



THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE
CONFERENCE IN THE ARAB COUNTRIES

Life Cycle Assessment of Concrete Maintenance Effect on the Environment and Sustainability

Rami Alsodi, Mufid Samarai.

    #OmaintecConf

An Initiative by



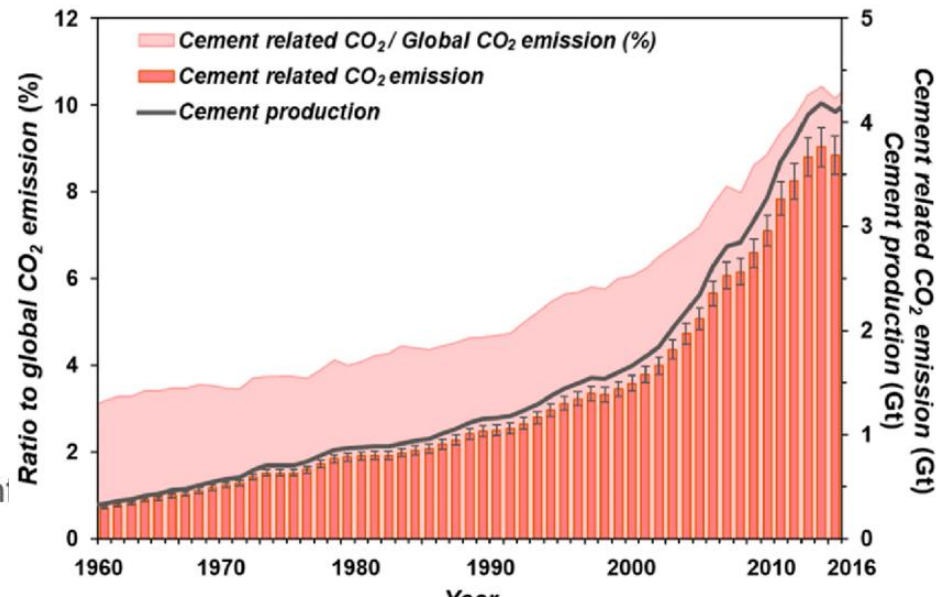
Organized by



OMAINTEC
20 YEARS

Introduction

- The construction industry has a high impact on the environment due to associated emissions, energy expenditure, and resource depletion.
- It is responsible for producing approximately 10% of the total global emissions of Carbon Dioxide.



Attacks on Concrete



Sulfate Attack

Heaving and Cracking on the Surface



Leaching

Leaking of Calcium Chloride Ions



Concrete Cancer

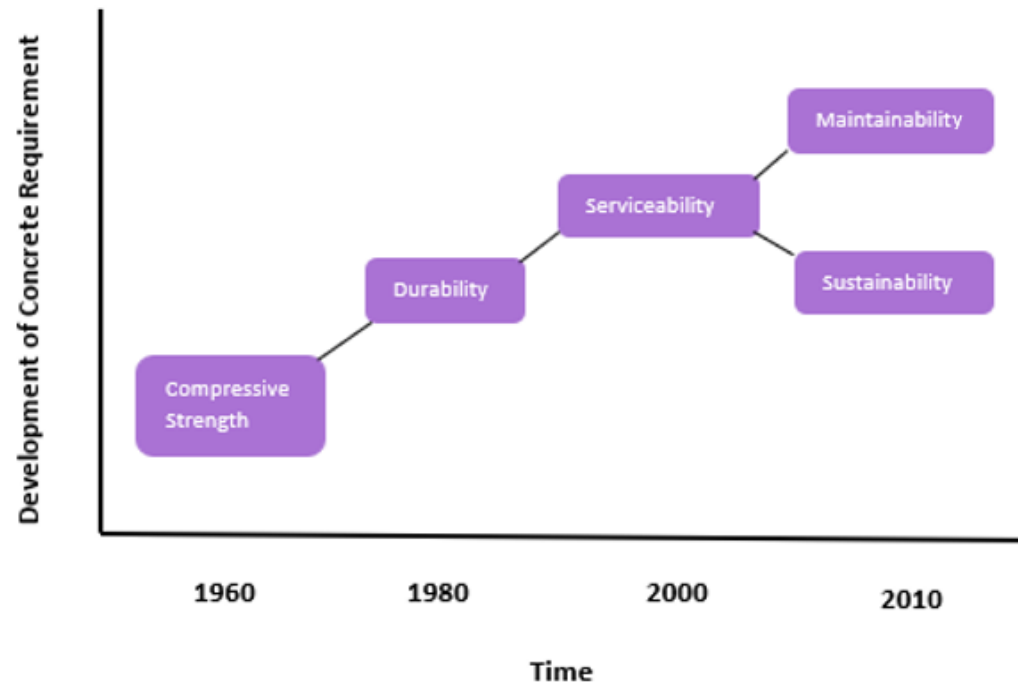
Deleterious swelling reaction between
aggregate and cement



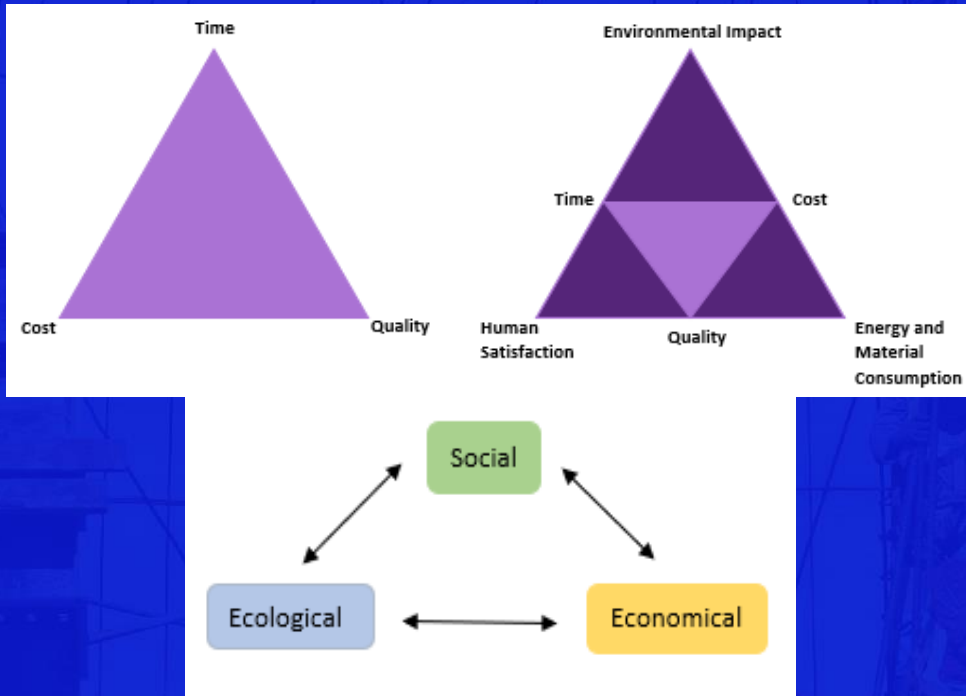
THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE CONFERENCE IN THE ARAB COUNTRIES

Concrete Studies

- Interest in increasing serviceability and sustainability has increased over the years



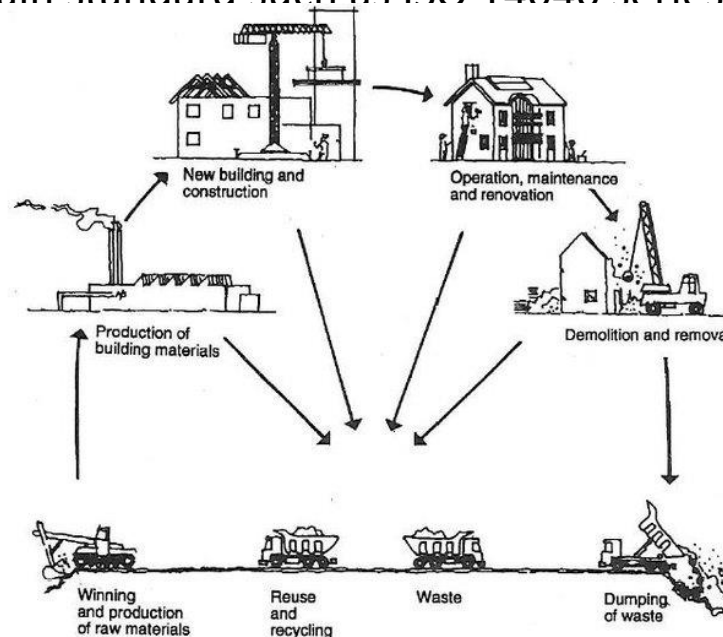
Construction Lifecycle and Sustainability



- Construction practices were always based on Cost, Time and Quality.
- Human satisfaction, Environmental impacts, Materials and Energy consumption are emerging recently.
- Sustainability have three main dimensions (Social – Ecological – Economical)
- These dimensions are interchangeable and must be considered when evaluating the Sustainability of Concrete structure.
- Life cycle assessment is a great tool to evaluate the overall sustainability of concrete and construction.

Concept of Life Cycle Assessment (LCA)

- It is a methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service.
- The methodology must follow a certain standard such as ISO 14040 series





THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE
CONFERENCE IN THE ARAB COUNTRIES

Standard Life Cycle Assessment (LCA)

- **Goal and Scope Definition**

Identifying the purpose and boundaries of the study

- **Life Cycle Inventory**

Quantifying the inputs (energy and raw material) and outputs (Emissions and environmental Releases)

- **Life Cycle Impact Assessment**

Assessing the impacts on human health and the environment associated with the life cycle inventory results

- **Interpretation**

Analysis of the results of the inventory and model the impact



THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE CONFERENCE IN THE ARAB COUNTRIES

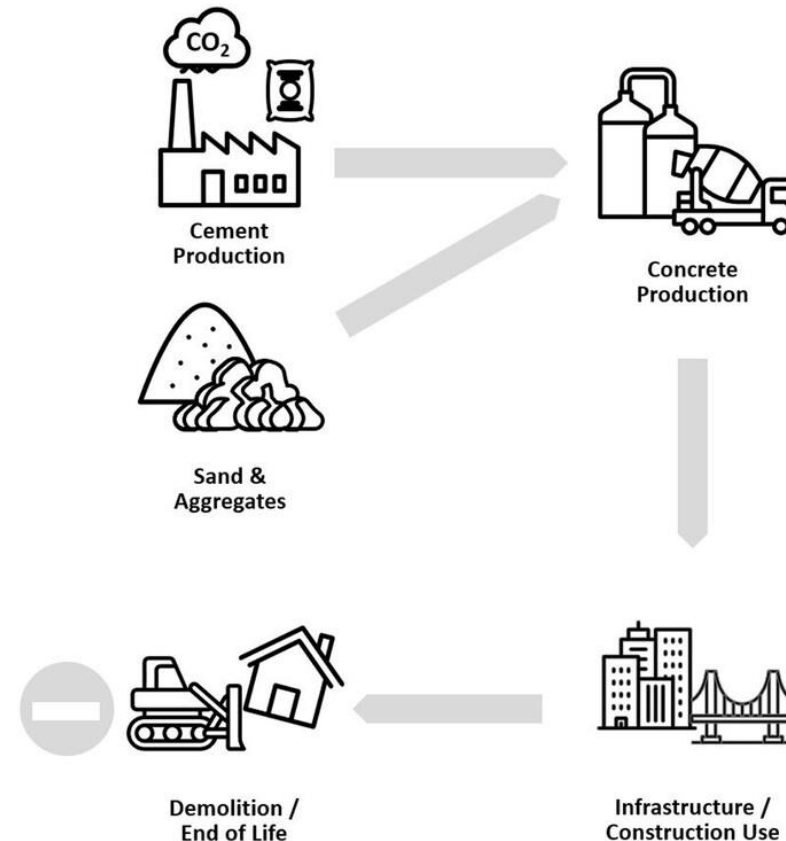
Importance of Life Cycle Assessment (LCA)

- Sometimes it is hard to select the more sustainable choice
- Comparing Disposable Cutlery (Plastic) vs using Reusable Cutlery (Metal)
- Studies have shown that reusable items have a meaningful environmental impact due to the energy, water and detergents use during washing
- This justifies a need for a detailed LCA study to evaluate the proper choice at the suitable location for the selected purpose (Functional Unit)



Concrete Environmental Impact

- Typical Concrete Life Cycle Inventory consists of:
 - Raw materials use: (Resource Depletion)
 - Water consumption: (Water footprint)
 - CO₂ emissions: (Global Warming Potential)
 - PO₄ emissions: (Eutrophication Potential)
 - SO₂ emissions: (Acidification Potential)
 - NO emissions (Human Health Hazard)
 - PM emissions (Human Health Hazard)
 - VOC emissions (Ground Level Ozone)





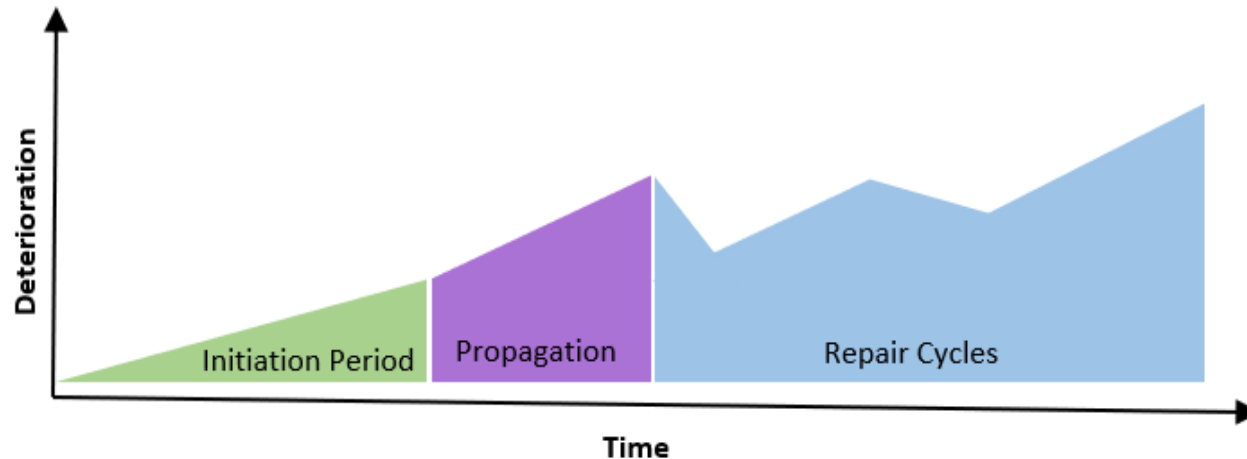
THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE CONFERENCE IN THE ARAB COUNTRIES

Maintenance as a Tool to Enhance Concrete Life-Cycle

- This could be achieved by either:
 - a) Using green and energy-efficient materials and green technologies
 - b) Preserving the already constructed structures through regular maintenance and repair.
- Periodic Maintenance can help extend the building service life and avoid new construction and the adverse effects associated with it.
- It helps avoid major and costly repairs as well



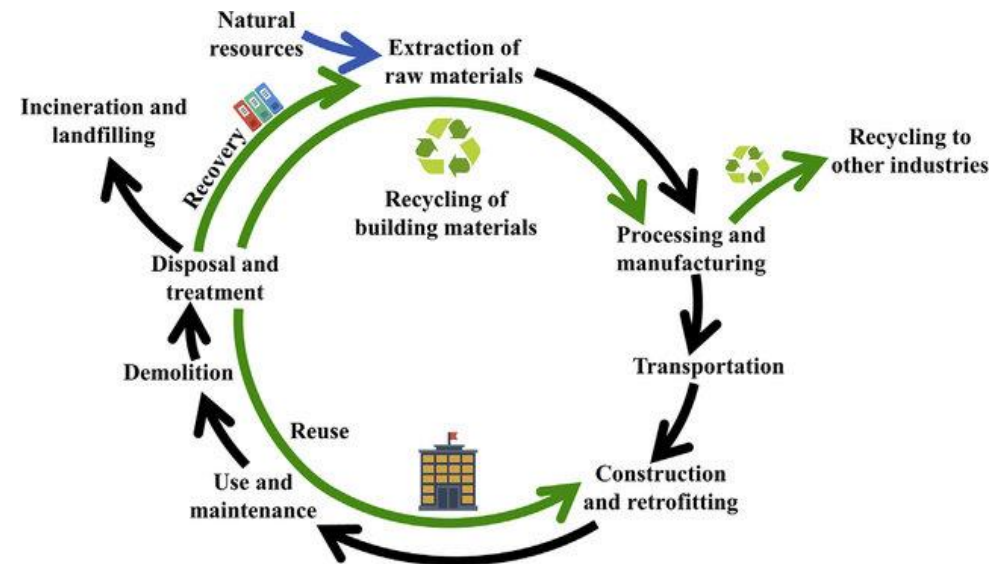
Maintenance as a Tool to Enhance Concrete Life-Cycle



Multiple repair cycles can increase the age of the building after it is exposed to any form of chemical attack or damage

Life Cycle Stages of a Concrete Building

- Must include all processes of its lifetime
- Starting at Material acquisition, manufacturing and/or construction, operation and maintenance , and finally the demolition.
- Examples of the operations are transportation, on-site fabrication, and equipment energy expenditure.
- Energy and water use throughout it's lifetime and waste generation and material disposal.





THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE CONFERENCE IN THE ARAB COUNTRIES

Maintenance vs. Construction LCA: Case Study

- a Small-scale LCA study for a G+2 building of a volume of 50000 m³ was performed.
- The functional unit (FU) is having the building to serve for 50 years.
- Data were collected from multiple sources, including literature, interviews and databases.
- SimaPro software was used for the analysis. A Commercial and Professional LCA software.

Type	New Construction Expenditure	Maintenance Expenditure per 10 years
Energy (Electricity and Heat)	1000 MW.h	30 MW.h
Fuels	100,000 kg	3,000
Building Material	15,000,000 kg	500,000
Water	3,000 kg	100 kg



THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE
CONFERENCE IN THE ARAB COUNTRIES

Maintenance vs. Construction LCA: Case Study

Case 1

The first case is to do zero maintenance and intends a whole new construction after 25 years. Assuming the building will last 25 years so the whole service-life will be 50 years.

vs.

Case 2

The second case is to apply overall evaluation and maintenance every 10 years to support the same building to last for 50 years.

Maintenance vs. Construction LCA: Case Study

- CML-IA methodology was used to evaluate the impact assessment in this study.
- Raw material extraction and processing, energy consumption, transportation, vehicle and equipment use and mobilization as well as construction operations.
- The impact was evaluated in terms of Acidification, Eutrophication and Climate Change.

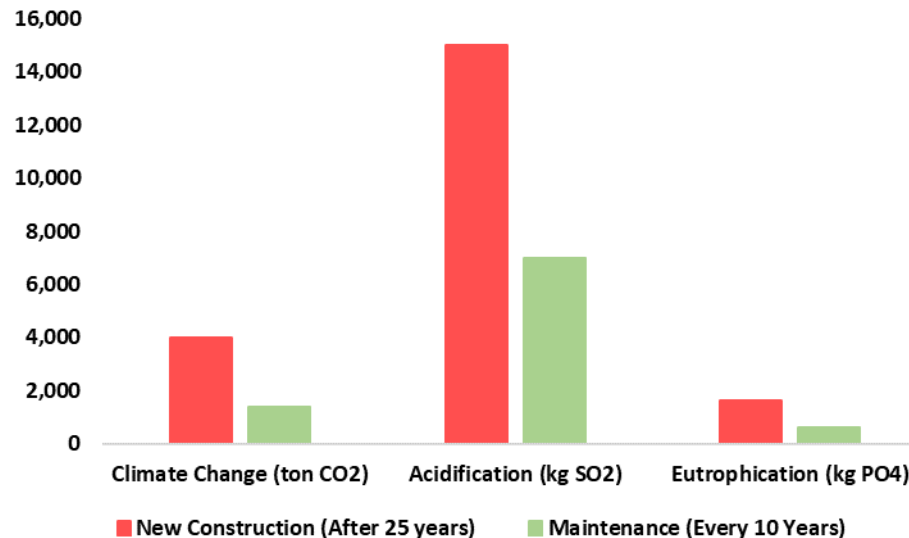




THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE CONFERENCE IN THE ARAB COUNTRIES

Maintenance vs. Construction LCA: Case Study

- A clear advantage of reducing negative emissions is to the application of periodic maintenance.
- We can have the same building and serve the same purpose with minimal impact on the environment and resource depletion.





THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE CONFERENCE IN THE ARAB COUNTRIES

References

- Liao, S., Wang, D., Xia, C. *et al.* China's provincial process CO₂ emissions from cement production during 1993–2019. *Sci Data* **9**, 165 (2022). <https://doi.org/10.1038/s41597-022-01270-0>
- Lauritzen, Erik & Advising, Lauritzen & Denmark,. (2016). Erik K. Lauritzen: Sustainable recycling of concrete – challenges and opportunities, CEMENTOS ARGOS S.A. FORO ARGOS 360 0 EN CONCRETO SUSTAINABLE RECYCLING OF CONCRETE – CHALLENGES AND OPPORTUNITES.
- Huang, B., Gao, X., Xu, X., Song, J., Geng, Y., Sarkis, J., ... & Nakatani, J. (2020). A life cycle thinking framework to mitigate the environmental impact of building materials. *One Earth*, 3(5), 564-573.



THE 20TH INTERNATIONAL OPERATIONS & MAINTENANCE
CONFERENCE IN THE ARAB COUNTRIES

THANK
YOU!

    #OmaintecConf

An Initiative by



Organized by



OMAINTEC
20 YEARS