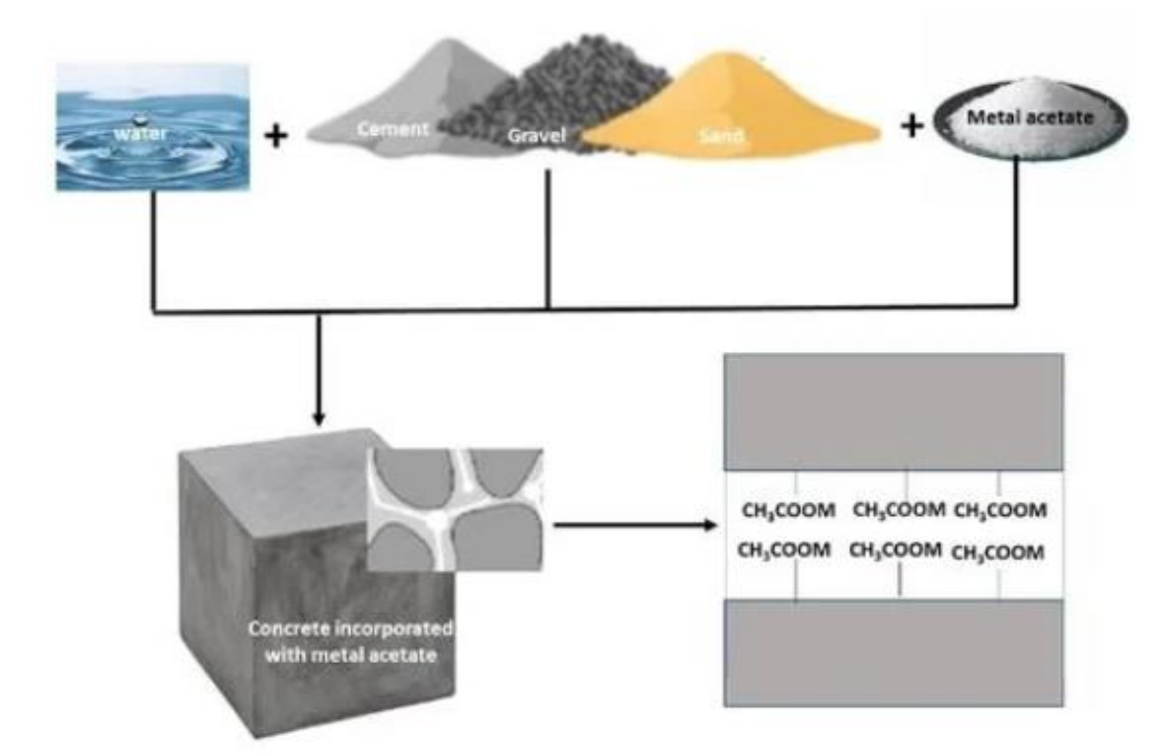
CONCRETE PROPERTIES

What is Concrete?

Concrete is a composite material composed mainly of cement, water, aggregates (such as sand or gravel), and sometimes additives or admixtures. It is one of the most widely used construction materials in the world due to its versatility, durability, and relatively low cost.

Binding material is the main element of a concrete material mix. Cement is the most commonly used binding material. Lime could also be used. When water is mixed with the cement, a paste is created that coats the aggregates within the mix. The paste hardens, binds the aggregates, and forms a stone-like substance.



Cement

Cement acts as a binder in concrete. The most common type of cement used in concrete production is Ordinary Portland cement (OPC) and Sulphate Resistant Cement, which is made by heating limestone, clay, and other materials in a kiln and then grinding the resulting clinker into a fine powder cement.

Water

Water is essential for the chemical reaction to create binding paste that causes cement to harden and bind with the aggregates. The water-to-cement ratio is crucial in determining the strength and durability of the concrete.

Aggregates

Aggregates, such as sand, gravel, crushed stone, or recycled concrete, make up the bulk of the concrete mixture. They provide volume, stability, and strength to the concrete.

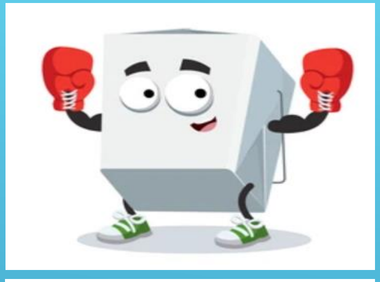
Additives or Admixtures

These are substances added to the concrete mixture to enhance certain properties or improve workability, durability, or curing time. Admixtures can include plasticizers, accelerators, retarders, air-entraining agents, and others.

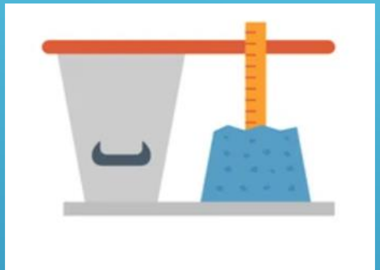
Once all concrete components are mixed together, concrete can be poured into molds or forms to create various structures, such as buildings, bridges, roads, sidewalks, dams, and more. It undergoes a curing process, during which it hardens and gains strength over time, making it suitable for load-bearing applications. Concrete is valued for its strength, durability, fire resistance, and ability to resist weathering and corrosion, making it an indispensable material in the construction industry.

Concrete possesses several properties that make it an ideal construction material for a wide range of applications. Here are some key properties of concrete:

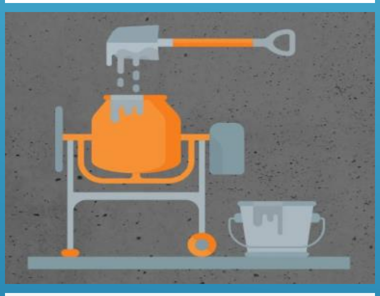
Strength:
Concrete exhibits excellent compressive strength, which is its ability to withstand loads pushing or squeezing it together. The compressive strength of concrete can vary depending on factors such as the mix design, curing conditions, and additives used.



Workability:
Concrete can be easily mixed, poured, and placed into forms or molds, allowing for efficient construction processes. The workability of concrete can be adjusted by modifying the mix design or using additives to improve flow and handling characteristics.



Durability:
Concrete is highly durable and can withstand harsh environmental conditions, including exposure to moisture, chemicals, and temperature fluctuations. Properly designed and cured concrete structures can have a long service life.



Sustainability:
Concrete can be produced using locally available materials, reducing transportation costs and carbon emissions. Additionally, it can incorporate recycled materials such as fly ash, slag, or recycled aggregates, making it a more sustainable choice for construction projects.

CONCRETE MIX DESIGN

Concrete mix design is the process of selecting suitable proportions of ingredients to produce concrete with desired properties such as strength, durability, workability, Sustainability and economy.

TYPICAL STEPS OF CONCRETE MIX DESIGN PROCESS

Specification of Requirements:
To determine the desired properties and performance requirements of the concrete based on the specific project requirements and environmental conditions. This includes factors such as strength, durability, exposure conditions, and any special requirements by local and international Standards.

Selection of Materials:
Select appropriate materials including cement, aggregates, water, and admixtures. The quality and properties of these materials will significantly influence the performance of the concrete.

Proportioning:
Based on the specified requirements and properties of the materials, the proportions of each ingredient are determined to achieve the desired characteristics of the concrete mix. This involves selecting the appropriate water-to-cement ratio (w/c ratio) and proportions of aggregates to achieve the desired workability, strength, and durability.

Mixing:
Once the proportions are determined, the materials are batched and mixed together to form the concrete mix. Proper mixing is essential to ensure uniform distribution of materials and achieve consistent properties throughout the concrete.

Testing and Adjustments:

Freshly mixed concrete is tested for various properties such as slump (workability), air content, and temperature. Based on the test results, adjustments may be made to the mix proportions or the addition of admixtures to achieve the desired properties.

Trial Batches:

Trial batches of concrete may be prepared and tested its compressive strength to validate the mix design and ensure that it meets the specified requirements before full-scale production.

Quality Control:

Throughout the production process, quality control measures are implemented to ensure that the concrete meets the specified requirements and standards. This includes monitoring and testing of materials, batching operations, and finished concrete properties.

Documentation:

Detailed documentation of the mix design, materials used, test results, and any adjustments made during the process is maintained for reference and quality assurance purposes.

CONCRETE MIX DESIGN PROPORTIONING

Method of Mix Design

Procedures for computing concrete mix proportions are prevalent in the world. All are based on the relation between strength and water-cement ratio as well as on the relationships between workability, water-cement ratio and aggregate-cement ratio. The ***absolute volume method*** is considered more exact when compared to ***weight method.***

Mix design procedure can be divided up into 8 basic steps:

1. Choice of slump
2. Maximum aggregate size selection
3. Mixing water and air content selection
4. Water-cement ratio
5. Cement content
6. Coarse aggregate content
7. Fine aggregate content
8. Adjustments for aggregate moisture

Slump
The choice of slump is actually a choice of mix workability. Workability can be described as a combination of several different, but related, PCC properties related to its rheology:

Ease of mixing
Ease of placing
Ease of compaction
Ease of finishing

Maximum Aggregate Size
Maximum aggregate size will affect such PCC parameters as amount of cement paste, workability and strength. In general, maximum aggregate size be limited to 1/3 of the slab depth and 3/4 of the minimum clear space between reinforcing bars. Aggregate larger than these dimensions may be difficult to consolidate and compact resulting in a honeycombed structure or large air pockets. Pavement PCC maximum aggregate sizes are on the order of 25 mm (1 inch) to 37.5 mm (1.5 inches)

Mixing Water and Air Content Estimation
Slump is dependent upon nominal maximum aggregate size, particle shape, aggregate gradation, PCC temperature, the amount of entrained air and certain chemical admixtures. It is not generally affected by the amount of cementitious material.

Note: that the use of water-reducing and/or set-controlling admixtures can substantially reduce the amount of mixing water required to achieve a given slump.

Water-Cement Ratio
The water-cement ratio is a convenient measurement whose value is well correlated with PCC strength and durability. In general, lower water-cement ratios produce stronger, more durable PCC. If natural pozzolans are used in the mix (such as fly ash) then the ratio becomes a water-cementitious material ratio (cementitious material = portland cement + pozzolanic material). Most tend to set a maximum water-cement ratio between 0.40 – 0.50 depending on project specifications.

Cement Content
Cement content is determined by comparing the following two items:

1. The calculated amount based on the selected mixing water content and water-cement ratio.
2. The specified minimum cement content, if applicable. Most projects specify minimum cement contents in the range of 300 – 360 kg/m3 and may varies depending on project specification.

Coarse Aggregate Content
Selection of coarse aggregate content is empirically based on mixture workability. The percentage (by unit volume) of coarse aggregate based on nominal maximum aggregate size and fine aggregate fineness modulus.

Fine Aggregate Content
At this point, all other constituent volumes have been specified (water, portland cement, air and coarse aggregate). Thus, the fine aggregate volume is just the remaining volume:

Adjustments for Aggregate Moisture

Aggregate moisture affects the following parameters:

Aggregate weights

Aggregate volumes are calculated based on oven dry unit weights, but aggregate is typically batched based on actual weight. Therefore, any moisture in the aggregate will increase its weight and stockpiled aggregates almost always contain some moisture. Without correcting for this, the batched aggregate volumes will be incorrect.

Amount of mixing water

If the batched aggregate is anything but saturated surface dry it will absorb water (if oven dry or air dry) or give up water (if wet) to the cement paste. This causes a net change in the amount of water available in the mix and must be compensated for by adjusting the amount of mixing water added.

Additional references:

BSEN 206:2013
ACI211.r
ASTM C94

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