Life Cycle Assessment and Life Cycle Costing of the World’s Longest Pier:

A case study on the environmental and economic benefits of stainless steel rebar

2014 [avniR] Conference,
Life Cycle in Practice

Lille, 5th November 2014
Rationale

Decision makers increasingly focus on environmental, economic and social considerations:

- Carbon footprint: *less impact in production is better*
- Costs of material chosen: *cheaper is more economic*
- Conflict minerals: *don’t use them / avoid them*
- Resource depletion: *do not use scarce raw materials*
- ...

Do such indicators / aspects tell the full story to take a sustainable decision?
Progreso Pier, Mexico

The oldest structure built with **stainless steel** reinforcement

Background: Progreso Pier built in 1941 and still in service today
Comparative Life Cycle Assessment

• What if the Progreso Pier had been built using other rebar?

Aim:

• Demonstrate the effectiveness of stainless steel rebar and other rebar in terms of:
  • Environmental performance
  • Economics (costs)

• Assess entire life cycle of the pier:
  • Production
  • Use phase
  • End of life
Methodology Overview

- **Comparative assertion**
  - Both designs serve the equivalent function
  - Stainless and carbon steel: same structural characteristics

- **Analysis period**
  - 79 years – conservative approach
  - Provides estimate of past (1941–2013) and future (2013–2020) performance

- **System boundaries**
  - Included: materials, transportation, maintenance, and end-of-life fates
  - Excluded: construction, use, and demolition as not expected to have a significant impact

- **Analysis methods**
  - Life cycle assessment (LCA) conformant to ISO 14040 series
  - Life cycle costing (LCC) conformant to ISO 15686-5

Integrity of study assured through Critical Review
Comparison: Designs

As-built Design (stainless steel rebar)

- **Materials**
  - Concrete: 72,500 m$^3$
  - Stainless steel rebar: 220 tons

- **Service life**: 79 years

- **Maintenance**: to be determined according to maintenance schedule (see following slide)

Alternative Design (carbon steel rebar)

- **Materials**
  - Concrete: 72,500 m$^3$
  - Carbon steel rebar: 220 tons

- **Service life**: 79 years

- **Maintenance**: to be determined according to maintenance schedule (see following slide)

Study compares same pier design with different materials. Conservative approach chosen as concrete thickness for SS rebar can be reduced.
Maintenance schedule was developed according to globally accepted US Navy predicted maintenance schedule (2012).
Comparison: Materials

Stainless Steel Rebar

Price (2013$): $2.99/kg

GWP [kg CO₂-eq/kg]
PED [MJ/kg]

GWP – Global Warming Potential [kg CO₂-eq/kg]
PED – Primary Energy Demand [MJ/kg]

Carbon Steel Rebar

Price (2013$): $0.45/kg

GWP [kg CO₂-eq/kg]
PED [MJ/kg]

The cost and carbon footprint of the rebar materials only look into first stage of the life cycle, but do not tell the full story in view of material use & maintenance.
LCA Results:
Breakdown of material contributions – initial construction

Concrete dominates the carbon footprint of the materials.

As-built design has 2% bigger carbon footprint than alternative design.
As-built design has 71% smaller carbon footprint than alternative design

AP = Acidification Potential
EP = Eutrophication Potential
GWP = Global Warming Potential, i.e. Carbon Footprint
ODP = Ozone Depletion Potential
POCP = Photochemical Ozone Creation Potential, i.e. Smog Formation Potential
Life Cycle Costing Results

Discount Rate of 0.01% (recommended by SETAC*)

Cost of the as-built design ($520k) is nearly 30% less than that of the alternative design ($730k).

A credit is applied to account for remaining structural service life.

Life Cycle Costing: LCC is sensitive to discount rate

- **EU:** “Use of a low (3% or less) or even a zero rate is recommended when LCC is used to assess the economic merits of alternative sustainability options.”*

- **US Navy** reports 0%, 1%, and 2.3%

- **US Circular A94** currently uses 1.1% based on the 30-year bond

- **SETAC:** 0.01% discount rate for long-term investments (over 30 years)


Discount rates between 0% and 1% are most commonly used by regulators and scientists whereas rates between 3% and 5% are seen as overly conservative.
The Sensitivity analysis shows that up to a discount rate of 4%, the as-built design is more economic when looking also into the use phase.
Conclusions

Environmental benefits and long term economic savings

**Environmental benefits**
- Use of stainless steel provided long service life of the Progreso Pier
- Increased service life provides environmental benefits over entire life cycle

**Economic benefits of Stainless Steel Rebar**
- Significant economic benefit of using stainless steel rebar
- Even at overly conservative discount rates (4%) there is still an economic benefit

Even with overly conservative approaches and assumptions used for the LCA, the use of SS rebar creates significant environmental and economic benefits.
Social considerations

Some thoughts on inclusion of social considerations

- There are social impacts but also benefits created
  - Employment in remote areas, wages
  - Social engagement of companies in communities, creation of infrastructure
- We have to be aware of target conflicts
  - Long life time of products and less maintenance vs. employment
- Complex value chains – challenging to track and ensure information flow
  - N° of stakeholders between raw material producers and end users
- Concern of oversimplifying things
  - Complex systems and interaction between environment, economics & social aspects
- There is already a lot done in the mining and metals industry
  - ICMM activities on responsible sourcing, conflict minerals, ...
Social considerations

Can and shall LCA address all dimensions of sustainability?

- LCAs show an added value for certain environmental and economic considerations
- LCA can also help companies to benchmark their performance on certain technical aspects and to demonstrate their performance
- When applying full life cycle thinking, LCA and LCC are useful to take adequate decisions
- We should avoid overlapping with other activities that better fit for the purpose
  - Risk Assessments (environmental, human health)
  - CSR activities by companies and sectors
  - Initiatives from industry (e.g. ICMM)
Full peer reviewed LCA report & more information:

www.nickelinstitute.org
mmistry@nickelinstitute.org