. One of the main advantages of this form of roof is the reduction in roof volume. The usual materials employed in the fabrication of flat top girders are timber and steel.

Typical Flat Top (Pratt Type) Girder Details —

- 2 No. 250 x 75 top chords 75 mm apart
- 225 x 75 purlins
- 200 x 75 "vertical" members
- 200 x 75 web members
- Support column
- 2 No. 250 x 75 bottom chords 75 mm apart
- Span - 20,000; Spacing - 3,000 mm
- Pitch - 5°; Material - SS graded softwood
- Corrugated or troughed roof sheeting
- Splice plates
- Packing
- Bolt and timber connectors

SECTION A-A
web sections

bow in pairs of laminated sections

depth, generally 0.125 to 0.167 span

span (in excess of 50m possible)

string in laminated timber pairs often cambered 10mm in every 2.4m
Space Deck ~ this is a structural roofing system based on a simple repetitive pyramidal unit to give large clear spans of up to 22,000 for single spanning designs and up to 33,000 for two way spanning designs. The steel units are easily transported to site before assembly into beams and the complete space deck at ground level before being hoisted into position on top of the perimeter supports. A roof covering of wood wool slabs with built-up roofing felt could be used, although any suitable structural lightweight decking is appropriate. Rooflights can be mounted directly onto the square top space deck units.
• Space Frames ~ these are roofing systems which consist of a series of connectors which joins together the chords and bracing members of the system. Single or double layer grids are possible, the former usually employed in connection with small domes or curved roofs. Space frames are similar in concept to space decks but they have greater flexibility in design and layout possibilities. Most space frames are fabricated from structural steel tubes or tubes of aluminium alloy although any suitable structural material could be used.
GEODESIC DOME

- lightweight roof finish
- single layer grid

DOUBLE LAYER GRID

- space frame connectors
- top chords
- bracing members
- column connector
- bottom chords

Typical Double Layer Grid Format

- upper grid connectors
- tubular top chords forming upper grid
- column connector
- tubular bracing members
- perimeter support column
- lower grid connectors
- tubular bottom chords forming lower grid

Span to depth ratio 1:15 (corner supports) & 1:20 (edge supports)
• Shell Roofs ~ these can be defined as a structural curved skin covering a given plan shape and area where the forces in the shell or membrane are compressive and in the restraining edge beams are tensile. The usual materials employed in shell roof construction are in-situ reinforced concrete and timber. Concrete shell roofs are constructed over formwork which in itself is very often a shell roof making this format expensive since the principle of use and reuse of formwork can not normally be applied. The main factors of shell roofs are:
extra trajectory reinforcement

upstand edge beam resisting thrust from shell and forming gutter

support columns

overall rise

width or chord length

span

economic design ratios - width : span 1:2 to 1:5
rise : span 1:10 to 1:15

combined edge beam and gutter

buttress at verge

outer radius

inner radius

overall rise = R

width or chord

upper surface of shell roof covered with thermal insulation and weathering materials as required
A form of stressed skin reinforced concrete construction also known as folded plate construction. The concept is to profile a flat slab into folds so that the structure behaves as a series of beams spanning parallel with the profile.

Optimum depth to span ratio is between 1 : 10 to 1 : 15, or a depth to width of not less than 1 : 10, whichever is greater.

Roof format ~ pitched, monitor or multi-fold.