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Talks Concrete

Net zero carbon concrete in Saudi Arabia – roadmap, opportunities and challenges

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Net Zero Carbon Concrete in Saudi Arabia

RoadMap – Opportunities – Challenges

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Outlines

- Introduction
- CO2 emission of Concrete (Sources & Methodologies).
- Challenge-1: Cement Emissions.
- Cement Decarbonizing Solutions (6 Solutions)
- Challenge-2: Aggregates Emissions.
- Aggregates Decarbonizaing Solution.
- Final equation of Net Zero Carbon Concrete.

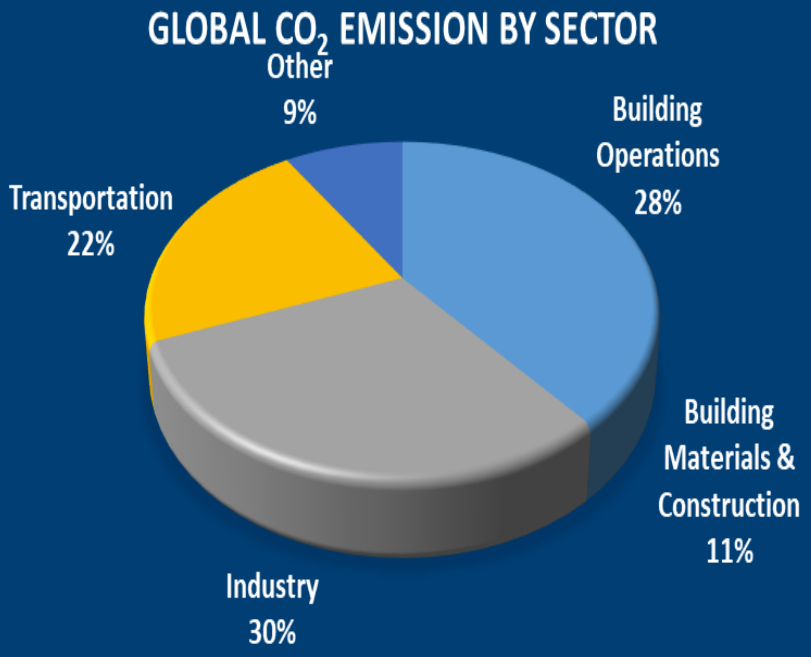
Introduction:

Construction emissions

Construction industry emits large amount of CO2 to the atmosphere annually. Construction sector contribute to about 11% of Global CO2 emission.

aggregates, water
the manufacturing
, the CO2 gas is

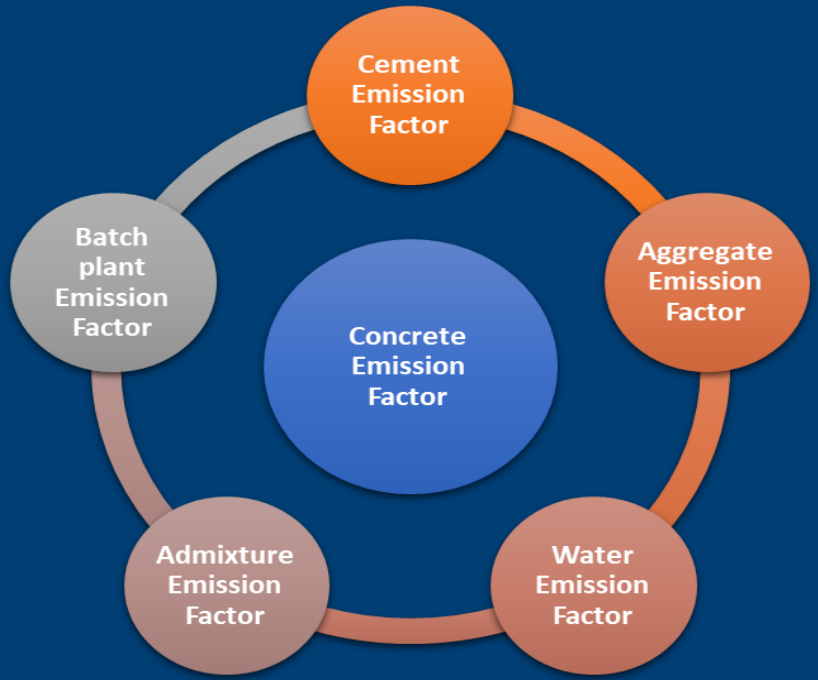
components: cement,
and admixture. During
of these components
released.



CO_2 emission factor Calculation

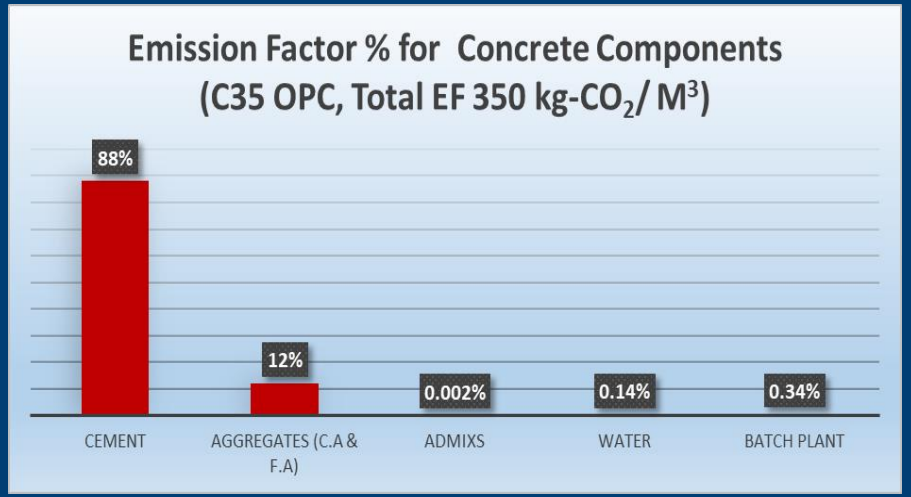
It is the sum of Emission factors of all raw materials (Collected from inventory data or provided by local manufacturers) used in making ready-mix concrete plus the emission factor of the batching plant.

Emission factor for any constituent = Direct Emissions (Manufacturing & Fuel Consumption) + Indirect Emission (electricity used for external production, transportation of inputs and outputs, productions bought from third parties, etc.).

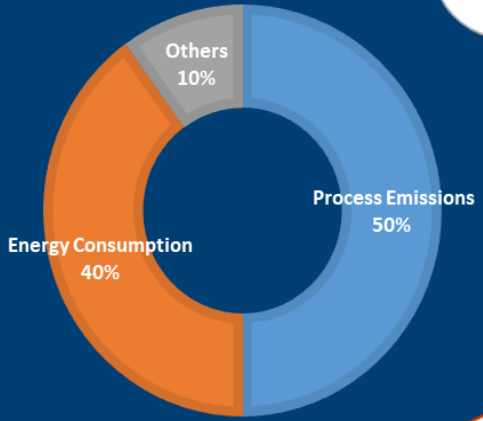


Source of Emissions in Concrete

- In normal practice, concrete mix proportion can be roughly estimated to consist of 10-22% of cement, 6-8% of water, 26-38% of fine aggregate and 38-48% of coarse aggregate.
  However, cement is the highest CO2 emission per unit-weight among all components.Therefore in order to reduce the amount of CO2 emission in any concrete mixture, it is quite straightforward to set the main target at cement.



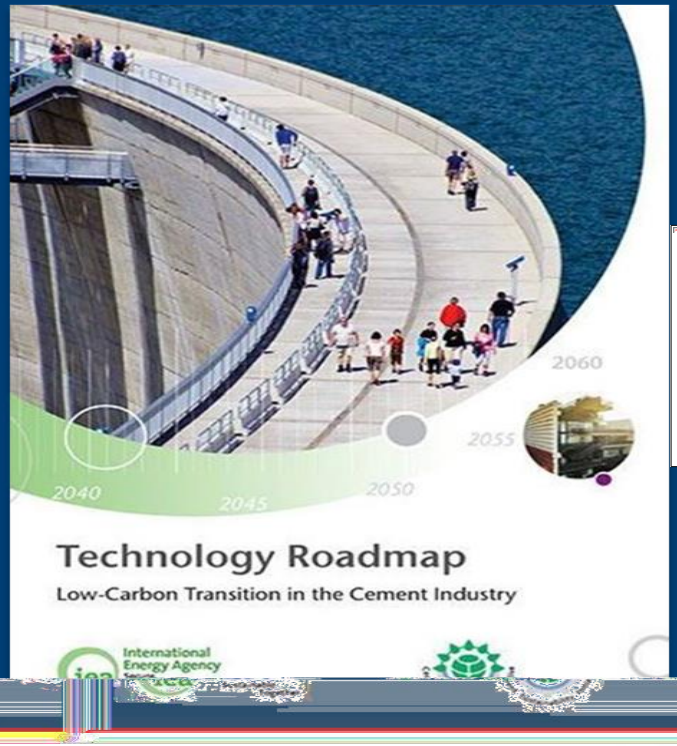
Challenge-1: Cement Emissions



- For each ton of Ordinary Portland Cement (OPC) ~ 0.7 -1 ton of CO_2 is emitted
- 50% of the CO_2 emissions from manufacturing process (Calcination Reaction where limestone dissociates into CaO and CO_2.).
- 40% come from the energy combustion required to heat that process.
- 10% others

Solution: Decarbonizing Cement

IEA Low carbon transition pathway in cement



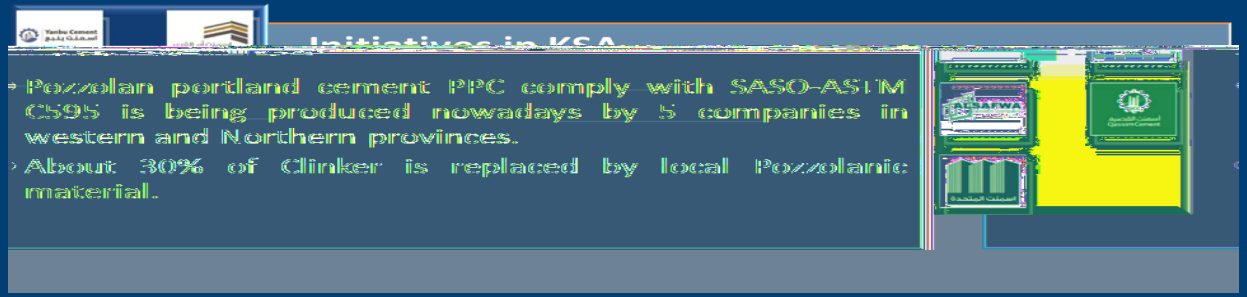
- Replacement of clinker by pozzolans
- Alternative fuels and energy efficiency
- CO_2 utilization emerging technologies

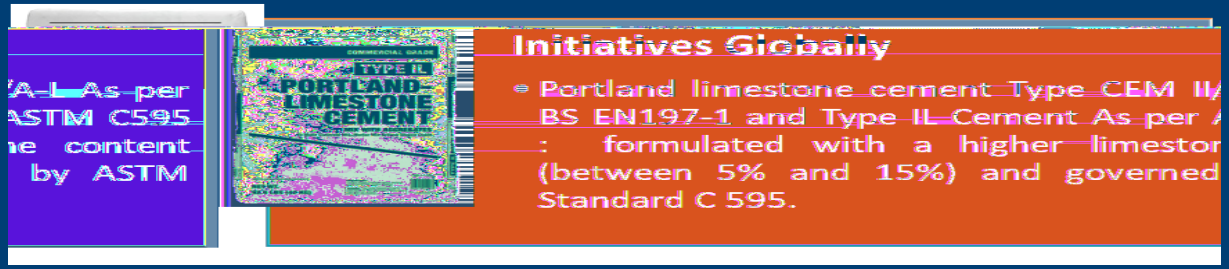
+

- Clean Electricity
- Innovative SCMs
- Geopolymers

1- Reducing Clinker Volume

Increasing the volume of decarbonated raw materials particularly those that can be sourced locally and are not transported over long distances to replace some of the Clinker in the kiln reduces total emissions from the production of Cement.



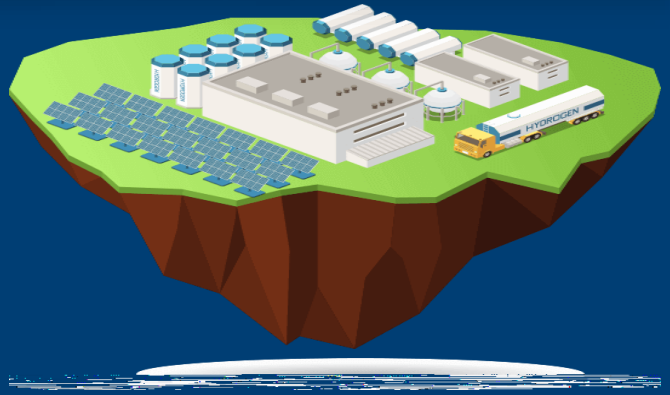


2- Increased use of alternative fuels & Improved Energy efficiency

Lower-carbon fuels examples :

- Biomass fuel (limitations)
- Green Hydrogen (limitations)

Initiatives in KSA : World largest green hydrogen plant in Neom.



initiatives Globally: TITAN Cement Group started using green hydrogen as green fuel in cement production.

TITAN

Media Release

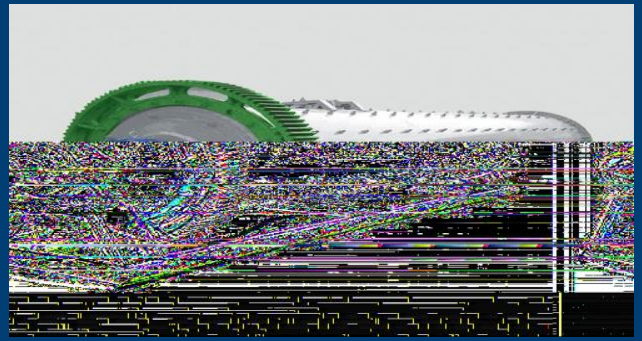
26 September 2022

TITAN Cement Group: H2CEM project is included in the "Hy2Use" Important Project of Common European Interest

The innovative project will use green hydrogen as climate-neutral fuel to further lower the carbon footprint of cement production

TITAN Group's H2CEM innovative project for the production and use of green hydrogen in the cement industry is included in the second Important Project of Common European Interest (IPCEI) "Hy2Use". H2CEM, with a total budget of €60 million, is currently the only project in the second IPCEI that concerns the use of hydrogen as a climate-neutral fuel for cement production. The project will contribute to TITAN Group's target to improve the carbon footprint of its operations, supporting the European goal for 55% greenhouse gas emissions reduction by 2030 and carbon neutrality by 2050.

Improving energy efficiency Include doing electrical retrofits and improving milling operations (e.g., switching from ball mill to vertical roller mill grinders).

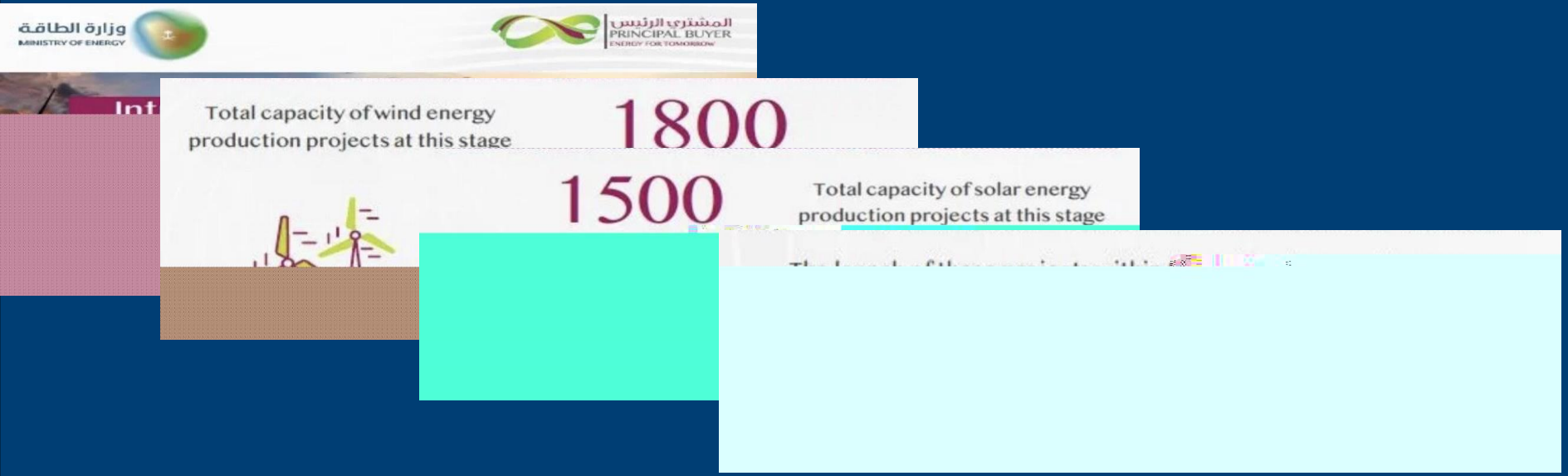


Ball mill (high energy consumption)

Vertical mill (low energy Consumption)

3- Using Clean electricity

Clean Electricity : Electrical power generated by renewable sources such as geothermal, solar, wind, waste…etc

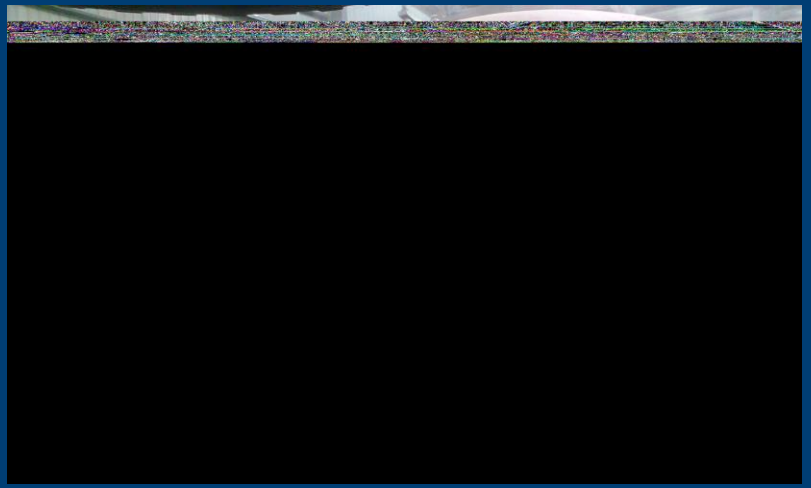


Employing Carbon Capture, Utilization and storage(CCUS)

CCUS technologies play a key mitigation role in the decarbonization of cement and concrete. The captured CO2 can be used again in Concrete industry through different technologies.

CarbonCure Technology

Carbonation Curing Technology

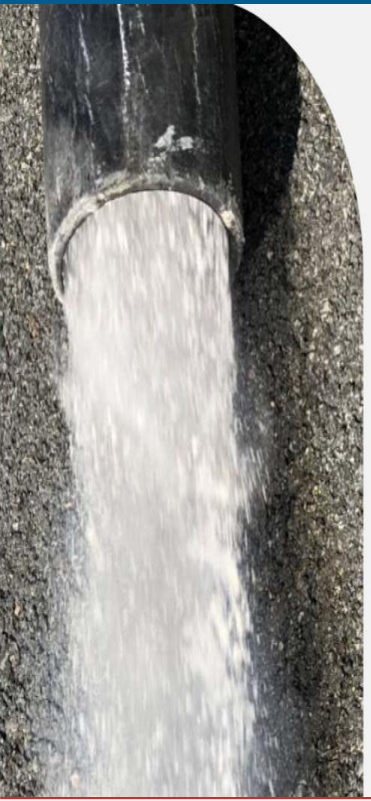


CarbonCure

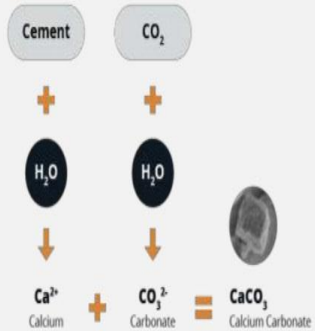
Same Concrete, Less Carbon

- CarbonCure injects CO_2 into ready mix where it converts to a mineral, improving compressive strength.
- This allows to optimize mix designs, safely reducing cement content by up to 5% and lowering the carbon footprint of concrete with no impact on quality or performance.
- CarbonCure Comply with ASTM C494 Type S.
- **CarbonCure technology allow reducing carbon foot of concrete by about 15 kg/M3 concrete.**

CO2 Injection



What Happens When CO_2 is Injected?



- CO_2 mineralization reaction occurs
- CO_2 converts into **$CaCO_3$ (solid limestone)**

Final ConClusion

+10% increase in compressive strength

Up to 6% reduction in Cement content

15-20 kg CO2 reduction / M3 concrete

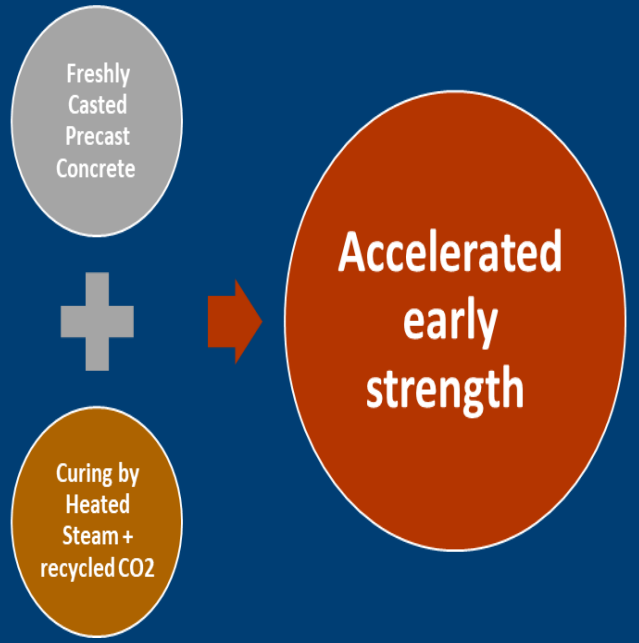
+ve to neutral effect on Durability

Neutral effect on fresh properties (workability/setting time ..etc)

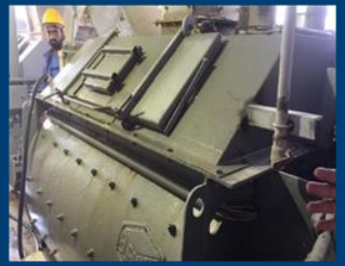
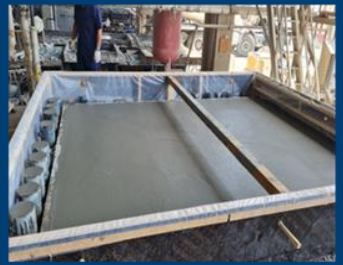
Neutral effect on alkalinity

Carbonation Curing

Carbonation curing is an accelerated curing process that can be carried out within 24/h after casting. If immediate carbonation is performed right after casting, carbonation curing happens between high-purity CO2 gas and calcium silicates in cement resulting in significant increase in early strength of concrete.



Impact on Curing time

Mixing	Transfer	Molding	Curing	Demolding
				
				

RJV between Alkifah & ARAMCO

>2x reduction in time to demold
(from 18 to 8 hours)

Final ConClusion

20% CO_2 Uptake

50% Reduction of the Curing Time

+1 Mtpa CO2 sequestration potential in KSA in precast

15-35% enhanced durability of Concrete

Innovative SCMs

Traditional SCMs

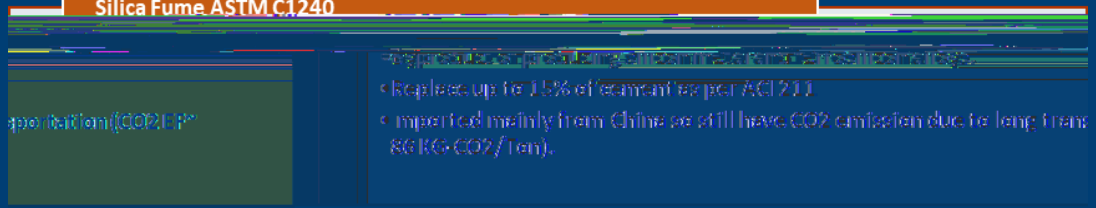
Fly Ash ASTM C618

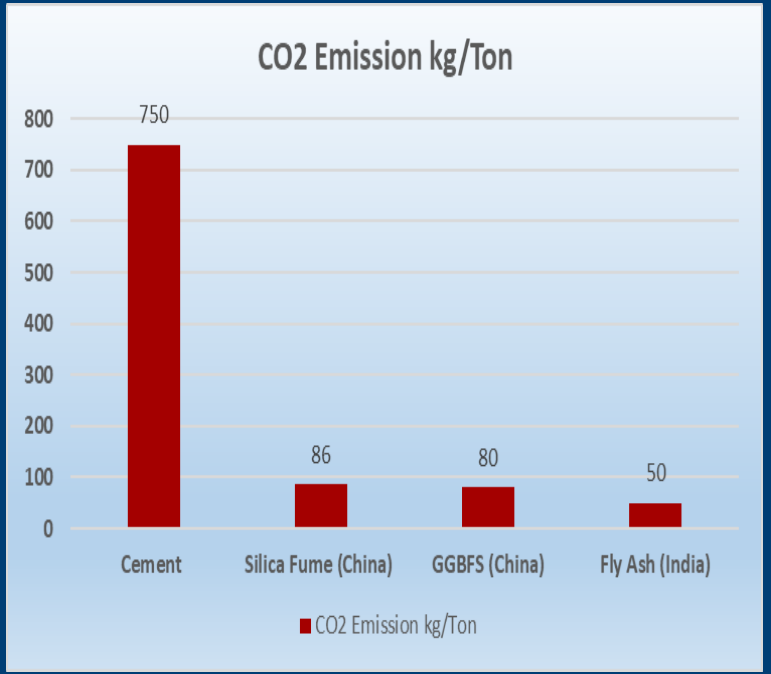
- byproduct of Coal fired power plants
- Replace up to 35% of cement as per ACI 211
- Mainly imported from India so CO2 EF reach about Avg. 50 kg-CO2 / Ton due to transportation (Sea freight + Road).

GGBFS ASTM C989

- Byproduct of iron in blast furnace
- Replace up to 70% of cement as per ACI211
- Mainly imported from China so CO2 EF reach about Avg. 80 kg-CO2 / Ton due to transportation (Sea freight + Road).

Silica Fume ASTM C1240





Reference: Kuehne+Nagel CO2 emission Calculator for Ocean freight.

Local Initiatives (innovative SCMs)

Local Natural Pozzolan

Recently there is more attention towards research on local natural pozzolan due to increase the cost of imported SCMs and high CO2 emission attributed to its transportation.

Intensive research studies made in Alkifah R&D Center that proved the good performance of local natural pozzolan.

Al Kifah R&D Center

Keep it ConGreen

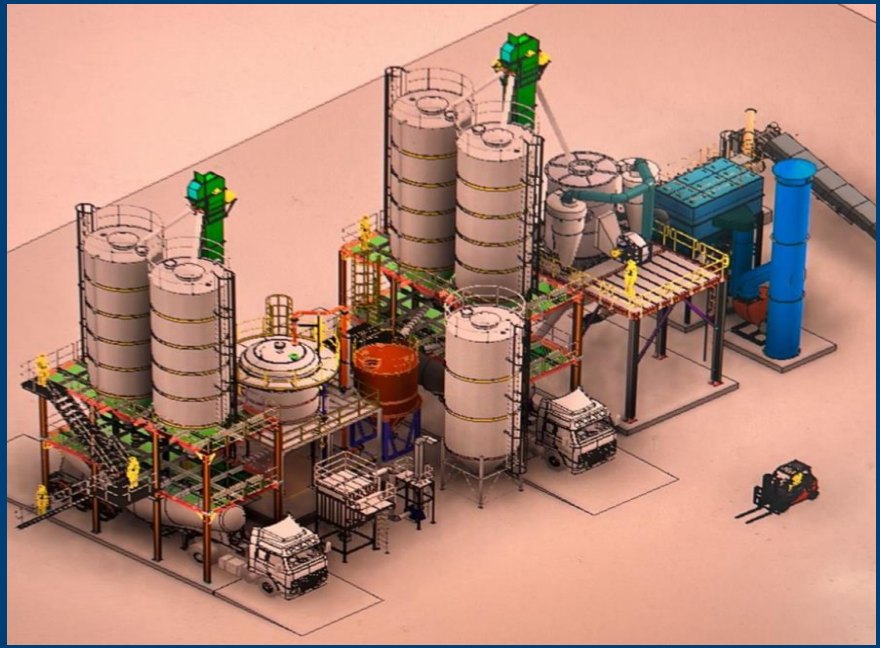
American Concrete Institute

دائما تتقدم

Alkifah Natural Pozzolan plant.

Under final engineering phase project, it is planned to start operation by second half of 2023.

NP can be used to replace cement by up to 30%.



Alkifah Natural pozzolan plant

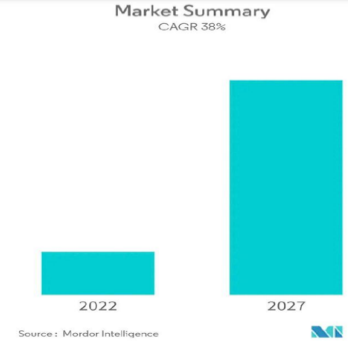
Geopolymers

Aluminosilicate-rich materials(fly ash, Natural Pozzolan, blast furnace slag, steel slag, or other aluminosilicate-rich materials) + Source of alkali (used as the activator such as sodium silicate, sodium hydroxide, or a combination of the two) + Knowhow= **Geopolymer Concrete**

Geopolymers Market segmentation (by End-use industry)

- Building Construction
- Infrastructure
- Industrial
- Art and Decoration
- Others

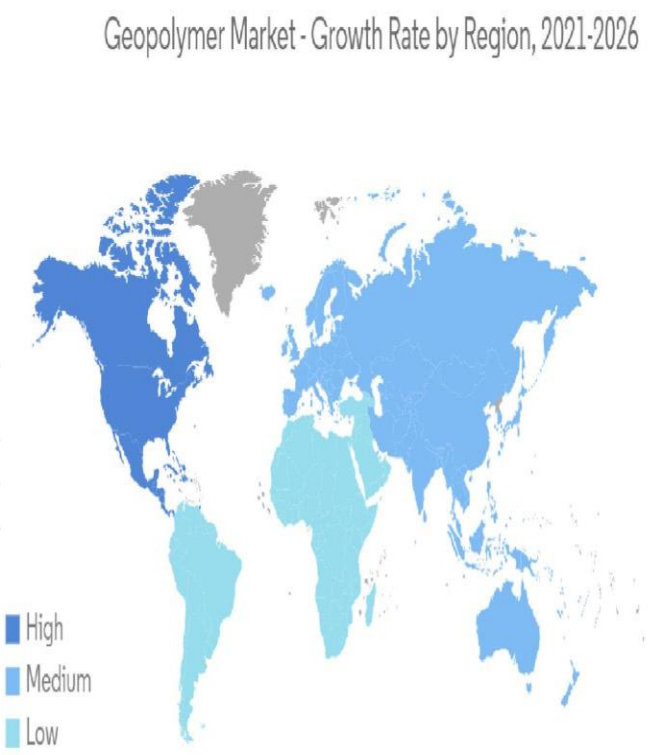
Geopolymer Market



Study Period:	2017-2027
Fastest Growing Market:	North America
Largest Market:	Asia-Pacific
CAGR:	> 38 %

Major Players

*Disclaimer: Major Players sorted in no particular order



Market Concern

Challenge-2: Aggregates Emissions

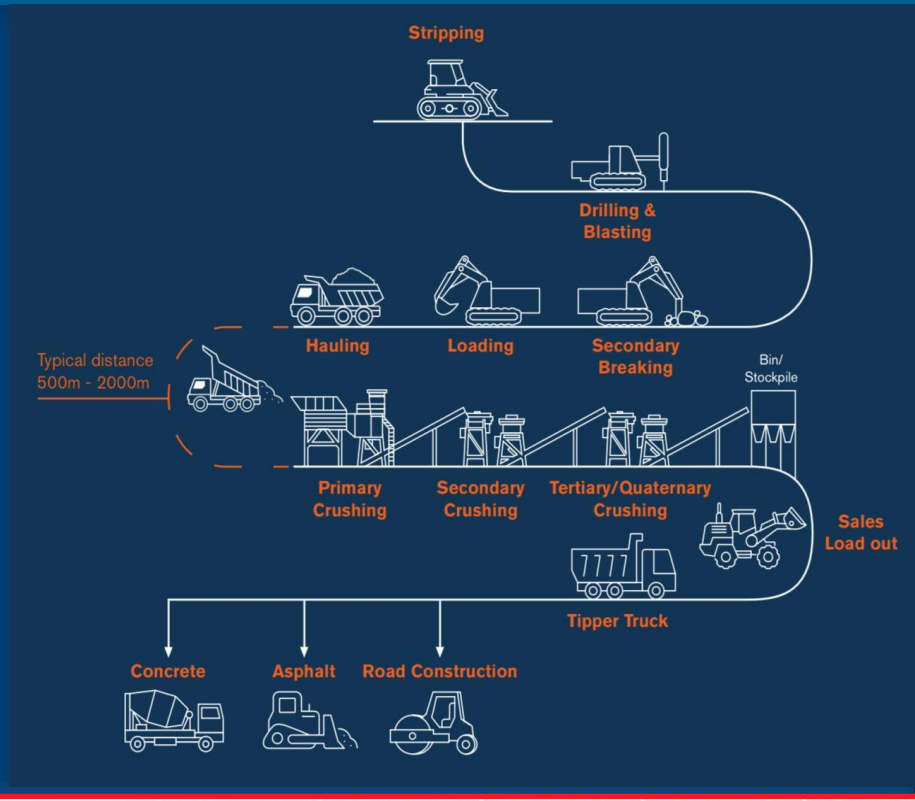
The Coarse aggregates production process has three main sources of CO2 emissions:

1: Production emissions, own transport emissions.

2: Emissions from electricity consumption.

3: Emissions from purchased goods and services.

Avg. CO2 Emission factor for crushed aggregates is about 48 kg-CO2 / Ton, 37 kg-CO2/Ton for Calcerious and Non Calcarious aggregates respectively.



Solution: Recycled Aggregates

Sustainable , Eco friendly option for decarbonizing aggregate component of concrete mix.

Two kinds of recycled aggregates has been tested in Alkifah R&D and available currently in the saudi market for commercialization.

A- Metal Slag Aggregates (MSA)

MSA are manufactured from iron and steel slag that is generated as a byproduct of iron and steel manufacturing processes. available locally in different sizes.

Steel/Iron industry wastes

Metal slag aggregates

B- Recycled aggregates from Construction demolition wastes (RADW).

RADW is made from processing Construction demolition wastes. Available locally in different sizes.

Construction wastes demolition

Coarse aggregates

Final Equation of Net Zero Carbon Concrete

Net Zero Carbon or Net Negative Carbon Concrete

Thank you

For the most up-to-date information please visit the American Concrete Institute at:
www.concrete.org