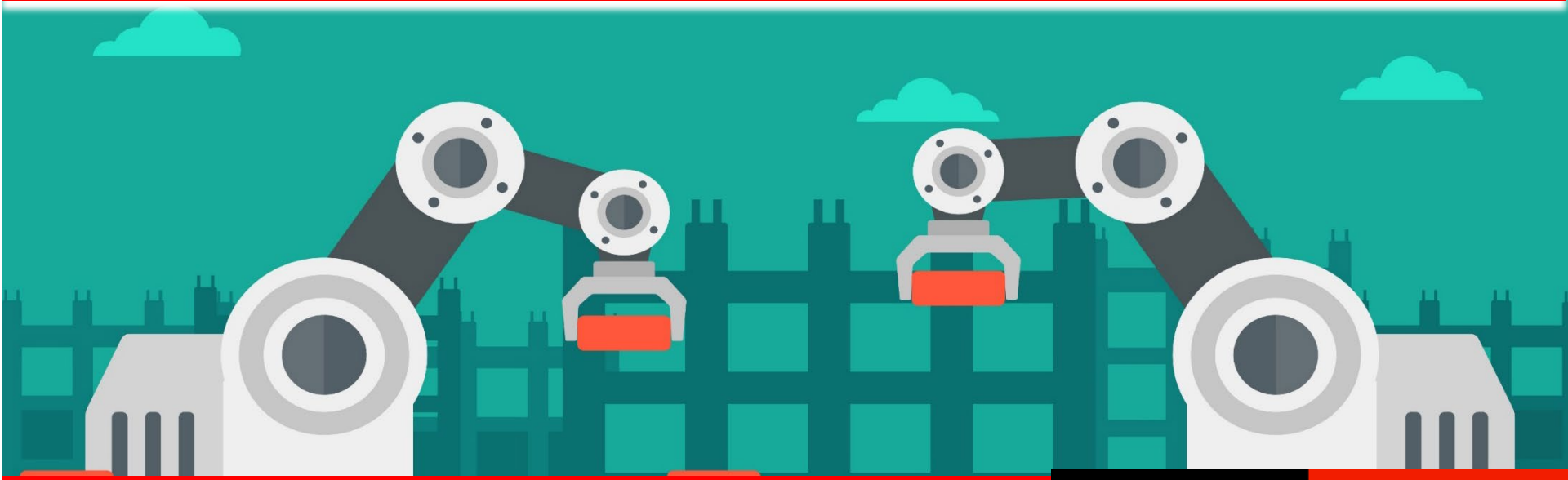
Green Construction Technologies for Civil Infrastructure



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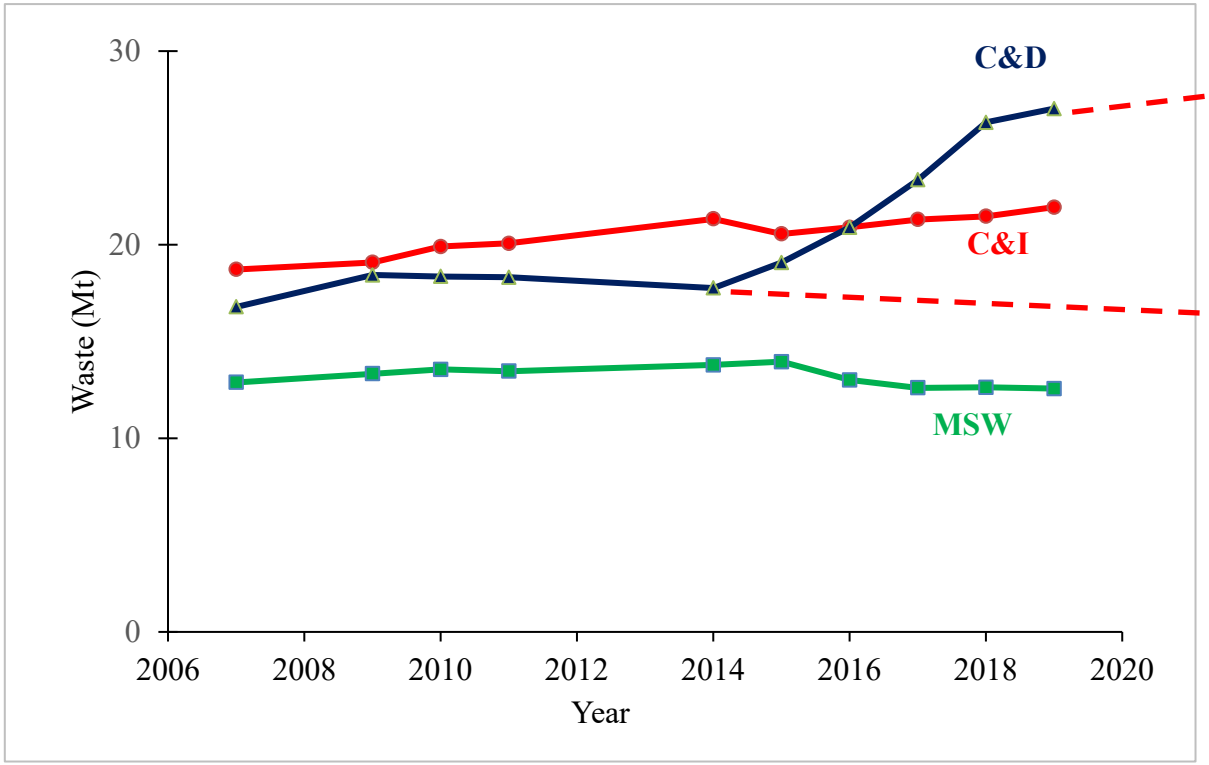
Waste Generated by Construction Sector in Australia

- Total 62 million tons: 44% from Construction and Demolition
- Difficult to dispose waste: concrete, bricks, timber, . .
- Waste disposal expenses: $2 Billion
  - Manufacturing spent $1.2 Billion
  - Households spent $0.6 Billion

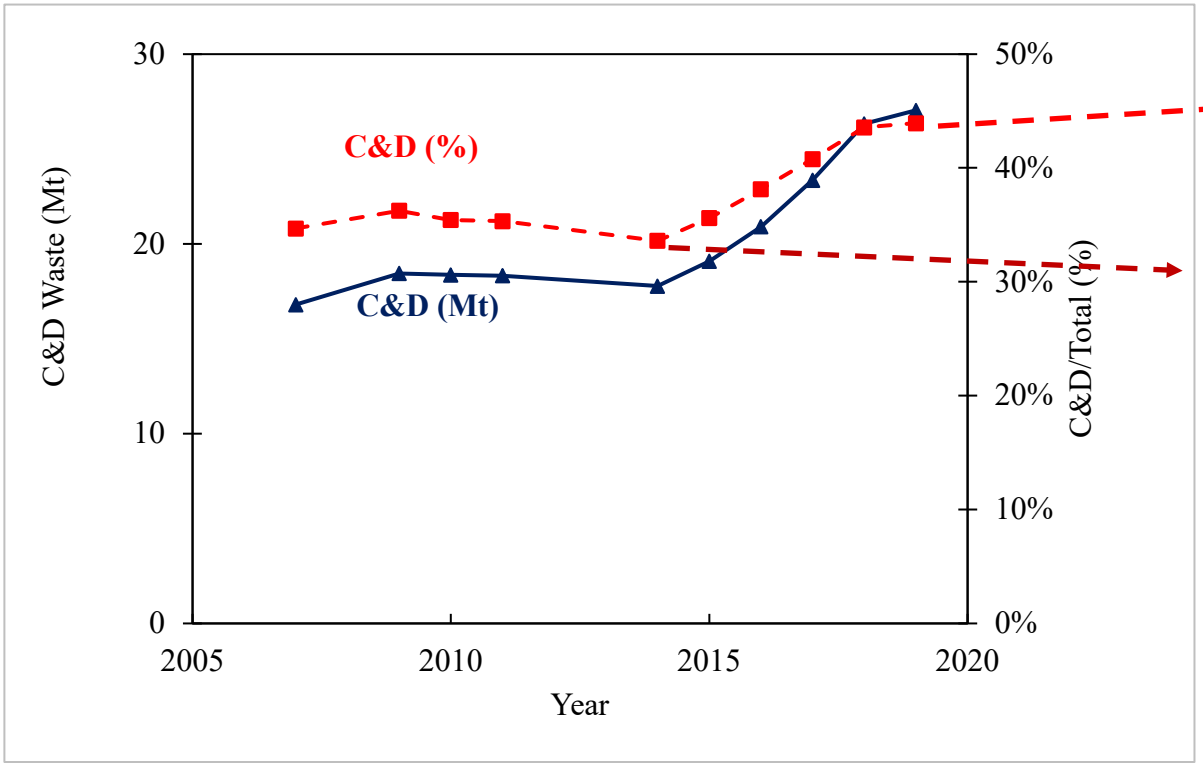
Waste Trend in Australia



27 Mt in 2019

18 Mt in 2014

Waste Trend as a % of Total



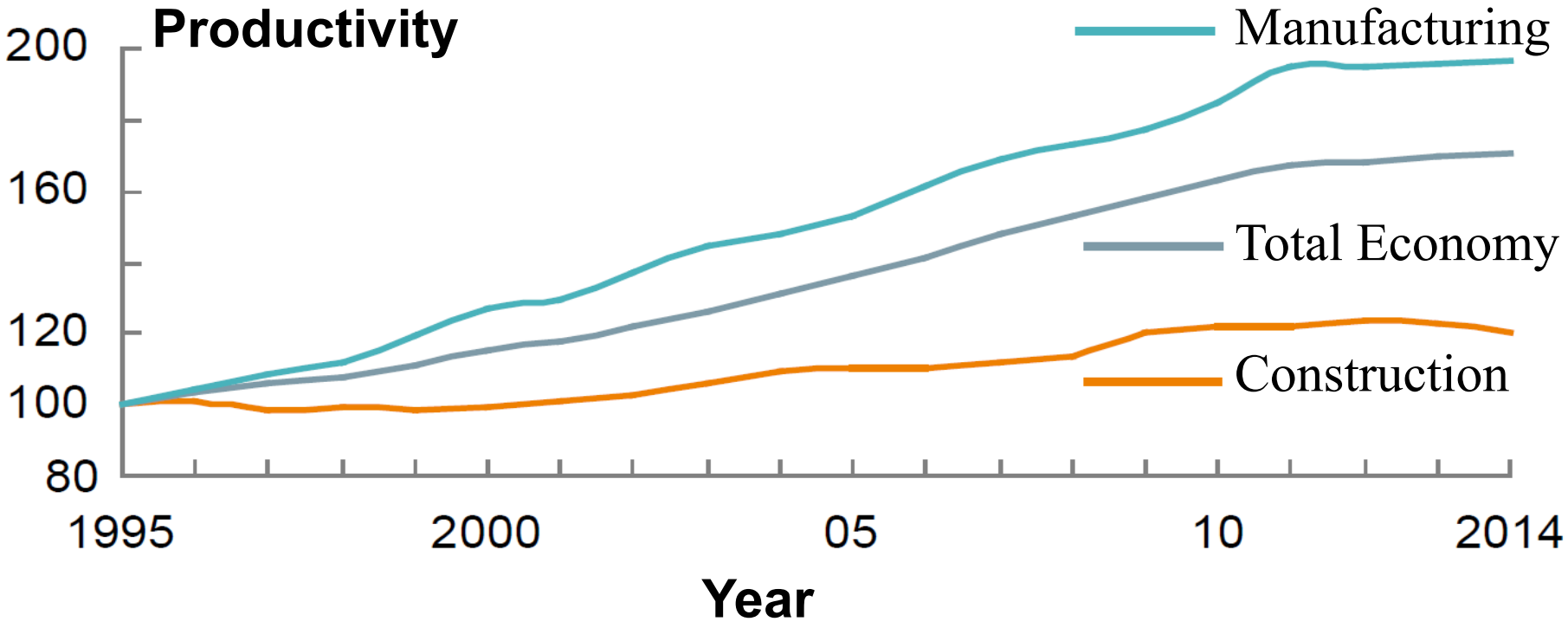
44% in 2019

34% in 2014

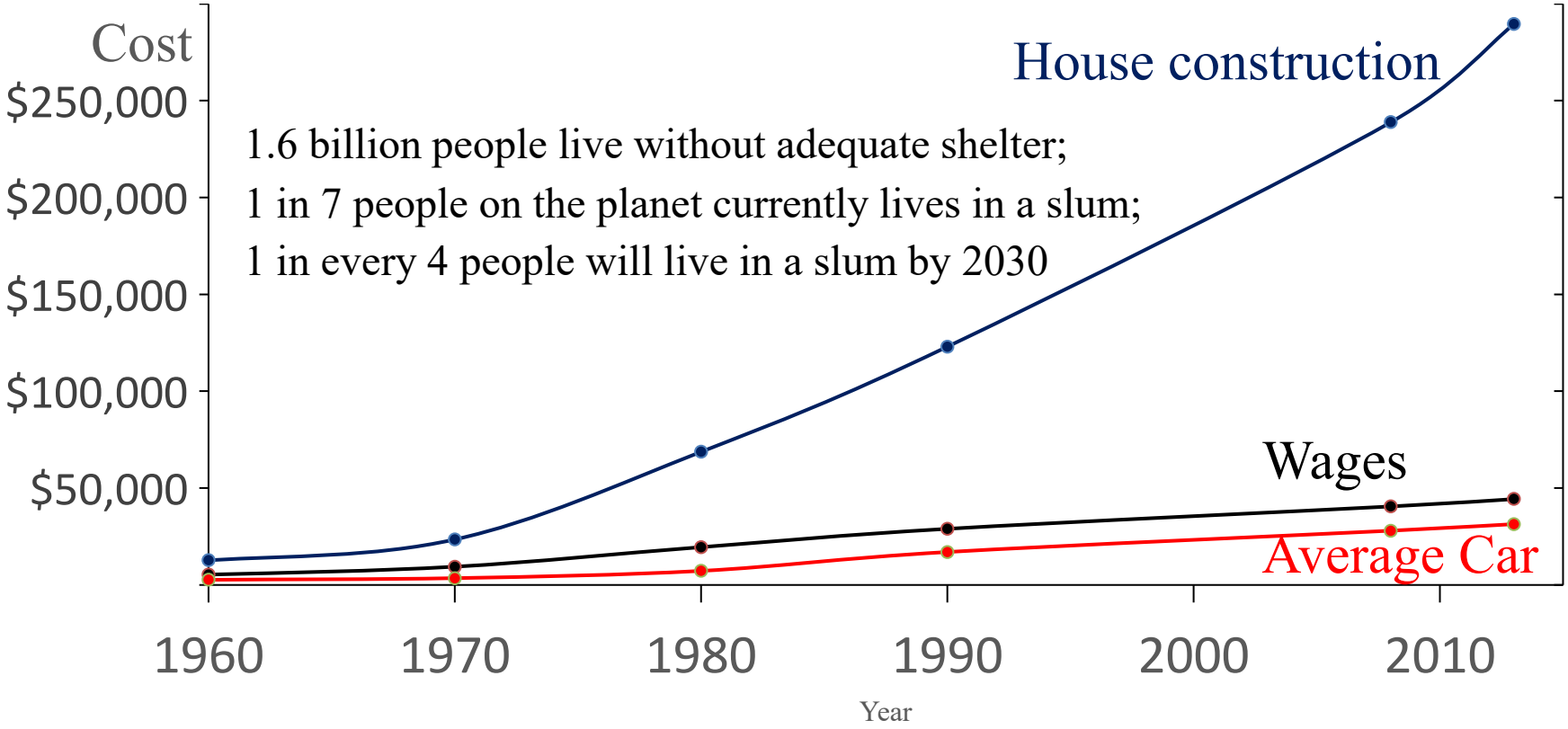
Why?

- Construction processes are ***inefficient***
- 30% of the new materials are returned as waste
  - temporary works (formworks, timber, . .)
  - damaged items (broken tiles, bricks, .)
  - excessive items (inaccurate estimations)

Inefficiency ⇔ Productivity



Implications of Lagging Productivity



Lag in Digital and Automation

Automotive, aerospace, ship building and manufacturing industries:

- CAD modelling
- Additive manufacturing technologies
- Automatic assembly methods

Construction Sites lags behind in:

- Low labour efficiency
- High accident rates
- Quality control difficulties

3D Printing: Concrete

- No Formwork
  - Savings of 35 to 60% of the cost
  - Reduce wastage
- Free from rectilinear designs

Material usage efficiencies vs Technology

Modular/Offsite constructions

- Imported from automotive and other manufacturing
- tight inventory control
- Factory-controlled environment
- Many projects in parallel so re-inventory of materials

Off-Site Construction

On-Site Construction Waste

Depletion of Resources and Materials by Construction

- Consumption of 60% of the raw materials
- 35% carbon emissions
- 30% of the global waste

Strategies to Minimise Waste

1. Extending the Life of existing Infrastructure
2. Waste Reductions in new Constructions
3. Use of Recycled Materials

Extending the Life of existing Infrastructure

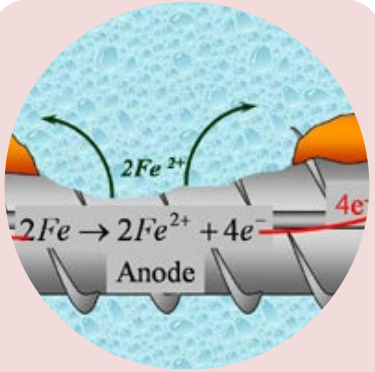
- Improved knowledge about the infrastructure performance and life time prediction
- Extending the life of infrastructure with strategic maintenance and reduce the need for new construction.

Extending the Life of existing Infrastructure

Artificial Intelligence and Machine Learning

Intelligent sensor, UAV (drones), VR technologies

Integration of data and expert domain knowledge

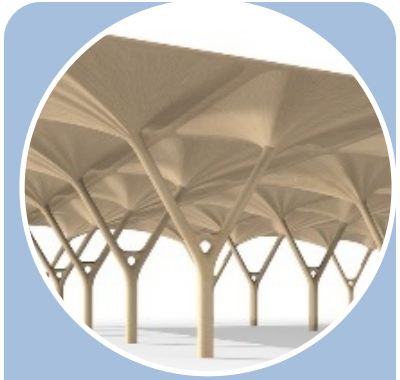


Knowledge on Deterioration Mechanisms

Waste Reductions in new Constructions

Modular & Off-site construction

Digital Automation (3D concrete printing)



Reduce consumption by efficient design & processes

Use Low carbon, low embodied energy materials

Recycling Technologies in Construction

Cements using wastes (fly ash, waste glass, brick waste, calcined clay)

Recycled Concrete for making new concrete

Recycled plastics for reinforcements

Construction Materials – Carbon Intensive

Timber Manufacture & Loss of Forest

Steel

Glass, Brick

Alternatives to Portland Cement Concrete

- Geopolymer/alkali activation or Blended Cement
  - Fly ash
  - Slag
  - Calcined clay
  - Rice Husk Ash
  - . . .

Conclusions

Increasing pressure on construction will be placed in the future due to:

- Cost pressures
  - Efficiency improvements (materials, labour, waste reductions)
- Emissions from cement is tipped to increase to 40% by 2050
- Waste disposal is becoming expensive