# LECTURE NOTES

# APBL20033 CONSTRUCTION ANALYSIS

# SEMESTER 2
# 2016

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## Lecture 3: Materials and systems: Timber

**Timber**

- o Obtained by converting log into more regular geometries
- o Centre of log is hardwood → good for construction
- o Get it from managed native forests (hardwoods) or plantations (soft and hardwoods)
- • Wood
- o Fibrous cellular composite that evolves naturally as strong material
- o Supports self-weight and wind stress
- o There is water content
- • S**oftwood** is used for structural purposes, not very dense
- o Moist, still alive, not good for construction
- • **Hardwood** is used for flooring and cladding, much denser
- o Good for construction
- • Timber conversion:
- o Effects strength, durability and quality of the sawn products

**Two main methods: back sawing (for plain-sawing) and quarter-sawing**

- • **Back sawn advantages**:
- o Structural purposes – pine, Oregon
- o Higher recovery from the log, simpler and faster to produce
- o Separation of sapwood and knotty areas is often more effective
- o Rapid seasoning with less shrinkage
- o With some soft woods (pine and Oregon) the giure is revealed only with back sawing
- o For many timbers, back sawn face is less prone to splitting when nails are driven
- • **Quarter-sawn timber:**
- o Cladding, flooring
- o Reveal rich figure with interlocking grains
- o For flooring and joinery timber is often quarter-sawn to produce boards with 'edge gran' that wears better than back-sawn
- • Dries more slowly but less prone to develop defects in seasoning like cupping & warping

**Process**

1. Growth / regeneration
2. Assessment
3. Harvesting
4. Trimming

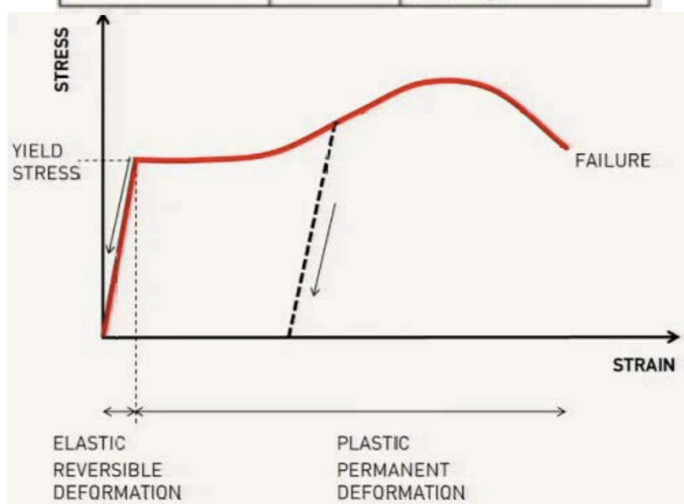
5. Transport
6. Milling

## Lecture 4: Materials and systems: Steel

(Possible exam questions: Highlight differences, advantages of timber vs. steel)

| *Type* | *Carbon content (% by weight)* | *Typical uses* |
|---|---|---|
| Cast iron | 1.8–4 | Low-stress uses—machine bases, heavy equipment, tunnel linings |
| High-carbon steel | 0.7–1.7 | High-stress uses—springs, cutting tools, dies |
| Medium-carbon steel | 0.3–0.7 | Medium-stress uses—machine parts, nuts and bolts, gears, drive shafts |
| Low-carbon or mild steel | 0.04–0.3 | Low-stress uses—construction steel (suitable for welding) |

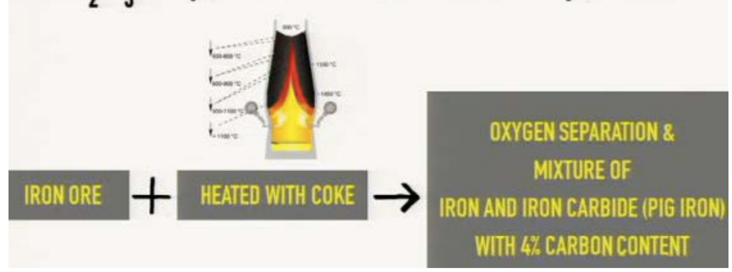
- **Wrought iron** (purest), cast iron, steel, stainless steel, ductile, good for ornamental ironwork
- Percentage of iron in the mix makes the difference
- Capability to weld 2 pieces together
- Almost impossible to weld two pieces together of wrought or cast iron
- **Eiffel Tower**: wrought iron, make shapes but has to be worked by hand. All connections done with no welding at all
- **Cast Iron:** other extreme. Very strong. Good fluidity, has low melting point which makes it almost impossible to weld
- Metals deform greatly before breaking
- → Tactile material has long plastic phase
- **Mild Steel:** iron alloys are preferred when they have these properties:
  - o Weldability (<0.5% carbon), ductility (at service temp), low cost (to strength ratio), availability (in sections and plates)
- **Steel advantages:**
  - o High strength in compression, tension and shear
  - o Excellent strength/weight ration
  - o High stiffness: less prone to deflection
  - o Not prone to creep (shrinkage)
  - o Relatively easy to connect
  - o Allows design flexibility: large open spans opening planning, high-rise




- **Steel disadvantages:**
  - o Doesn't provide the dual function of structure and envelope of other materials (masonry, concrete)
  - o Prone to corrosion, it must be protected (From water)
  - o Poor performance under fire threat
  - o Iron ore → coal → pig iron → furnace → casting/slabs/billets
- Blast furnace: material is taken and heated up 1,400 degrees and becomes liquid and called pig iron

$$3Fe_2O_3 + 11C \rightarrow 2Fe_3C + 9CO$$

$$3Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$



- Separate oxygen from iron to get carbon rebutting
- Secondary steel making: additives
- Shaped to perform structurally with minimum amount of material

**Hot rolling:**

1. Rougher → 2. Edger → 3. Finisher

- Universal Beam (UB) 2 flanges, web is longer than flange, edger are 90 degrees but there is a fillet
- Universal Column (UC). Flanges have close to same dimensions of the web.
  - Fillet. Axil forces
- Parallel flange Channels (PFC) – aesthetic purposes, can connect other steel elements, easy to work with
- Equal Angles (EA) A and B are equal
- Unequal Angles (UA) A and B are not same dimensions. A>B but still 90 degrees

**Cold forming:**

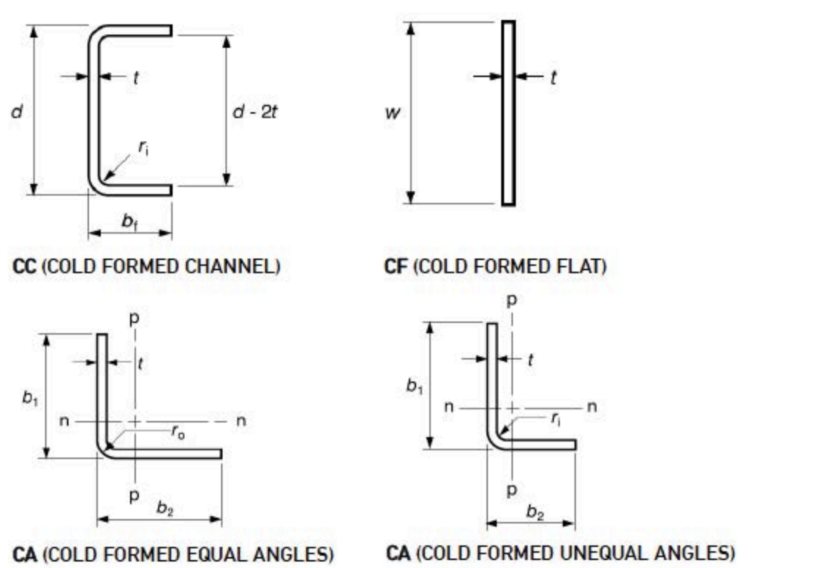
From the (cold forming) sheets we can:

**1.** Change shape of these sheets by true folding
**2.** By corrugating sheets
**3.** By curling sheets – circular hollow profiles

- 'C' or 'Z' shaped profiles
- Weaker because sheets are thinner

- Cold Formed Channel (CC)
- Cold Formed Flat (CF)
- Cold Formed Equal Angles (CA)
- Cold Formed Unequal Angles (CA)
- Circular Hollow Sections (CHS)
  - Structurally sound because of cavity
- Square Hollow Section (SHS)
  - Fillet on both sides = cold formed
- Rectangular Hollow Section (RHS)

**STANDARD COLD FORMED SECTIONS)**




- ****You know its cold formed if fillet is inside and outside**
- **** Hot rolling – fillet inside and sharp 90 degree angle on outside**

**Compaction**

- 5% - 10% of air inside mixture → need to take air out
- **Compaction**: expels entrapped air from freshly placed concrete
  - Vibration process: increases density by packing aggregrates together
  - Benefits
    - Increases: strength, abrasion resistance, durability
    - Decreases: permeability
    - Minimizes: shrinkage
  - Done vertically not diagonally
  - Don't spread concrete with vibrator → don't want segregation
  - Other method: surface vibrator (vibrating beam) (machincal screed)

**Curing**

- Process of controlling moisture
- 95% of strength after 28 days
- Concrete loses moisture – 'concrete bleeding'
- Methods:

1. Impermeable-membrane curing
2. Water curing
3. Temperature curing

**Drying shrinkage**

- Time dependent and not load induced
- Factors:

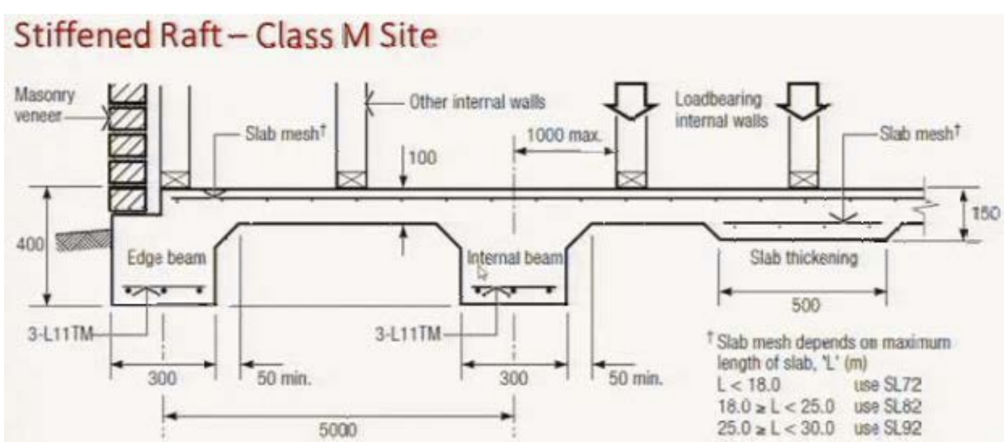
1. Ambient conditions (promote water evaporation)
2. Member geometry and size (smaller elements = shrink more)
3. Poor aggregate quality (they usually restrain shrinkage)
4. Water content (high water cement ration = increase shrinkage)

**Formworks**

- Mold for concrete, structural support while concrete sets and cures to desired strength

1. Traditional formwork (timber, properly clamped, most flexible, labour intensive)
2. Engineered formwork (prefabricated modules with metal frame, usually steel)
3. Lost formwork (stays in place after concrete cured, Bondek (corregated sheet), can also include hollow polystyrene blocks to form the underside of slabs on ground)

**Slabs on ground**



EXAMPLES/ARCHITECTS

- Henrik Petrus Berlage, Amsterdam Stock Exchange
  - Massive but honest, materials shown for what they are, joint same representation as studies
- Sheepvaarthus, Amsterdam
  - Tension between verticality of façade, courses emphasis horizontality
- Frank Lloyd Wright
  - Robie House – roman units: wide and thin, horizontality, minimized vertical lines
  - Morris Shop – arch opening: monolithic element
- Gropius, Fagus Factory
  - Masonry for solid part of building, can see masonry units
- Mies Van Der Rohe, Lange House
  - Windows wider than normal: more light, masonry to show solid, load bearing
- Alvar Aalto
  - Summer House – sophisticated way
  - Sāynātsalo Town Hall – cappings and seals done in sophisticated way
- Le Corbuiser, Maison Jaoul
  - Mixture of concrete slabs done with same sand used for mortar → same colour
  - Thermal bridge – not insulated
  - Not being used because of thermal bridges these days
- Louis Kahn
  - Richards Medical Laboratories – lighter by removing corners: exposes thickness of walls
  - Lim, Amhedabad – arches and circles, combined arch and lintel
- Residintential Building, Torino Italy – rotate brick, one single formwork for columns
- Carlo Mollinio, Teatro Regio (Royal Theatre) Torion 1967
  - Patterns, insipired by Palazzo 1679
- Aldo Rossi Casa Aurorra Torino, attentive of site characteristics
  - Local elements applied in post modern way
- Adolfo Natalini, Centro Contabile – control joints
- Maro Botta, Church in Lavinio
  - Oriental way of masonry, 'bladder of fish'
- Giogio Grassi
  - Projects in Den Hasg and Berlin – control joints
  - Roman Amphitheatre, Sagunto – reconstruction
- Rafael Moneo, National Museum of Roman Art – arches
- John Wardle, Nigel Peck Centre
  - Specific pattern so it doesn't fall
- Mark Koheller, House Ijburg – core units
- Stefano Pujatti, Elastico Spa – bricks in arbitrary way, want materials to look ugly

## Lecture 11: Waterproofing – Principles and Practice

**Waterproofing**

- Water management
- Allowing water not to become a problem inside the building
- Form of: rain, snow, underground humidity, water vapor, building services
- Forces: gravity, wind, surface tension, capillary action, hydrostatic pressure, deflection

**Water penetration – 3 conditions**

*Need all 3 for a leak to occur

1. WATER Water must be present on external surface of building system
2. GAP Opening to permit the passage of water
3. FORCE A force to drive water through the opening

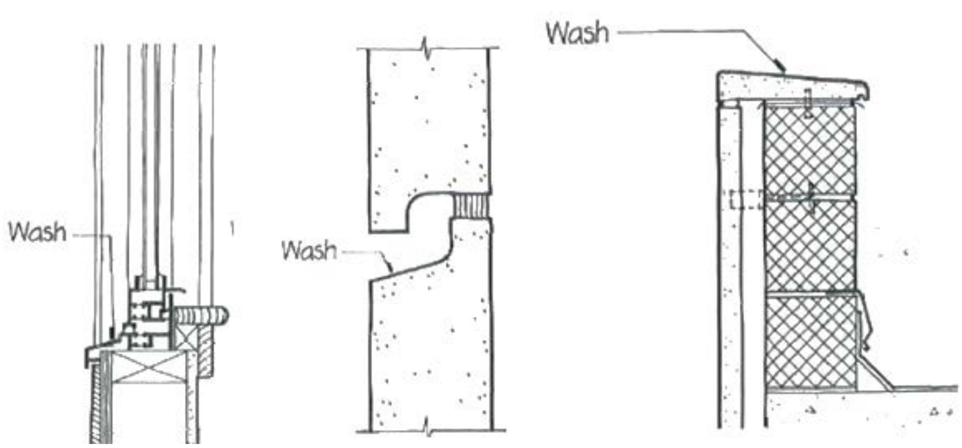
→ Do opposite to prevent a leak

1. DIVERSION Divert water
2. CLOSING GAPS Seal gaps
3. Neutralize forces (drips, eliminate surface tension)

90% of water leaks occur within 1% of total building envelope
1% of water leaks are caused by system or material failures
→ must always think of backups

DIVERSION

- **Drain, wash/fill, flashing/up stand, drip, lap, weep** (condensation in brick veneer)
  - o Wash: allowance for water that shouldn't come in to come out



Minimal surfaces, soap bubbles

- One closed frame – structure in state of pure tension – if invert applied loading = compression
- Two closes frames – catanoid; surface of revolution is catenary
- More than two closes frames
- *Bridge south of Italy 1971
  - Designed using soap bubbles and hanging fabric
  - Modular elements
  - Ground compressing structure
  - → From pure tension you get pure compression
  - 4 different parts
  - Minimal surface used to design bridge

Pneumatic Method/inflated hill method

- Once you have model, need to find way to make drawings out of it
  - Can measure, take photos, draw grid on top
- Binishells – Construction sequence
  - Structure inflated
  - Reinforcing bars bend to shape – no bar chairs but rather springs to keep in position
  - Cut off opening and then deflate structure
  - *Narrabeen North Public School - library
- Geometric Forms (analytical shapes)
  - Sydney opera house (wings taken as portion of a sphere)
  - Félic Candela, Mexico 1958
    < Hyperbolic paraboloid
    < Ruled surface
  - Church, Italy
    < Hyperbolic parabolas
    < 4 identical quarters

Félix Candela, Xochimilco, Mexico, 1958

Form finding – optimal since the beginning
Free form – nothing is optimal, only an idea concept, need to make sure it works and can build it