

UNIVERSITY OF TLEMCCEN

**THE INSTITUTE OF TECHNICAL AND APPLIED SCIENCES
(ISTA)**

Chapter 1: Definition and Composition of Concretes

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1.1 Introduction to Concrete

Definition of Concrete

- Concrete is a composite material used in construction.
- It is composed of several main components: cement, water, aggregates.



CEMENT



WATER



WATER



AGREMAITS



AGGREGATES

Importance of Concrete

- The most widely used construction material in the world.
- Moldable (Façonnable)
- Does not require baking
- Can be moulded on-site or prefabricated
- Known for its compressive strength and durability.
- Used in various types of constructions, from foundations to complex structures.

Formulation of Concrete/ Fundamental Principle

Formulating concrete involves integrating essential parameters such as:

- ✓ the quality of available materials,
- ✓ the nature of the project to be carried out,
- ✓ the means of implementation available on site,
- ✓ the quality of the environment in which the structure will "live",
- ✓ the conditions of implementation (requirements for workability, early-age strength, ...),
- ✓ the deadlines for completion.

➤ **In order to meet the objectives of:**

- durability,
- aesthetics,
- mechanical resistance,
- watertightness. (étanchiété)

Composition of Concrete

Cement: The primary binder, often Portland cement.

Water: Necessary for the hydration of cement.

Aggregates: Sand and gravel, representing 70-80% of the volume.

Admixtures: Modify certain properties of concrete (setting time, fluidity, etc.).

Ciment : Le liant principal, souvent du ciment Portland.

Eau : Nécessaire pour l'hydratation du ciment.

Granulats : Sable et gravier, représentant 70 à 80 % du volume.

Adjuvants : Modifient certaines propriétés du béton (temps de prise, fluidité, etc.).

The constituents of concrete

Cement
7 to 14%
of the volume

Aggregates 60%
to 70% of the
volume

Water 14% to
22% of the
volume

Admixtures 0%
to 2% of the
volume

Air 1% to 6% of
the volume

Detailed Composition

1. Types of Cement:

- Ordinary Portland Cement (OPC)
- Blended Cements (e.g., fly ash, slag), Ciments mélangés (par exemple, cendres volantes, laitier)
- Rapid Hardening Cement, Ciment à prise rapide
- Sulfate Resisting Cement, Ciment résistant aux sulfates

Detailed Composition

2. Properties of Aggregates:

- Size and shape influence workability, La taille et la forme influencent la maniabilité
- Cleanliness affects bond strength, La propreté affecte la résistance du lien
- Grading affects strength and durability, Le calibrage affecte la résistance et la durabilité

Detailed Composition

3. Water Quality:

- Clean water free from contaminants
- Water/cement ratio is critical for strength,

Water Role

Its role:

- To allow the hydration of the cement paste
 - To wet the surface of the aggregates so that the cement paste can adhere to them
 - To enhance the workability of the concrete (slump test).
-

Types of Concrete

- **High-Performance Concrete:**

- Superior mechanical and durability properties.
- Uses special aggregates and admixtures.

- **Lightweight Concrete:**

- Lower density, made with lightweight aggregates.
- Used for thermal insulation and reduced dead load.

Ordinary Concrete (Non-Reinforced Concrete)

- **Composition:** Standard mix of cement, water, fine aggregates (sand), and coarse aggregates (gravel).
 - **Usage:** Primarily used for structures where compressive strength is required but without steel reinforcement (e.g., sidewalks, floor slabs).
-

1. Béton Ordinaire (Béton Non Armé)

- *Composition : Mélange classique de ciment, d'eau, de granulats fins (sable) et de granulats grossiers (graviers).*
- *Utilisation : Principalement pour les constructions où la résistance en compression est requise, mais sans renfort en acier (ex. trottoirs, dalles de plancher)*



Ordinary Concrete (Non-Reinforced Concrete)



Reinforced Concrete

- **Composition:** Concrete reinforced with steel bars (reinforcement).
- **Usage:** Used for structures requiring both compressive and tensile strength, such as foundations, beams, columns, and slabs.

Reinforced Concrete



**Steel reinforced
bars**

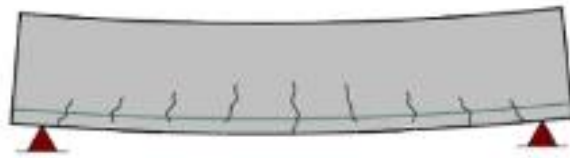
Concrete



Prestressed Concrete

- **Composition:** Similar to reinforced concrete, but the steel reinforcement is stretched before the concrete is placed.
 - **Usage:** Employed for structures requiring long spans without intermediate supports (e.g., bridges, beams).
-
- **Béton Précontraint**
 - **Composition :** Similaire au béton armé, mais l'acier de renforcement est tendu avant la mise en place du béton.
 - **Utilisation :** Employé pour les structures nécessitant de grandes portées sans supports intermédiaires (ex. ponts, poutres).

Reinforced Concrete



Cracked under Dead Load & Service Loads

Partially Prestressed Concrete

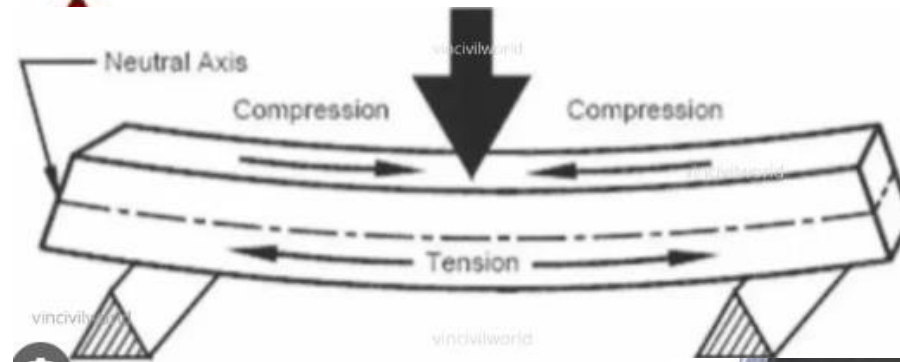


Uncracked under Dead Load
Cracked under Service Loads

Full Prestressed Concrete



Uncracked under Dead Load & Service Loads



Prestressed Concrete



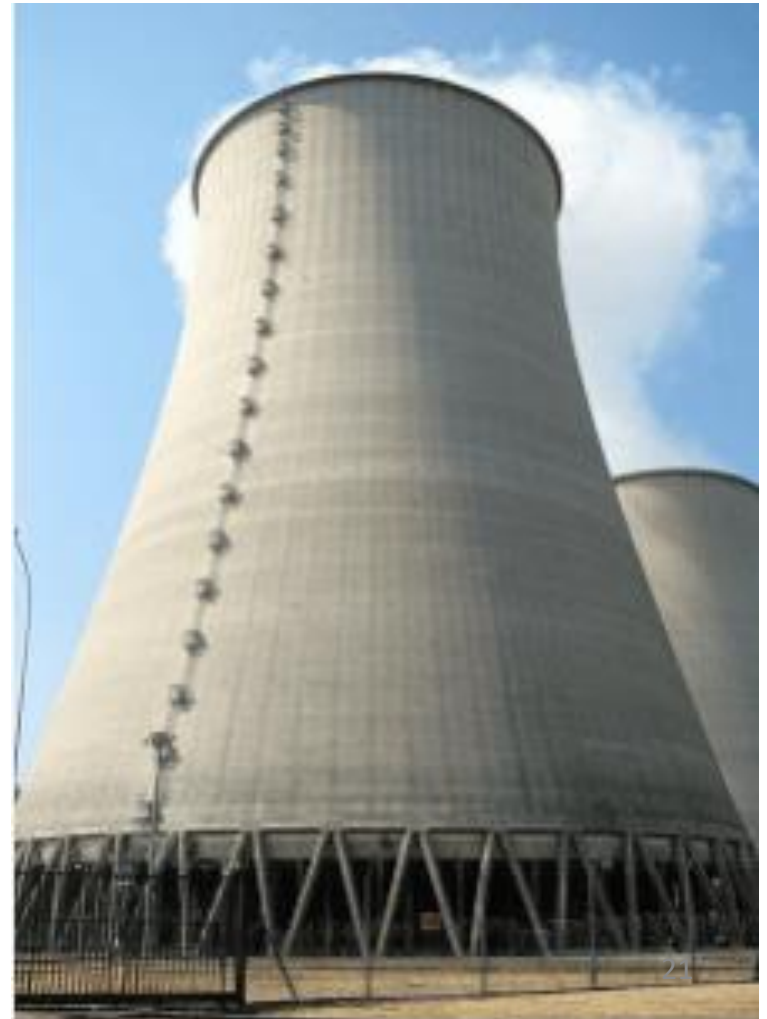
Heavyweight Concrete

- **Composition:** Uses heavy aggregates like barite or hematite.
 - **Usage:** Primarily in applications requiring radiation shielding (nuclear power plants, hospitals).
-

- **Béton Lourd**
- **Composition :** Utilise des granulats lourds comme la barytine ou l'hématite.
- **Utilisation :** Principalement dans les applications nécessitant une protection contre les radiations (centrales nucléaires, hôpitaux).



Heavyweight Concrete

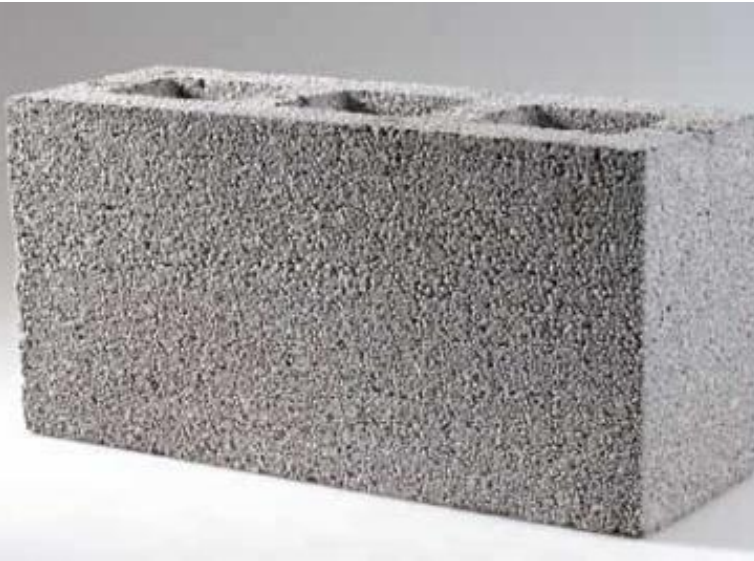
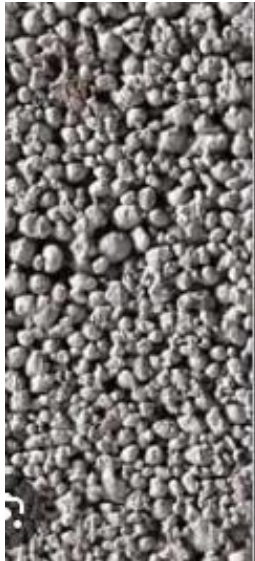


Lightweight Concrete

- **Composition:** Uses lightweight aggregates (pumice, expanded clay).
 - **Usage:** For constructions where weight reduction is critical (e.g., prefabricated panels, lightweight floors).
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Béton Léger

- **Composition :** Utilise des granulats légers (pierre ponce, argile expansée).
- **Utilisation :** Pour les constructions où la réduction du poids est primordiale (ex. panneaux préfabriqués, planchers légers).



Lightweight Concrete

High-Strength Concrete

- **Composition:** Concrete with a very low water-cement ratio, generally less than 0.35, often enhanced with admixtures.
 - **Usage:** For structures subjected to high loads or extreme conditions (e.g., skyscrapers, bridges).
-

Béton à Haute Résistance performance

- **Composition :** Béton avec un rapport eau-ciment très faible, généralement inférieur à 0,35, et souvent enrichi avec des adjuvants.
- **Utilisation :** Pour les structures soumises à des charges importantes ou à des conditions extrêmes (ex. gratte-ciels, ponts).

High-Strength Concrete



High-Performance Concrete (HPC)

- **Composition:** Concrete mix optimized for superior mechanical and durability performance.
 - **Usage:** Used in harsh environments or structures requiring a very long service life (e.g., marine infrastructures).
-

Béton à Haute Performance (BHP)

- **Composition :** Mélange de béton optimisé pour obtenir des performances mécaniques et de durabilité supérieures.
- **Utilisation :** Utilisé dans des environnements sévères ou des structures nécessitant une très longue durée de vie (ex. infrastructures maritimes).



Vidya Sagar Setu Bridge, Kolkata, India

Self-Compacting Concrete (SCC)

- **Composition:** A fluid concrete that self-levels without vibration, often with superplasticizers.
 - **Usage:** Used for constructions requiring rapid placement or in difficult-to-reach areas.
-

Béton Autoplaçant (BAP)

- **Composition :** Un béton fluide qui se met en place sans vibration grâce à un mélange très maniable, souvent avec des superplastifiants.
- **Utilisation :** Utilisé pour les constructions nécessitant un coulage rapide ou dans des endroits difficilement accessibles.



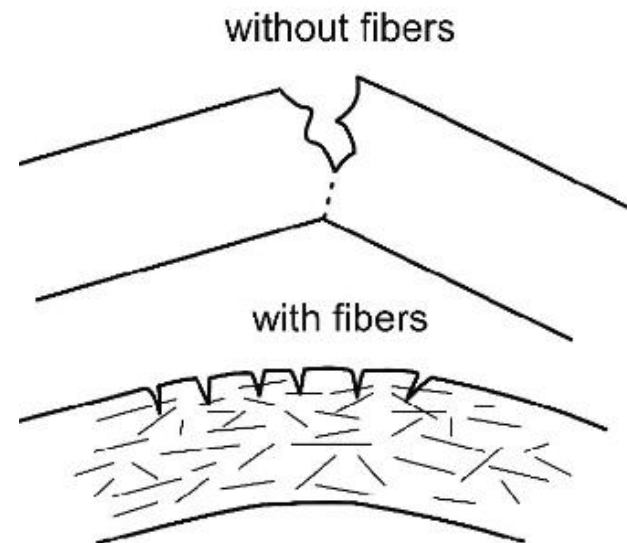
Fiber-Reinforced Concrete

- **Composition:** Incorporates fibers (metallic, synthetic, or natural) to improve cracking and tensile resistance.
 - **Usage:** Reduces plastic shrinkage and cracking, ideal for industrial flooring and structures subjected to impacts.
-

Béton Fibré

- **Composition :** *Incorporation de fibres (métalliques, synthétiques ou naturelles) dans le béton pour améliorer sa résistance à la fissuration et à la traction.*
- **Utilisation :** *Réduction du retrait plastique et des fissures, idéal pour les dallages industriels et les structures soumises à des impacts.*

Fiber-Reinforced Concrete



Fiber-Reinforced Concrete



Hooked-end



Twisted



Straight

Synthetic fibers



Polypropylene



Glass



Carbon

Refractory Concrete

- **Composition:** A concrete capable of withstanding very high temperatures (above 600°C), usually made from aluminous cement.
- **Usage:** Used in furnaces, industrial chimneys, or thermal power plants.

Béton Réfractaire

- **Composition :** Un béton capable de résister à des températures très élevées (au-delà de 600°C), généralement fabriqué à partir de ciment alumineux.
- **Utilisation :** Utilisé dans les fours, cheminées industrielles ou les centrales thermiques.

Refractory Concrete



Pervious Concrete

- **Composition:** Porous concrete with little to no fine aggregates (sand), allowing water to permeate through.
 - **Usage:** Ideal for areas requiring stormwater management (parking lots, pedestrian paths, landscaping).
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Béton Drainant

- **Composition :** Béton poreux avec peu ou pas de fines (sable), ce qui permet à l'eau de s'infiltrer à travers.
- **Utilisation :** Idéal pour les zones nécessitant une gestion des eaux de pluie (parkings, routes piétonnes, aménagements paysagers).

Pervious Concrete



infiltration
des eaux de pluie

infiltration dans le sol /
nappe phréatique



Polymer Concrete

- **Composition:** Uses polymer resins as a binder instead of traditional cement.
 - **Usage:** Used for specific applications like rapid repairs or industrial coatings.
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Béton Polymère

- **Composition :** *Utilise des résines polymères comme liant au lieu du ciment.*
- **Utilisation :** *Utilisé pour des applications spécifiques comme les réparations rapides ou les revêtements industriels.*



AVANT



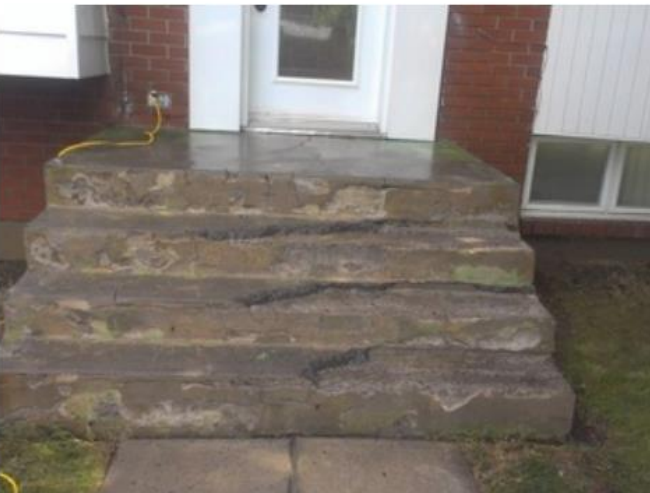
APRÈS



AVANT



APRÈS



Shotcrete (Sprayed Concrete)

- **Composition:** Concrete applied by spraying at high pressure onto a surface.
 - **Usage:** Used to reinforce existing structures, such as tunnels or rock faces.
-

Béton Projeté

- **Composition :** *Béton appliqué par projection à haute pression sur une surface.*
- **Utilisation :** *Employé pour renforcer des structures existantes, comme les tunnels ou les parois rocheuses.*



Properties of Concrete

Mechanical Properties:

- Compressive Strength: Ability to withstand loads.
- Tensile Strength: Resistance to pulling forces.

Physical Properties:

- Workability: Ease of mixing and placement.
- Durability: Resistance to environmental effects.

Chemical Properties:

- Reactivity with water and other chemicals.
- Alkalinity can affect reinforcement steel.

Applications of Concrete

- - Foundations and slabs for buildings.
- - Roads, bridges, and tunnels.
- - Precast concrete products (e.g., beams, panels).
- - Decorative concrete in landscaping and architecture.

Mix Design

- Concrete Mix Design Process:
 - - Determine required strength and durability.
 - - Select appropriate materials (cement, aggregates, water).
 - - Calculate water/cement ratio and adjust for workability.
 - - Conduct tests to verify performance.

Conclusion

- Concrete is essential in the construction industry.
- Understanding its composition and properties is crucial for ensuring its quality and durability.