# Properties of Materials

## (PHYSICAL AND MECHANICAL)

# CONCRETE

Ingredient – cement, water, small stones

Strength – cheap, fireproof & weatherproof, molds any shape, strong in compression

Weaknesses – cracks with temperature changes, weak in tension

Applications – early arch bridges & domes

# REINFORCED CONCRETE

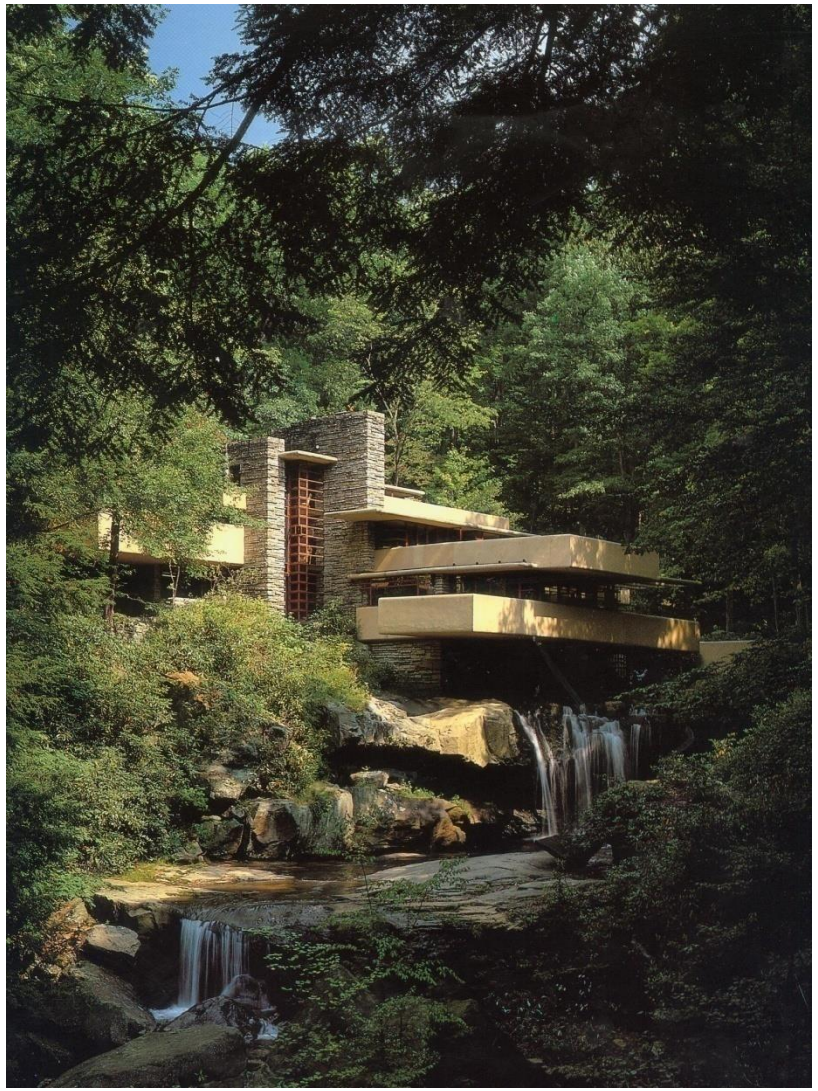
Type – fine-grained concrete with high strength steel

Ingredient – steel bars hidden in concrete

Strength – low-cost, fireproof & weatherproof, molds any shape, strong in compression & tension

Weaknesses – can crack as it cools & hardens

Applications – bridges, dams, domes, buildings



# BRICK

Type – ordinary brick

Ingredient – burned clay

Strength – cheap, strong in compression

Weaknesses – heavy, weak in tension

Applications – walls of early skyscrapers and tunnels, domes

# CAST IRON

Type – cast iron

Ingredient – iron with lots of carbon

Strength – molds to any shape, strong in compression

Weaknesses – weaker than steel in tension, breaks without warning

Applications – arch bridges, cannons, domes

# STEEL

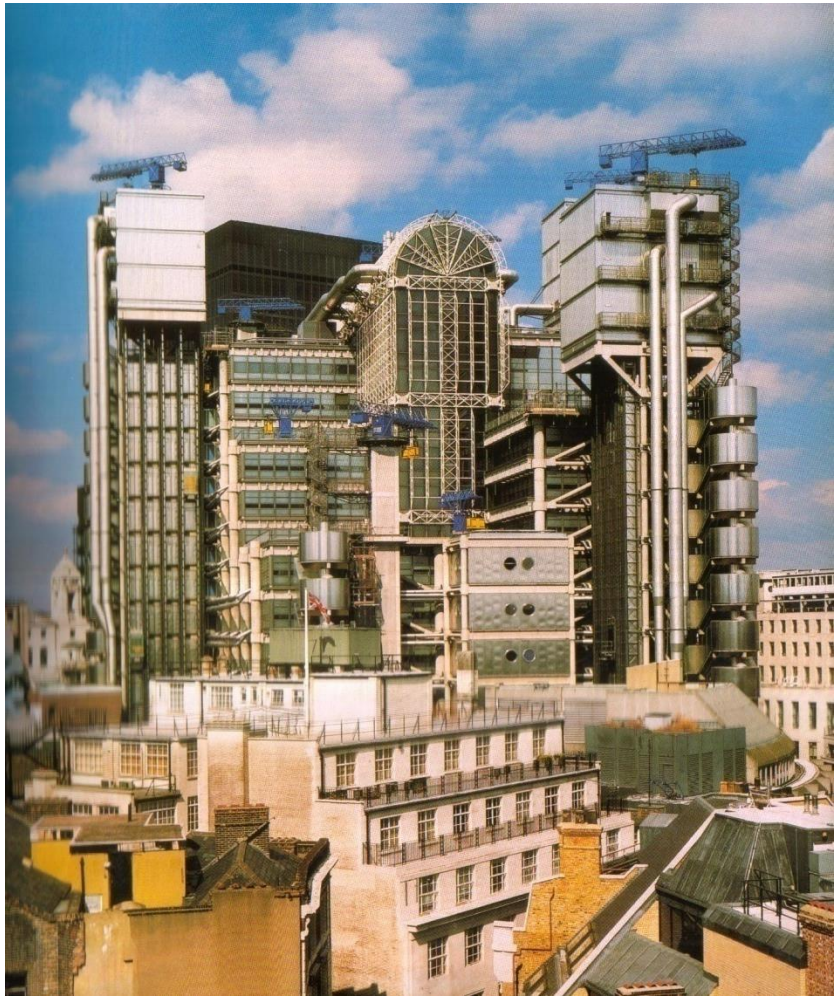
Type – high-strength steel

Ingredient – iron with a touch of carbon

Strength – one of the strongest materials used in construction, strong in compression & tension

Weaknesses – rusts, loses strength in extremely high temperature

Applications – cables in suspension bridges, buildings



# ALUMINUM

Type – aluminum alloy

Ingredients – aluminum w/ magnesium & copper

Strength – lightweight, doesn't rust, strong in compression & tension

Weaknesses – expensive

Applications – airplane wings, boats, skyscrapers "skin"

# WOOD

Strength – cheap, lightweight, moderately strong in compression & tension

Weaknesses – rots, swells and burn easily

Applications – bridges, houses, 2 or 3-story buildings


# PLASTIC

Type – high-strength plastic fabric

Ingredients – long chain of molecules

Strength – flexible,  lightweight, long lasting, strong in compression & tension

Weaknesses – expensive

Applications – tent structures, inflatable roofs

# Properties of Quality Concrete

- Workability (ease of placement; resistance to segregation homogenous mass as well bleeding)
- Consistency (ability to flow)
- Uniformity

# Workability

- Workability is the property that determines the ease with which freshly mixed concrete can be placed and finished without segregation.
- Workability is difficult to measure but ready-mix companies usually have experience in determining the proper mix.
- Therefore, it is important to accurately describe what the concrete is to be used for, and how it will be placed.

# Properties of hardened concrete

Fully cured, hardened concrete must be strong enough to withstand the structural and service loads which will be applied to it and must be durable enough to withstand the environmental exposure for which it is designed. If concrete is made with high-quality materials and is properly proportioned, mixed, handled, placed and finished, it will be the strongest and durable building material.

# Properties of hardened concrete

- Strength
- Creep
- Durability
- Shrinkage
- Modulus of Elasticity
- Water Tightness (impermeability)
- Hardness
- Toughness

# Properties of hardened concrete

- **Strength:**

When we refer to concrete strength, we generally talk about compressive strength of concrete. Because, concrete is strong in compression but relatively weak in *tension* and *bending*. Concrete compressive strength is measured in pounds per square inch (psi). Compressive strength mostly depends upon amount and type of cement used in concrete mix. It is also affected by the water-cement ratio, mixing method, placing and curing. Concrete tensile strength ranges from 7% to 12% of compressive strength. Both tensile strength and bending strength can be increased by adding reinforcement.

# Properties of hardened concrete

- **Creep:**

Deformation of concrete structure under sustained load is defined as concrete creep. Long term pressure or stress on concrete can make it change shape. This deformation usually occurs in the direction the force is applied.

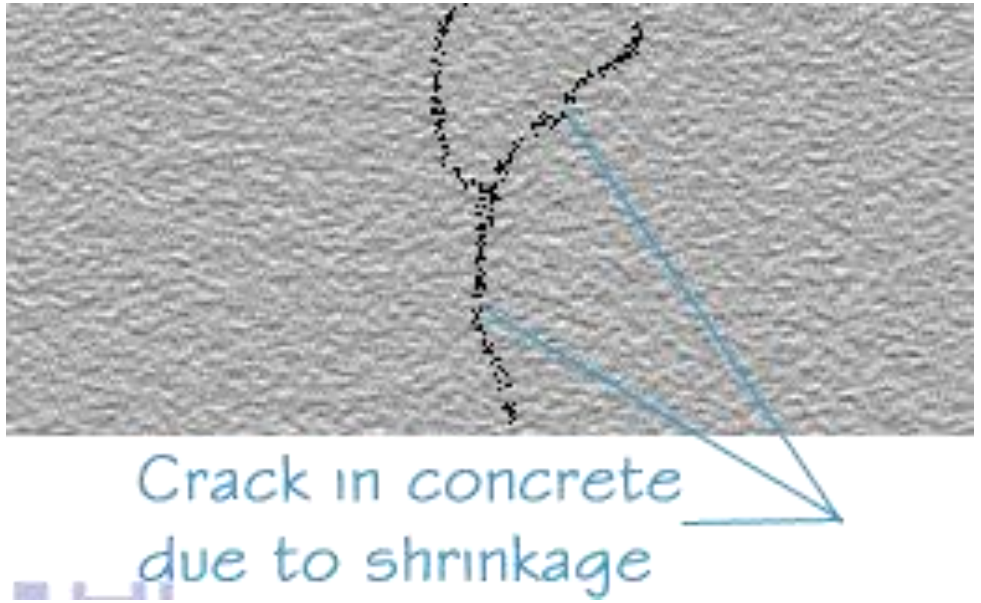
- **Durability:**

*Durability* might be defined as the ability to maintain satisfactory performance over and extended service life. The design service life of most buildings is often 30 years, although buildings often last 50 to 100 years. Most concrete buildings are demolished due to obsolescence rather than deterioration. Different concretes require different degrees of durability depending on the exposure environment and properties desired. Appropriate concrete ingredients, mix proportions, finishes and curing practices can be adjusted on the basis of required durability of concrete.

# Properties of hardened concrete

- **Shrinkage:**

Shrinkage is the volume decrease of concrete caused by drying and chemical changes. In another word, the reduction of volume for the setting and hardening of concrete is defined as *shrinkage*.



# Properties of hardened concrete

- **Water tightness:**

Another property of concrete is water tightness. Sometime, it’s called impermeability of concrete. Water tightness of concrete is directly related to the durability of concrete. The lesser the permeability, the more the durability of concrete. Now the question is, what is the permeability of concrete?
In simple word, the capability of penetrating outer media into concrete is the permeability of concrete. Outer media means water, chemicals, sulphates, etc.

# Properties of hardened concrete

- **Modulus of Elasticity:**

The *modulus of Elasticity* of concrete depends on the Modulus of Elasticity of the concrete ingredients and their mix proportions. As per ACI code, the modulus of Elasticity to be calculated using following equation:

$$E_c = 33\omega_c^{1.5}\sqrt{f'_c} \quad (psi)$$

*Where*, $\omega_c$ = unit weight of concrete, $^{lb}/_{ft3}$

$f'_c$ = 28 days compressive strength of concrete

For normal weight concrete (90 $^{lb}/_{ft}3$ to 160 $^{lb}/_{ft}3$), we assume that formula

$$E_c = 57000\sqrt{f'_c}$$

# *Compressive strength depends upon three factors.*

1- Paste Strength
2- Interfacial Bonding
3- Aggregate Strength

**1. Paste strength:**

It is mainly due to the binding properties of cement that the ingredients are compacted together. If the paste has higher binding strength, higher will be strength of concrete.

**2. Interfacial bonding:**

Interfacial bonding is very necessary regarding the strength. Clay hampers the bonding between paste and aggregate. The aggregate should be washed for a better bonding between paste and aggregate.

**3. Aggregate strength:**

It is mainly the aggregate that provide strength to concrete especially coarse aggregates which act just like bones in the body. Rough and angular aggregate provides better bonding and high strength.

# Factors affecting Strength of concrete

Following are the factors that affect the strength of concrete:

1. Water-Cement ratio
2. Type of cementing material
3. Amount of cementing material
4. Type of aggregate
5. Air content
6. Admixtures

**1. Water-Cement ratio:**

It is water cement ratio that basically governs the property of strength. Lesser the water cement ratio, greater will be strength.

**2. Type of cement:**

Type of cement affect the hydration process and therefore strength of concrete. Amount of cementing material: it is the paste that holds or binds all the ingredients. Thus greater amount of cementing material greater will be strength.

**3. Type of Aggregate:**

Rough and angular aggregates is preferable as they provide greater bonding.

**4. Admixtures:**

Chemical admixtures like plasticizers reduce the water cement ratio and increase the strength of concrete at same water cement ratio. Mineral admixtures affect the strength at later stage and increase the strength by increasing the amount of cementing material.