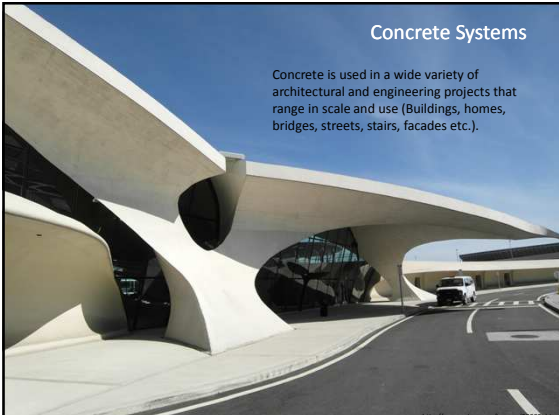



**Concrete Systems**

Concrete is used in a wide variety of architectural and engineering projects that range in scale and use (Buildings, homes, bridges, streets, stairs, facades etc.).



[http://www.stroco.eu/images/2003\\_1.jpg](http://www.stroco.eu/images/2003_1.jpg)

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Concrete Structure  
David Chipperfield Architects  
Americas Cup Building  
Valencia Spain

**Structural Systems - Concrete**


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Concrete House  
Frank Lloyd Wright  
Falling Water  
Mill Run Pennsylvania

**Structural Systems - Concrete**

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Boat Lift  
Nicoll Russell Studios  
Falkirk Wheel  
Falkirk Scotland

Connects Forth and Clyde Canal  
24M high

**Structural Systems - Concrete**

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<http://www.youtube.com/watch?v=n61KUGDWzZA>




Boat Lift  
Nicoll Russell Studios  
Falkirk Wheel  
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24M high

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Concrete Dome  
Pantheon  
Rome Italy

Largest unreinforced concrete dome  
126AD

**Structural Systems - Concrete**

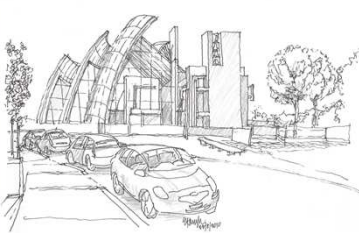

Concrete is used in a wide variety of architectural and engineering projects that range in scale and use (Buildings, homes, bridges, streets, stairs, facades etc.).

Facade  
Richard Meier  
Jubilee Church  
Rome Italy

**Structural Systems - Concrete**

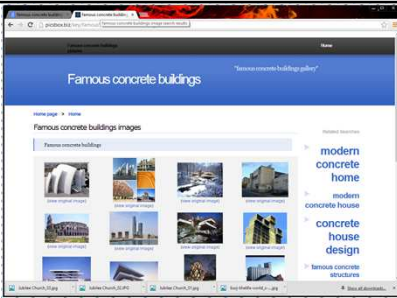
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Facade  
Richard Meier  
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**Structural Systems - Concrete**

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Famous Concrete Buildings  
<http://picsbox.biz/key/famous%20concrete%20buildings#>

**Structural Systems - Concrete**

Concrete Materials:

- Portland Cement
- Water
- Fine Aggregate
- Coarse Aggregate






**Structural Systems - Concrete**

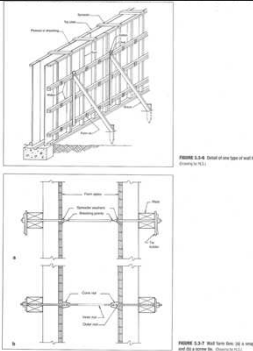
Concrete Formwork



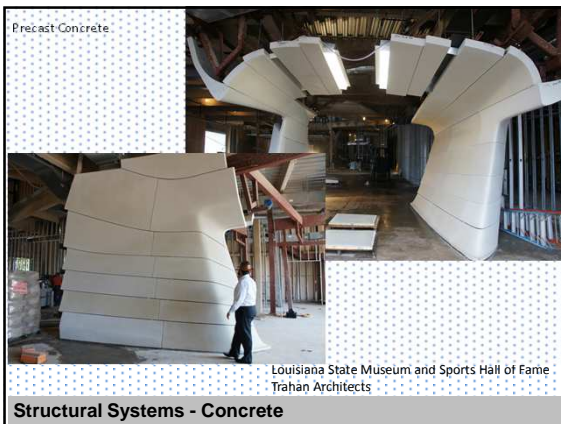
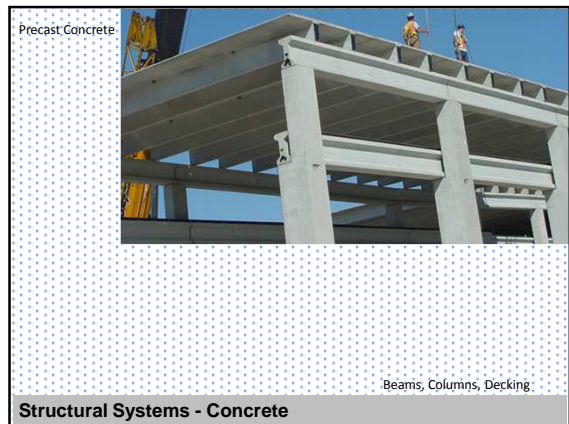
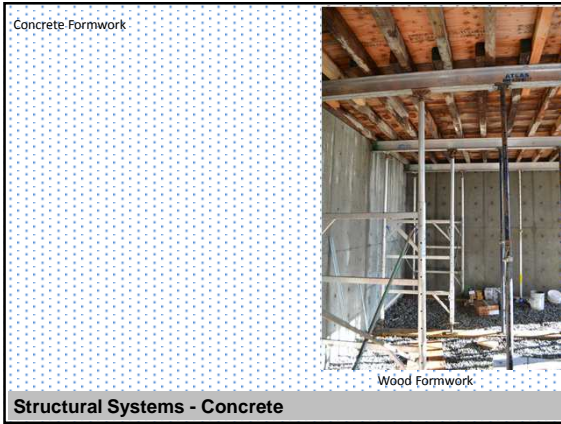
Reusable Aluminum Formwork

**Structural Systems - Concrete**


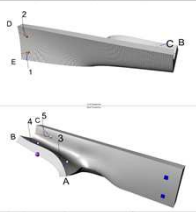
Concrete Formwork



**Structural Systems - Concrete**



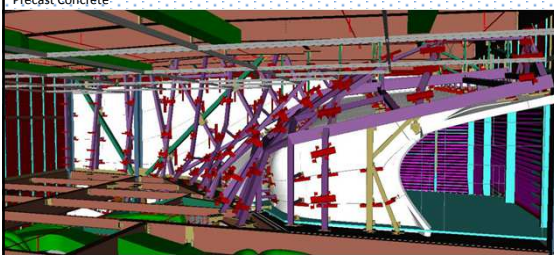
Precast Concrete

Louisiana State Museum and Sports Hall of Fame - Trahan Architects

**Structural Systems - Concrete**

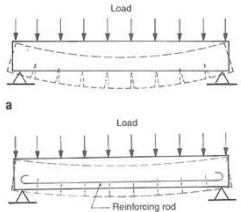
Precast Concrete



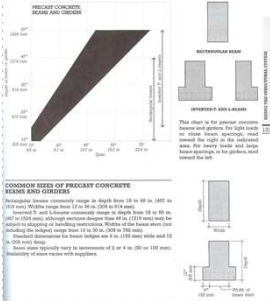
Louisiana State Museum and Sports Hall of Fame - Trahan Architects

**Structural Systems - Concrete**

Precast Concrete Beams and Girders



**PRECAST CONCRETE BEAMS AND GIRDERS**



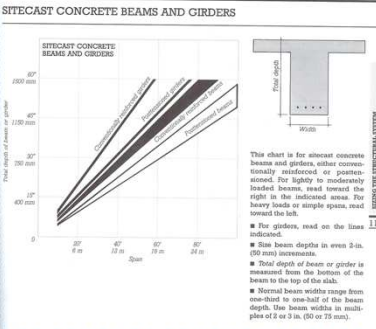
**COMMON SIZES OF PRECAST CONCRETE BEAMS AND GIRDERS**

Rectangular beams commonly range in depth from 18 in. to 48 in. (457 to 1219 mm) and span from 12 to 24 ft (3.7 to 7.3 m).

**Structural Systems - Concrete**

Concrete Beams and Girders

**SITECAST CONCRETE BEAMS AND GIRDERS**

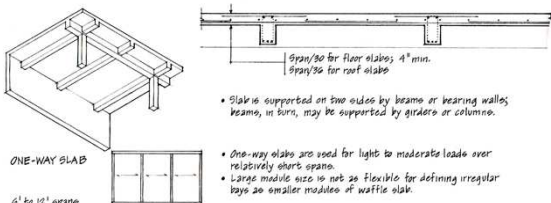


This chart is for almost concrete beams and girders, either conventionally reinforced or post-tensioned. For lightly to moderately loaded beams, read toward the right in the indicated areas. For heavy loads or simple spans, read toward the left.

- For girders, read on the lines indicated.
- Use beam depths in even 3-in. (50 mm) increments.
- Total depth of beam or girder is measured from the bottom of the beam to the top of the slab.
- Normal beam widths range from one-third to one-half of the beam depth. Use beam widths in multiples of 2 or 3 in. (50 or 75 mm).

**Structural Systems - Concrete**

Concrete Systems – one way slab



ONE-WAY SLAB  
6' to 12' spans

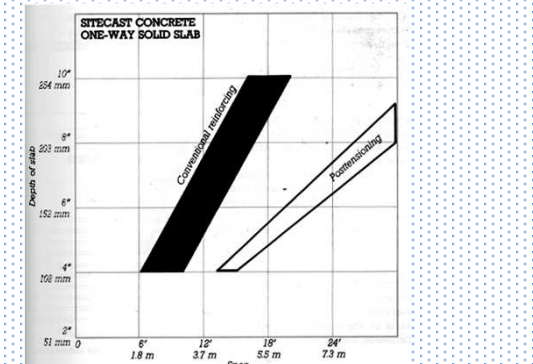
- Slab is supported on two sides by beams or bearing walls; beams, in turn, may be supported by girders or columns.
- One-way slabs are used for light to moderate loads over relatively short spans.
- Large module size is not so flexible for defining irregular bays as smaller modules of waffle slab.

Span/36 for floor slabs; 4' min.  
Span/36 for roof slabs

**Structural Systems - Concrete**

Concrete Systems – one way slab

**SITECAST CONCRETE ONE-WAY SOLID SLAB**



Depth of slab: 10" (254 mm), 8" (203 mm), 6" (152 mm), 4" (102 mm), 2" (51 mm)

Span: 6' (1.8 m), 12' (3.7 m), 18' (5.5 m), 24' (7.3 m)

Conventional reinforcing  
Post-tensioning

**Structural Systems - Concrete**

### Concrete Systems – one way joist

ONE-WAY JOIST SLAB

16' to 36' spans

2 1/2" to 4 1/2"

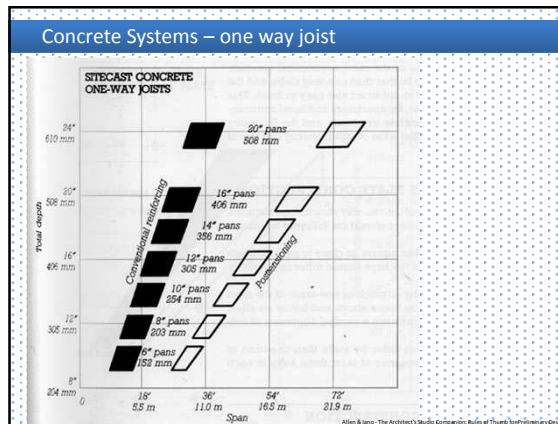
6" to 9" 20" and 30" pan forms typical

6" to 20" increments (min total depth = span/24)

Distribution rib for spans over 20'; space not more than 16" o.c. for spans over 30'

- Joist band is an economical alternative to conventional beams; it has the same depth as the joist but is broader.
- One-way joist slabs are used for longer spans and heavier loads than practical for one-way solid slabs, but are available for large concentrated loads.
- Joists may be flared at the beam supports for greater shear resistance.

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### Concrete Slabs

- One way slab
- Two way slab
- Flat plate slab
- Waffle slab

ONE-WAY SLAB

6' to 12' spans

One way slab – spans a distance much greater in one direction than in the other

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### Concrete Systems – two way slab

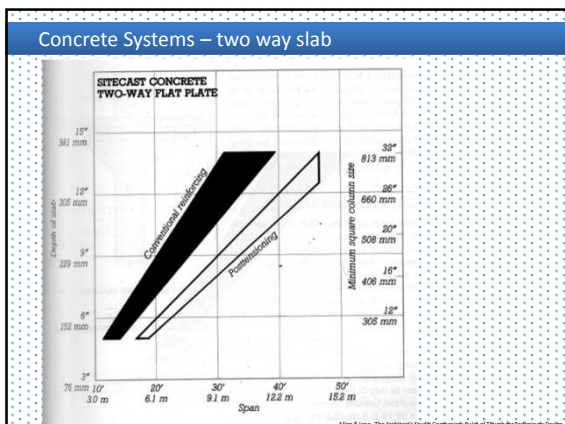
Depth = slab perimeter/100; 4" min.

- Two-way slab is supported on four sides by beams; bay should be as nearly square as possible.
- Two-way slabs with beams are used for long spans and heavy loads, or when a high resistance to lateral forces is required. Two-way slabs, however, are usually made without beams. See below.

TWO-WAY SLAB WITH BEAMS

16' to 40' spans

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### Remember one way slabs need to nearly square

One-way and two-way slab action, with deflections greatly exaggerated.

One-Way Slab Action

Two-Way Slab Action With Beams

Two-Way Slab Action Without Beams

Concrete Slabs

- One way slab
- Two way slab
- Flat plate slab
- Waffle slab

**TWO-WAY SLAB WITH BEAMS**

15' to 40' spans

Two way slab – create a(n) almost square column spacing.

**Structural Systems - Concrete**

Concrete Slabs

- One way slab
- Two way slab
- Flat plate slab
- Waffle slab

**SITECAST CONCRETE TWO-WAY FLAT PLATE**

Simple to construct and easy to finish.

Two way flat plate slab – create a(n) almost square column spacing.

**Structural Systems - Concrete**

Concrete Slabs

- One way slab
- Two way slab
- Flat plate slab
- Waffle slab

**SITECAST CONCRETE TWO-WAY FLAT SLAB**

Column caps

Two way flat plate slab – create a(n) almost square column spacing.

**Structural Systems - Concrete**

Concrete Slabs

- One way slab
- Two way slab
- Flat plate slab
- Waffle slab

**Structural Systems - Concrete**

Concrete Slabs

- One way slab
- Two way slab
- Flat plate slab
- Waffle slab

**SITECAST CONCRETE WAFFLE SLAB**

Two way flat plate slab – create a(n) almost square column spacing.

**Structural Systems - Concrete**

Concrete is used in a wide variety of architectural and engineering projects that range in scale and use (Buildings, homes, bridges, streets, stairs, facades etc.).

2722 Feet tall  
163 floors

Tower  
Adrian Smith @ SOM  
Burj Khalifa  
Dubai UAE

**Structural Systems - Concrete**

**REINFORCING CONCRETE: Burj Dubai**

United Arab Emirates,  
2,717 ft (828m)  
162 floors  
architecture SOM  
58,900 cu yd of  
concrete, weighing  
+110,000 tonnes

**REINFORCING CONCRETE: Burj Dubai**

Concrete is used in a wide variety of architectural and engineering projects that range in scale and use (Buildings, homes, bridges, streets, stairs, facades etc.).

2722 Feet tall  
163 floors

Tower  
Adrian Smith @ SOM  
Burj Khalifa  
Dubai UAE

**Structural Systems - Concrete**

**Concrete Systems – two way flat slab**

Min. depth =  $\frac{\text{span}}{36}$  or 4" (6" to 12" typ.)

Min. depth =  $\frac{\text{span}}{36}$   
Min. width = 4x span

Drop panel  
Column cap

- Two-way slab is supported by columns without beams.
- Drop panels and/or column caps reinforce slab at column supports.
- Reinforcing steel is arranged to handle varying stresses within a slab of uniform thickness; this also applies to flat plates below.

TWO-WAY FLAT SLAB  
16' to 40' spans

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**Concrete Systems – two way flat slab**

Min. depth =  $\frac{\text{span}}{33}$  or 6" (6" to 14" typ.)

- Minimal construction depth can minimize building heights.
- Two-way flat plates are similar to two-way slabs but have no drop panels.
- Flat plates are suitable for moderate loads.
- They are simple to form, and permit some flexibility in column placement.

TWO-WAY FLAT PLATE  
16' to 36' spans

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### Concrete Systems – Precast Units

TYPE OF PRECAST CONCRETE UNIT	THICKNESS or DEPTH in inches	SPAN RANGE in feet
<p>* Exact dimension varies to allow space for reinforcement and grouting.</p> <p><b>SOLID FLAT SLAB</b></p>	4 6 8	12 - 16 14 - 24 10 - 30
<p>* Also available in 1'-4", 2'-0", 3'-4", and 5'-0" widths.</p> <p><b>HOLLOW CORE SLAB</b></p>	6 8 10 12	14 - 22 20 - 32 24 - 40 30 - 44

### Concrete Systems – Precast Units

**PRECAST CONCRETE SOLID AND HOLLOW CORE SLABS**

Precast Concrete Slabs

- Solid flat
- Hollow Core
- Single Tee
- Double Tee

**Structural Systems - Concrete**

### Concrete Systems – Precast Units

12	20 - 40
18	36 - 60
24	48 - 70
30	54 - 80
36	62 - 90
48	80 - 110

20	18 - 30
28	22 - 40
36	26 - 50
44	30 - 55
52	34 - 70
60	42 - 80

Rectangular BEAMS    L-shaped    Inverted tee

*1/2 to 1/4 of total depth*

### Concrete Systems – Precast Units


**PRECAST CONCRETE SINGLE AND DOUBLE TEES**

### Concrete Systems – Thin Shell Structures

Concrete "Umbrella"  
Felix Candela  
Mexico




Concrete Systems – Precast Units




Concrete Warehouse  
Felix Candela  
Mexico

Concrete Systems – Precast Units



Airplane Hanger  
Pier Luigi Nervi  
Italy

Concrete Systems – Precast Units



Concert Hall  
Jorn Utzon, Ove Arup  
Sydney Australia

Concrete Systems – Precast Units

<http://www.columbia.edu/cu/gsap/bt/BSI/GRAVSYS/grav1.html>  
<http://faculty.delhi.edu/huitendc/JAECT480-Lecture%207.pdf>  
<http://picsbox.biz/key/famous%20concrete%20buildings#>  
<http://lebbeuswoods.wordpress.com/2009/12/02/big-tops/>  
<http://thepost-it-effect.blogspot.com/2010/09/new-structuralism-designengineeringand.html>  
<http://www.generativeart.com/on/cic/papers2005/37.SemraArslanSelcuk.htm>  
[http://en.wikipedia.org/wiki/Concrete\\_shell](http://en.wikipedia.org/wiki/Concrete_shell)

Architect's Studio Companion, Rules of Thumb For Preliminary Design [pg 19 – 29, 107 – 135]  
Construction Principles, Materials, And Methods [chapter 3]