Course: Concrete Technology

Lecture 1: Introduction to concrete technology

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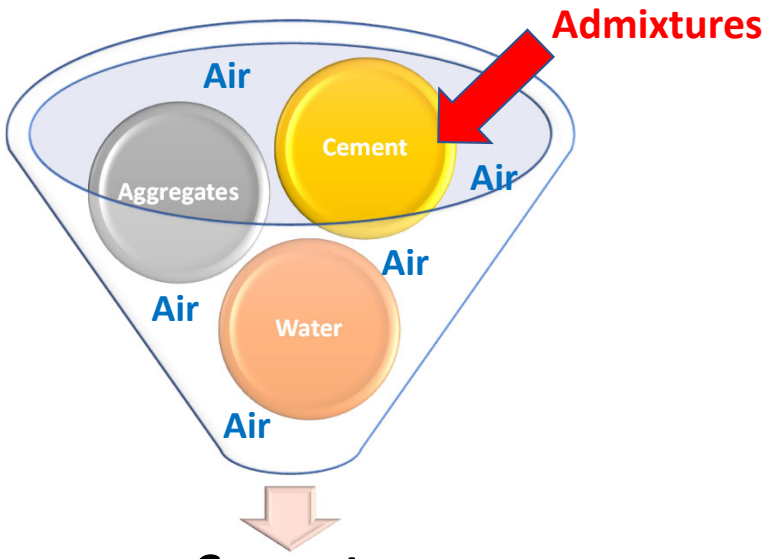
Content

- Concrete as a Construction Material
- Historical Background Worldwide
- Current and Future Prospects

Concrete as a Construction Material

Concrete as a Construction Material

- **Fundamental Material**
  Composed of a binder (hydraulic Portland cement and/or supplementary cementitious materials), filler materials (aggregates), water, and admixtures.



Source: Author's own elaboration.

Concrete as a Construction Material

- **High Versatility**
  Ability to achieve a wide range of geometries
  Cost-effectiveness
  Durability → Structural element (Reinforced Concrete)

Tille, Andreas (2013). *Hallgrímskirkja, Reykjavik, Iceland [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Hallgr%C3%ADmskirkja.jpeg

Concrete in Infrastructure

- Sidewalks
- Curbs
- Urban pavements
- Nuclear power plants
- Structural slabs
- Large-scale hydraulic works

OLU (2008). *Clywedog Dam [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Clywedog_Dam_-_geograph.org.uk_-_784825.jpg

Precast Concrete Elements

- New Jersey barriers
- Drainage channel section
- Curbs, and culverts
- Structural components such as prestressed and post-tensioned beams

Sindugab (2024). *Precast concrete manholes [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Precast_concrete_manholes.jpg

Ready-Mix Concrete

- Produced in specialized batching plants under controlled conditions
- Uses advanced technology for precise proportioning and consistent quality
- Enables large-scale production for multiple projects
- Transported by transit mixers to maintain workability
- Placed using pumps (e.g., boom pumps) for efficient delivery

Wikideas1 (2025). *Concrete boom pump [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Concrete_boom_pump.jpg

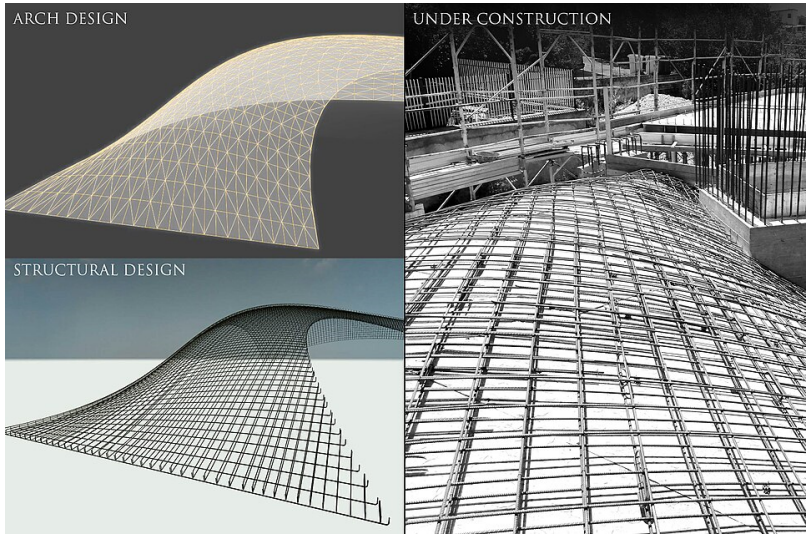
On-Site Concrete Production

- Mixed directly on-site (manual or small mixers)
- Flexible and low transport cost
- Lower quality control and consistency
- Common in small-scale projects

NBL (2023). *Concrete mixer [Photograph].* Roboflow Universe. https://universe.roboflow.com/nbl/concrete-mixer

Concrete as a Construction Material

- Concrete: strong in compression, weak in tensión
- Steel reinforcement adds tensile strength
- Composite material: concrete + Steel
- Enables structural elements (beams, slabs, columns)

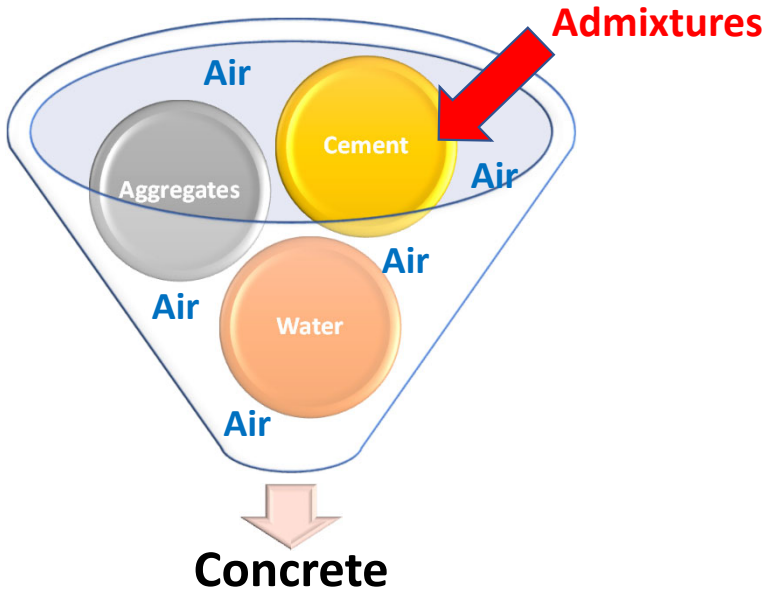


Wiki1977it (2020). *Reinforced concrete freeform constructive process in summary [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Reinforced_concrete_freeform_constructive_process.jpg

Mix Design

Mix design

- ✓ Economy
- ✓ Workability
- ✓ Strength
- ✓ Durability
- ✓ Aesthetics



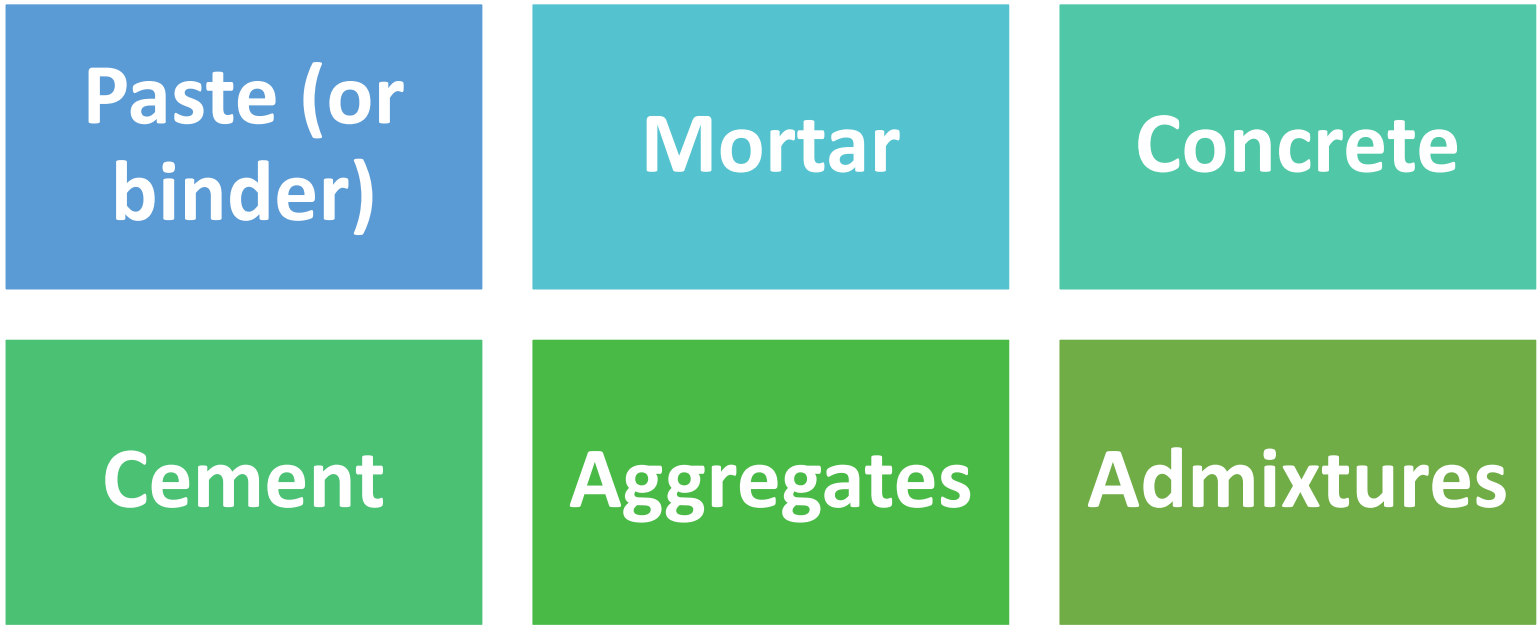
Source: Author's own elaboration.

States of Concrete

- Fresh: workable and moldable
- Setting: transition to solid
- Hardened: gains strength and stiffness

Tano4595 (2006). *Measuring the slump of the concrete [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Cono_de_Abrams_05.jpg

Basic Terminology



Source: Author's own elaboration.

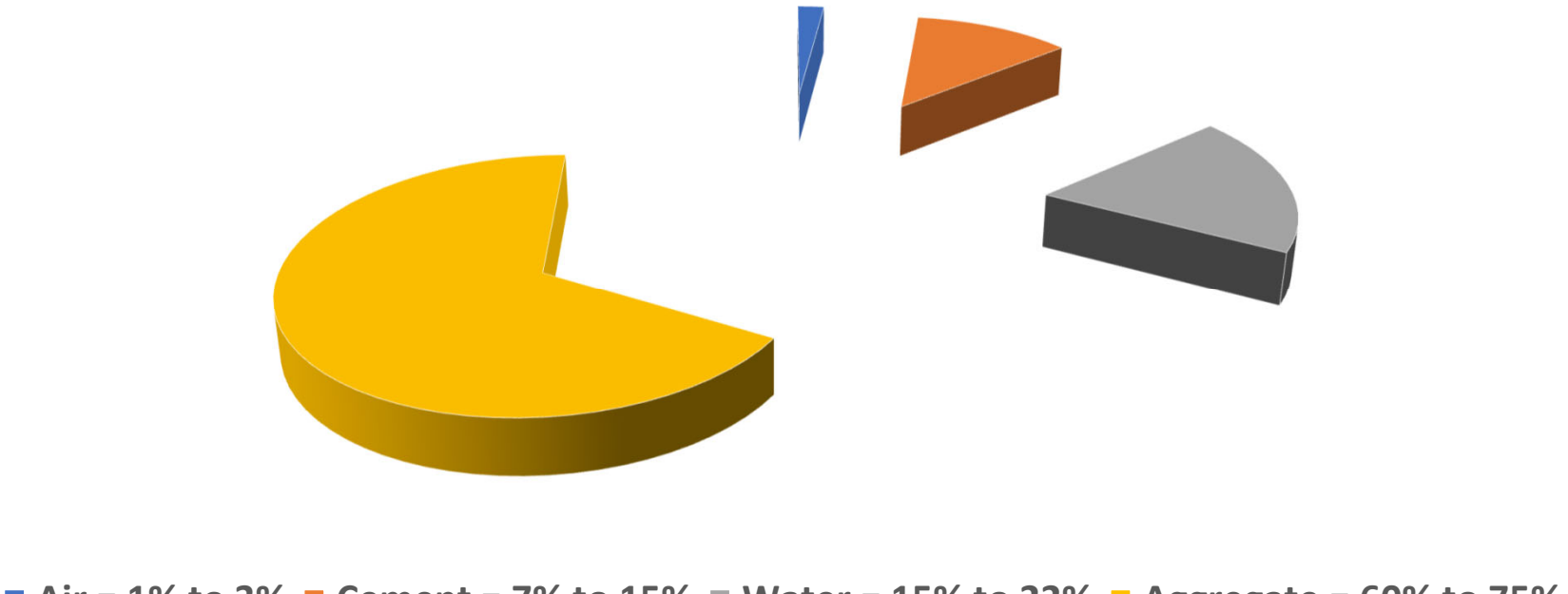
Concrete components

Concrete Components

- Active: cement + water (hydration)
- Passive: aggregates + air
- Aggregates provide strength and stability
- Air affects workability and durability

Wetzig, Elke (2007). *Flagstone of washed-out concrete [Photograph]. Wikimedia Commons.* https://commons.wikimedia.org/wiki/File:Waschbetonplatte.jpg

Concrete Composition



Source: Author's own elaboration.

Portland Cement

- Main binding material in concrete
- Produced from limestone + clay → clinker
- Types I–V for different conditions
- SCMs improve performance and sustainability

Scann (2022). *Bolsas de cemento del mundo [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Collage_cement.jpg

Aggregates

- 60–75% of concrete volume
- Fine (sand) and coarse (gravel)
- Affect strength, durability, and economy
- Require proper grading and quality control

Craven, Peter (2011). *20 to 40mm recycled aggregates[Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:20_to_40mm_recycled_aggregates_%286069277558%29.jpg

Water

- Enables cement hydration
- w/c ratio controls strength and durability
- Excess water ↓ strength
- Must meet quality standards

Bradley, Bill (2025). *A concrete slab ponded while curing [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Curing-concrete.jpg

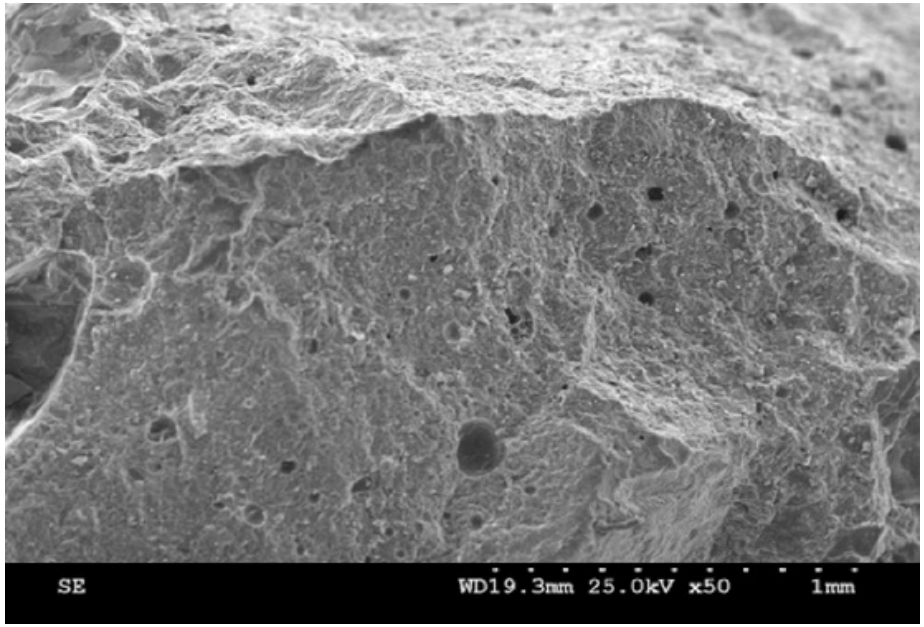
Admixtures

- Modify fresh and hardened properties
- Types: plasticizers, accelerators, retarders, air-entrainers
- Improve workability, strength, and durability

Siddique, M. Javeed ; Akhas, Punitha (2024). *(a) Low-density polyethylene, (b) high-density polyethylene, (c) polypropylene, and (d) polyester [Photograph].* Researchgate. https://www.researchgate.net/figure/a-Low-density-polyethylene-b-high-density-polyethylene-c-polypropylene-and-d_fig1_386054509

Air

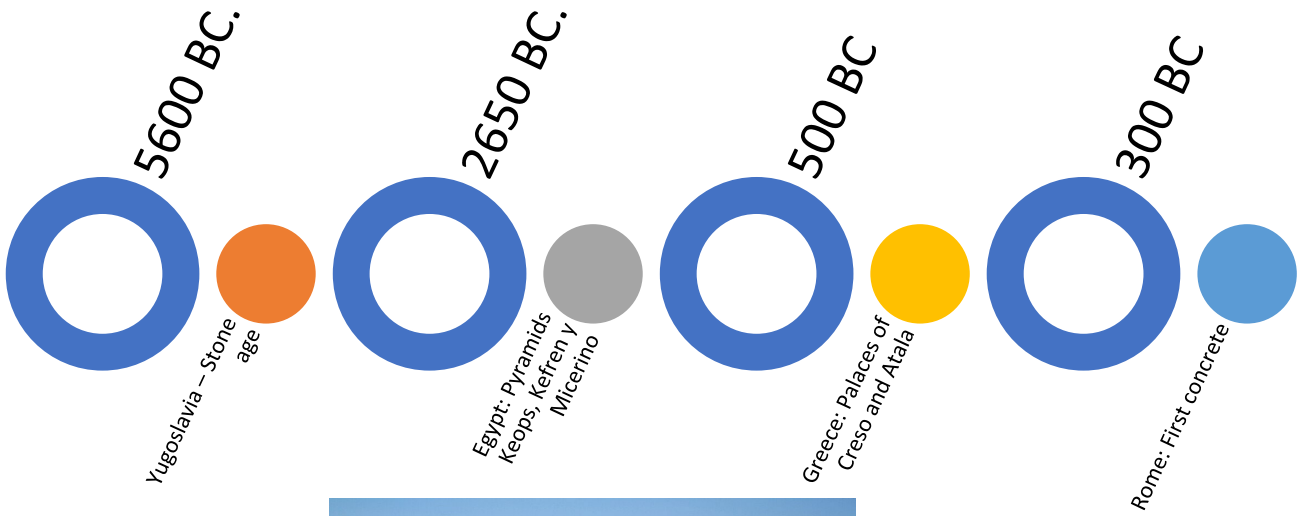
- Entrapped air: natural (1–3%)
- Entrained air: improves freeze-thaw durability
- Excess air reduces strength



Zhu, Fangzhi; Ma, Zhiming; Zhao, Tiejun (2016). *Pore structures in fresh concrete[Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Pore-structures-in-fresh-concrete-and-air-entrained-concrete.jpg

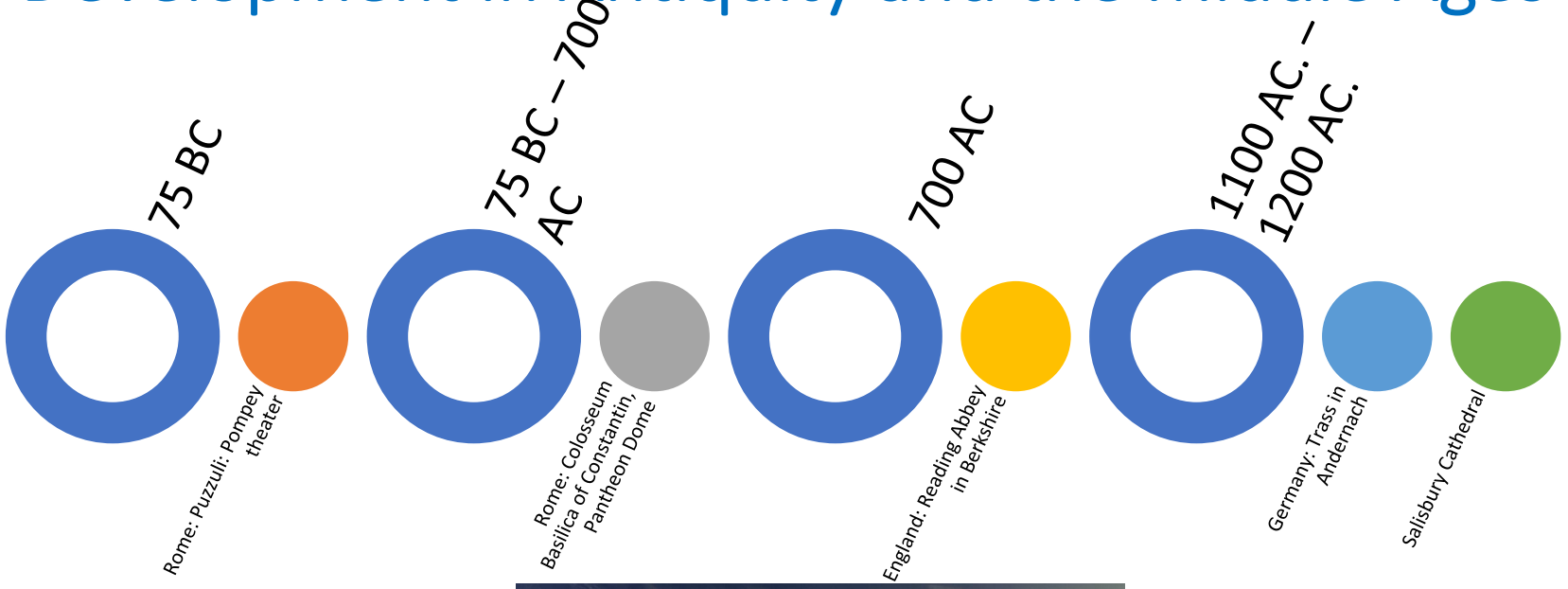
Historical Background Worldwide

Origins of Cementitious Materials



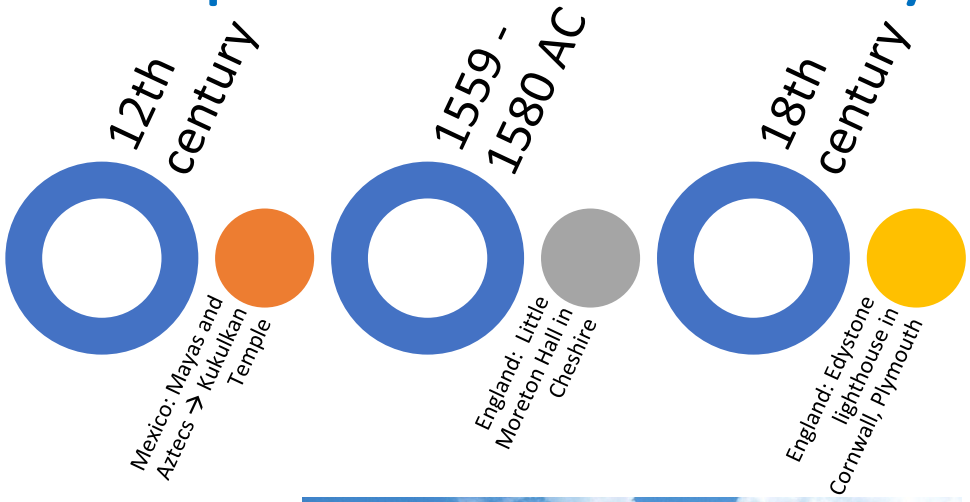
Liberato, Ricardo (2006). *All Giza Pyramids in one shot [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:All_Gizah_Pyramids.jpg

Development in Antiquity and the Middle Ages



Valadi, Sam (2012). *The Colosseum [Photograph].* Wikimedia. https://commons.wikimedia.org/wiki/File:Colosseum_-_Rome_-_Italy_%2816800139540%29.jpg

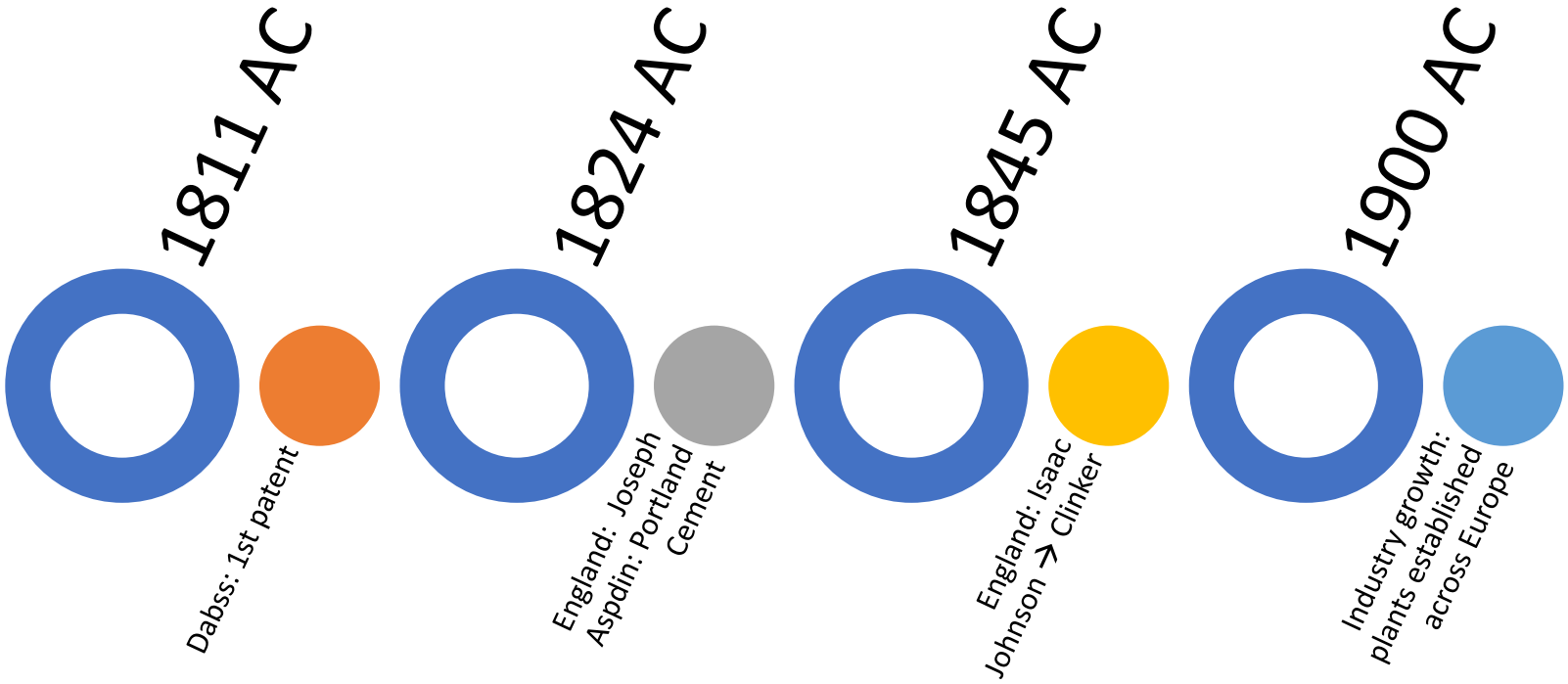
Developments in the Early Modern Period



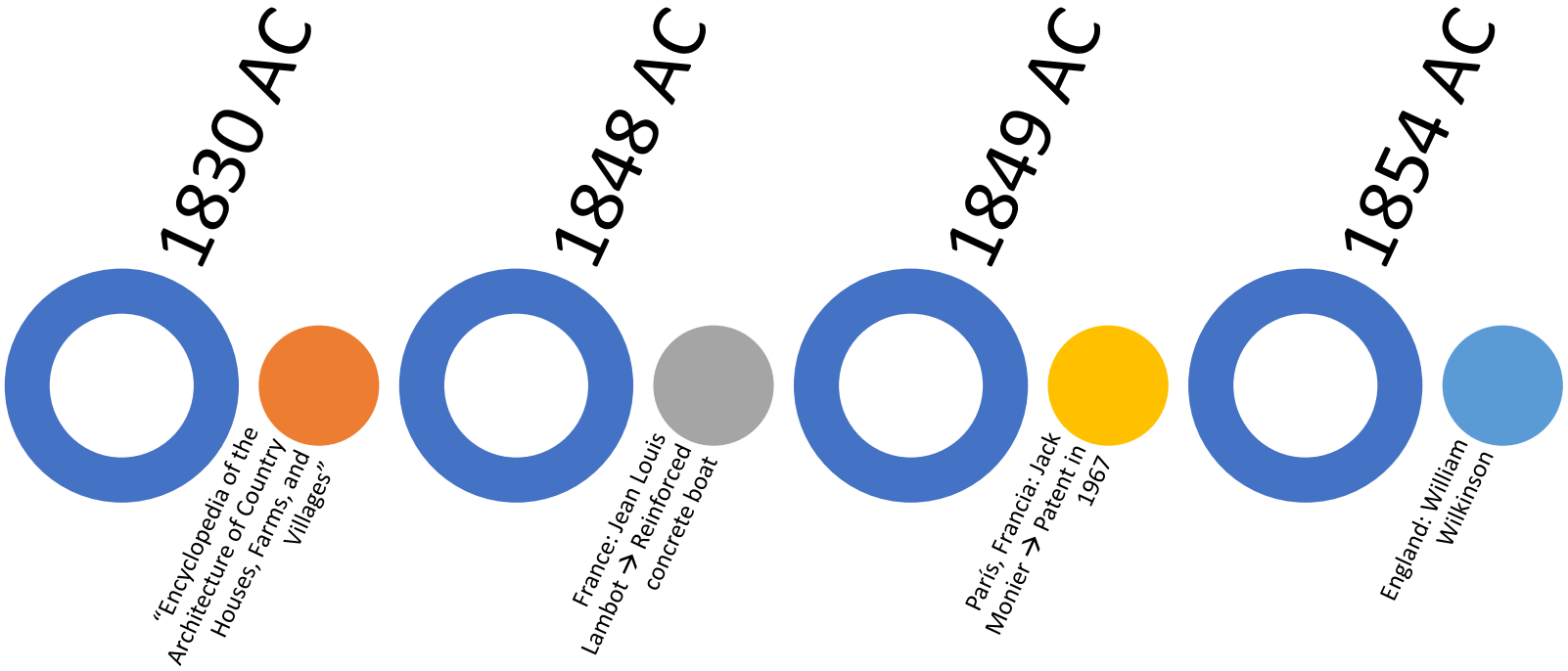
Fareham, Steve (2012). *Eddystone lighthouse [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Eddystone_lighthouse_-_geograph.org.uk_-_3154373.jpg

Simourd, Kyle (2007). *Kukulcan, the main temple at Chichen Itza [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Kukulcan,_Chich%C3%A9n_Itz%C3%A1.jpg

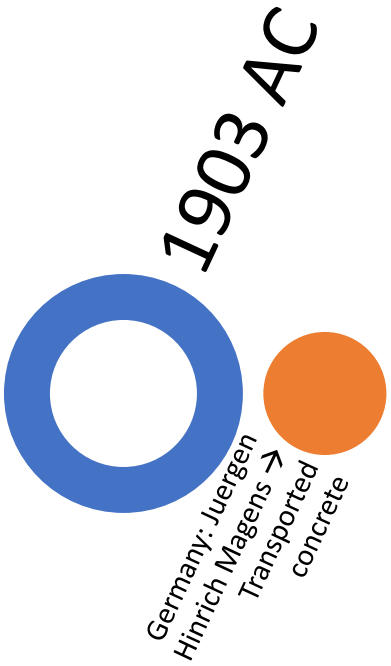
Invention of Portland Cement

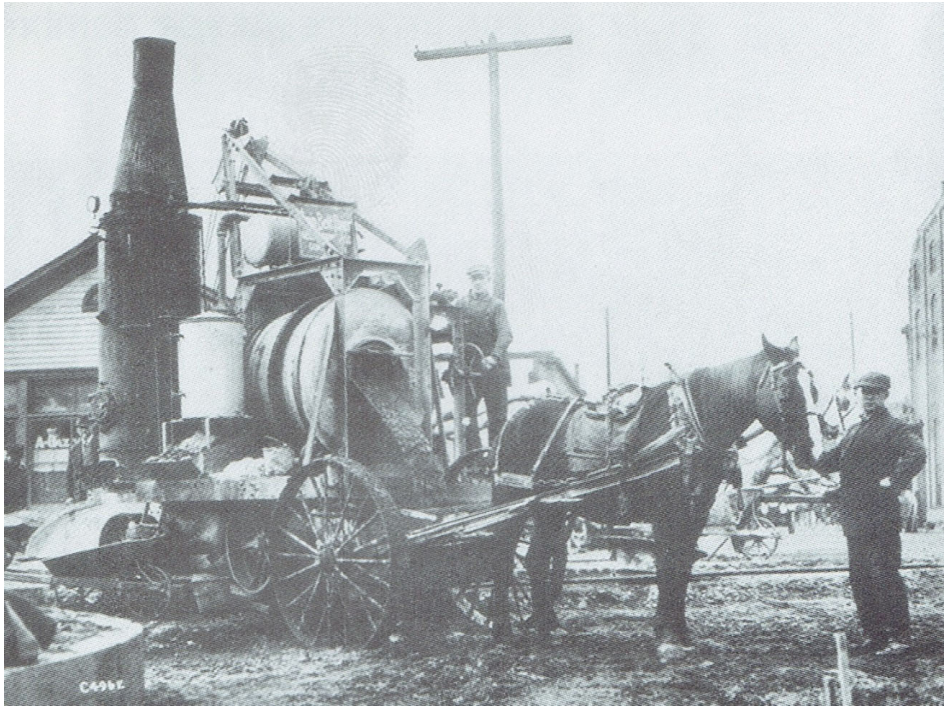


Reinforced Concrete



Concrete Transportation



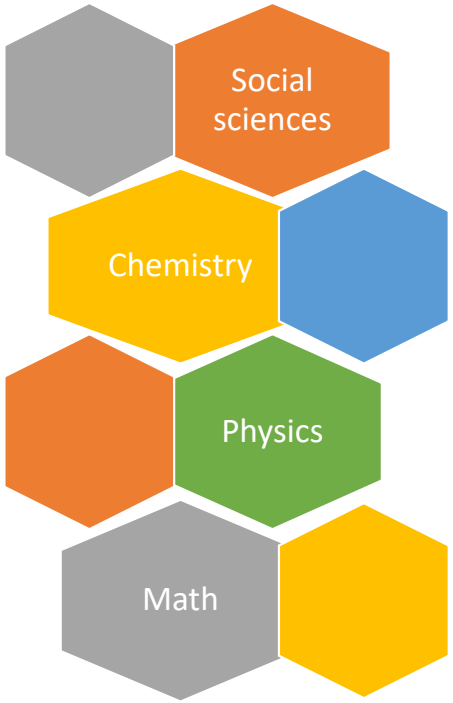


Gomezjurado, J., Osorio, J., & Niño, J. (1998).*Picture from the book "Jaar betonmortelindustrie in Nederland 1948-1998" [Photograph]* Tecnología del Concreto: Materiales, propiedades y diseño de mezclas. Bogotá: Asociación Colombiana de Productores de Concreto

Current and Future Prospects

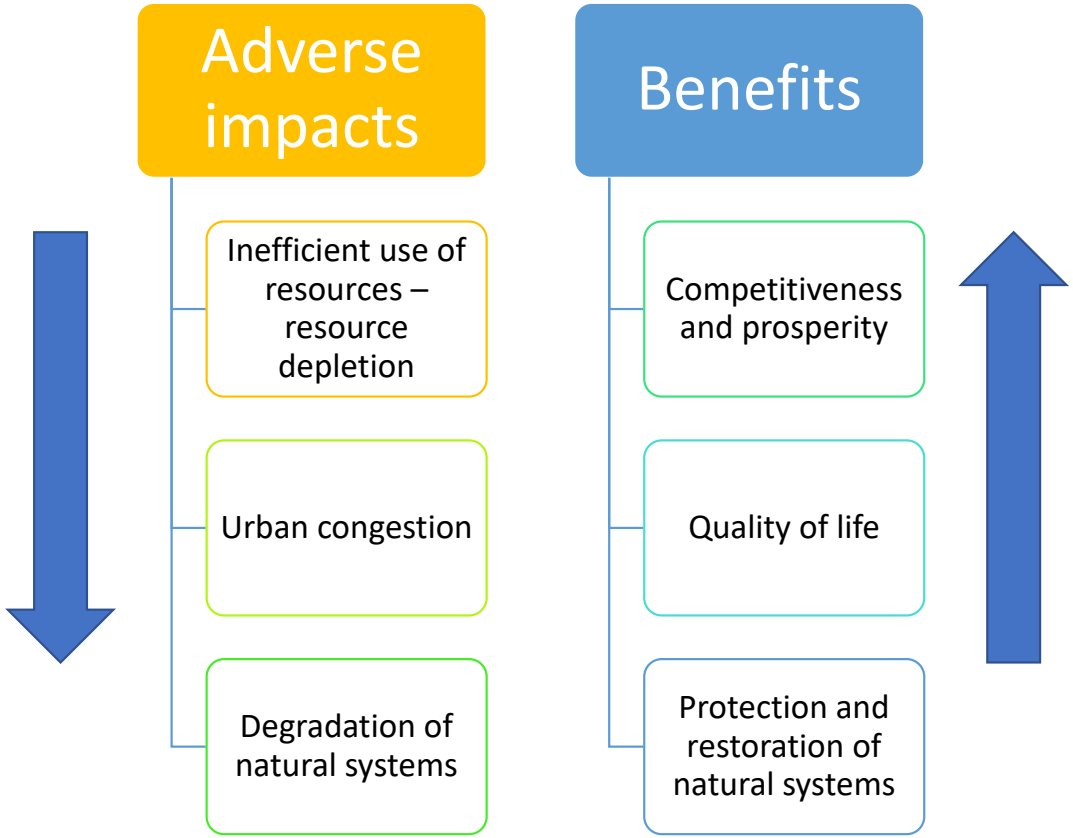
Engineering Principles

- Applies science to solve societal needs
- Civil engineers design infrastructure
- Must consider safety, economy, environment
- Ethical responsibility is key



Source: Author's own elaboration.

Green Engineering



Source: Author's own elaboration.

Recycled Concrete and Green Engineering

- Conventional concrete → high environmental impact
- Extraction, transport, production, placement
- Recycled concrete reduces these impacts

Fsmazlum (2020). *Mobile concrete batch plant [Photograph].* Wikimedia Commons. https://commons.wikimedia.org/wiki/File:MOBILE_CONCRETE_BATCHING_PLANT_mekaglobal.jpg

Recycled Concrete and Green Engineering

- Reuse demolished structures
- Reduces waste and resource demand
- Promotes sustainable construction

Richfield, Jon (2010). *Retaining wall building [Photograph].Wikimedia* Commons. https://commons.wikimedia.org/wiki/File:Concrete_wall_cracking_as_steel_reinforcing_corrodes_and_swells_9058.jpg

Recycled Concrete and Green Engineering

- Demolition + crushing → recycled aggregates
- Requires cleaning and classification
- Some environmental impact remains

Rondeau, Charles (2025). *Waste Concrete [Photograph].* Public Domain Pictures. https://www.publicdomainpictures.net/en/view-image.php?image=85674&picture=waste-concrete

Recycled Concrete and Green Engineering

- Replacement: 20–50% (up to 100%)
- Similar compressive strength
- Higher water absorption
- Supports sustainability

Macrolepis (2008). *Unfinished concrete building [Photograph].Wikimedia* Commons. https://commons.wikimedia.org/wiki/File:Unfinished_concrete_building_-_panoramio.jpg

Special Concretes

- Shotcrete (sprayed)
- Pervious (drainage)
- Photocatalytic (pollution reduction)
- HPC, SCC, UHPC for advanced performance

Torres, Roman (2026). *Shotcrete [Photograph].* RJT Construction. https://rjt-constructionllc.com/how-shotcrete-enhances-modern-construction/

Conclusions

- Concrete comprises active and passive components, depending on their contribution to the development of its properties.
- The use of concrete dates back more than 75 centuries. Portland cement was patented nearly three centuries ago, while admixtures have been in use for just over half a century.
- There remains significant potential for improvement, discovery, and further development in concrete technology.

References

- Pasquel, E. (1998). *Tópicos de Tecnología de Concreto en el Perú.* Lima: Colegio de Ingenieros del Perú - Consejo Nacional
- Gomezjurado, J., Osorio, J., & Niño, J. (2014). *Tecnología del Concreto: Materiales, propiedades y diseño de mezclas.* Bogotá: Asociación Colombiana de Productores de Concreto

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