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Introduction

Week 1

Lec 2:

1. 4 main types of materials:

Materials	**Uses and type of atomic bonding**	**Properties**	**Example**
Metals and alloy	Metallic bond is a sharing of electrons between many atoms of a metal element Alloy is a homogeneous mixture of 2 or more element	Usually ductile Strong Intermediate to high melting temperature Subject to corrosion Dense Conductive	Steal Aluminium Brass Titanium Copper
Ceramics	Inorganic covalent or ionic bonding	Britte Strong High use and melting temp Resistant to oxidation Moderate to low density Insulators	Aluminia Glass Concrete
Polymer	Organic covalent bonds	Ductile or brittle Moderately strong Lower temp use but low melt temp easy for process Resistant to corrosion Very low density Insulators	Polyvinylchloride Epoxy Rubber
Composites		A mixture of two or more materials, composites ideally have combined properties that exceed the individual properties of any single component.	reinforce concrete fibre glass carbon fibre reinforced polymer

2. **Deadload vs live load**
   Dead load includes the weight of all items **that attached** to the structure and likely to **remain** in the as-built location throughout **the life of structure**. **beams, columns, floor slabs, walls, roofs, mechanical equipment.**
   Live load includes anything **can be moved in or out** the structure over the course of **its life**. **People, furniture, equipment**. Predict on the live load will depends on the use.
3.
   - Young modulus = stress/strain, when applied force, force will transfer to the high young modulus. To avoid we put gap b/w
   - Stiffness is important because sharing stress is proportional to E
4. **Tension test of steel**: **Commonly** used for **quality control** to determine **tensile** strength and **young's modulus**
   Compression test of concrete: **commonly** used for **quality control** to determine compressive **strength and young's modulus**
   Testing tensile of concrete (**not frequently** use - **not** for **quality control**)
   Bending test of glass: (measure modulus of **rupture**) Used to determine **the flexural tensile strength** of glass materials (**not** for **quality control**)

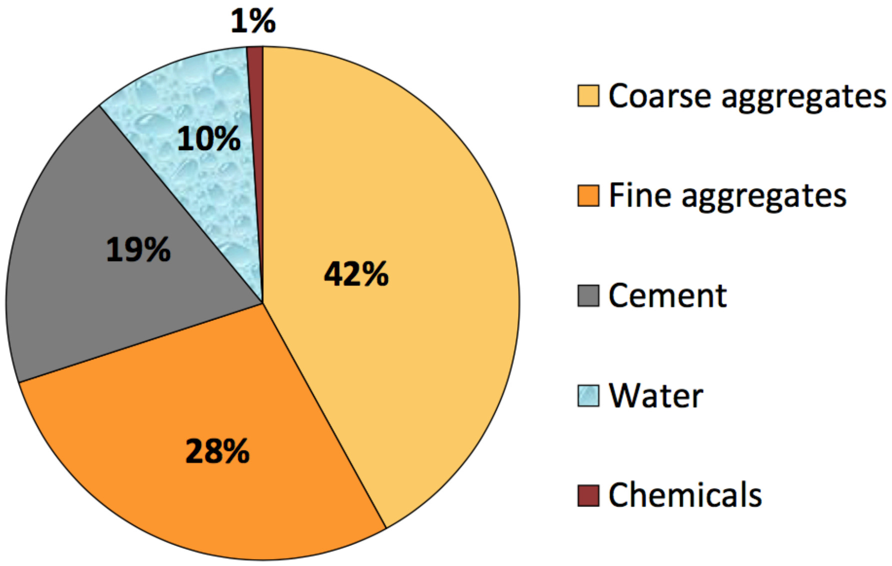
5. **Material processing** is defined as **series of steps** or unit operations used in the manufacture of **raw materials into finished good**

Concrete

1. **Pros and Ctowns of Concrete**
   - Pros:

   Raw materials are readily available
   Concrete itself is low cost material
   Easy to transport and handle
   Does not Burn
   Strong in compression
   - Cons:

   Concrete has no form of its own
   No useful tensile strength, and bending.
2. **Usual concrete composition**



Paste : 30-40% of the mix
Aggregates: 60~70% of the mix

3. Water cement ratio:
    - w/c = **0.3**: **high** performance concretes (>60MPa)
    - w/c = **0.6: Low** strength concretes (<20Mpa)
    - Water and cement react to form cement hydration product. The hydration process affects hardening of concrete. Increase in w/c ratio decrease concrete strength.
4. **Aggregates**: represent **60~70% of concrete**.
    - Relatively **inert materials** (**no chemical reaction** expected with cement paste)
    - **Influence** on concrete properties: **strength, stability with time, workability**.

    3 main **functions** of aggregates:
    - Provide a **mass of particles** which are suitable to **resist the action of applied load** & show **better durability** than cement paste alone.
    - **Cheap** filler for the cementing material
    - To reduce **volume change** from **setting & hardenin**g process **& moisture change** in drying, wetting

    Good aggregate:
    - Must be **chemical inert**
    - **Free** of **organic matter**
    - **Good grading**
    - **Good particle shape**
    - **Low** volume of **voids**
    - Particle surface texture and strength must afford a **good bond plane** for the **cement paste.**

    2 types of aggregates:
    - **Coarse** aggregates: crushed **rock**, **gravel** or **screening**
    - **Fine** aggregates: fine and coarse **sands**, crusher **fines**
5. Hydration of cement:
    - Concrete does **not harden** by **drying** out

- **Hydration** is the general term used to describe the **chemical reaction** that takes place b/w **cement grains and water**
- Forming **strong crystals** that **bind** the **aggregates** together
- => Call **curing**
- Chemical reaction **starting immediately** once cement is contact with water: exothermic reaction (**releases heat**), hydration **starts at the surface** of **cement grain**.

More detail:
  - **cement grain becomes smaller** as hydration progress following a **complex dissolution and precipitation process**
  - All component (**C3S, C2A, C3A, C4AF**) react **simultaneously** but at **different rates** and **product different hydrates**
  - **Smaller** cement grains are the **first** to be **completely** hydrated
  - **Largest** cement grains **never completely hydrate** even after yeas
  - **Hydration** is a very **long process** (stiffening and hardening over years)

6. Reinforce concrete:
   - **Concrete** has high compressive strength but **no** useful in **tensile strength**.
   - **Steel** has **high tensile strength**, and steel is compatible with concrete.
   - **Put** steel bars in the areas of concrete **where tensile stress will develop**
   - Steel bar **reinforce concrete (composite material**)
   - Some issue: **cost** (steel has high cost, **corrosion**: steel protected by **high Ph**, after a while, **ph. will decrease**, **surface pores open**, steel **corrodes**, **weaken** steel.
7. Porland Cements:
   - **Dry powder** of very **fine particle**
   - forms a **paste** when mixed with **water**
   - **hydration**: chemical reaction
   - **glue**
   - **paste** coats all the **aggregates** tgt
   - **hardens** and forms a **solid mass**.

   Chemical combination: calcium carbonate **CaCo3**, silica **SiO2**, alumina **Al2O3**, iron oxide **Fe2O3**, gypsum **CaSO4**

   2 Stages :
   - **clinker**: produced when **limestone** and **clay** are **burnt**
     At 750 -950: CaCO3 -> CaO + CO2
     At 1350: Reaction between CaO and Si, Al, C2S
     At 1450: liquid formation with C3A and C4AF
   - **Portland cement**: produced by **grinding clinker** and small amount of **gypsum**
8. Decarbonation of limestone, high release of CO2: 1 ton of CaCo3 releases 440 kg of CO2.
   Cement is 3^{rd} highest of global CO2 emission (8%) will be 16% (low) in 2050 or 24% in 2050 (high)
9. Principal cement in AU:
   GP: **general** purpose **porland** cement
   GB: **general** purpose **blended** cement

LH: **low heat** cement – when temp is high, reaction is quick => use this
HE: **high early** strength cement – C3S is the first one react, use less C2S
SL: Shrinkage Limited cement
SR: Sulphate Resisting cement – react very well with C3A, reduce C3A

Various cement consituents: There are 4 major constituents of portland cement:

- C3S tricalcium silicate
- C2S dicalcium silicate
- C3A tricalcium aluminate
- C4AF tetracalcium aluminofererite
- Mgo
- CaO

C3A react first if there is **no gypsum** in the cement. It causes what we call **flash setting** (to avoid this we add few **percent of gypsum** in the cement to **control the reactivity of c3A**)
C3S react first in a cement with **gypsum** and is the component control **the early strength of cement paste**. C3S is the component that contributes the **most to the strength of the cement paste.**
C2S reacts second in a cement with gypsum, it also **contribute a lot to the strength of cement paste.**

HE cement need highest amount C3S in clinker, hence, clinker A, some gypsum to control flashsetting around 4~5%.
SR have to choose the lowest amount of C3A => clinker A again. Not have more than 1% gypsum.