

# BUILDING CONSTRUCTION ILLUSTRATED

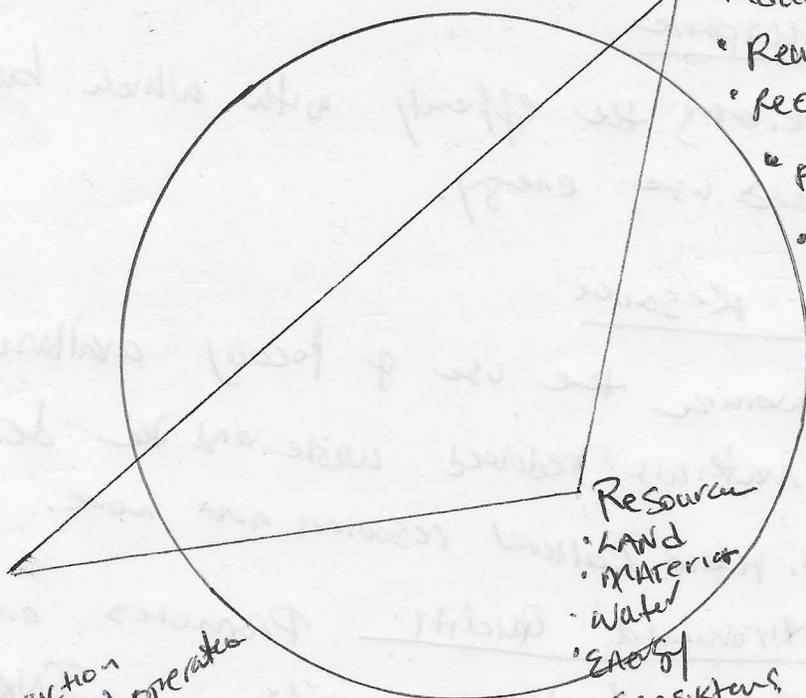
## Chapter 1

### FACTS

- Buildings do not exist in isolation,
- They are conceived to house support, and inspire a range of human activities.
- The microclimate, topography, and natural habitat of a site all influence design decisions at a very early stage in the design process.
- In addition to environmental forces, the regulatory forces of zoning ordinances, these regulations take into account existing land-use patterns and prescribe the acceptable use and activities.

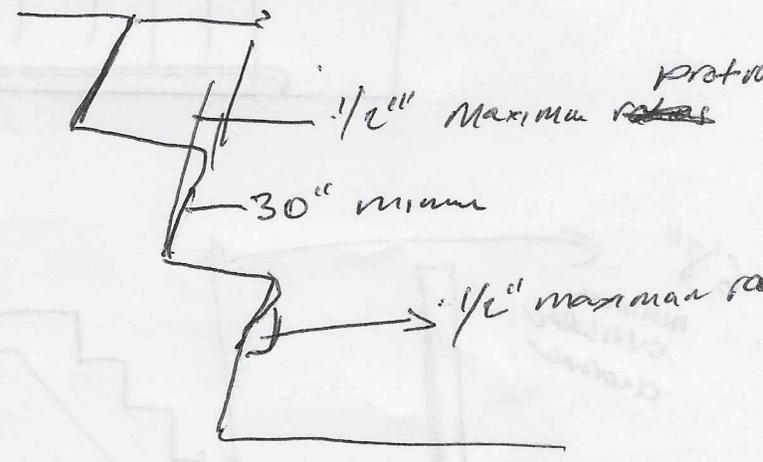
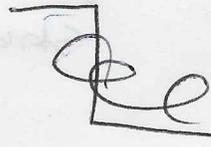
### Principles

- Reduces resource consumption
- Reuse resources
- Recycle resources and reuse
- Protect nature
- Eliminate toxics
- Apply life-cycle costs
- Focus on quality



### Phase

- PLANNING
- DEVELOPMENT
- DESIGN
- CONSTRUCTION
- USE AND OPERATION
- MAINTENANCE
- MODIFICATION
- DECONSTRUCTION

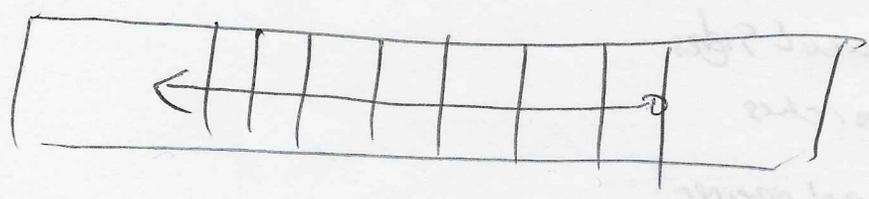


### RISERS AND TREADS

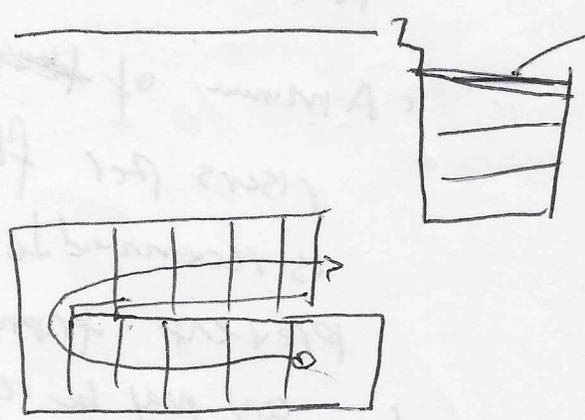
- Tread Depth 11"
- Riser height 4"
- uniform riser and tread dimensions

### RAMP

provide smooth transitions between the floor levels.



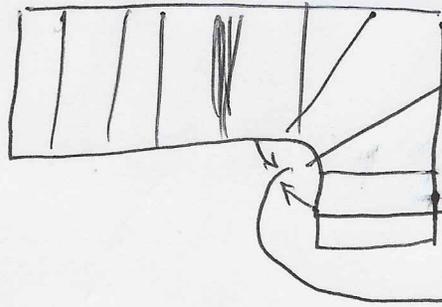
Straight run stairs  
Extends from one level to another.



LANDING that are below normal eye level and provide a place to rest of people.

# Winding stair

A winding stair is any stairway with winders as a circular or spiral stair.

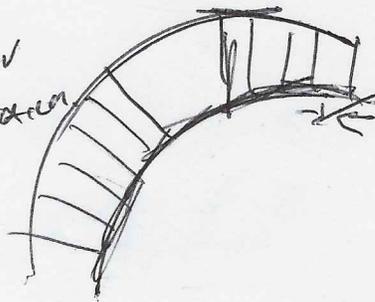


Winders must have the required tread dimensions at point.

6" minimum at the narrow end of the treads

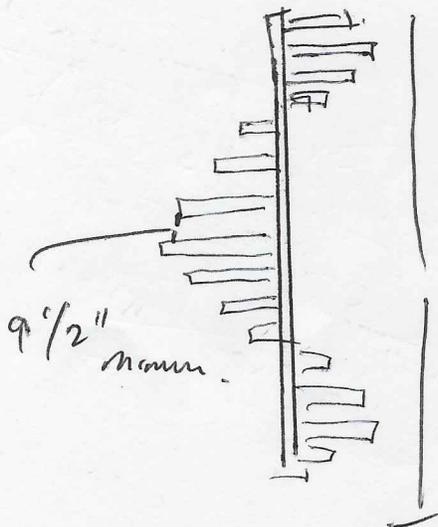
# Circular stair

Has a circular Plan Configuration



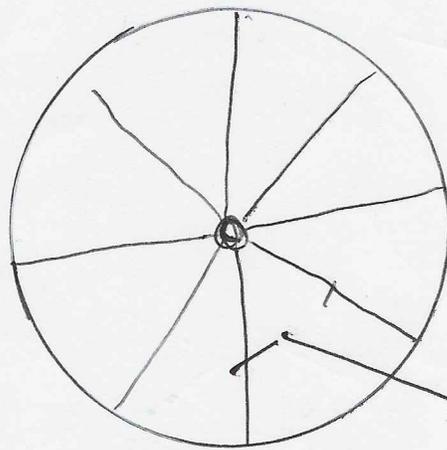
6" minimum at the narrow ends of the treads

# Spiral stair

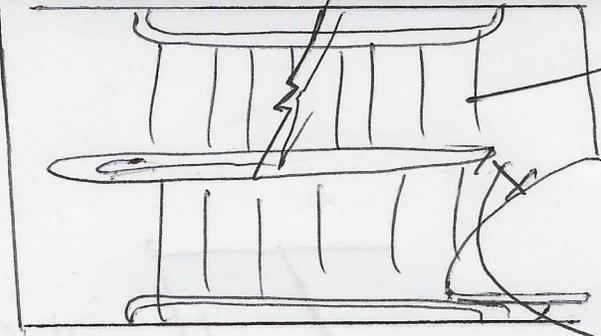


9 1/2" minimum

6'6"

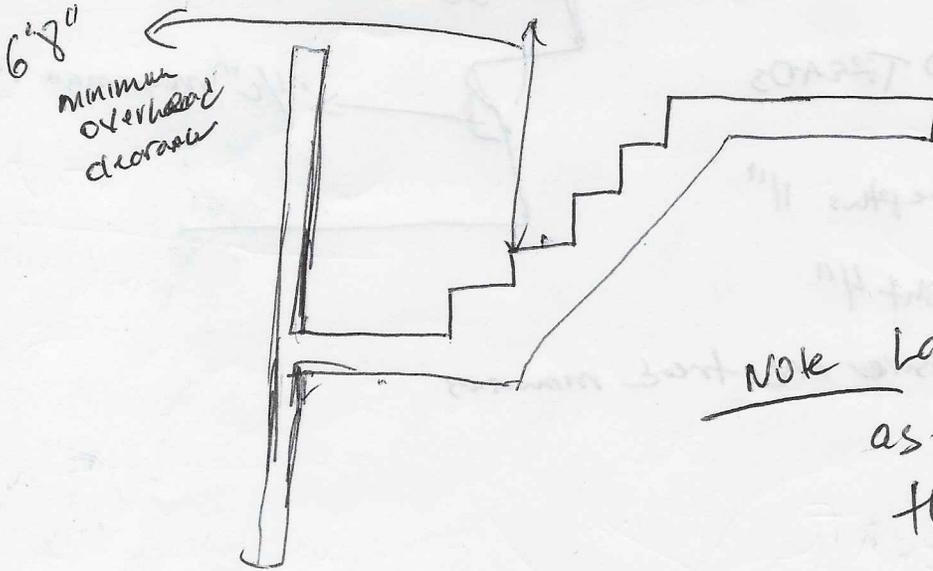


7 1/2" minimum



44 inches - minimum width  
36" minimum for  
handrail.

Hand rail may project  
a maximum  
width of  $4\frac{1}{2}$ "



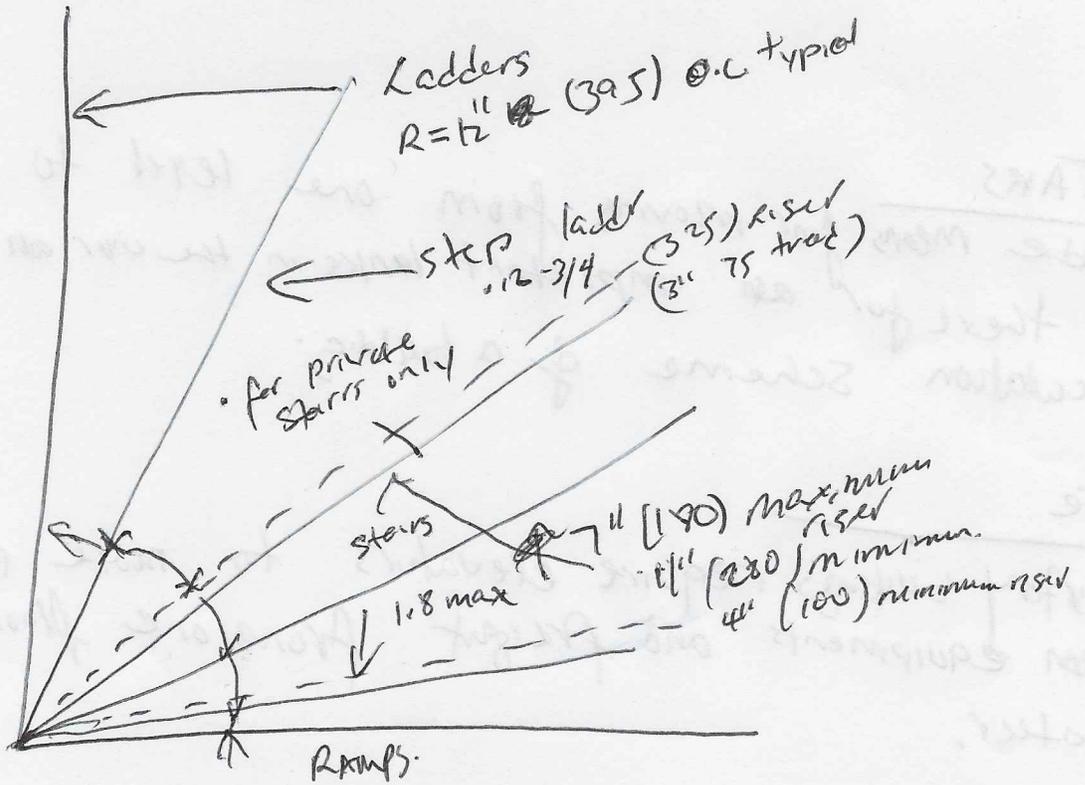
Note Landings should be at least  
as wide as the stairway  
they serve have a minimum  
length equal to the  
stairway width.

Guard rails are required to  
protect the open or glazed sides  
of stairways, ramps, porches  
and enclosed floor and roof openings.

### TREADS, RISERS and NOSING

- A minimum of ~~three~~ three  
risers per flight  
is recommended to  
prevent tripping  
and may be required  
by the ~~building~~ code.

# STAIRS DESIGN



## RISER AND TREAD DIMENSIONS

RISER	TREAD
inches	inches
5	15
5-1/4	14-1/2
5-1/2	14
5-3/4	13-1/2
6	13
6-1/4	12-1/2
6-3/4	11-1/2
7	11
7-1/4	10-1/2
7-1/2	10

————— maximum riser height

# Special CONSTRUCTION

## Chapter 9.

### STAIRS

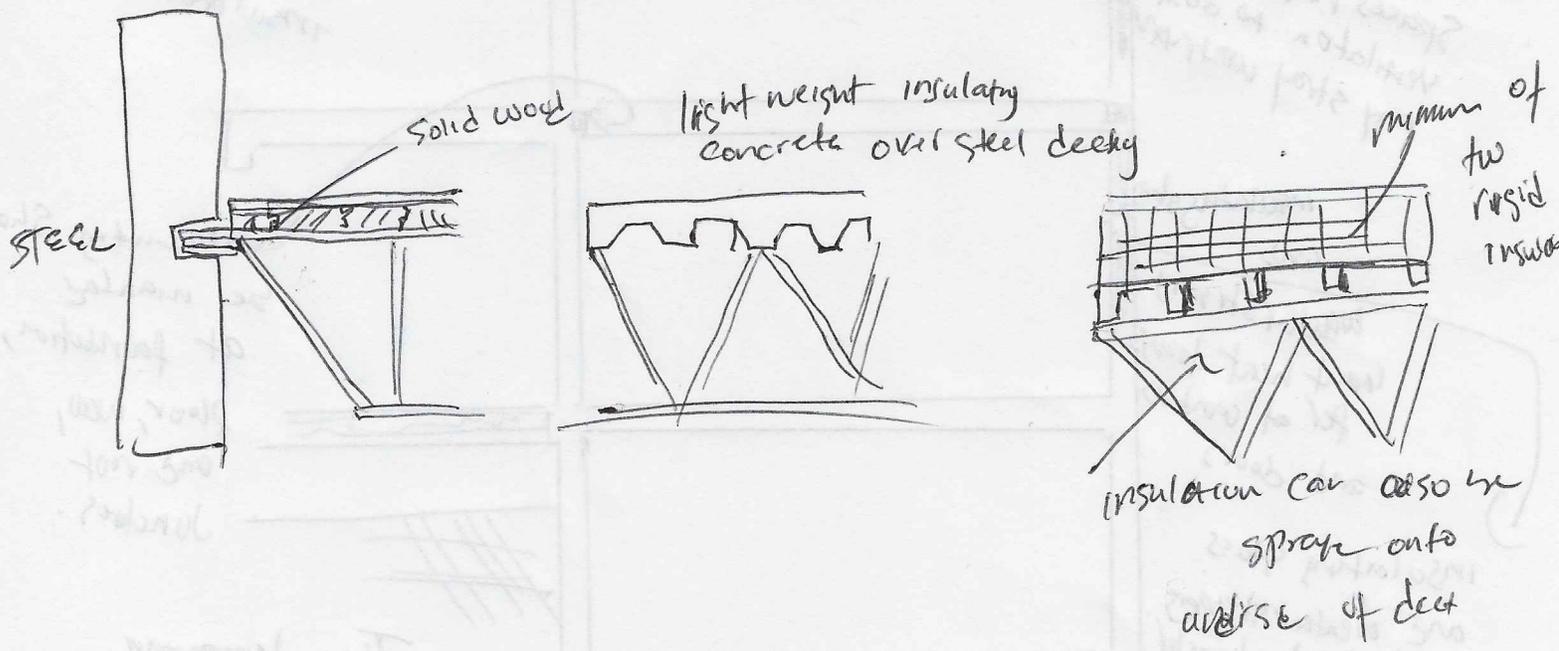
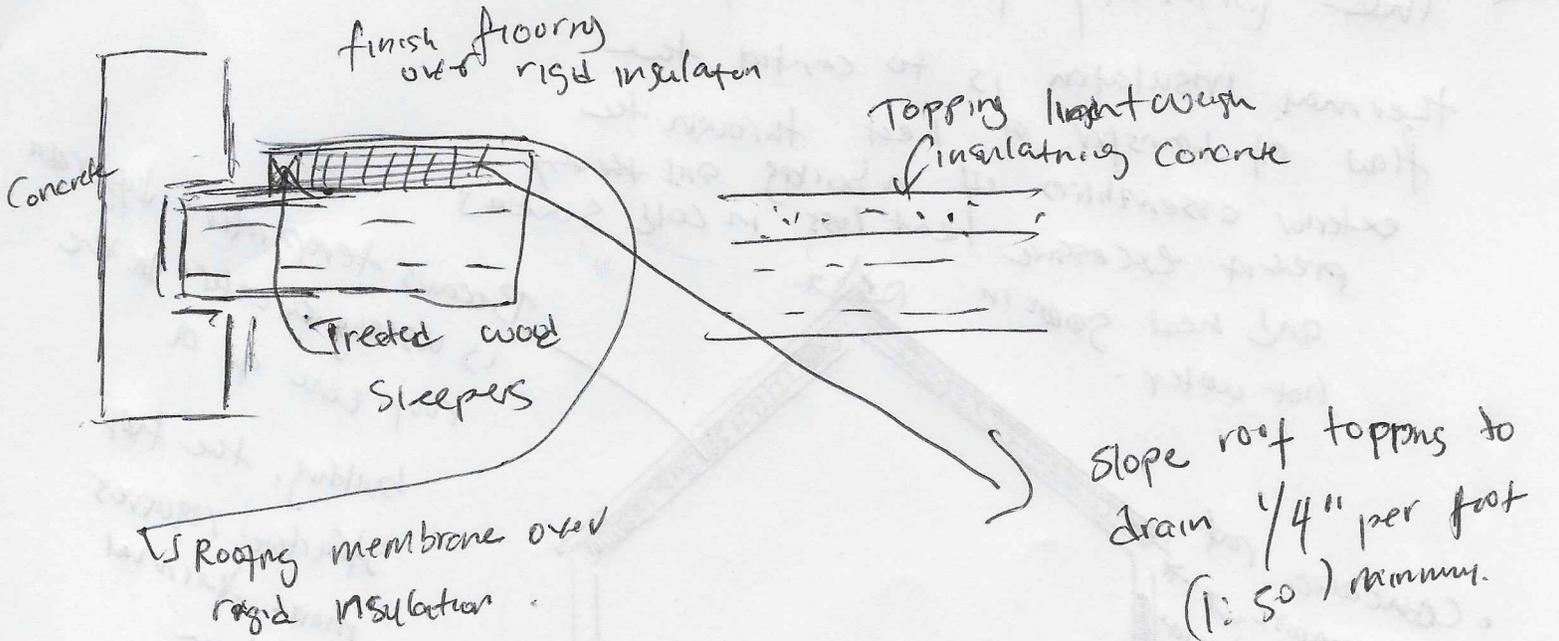
Provide means for moving from one level to another and there for an important links in the over all circulation scheme of a building.

### Note

Multistorey buildings require elevators to move people ~~from~~ equipments and freight from one floor to another.

fire place and wood burning stoves are sources of heat and visual points of interest for any interior spaces the placement and size of a fireplace or stove in a room should be related to the scale and use of the place

Kitchens and bathrooms are unique areas of a building that demands the careful integration of plumbing, electrical and heating ventilation systems with the ~~the~~ functional and aesthetic requirements of the spaces.



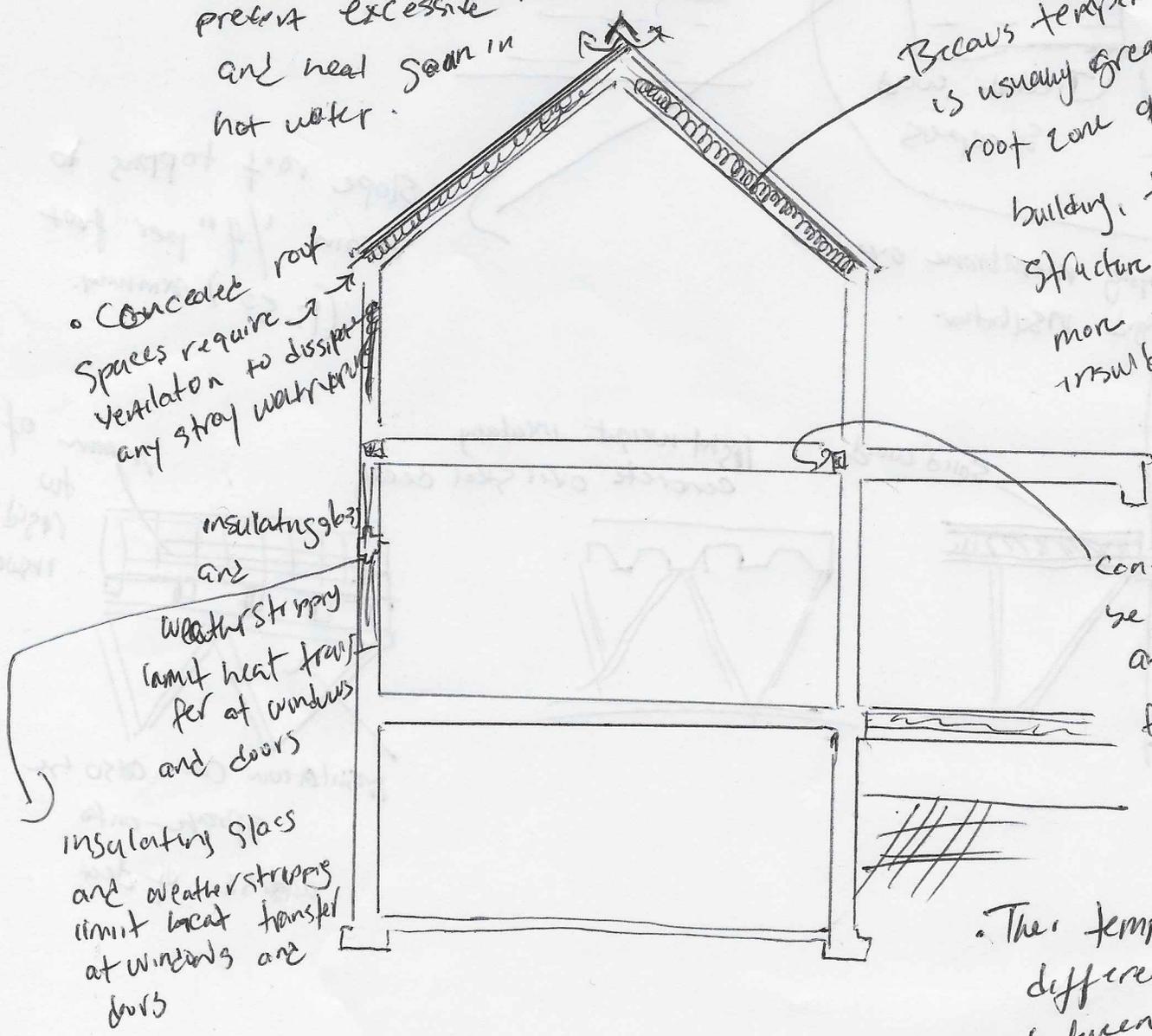
Resistance

Case	ceiling of roof	External wall	External floor
Minimum req.	10	10	10
Common case	20	15	15
High quality	30	20	20
Maximum	40	25	25

The primary purpose of

thermal insulation is to control the flow of transfer of heat through the exterior assemblies of a building and thereby prevent excessive heat loss in cold seasons and heat gain in hot water.

Because temperature differential is usually greater in the roof zone of a building, the foot structure requires more thermal insulation



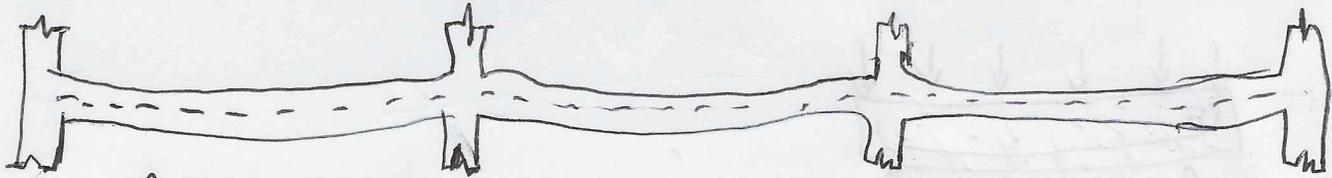
continuous sheathing mantle at foundation, floor, wall, and roof junctions.

The temperature differential between basement spaces and the outdoors above grade

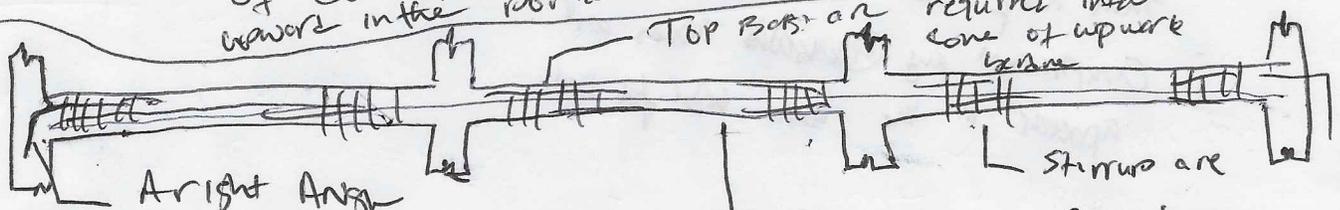
Recommended minimum thermal

Resistance -

ZONE	ceiling of Roof	Exterior WALL	FLOOR over Unheated SPACE
Minimum Rec.	19	11	11
Southern Zone	26	13	11
temperate zone	30	19	19
Northern	38	19	22

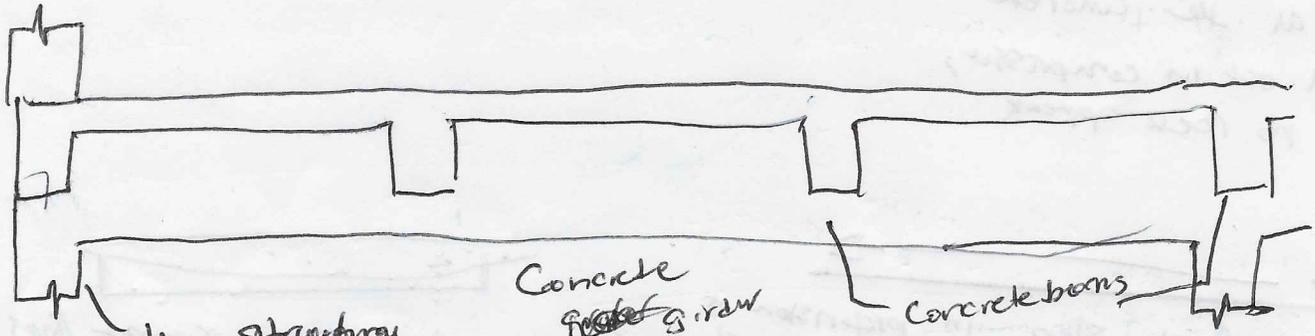


A continuous beam  
 tends downward in  
 the middle portion  
 of each span, and  
 upward in the portion  
 around the support

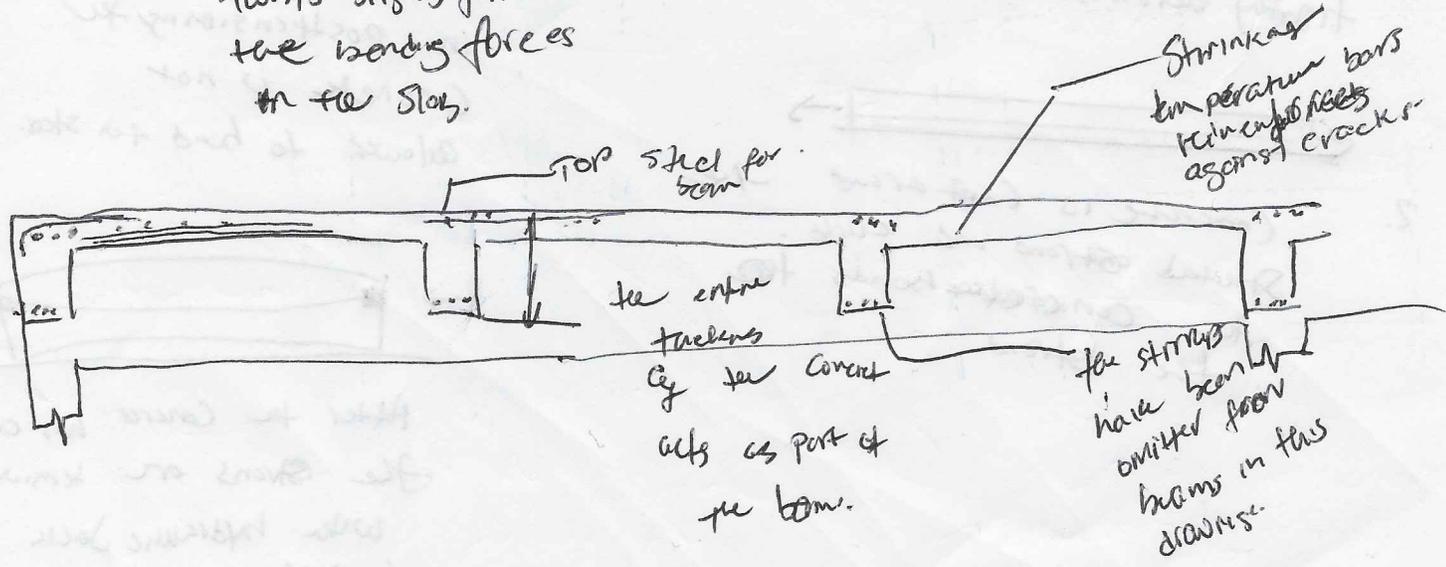


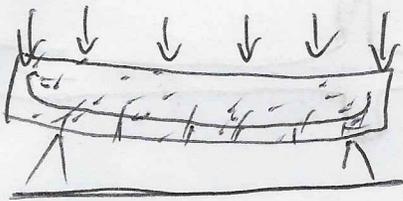
A right angle  
 bend is used in plan  
 at a hook where there  
 is sufficient space for  
 it in the concrete

Bottom  
 bars are  
 heaviest in  
 the central  
 portion of  
 the span.  
 Sometimes  
 spaces more closely  
 near column,  
 where the  
 diagonal tension  
 forces are  
 highest

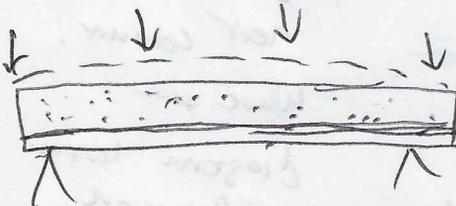


the structure  
 Spaced from  
 twists slightly from  
 the bending forces  
 in the slab.

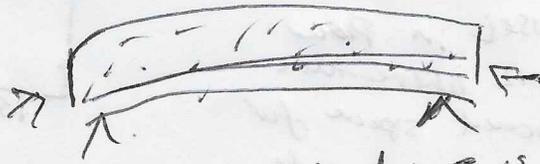




In a reinforced concrete beam, less than half the concrete is in compression and cracks will appear in the beam under full load.



Under loading, the prestressed beam becomes flatter and all the concrete still acts in compression, and no cracks appear.



When concrete beam is prestressed all the concrete acts in compression.

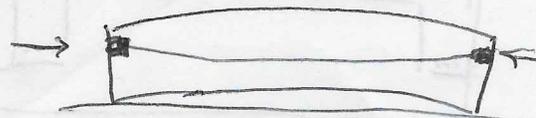
1. The first step in pretensioning is to stretch the steel prestressing strands tightly across the bed.



After the concrete has cured, the steel

in posttensioning the concrete is not allowed to bond to the steel.

2. Concrete is cast around the strands and cures. The concrete bonds to the strand.

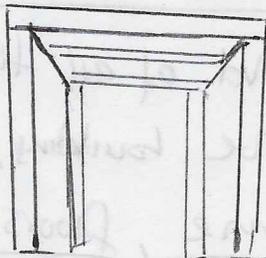
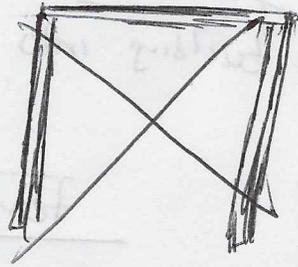


After the concrete has cured the strands are tensioned with hydraulic jack and anchored.

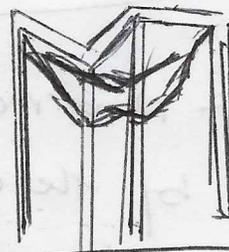
# FOUNDATION SETTLEMENTS.

## NOTE

All foundations settle to some extent as the earth materials around and beneath them adjust to loads of the building.



Structure before settlement  
uniform structure settlement



differential settlement

## EARTH MATERIALS

ROCK - Continuous mass of solid material such as

- granite or limestone

(Can only be removed by drilling)

SOIL - A general term referring to any earth material.

CLAY - PARTICLES are plate shape rather than spherical

# FOUNDATION

## Chapter 2.

THE function of a foundation is to transfer the structural loads reliable from a building into the ground

### Note

every building needs a foundation of some kind.

• LIVE LOADS - Nonpermanent loads caused by the weights of the buildings occupants, furnishing, and movable equipments.

• RAIN AND SNOW LOADS -

which act primarily downwards on building roofs.

• Seismic LOADS -

Horizontal and vertical forces caused by the motion of the ground relative to the building during an earthquake

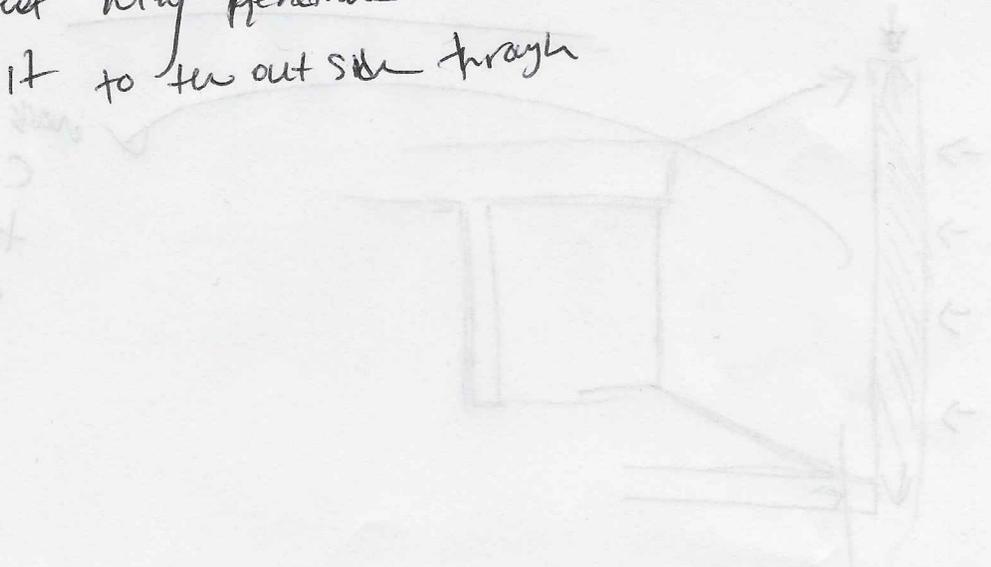
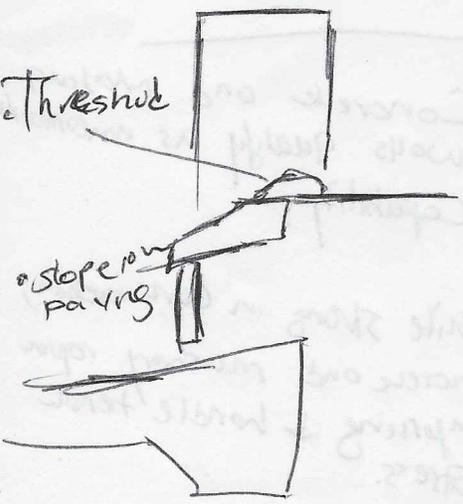
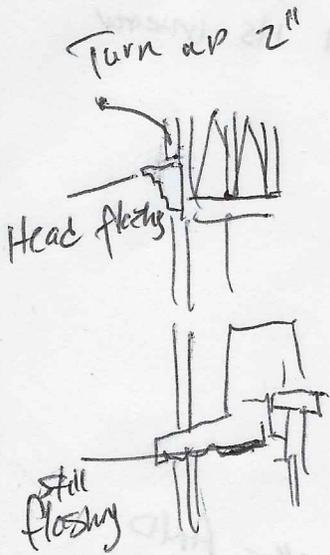
### FOUNDATION REQUIREMENTS

• Dead LOAD - the combined weight of all the permanent components of the building, including its own structural frame, floors, roofs and walls. MAJOR permanent electrical and mechanical equipment, and the foundation itself

WIND LOADS  
• RAIN AND SNOW LOADS -

which can act laterally (side ways), downwards, or upwards on a building.

Wall flashing is installed to collect any moisture that may penetrate wall and direct it to the outside through weep holes.

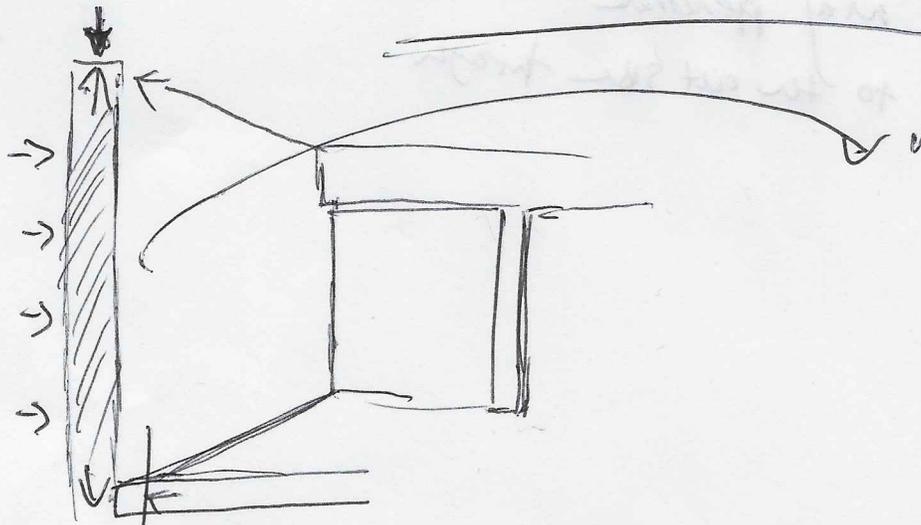


the top of the exterior wall  
 can collect water from the roof  
 and direct it to the outside  
 through weep holes.

Structural frames  
 Concrete frames are typical  
 for exterior walls. They are  
 made of concrete and steel  
 reinforcement. They are  
 designed to support the  
 weight of the roof and  
 other loads. They are  
 also designed to resist  
 lateral forces from wind  
 and seismic activity.

METAL STUD WALLS  
 METAL STUD WALLS  
 METAL STUD WALLS  
 METAL STUD WALLS

# WALL SYSTEMS



walls are the vertical constructions of a building that enclose, separate, and protect its interior spaces.

walls may serve as load bearing.

The pattern of these load bearing walls and columns should be coordinated with the layout of the interior spaces of a building.

## Concrete AND MASONRY BEARING WALLS

### Structural Frames

- Concrete frames are typically rigid
- Non combustible, fire resistant construction.
- Non combustible steel, frame may utilize movement connections and require fireproofing
- Timber frame require diagonal bracing or shear planes,
- Steel and concrete frames are able to span greater distance.

Structural concrete frames are able to span greater ~~than~~ distance and carry heavier loads

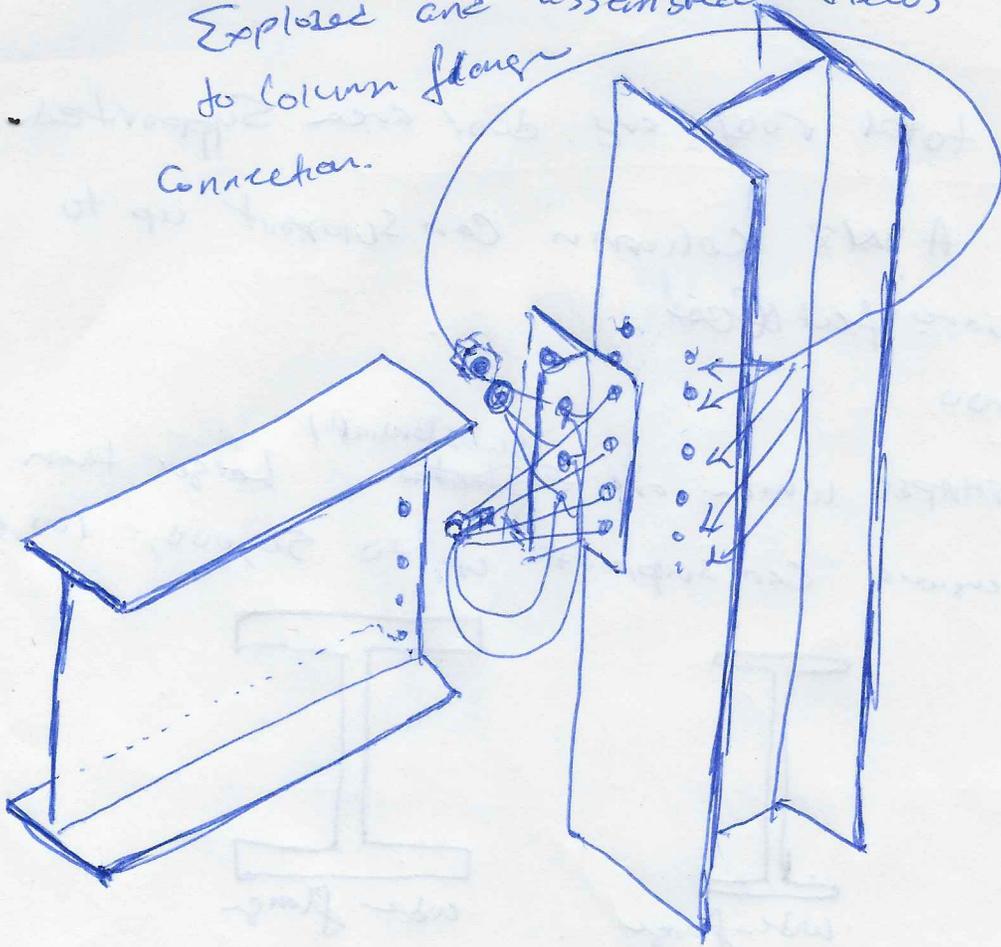
• Concrete and masonry walls qualify as noncombustible capability.

• while strong in compression concrete and masonry require reinforcing to handle tensile stress.

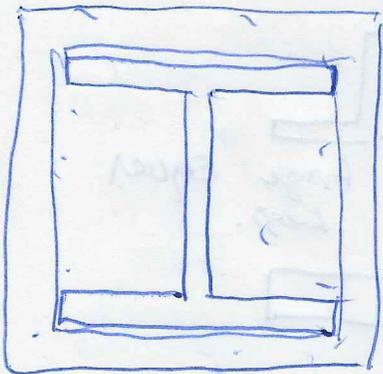
## METAL AND WOOD STUD WALLS.

• STUDS ~~are~~ <sup>of</sup> cold formed metal or wood are normally spaced @ 16" or 24"

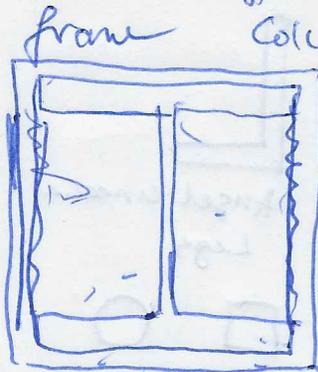
Exploded and assembled views of a bolted beam to column flange connection.



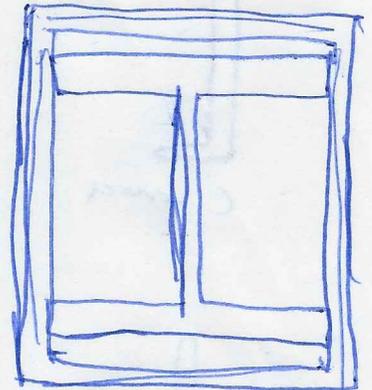
METHODS for fire proofing steel from columns.



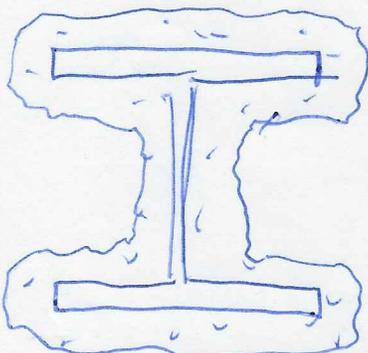
ENCASEMENT in reinforced concrete



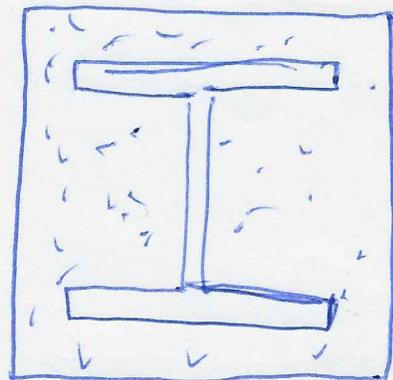
Enclosure in metal lath and plaster



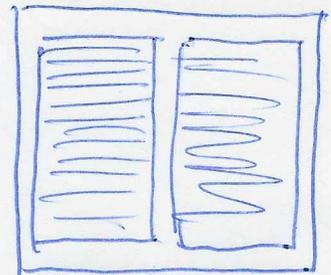
Enclosure in multiple layers of gypsum board



spray on fire proofing



Loose insulating fill



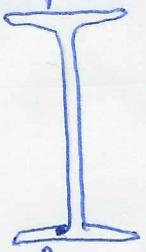
Wall filled box column use of a wide flange

# Steel Column

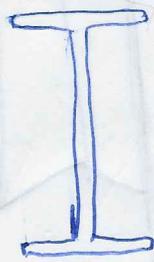
Add up to the total roofs and door area supported by the column. A W18 column can support up to about 4000 square feet

W14 column, 30,000

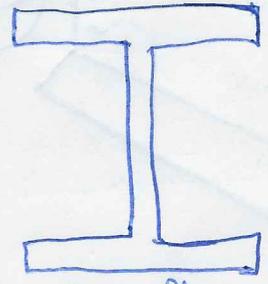
Very heavy W14 shapes which are ~~substantially~~ <sup>substantially</sup> larger than 14 inches in dimensions. Can support up to 50,000, - 100,000 square feet.



American Standard.



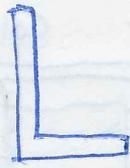
wide-flange



wide flange



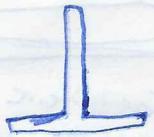
Channel



Angle unequal legs



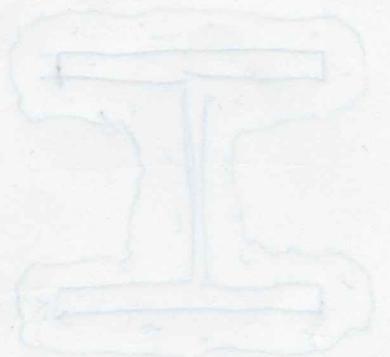
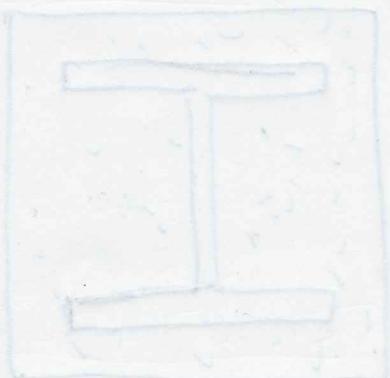
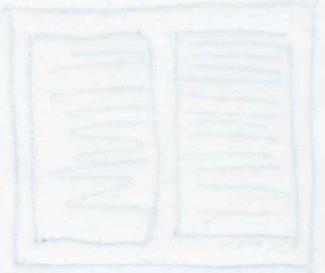
Angle Equal legs.



Structural Tee



Plate



## FOR PRELIMINARY DESIGN OF A STEEL STRUCTURE

Estimate the depth of of Corrugated Steel Roof Decking  
 $\frac{1}{40}$  of its span. Standard depths are 1,  $1\frac{1}{2}$ , and 2  
inches (25, 38, 50, and 100 mm).

Overall depth of Corrugated Steel floor decking plus  
Concrete topping at  $\frac{1}{24}$  of its span. Typical  
overall depths range from  $2\frac{1}{2}$  to 7 inches (65 to 150 mm)

Open-web Steel Joists at  $\frac{1}{20}$  of their span for  
heavily loaded doors or widely spaced joists and  
at  $\frac{1}{24}$  of their spans and for roofs, lightly loaded  
doors or closely spaced joists

Note typical joists space range from 2 to 10 feet

Steel Beams at  $\frac{1}{20}$  of their span and  
the depth of Steel Girders at  $\frac{1}{15}$  of their  
span. The width of a beam or girder is  
usually  $\frac{1}{3}$  to  $\frac{1}{2}$  of its depth.

TRIANGULAR STEEL ROOF TRUSSES at  $\frac{1}{4}$  to  $\frac{1}{5}$  of  
their span. For rectangular trusses the depth is typically  $\frac{1}{8}$  to  $\frac{1}{6}$  of their span.

# STEEL

## Chapter 11.

### STEEL

Steel is any of a range of alloys of Iron that contains less than 2 percent carbon. Ordinary structural steel, called mild steel, contains less than three tenths of 1 percent carbon. Plus traces of beneficial elements such as manganese and silicon, and of detrimental impurities such as phosphorus, sulfur, oxygen and nitrogen.

In contrast:

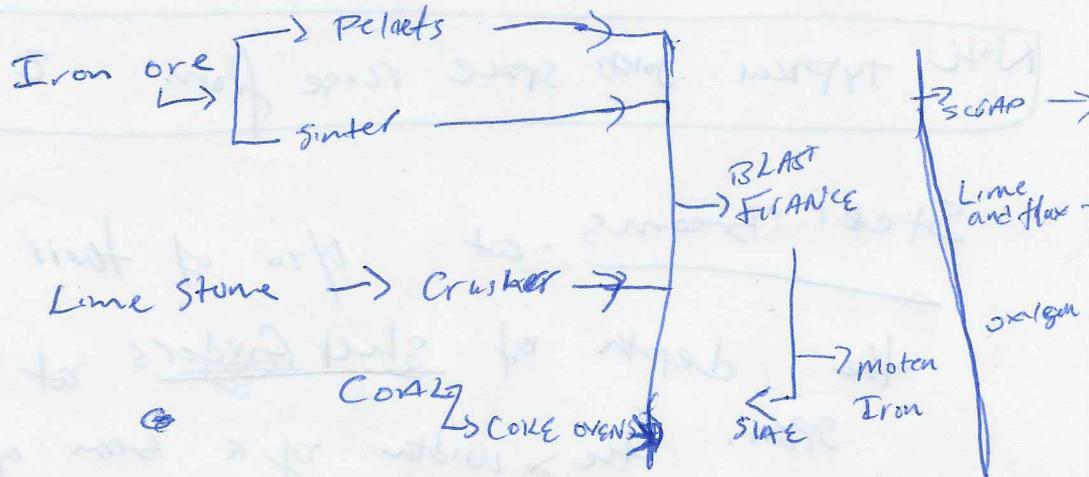
**Ordinary Cast Iron:** 3 to 4 percent CARBON and greater quantities of impurities than steel

### Rough Iron

contains even less carbon content. is a crucial determinant of the properties of any ferrans (Iron-based) metal.

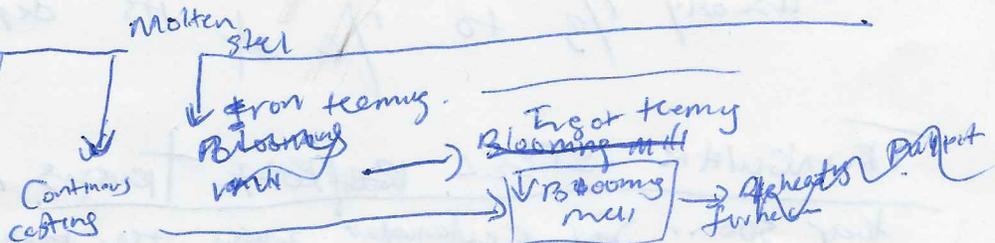
### The steel MAKING Proces

Note:  
The Eiffel tower was built of wrought Iron.



Continue

- Electric furnace
- Open Hearth furnace
- Basic oxygen furnace



## Two way flat plate

- A flat plate is a concrete slab of uniform thickness reinforced in two or more directions and supported directly by columns.

## Two-way flat slab

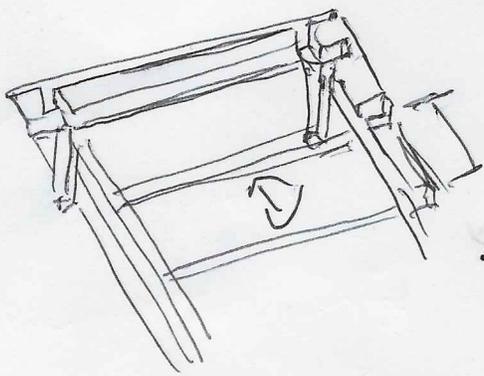
- 'A flat slab is a flat plate thickness of its columns ~~is~~ supported ~~to~~ increase its shear strength and moment-resisting capacity.

## Tensile Reinforcement

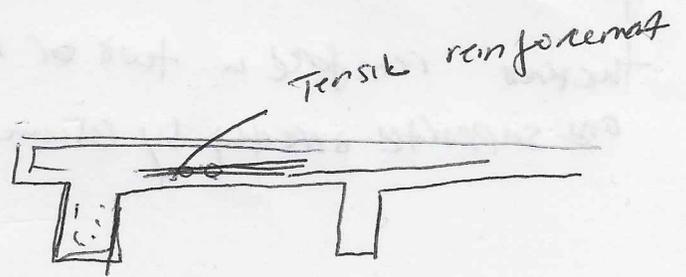
6" to 12" typical slab depth  
Rule of thumb for slab depth:  $\text{span} / 30$

- Dead Load Stress + prestress = Combined dead load and prestress stresses

Dead Load and prestress stresses + Live Load Stresses = final Combined stresses.



Suitable for ~~them~~ light to moderate loads  
over relatively short spans of 6' to 18'



### one way slab is

uniformly thick, reinforced in one direction and cast integrally with parallel supporting beams

### one-way joist slab

is a joist or ribbed slab is cast ~~the~~ integrally with a series of closely spaced joists, which in turn are supported by parallel set of beams.

### Two way slab beam

A two way slab beam of uniform thickness may be reinforced in two directions and cast integrally with supporting beams and columns on all 4 sides of sq. or nearly square ~~slab~~ slab.

### Two way waffle

A waffle slab is a two way concrete slab reinforced by ribs in two directions. waffle slabs are able to carry heavier loads.

Refer to images on pg. 4.05

Tensile reinforcement occurs in the ribs  
 & shrinkage and temperature reinforcement is placed in the slab.

### FACTS

Slab Depth: Rule of thumb total depth:  $\text{Span} / 24$

Distribution ribs formed perpendicular to the joists in order to distribute possible load concentrations over a large area.

# Facts.

Note - Beam depth

in 2" (51) increments

• Rule of thumb for estimating depth of a concrete beam:  $span / 12$

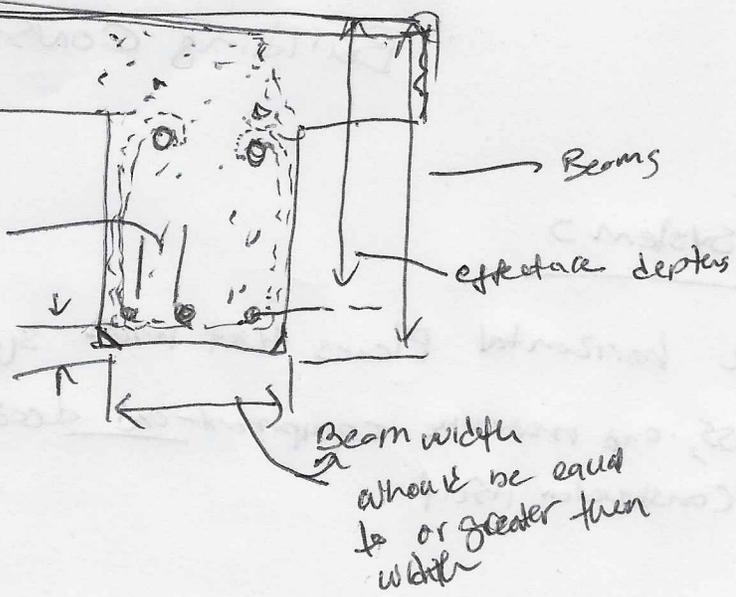
• Beam width is  $1/3$  to  $1/2$  of beam depth in 2" or 3"

Beam width should be equal to or greater than width of supporting column, whenever possible, may require steel reinforcement rather than beam size

- Reinforcement bars extend into and down column for structural continuity and develop the required embedment length for anchorage.

• Continuity between columns, beams, slabs and walls is required to minimize bending moments at these junctures.

Hooks are bends given to the end of tension bars to develop an equivalent embedment length for anchorage.



(Refer to images on page 4.04)

TOP Bars are longitudinal bars serving as tension reinforcement in the section of a concrete beam subject to the upward bending of a negative movement.

Bent Bars are longitudinal bars bent to an angle of  $30^\circ$  or more with the axis of a concrete beam

Bottom Bars are the longitudinal bars serving as tension reinforcement in the section of a concrete.

• Truss bars are longitudinal bars bent up or down at joints

### Floor Systems

Are the horizontal planes that must support both live loads - people, furnishings, and movable equipment - and dead loads - the weight of the floor construction itself.

#### NOTE

A floor system may be composed of a series of linear beams and joists overlaid with a plane of sheathing or decking, or consist of a nearly homogenous slab of reinforced concrete.

Because it must safely support moving loads, a floor system should be relatively stiff while maintaining its elasticity.

The depth of the floor construction and the cavities within it should be considered if it is necessary to accommodate runs of mechanical or electrical lines within the floor system.

Except for exterior decks, floor systems are not normally exposed to weather.

### Concrete

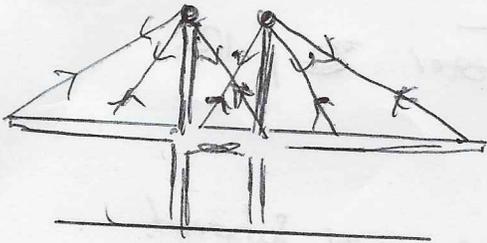
- Costs in place concrete floor slabs are classified according to their span and cast form.
- precast concrete planks may be supported by beams or load bearing walls.

### Steel

- Steel beams support decking or precast concrete planks.
- Beam framing is typically of girders, columns, or load bearing walls.
- Beam framing is typically an integral part of a steel skeleton frame system.

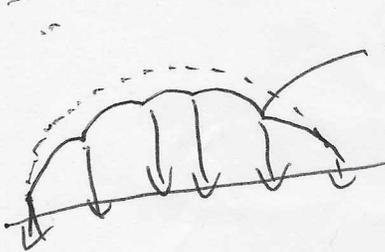
### WOOD

- Wood beams support structure.
- Planing of decking.
- Beams may be supported by girders, posts or load bearing walls.

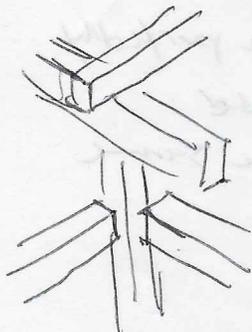


Cable stay structures have ~~the~~ vertical or inclined masts from which cables extend to support horizontally spanning members arranged in a parallel or radial pattern.

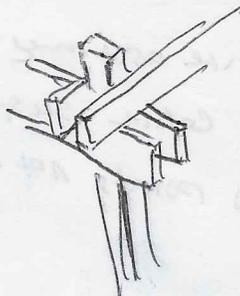
Membranes are thin, flexible surfaces that carry loads primarily through the development of tensile stress.



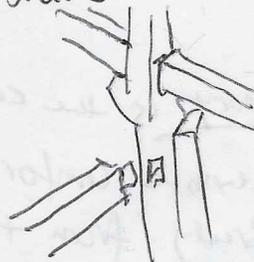
Some air-supported structures use a net cables placed in tension by the inflating force to restrain the membrane.



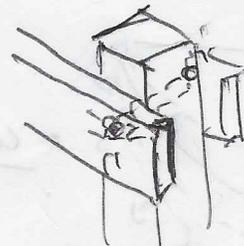
Butt joints



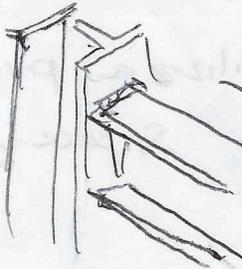
interlocking or overlapping joints.



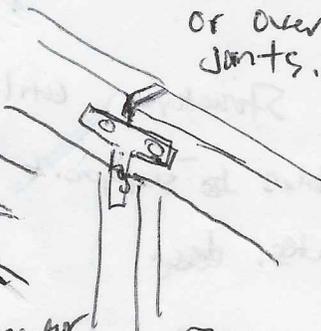
milled or shaped joints.



point connector bolt.



linear connector web.

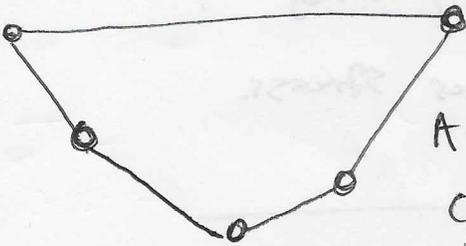


Bolted connections

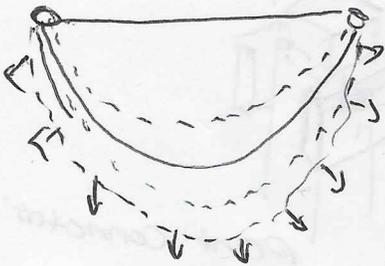
# Building Construction

Chapter 12

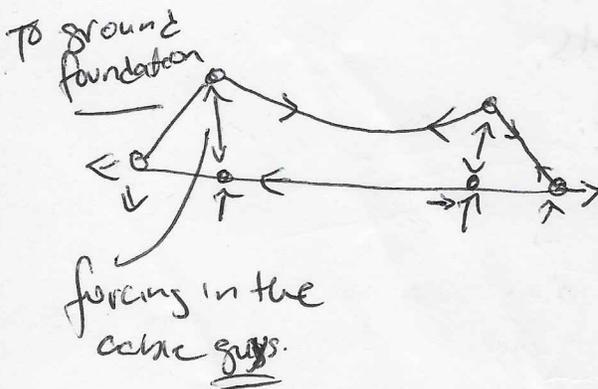
- Cable structures utilize the as the principal means of support. Because cables have high tensile strength but offer no resistance for compression or bending they must be used purely in tension.



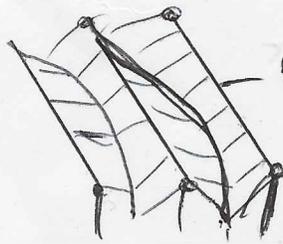
A funicular is the shape assumed by a freely deforming cable in direct response to the magnitude and location of external forces.



A catenary is the curve assumed by a perfectly flexible uniform cable suspended freely from two points not in the same vertical line.



Double Curvature Structures utilize a parallel series of cables to support surface-forming beams or plates.



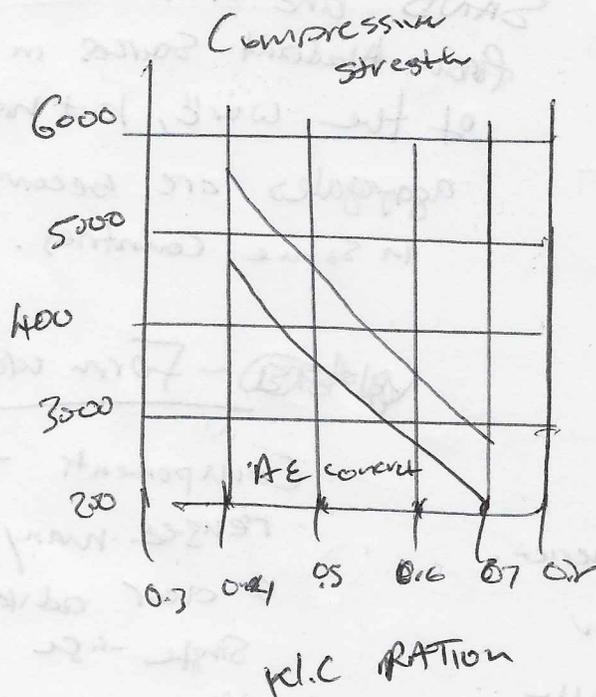
Double Curvature Structure consists of a field of crossed cables of different curvatures often reverse curvature.

## Reinforcing

Note: in ~~the~~ America  
 reinforcing bars are <sup>made</sup> ~~made~~  
 almost entirely from recycled  
 steel scrap primarily from  
 automobile.

## Supplementary Cementitious.

Various mineral products,  
 called ~~filler~~ <sup>filler</sup> may be added  
 to concrete mixtures as a  
 substitute for some portion  
 of the portland cement  
 to achieve a range of  
 benefits

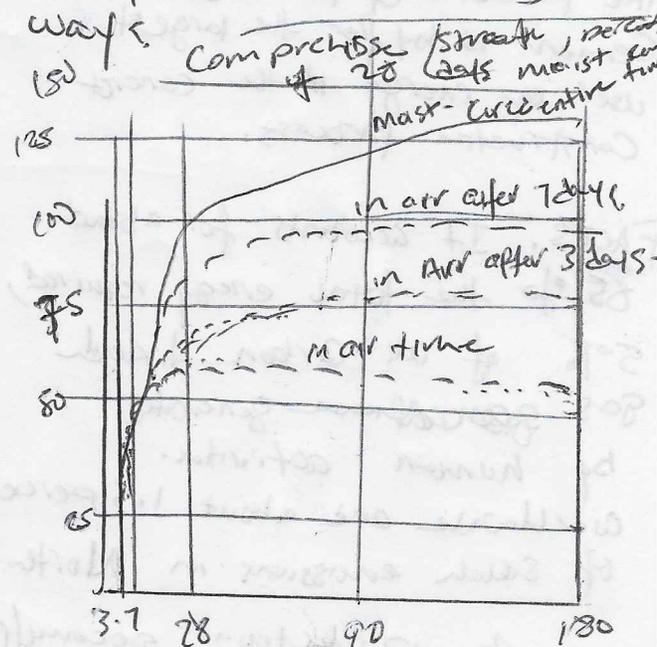


## Aggregates and WATER

Because aggregates makes up  
 roughly three quarters of the  
 volume of concrete, the structure  
 of a concrete is really  
 dependent on the quality  
 of its aggregates.

## Admixtures.

Ingredients other than cement  
 and other cementitious material  
 aggregates and water, broadly  
 referred to as admixtures, are  
 added to concrete to alter  
 its properties in various  
 ways.



The growth rate  
 of compressive strength in concrete  
 with time.

# Concrete Construction

Chapter 13 and 14

Concrete is the universal material of construction.

It is a rocklike material produced by mixing coarse and some aggregates, portland cement, and water allowing the mixture to harden.

Coarse aggregates is normally gravel or crushed stone.  
and fine aggregates is sand.

Note

- Cement is chemically combined with water.

## Portland Cement

The production of portland cement is by far the largest user of energy in the concrete construction process.

FACTS: It accounts for about 85% of the total energy required, 5% of all carbon dioxide gas generated by human activities worldwide and about 1.5 percent of such emissions in North America.

Cement production accounts for about 1.5 percent carbon dioxide emissions in the US.

## Aggregated water

SAND and crushed stone from abundant sources in many parts of the world, but highly quality aggregates are becoming scarce in some countries.

## Form work

Components that can be reused many times have a clear advantage over single-use forms, which represent a large waste of construction material.

# Green Building

The term green building and sustainable design are often used interchangeably to describe any building design in an environmentally sensitive manner.

## LEED RATING SYSTEMS.

### - Sustainable sites

Deals with reducing the pollution associated with construction activity. Selecting sites appropriate for development, protection environmentally sensitive etc.

- Water efficiency Promotes reducing the demand for potable water and the generation of wastewater conserving fixtures and more.

### - Energy Atmosphere

Encourages increasing the efficiency with which buildings and their sites acquire and use energy.

### - Materials and Resource

Seeks to maximize the use of locally available rapidly renewable and recycled materials. reduced waste and the demand for virgin materials, retain cultural resources and more.

- Indoor Environmental Quality Promotes enhanced, comfort productivity, and well building occupants.

### INNOVATION AND DESIGN

Practices exceeding the requirements set by the LEED-NC.