# Junkyard planet - opportunities for the re-use of builders rubble


## Chantal Rudman

(Agnello, Beardmore, Cleghorn, Bredenkamp, Goosen, Kotze, Nel, Semugaza, Tawine, Tredoux)

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**"Waste is the evidence we are doing something wrong.**

**Landfilling means we are *burying* the evidence.**

**Incineration means we are *burning* the evidence"**

**-Anon**

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## Waste crisis in South Africa

**Legal landfills are few and far between……..**

- 98 000 000 tonnes of waste generated
- 600 000 tonnes recycled

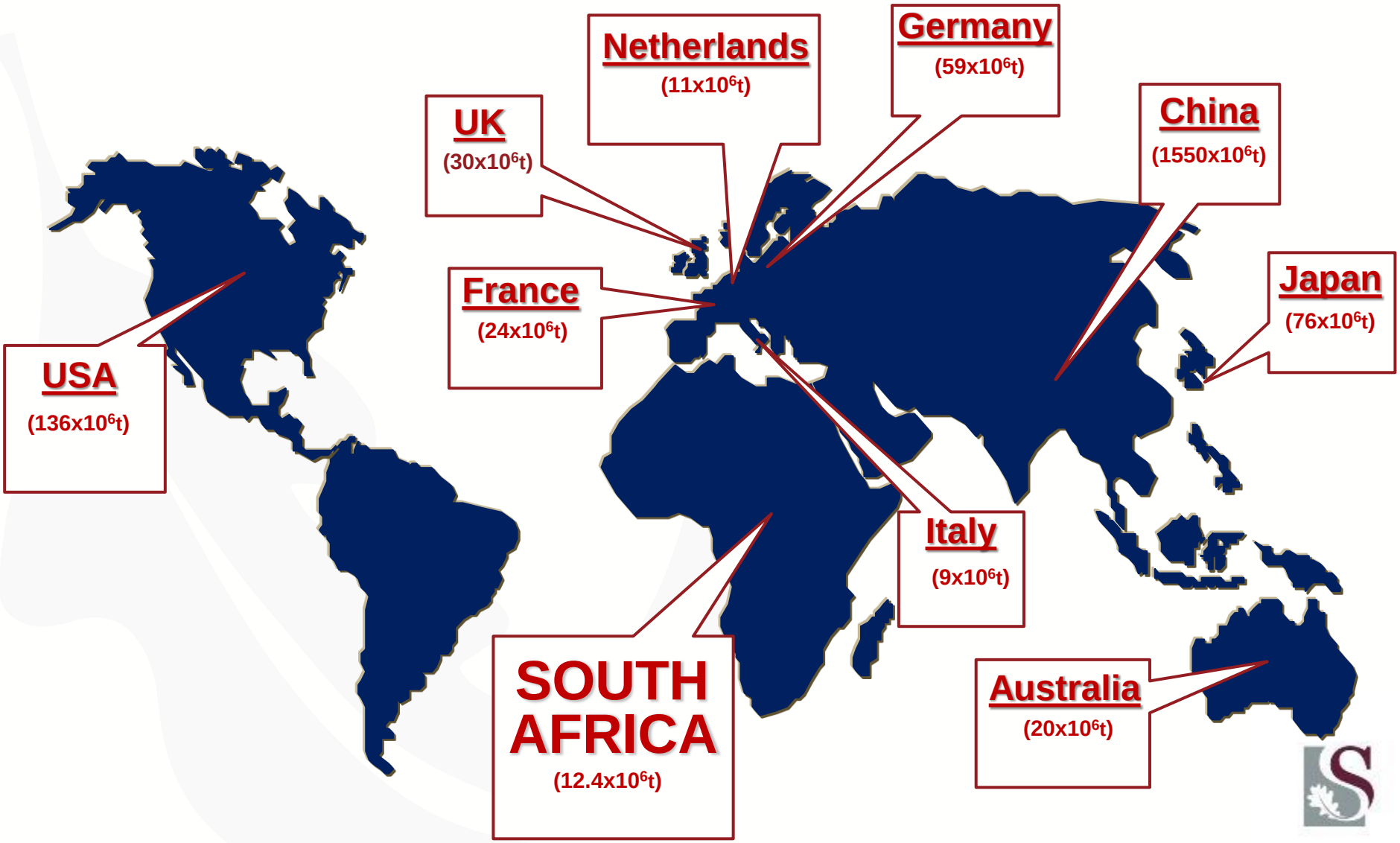
- Statistics show it takes **> 5 years** ( +1 year to build) if no public interventions. Currently **10 years**

- **Example: CoCT waste disposal currently spending 70% of their budget on operations**

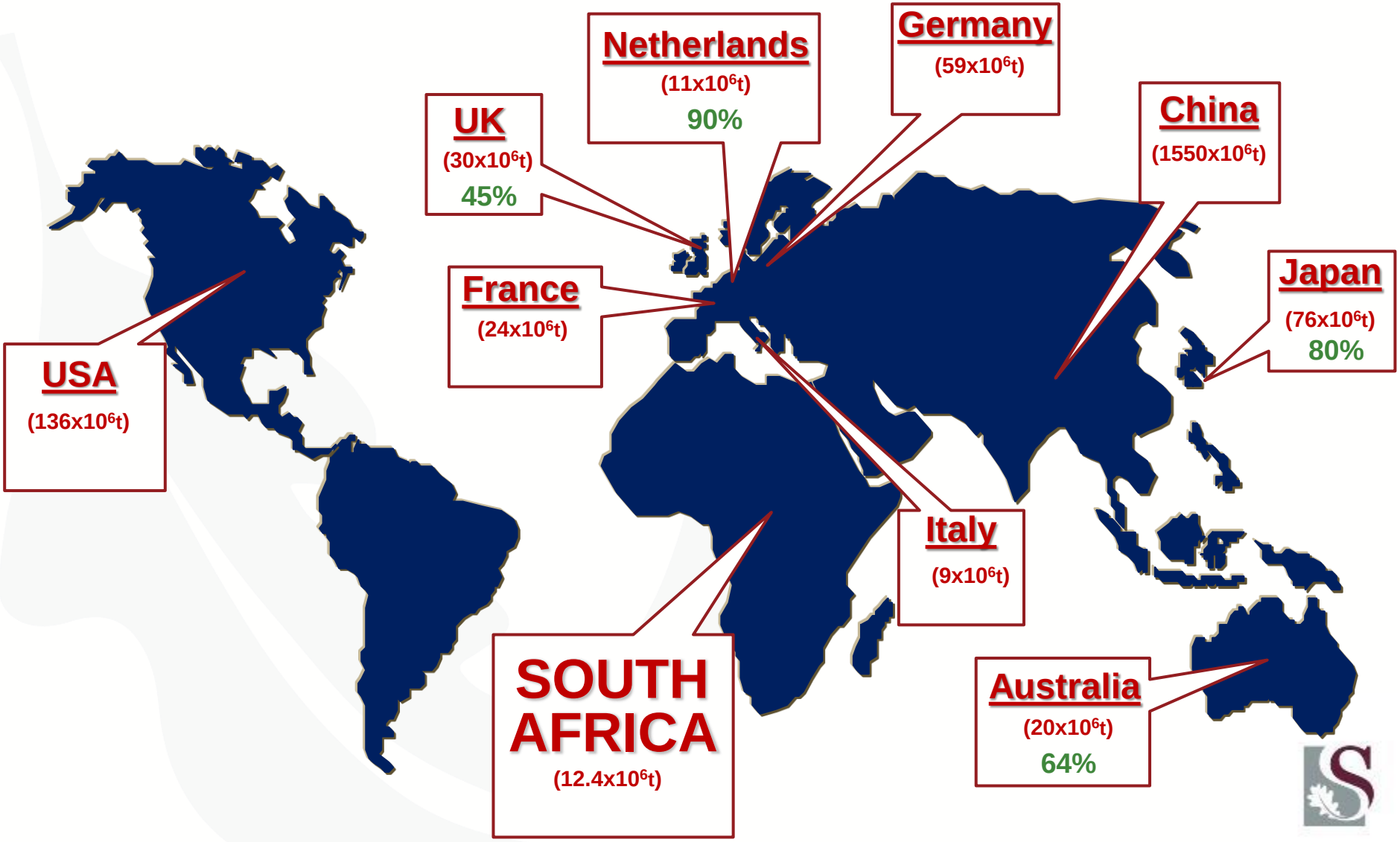
## Waste crisis in South Africa

# Around 20-30% of landfill sites are builders' rubble

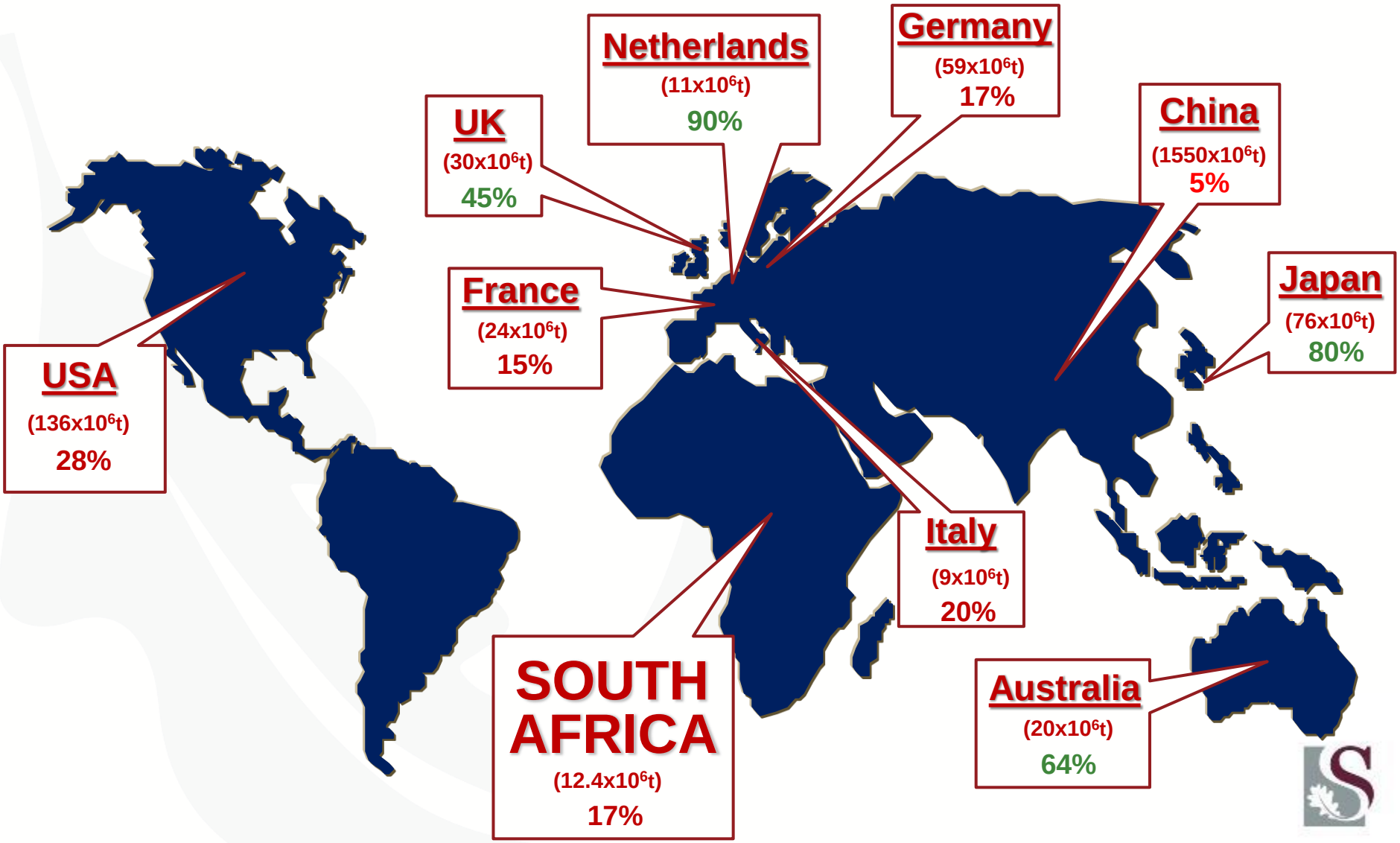
# Global statistics



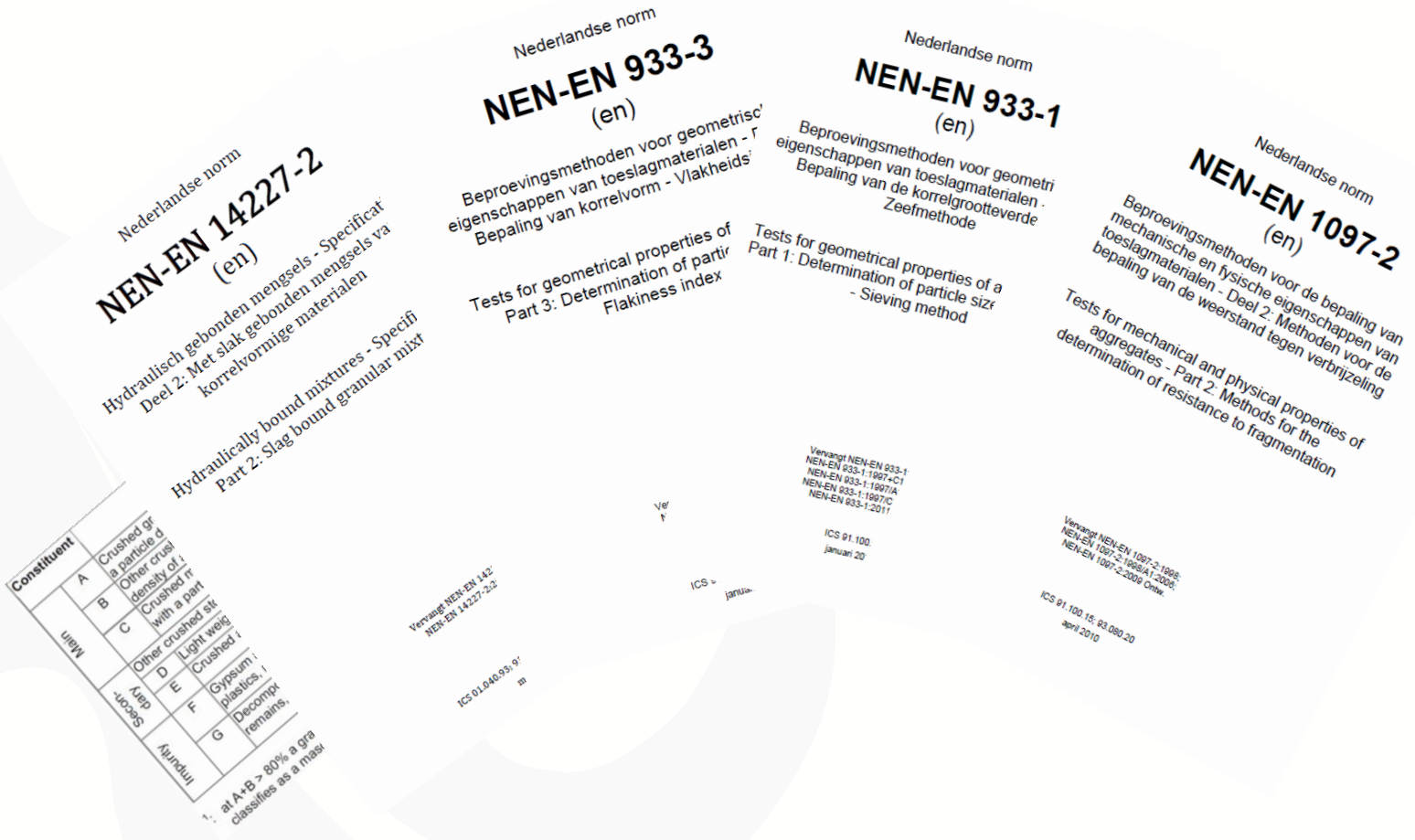
# Global statistics



# Global statistics



# Global statistics



## Problem Statement

### Why does SA not divert to alternatives???

- Supply and quality

### Virgin materials is not always better

- Cape quarries clay content
- New borrowpits take longer than 9 months to get approval

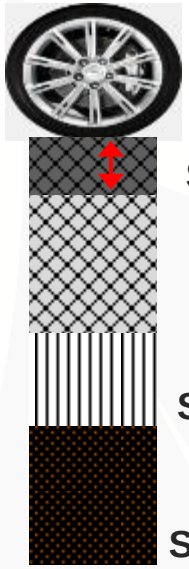
### It has monetary value

- CoCT at cost of landfilling at **R400/t**, cost savings will be R224 million from diverting 60% of material from 2015 baseline data in 1 year……. In perspective Capex for CoCT 2016/17 = R237 million
- Cost savings could be **95%** of capex budget for 2016/17
- Illegal dumping – **R350** million per year

## Problem Statement

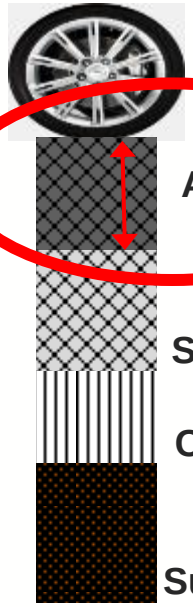
## Problem Statement

# Comparing the South African situation with other countries



| | |
|---|---|
| Surface | Asphalt Layer (20 - 50 mm) |
| Base | Unbound high quality crushed aggregate (100 - 300mm) |
| Subbase | Cemented mixture (100 - 300mm) |
| Subgrade | Soil fill and unbound Mixture (Natural and selected) |

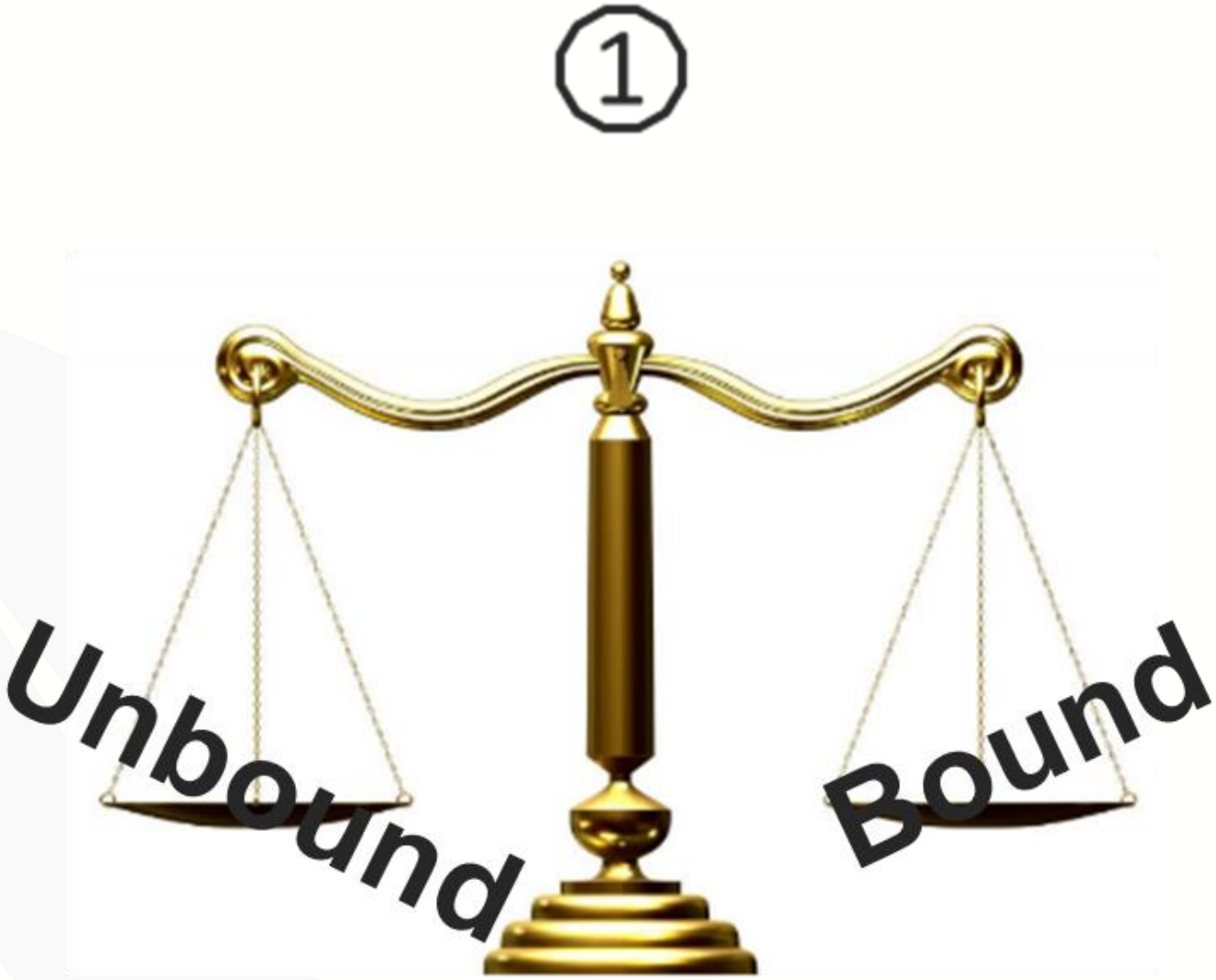
South Africa



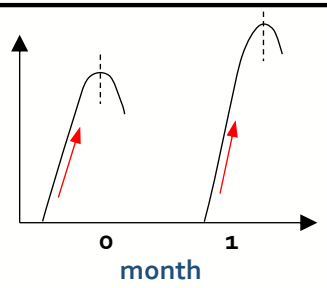
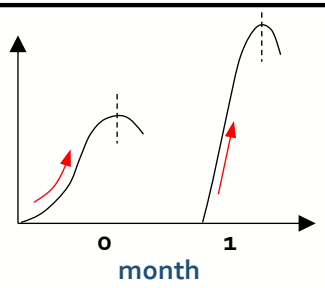
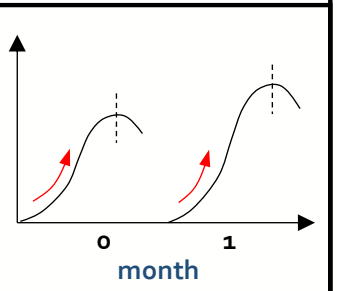
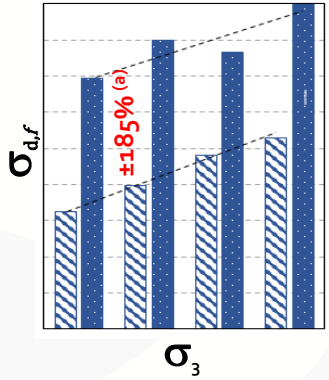
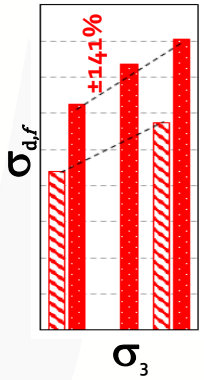
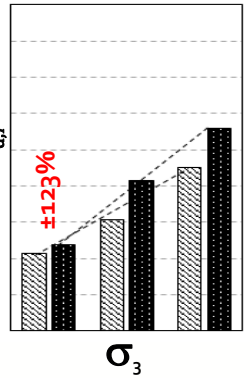
| | |
|---|---|
| Asphalt layer | > 100 mm (asphaltic layer(s) |
| Subbase | Unbound/hydraulically bound |
| Capping | Soil fill |
| Subgrade | Soil fill |

Industrialised Countries

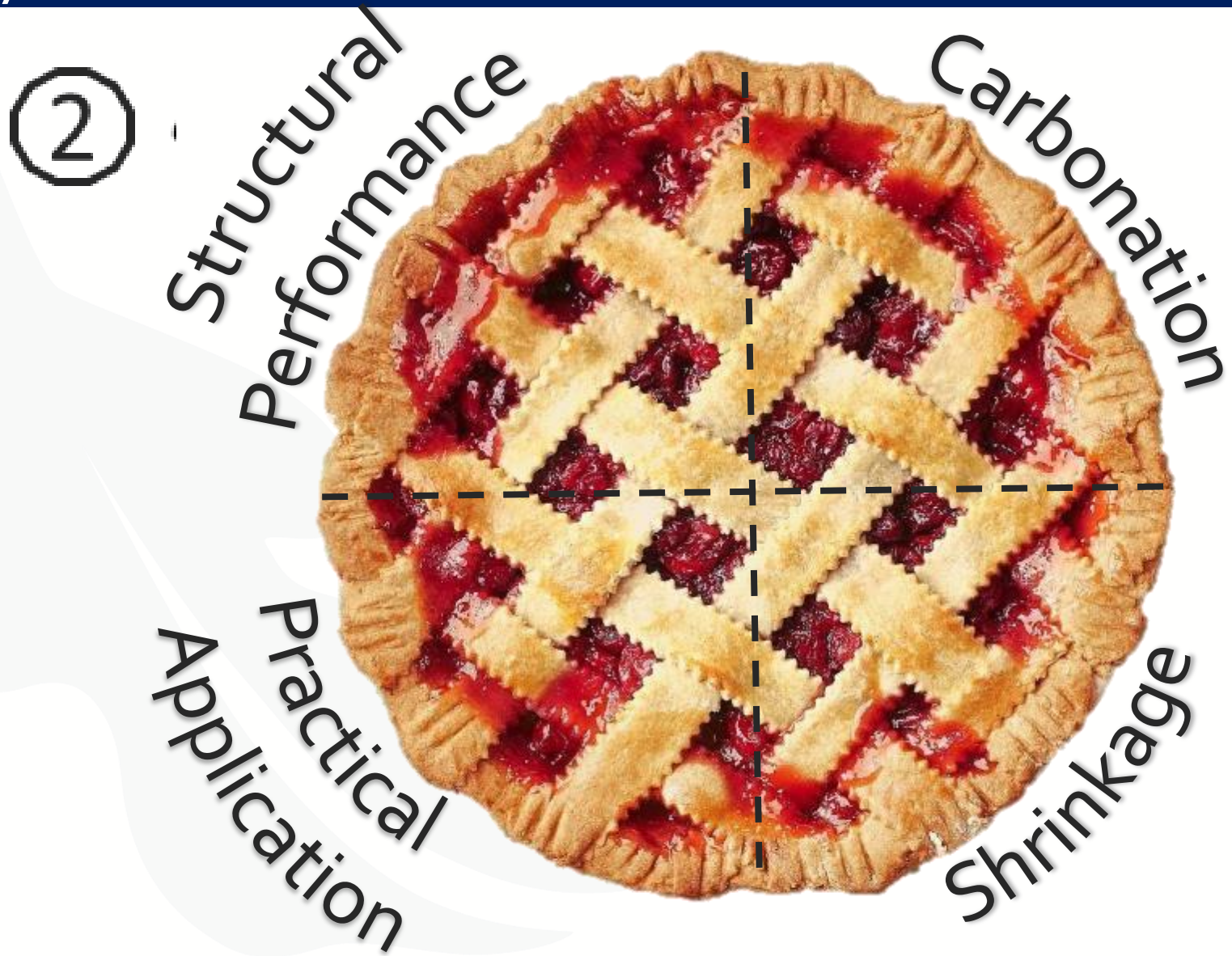
## Phase 1



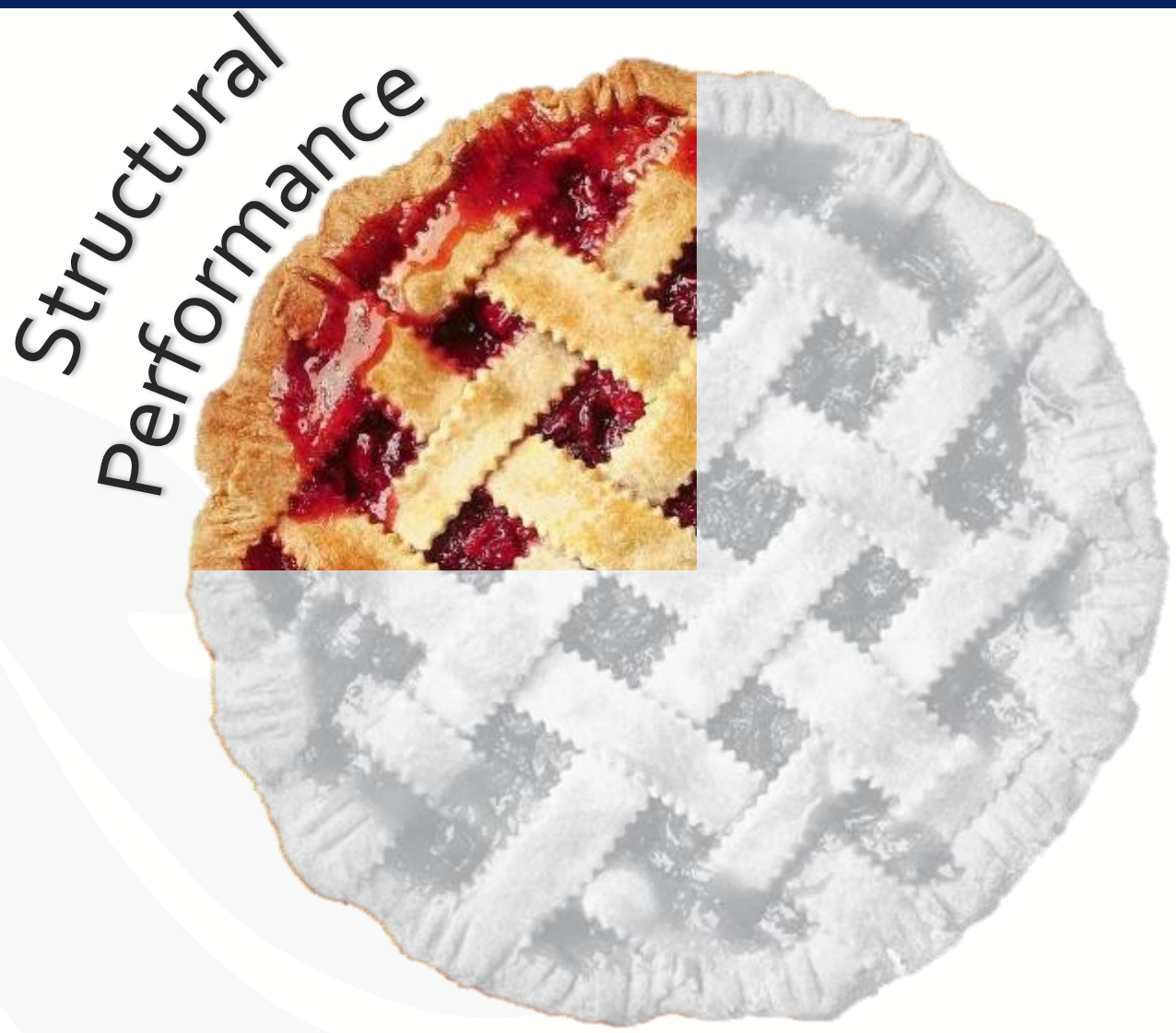
# Summary

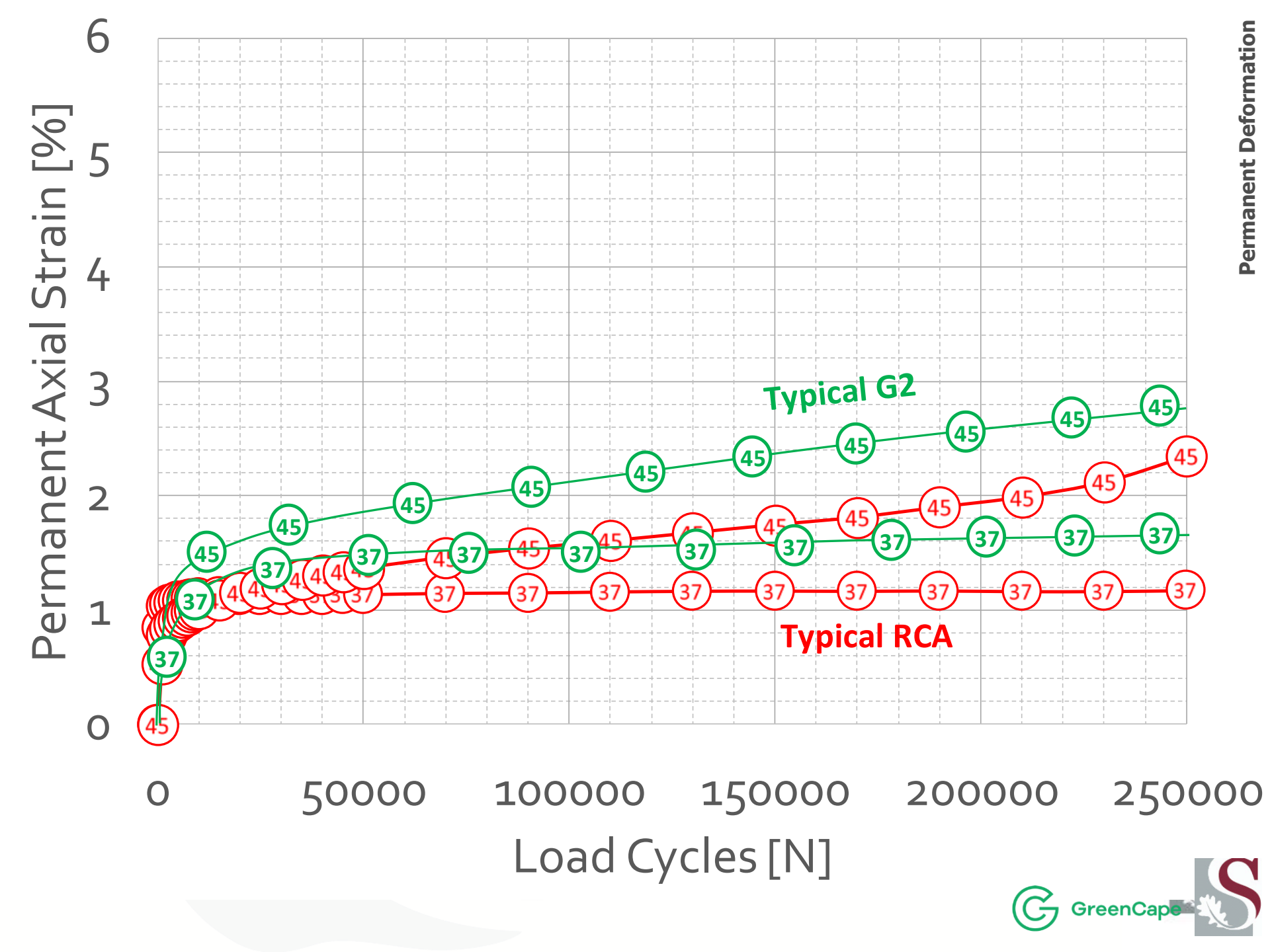
| | RCA-*New* | Unexposed | RCA-G1 |
|---|---|---|---|
| Stress-strain form |   |   |   |
| Ultimate strain decrease | 0.0015 → 0.00095<br>$\varepsilon_{f,1}$ 63%< $\varepsilon_{f,0}$ | 0.0025 → 0.00170<br>$\varepsilon_{f,1}$ 68%< $\varepsilon_{f,0}$ | 0.0025 → 0.0022<br>$\varepsilon_{f,1}$ 88%< $\varepsilon_{f,0}$ |
| Monotonic |   |   |   |
| pH/ | 13.1 | 11.9 | 10.9 |
| Phenolphthalein/ |  | - |  |
| Intensity | 28000 | - | 0 |

## **Layout** >> Phase 2

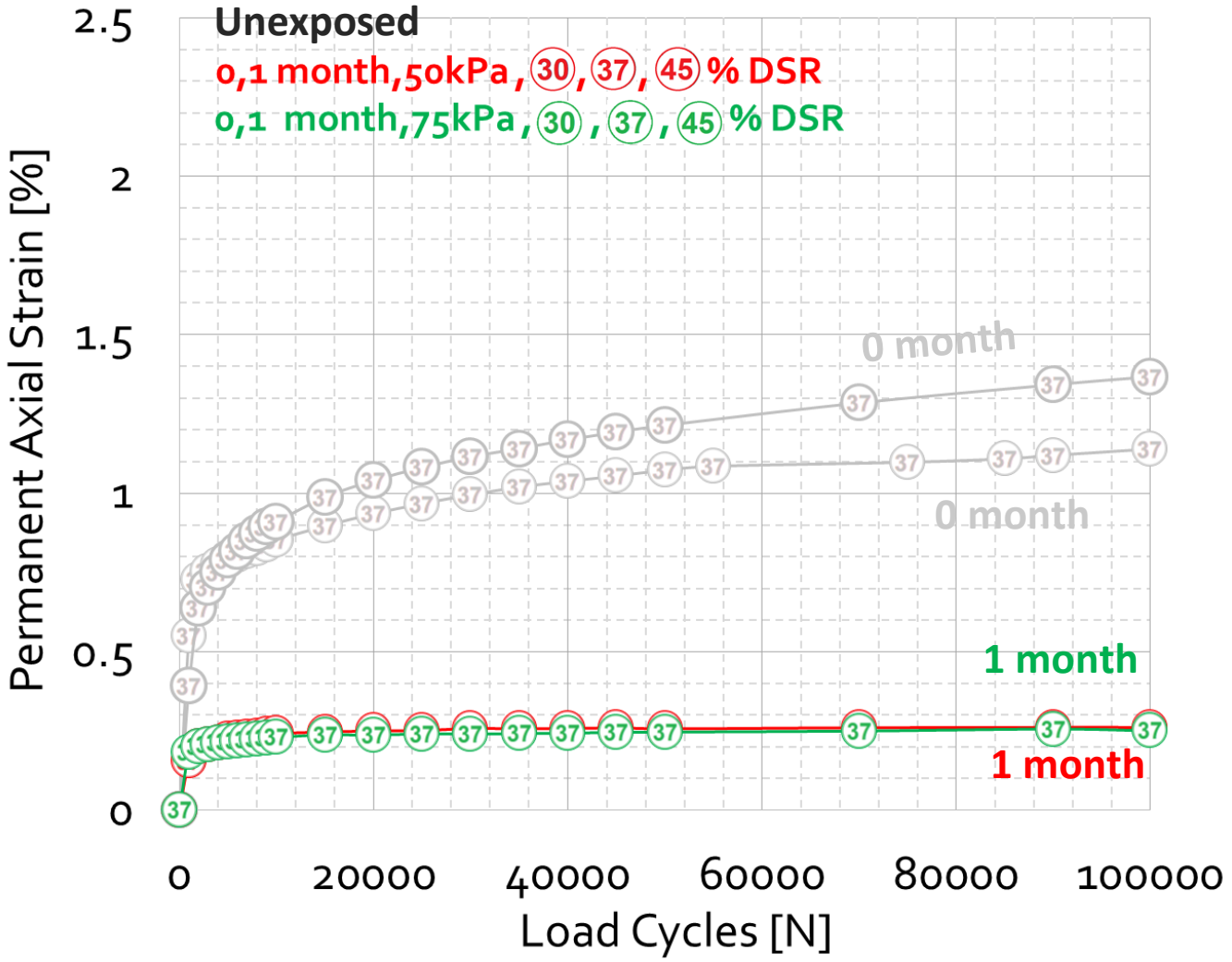


# Structural behaviour

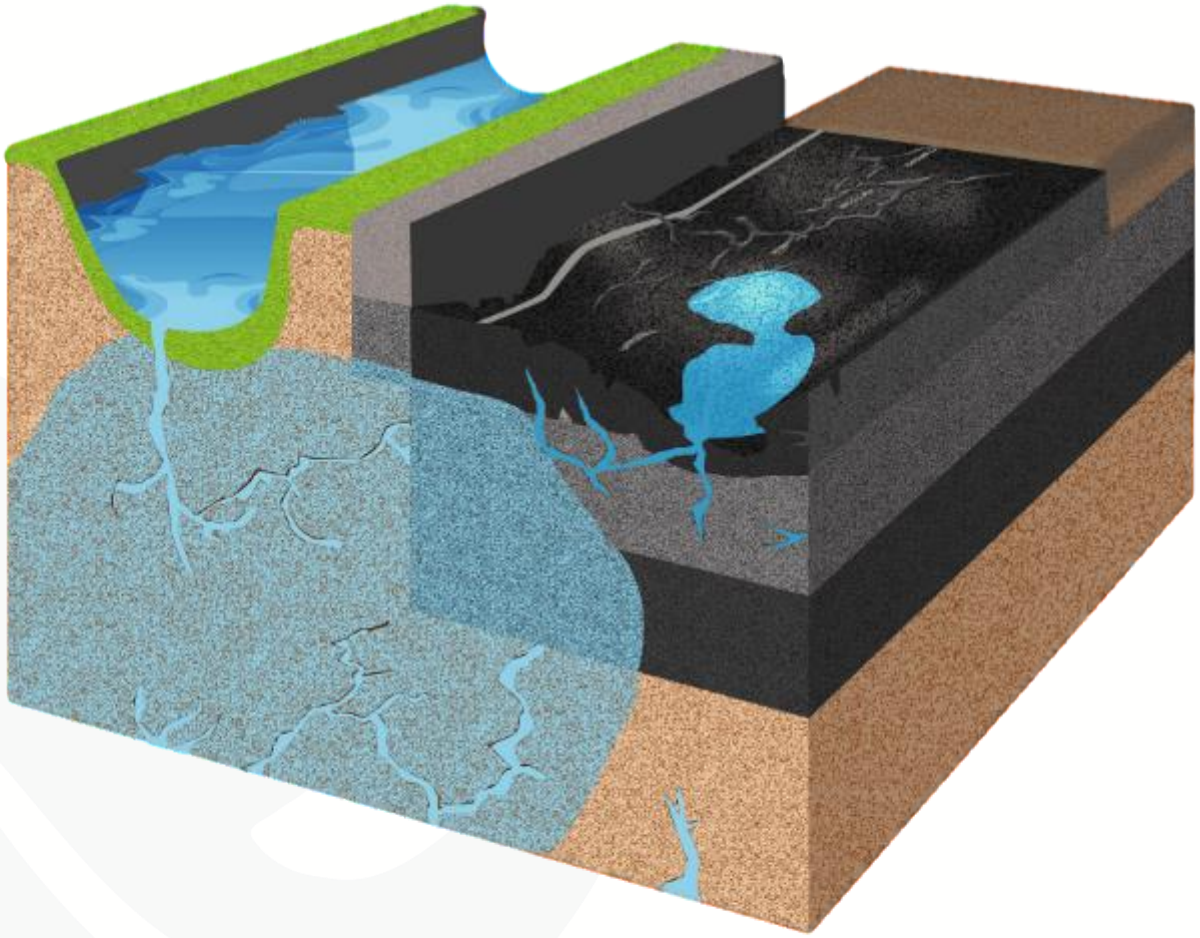



Permanent Axial Strain [%]
0
1
2
3
4
5
6
0
50000
100000
150000
200000
250000
Load Cycles [N]
Typical G2
Typical RCA
Permanent Deformation

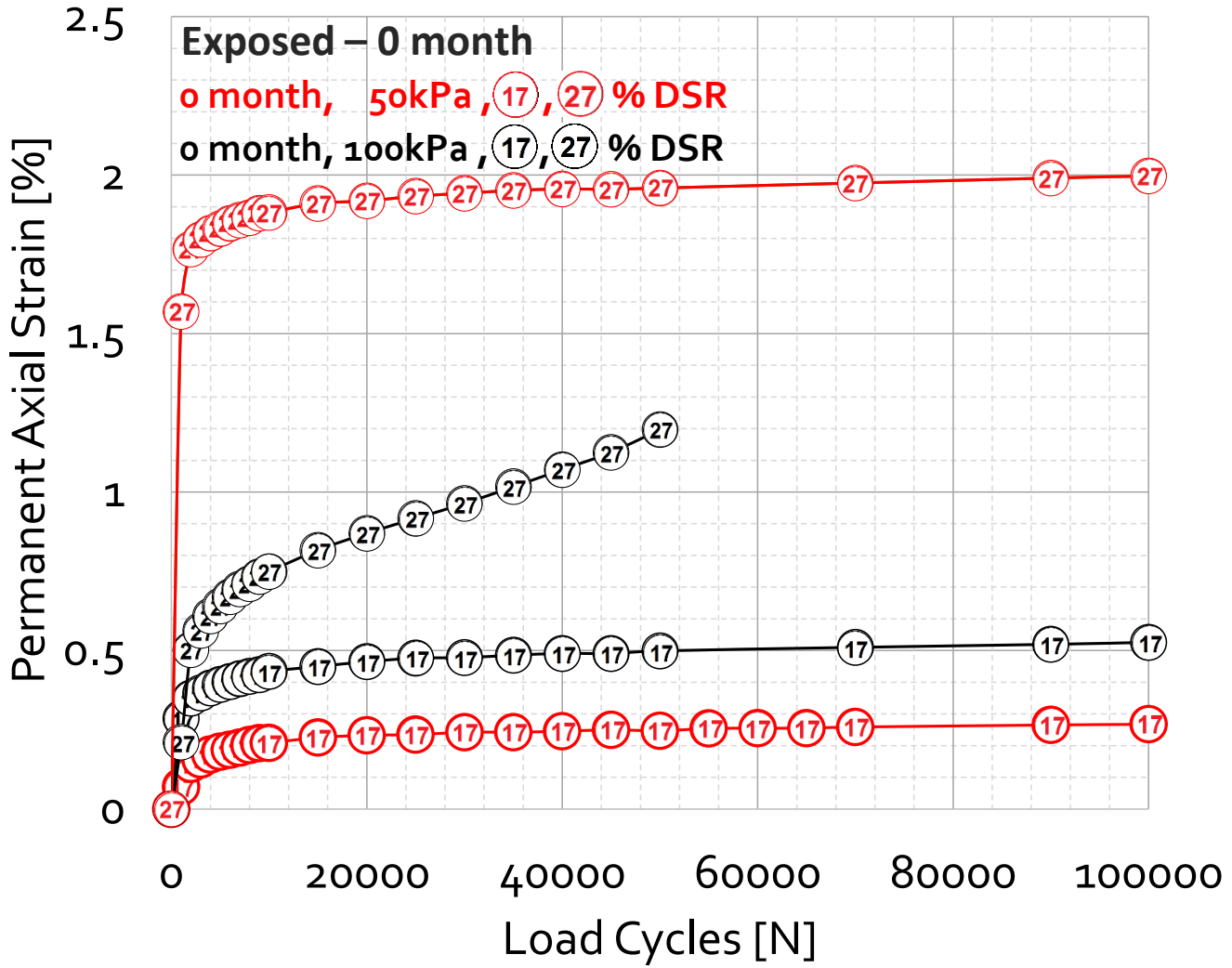
## **Permanent Deformation**>> Unexposed >> 0 month vs 1 month



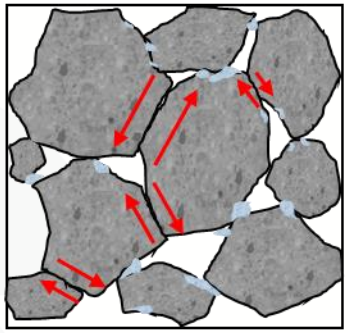
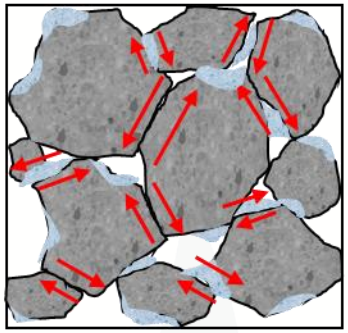
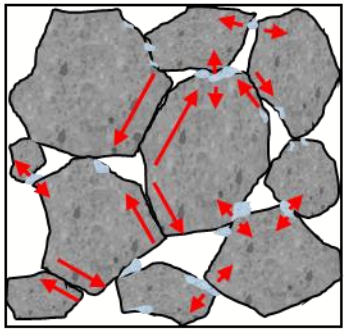
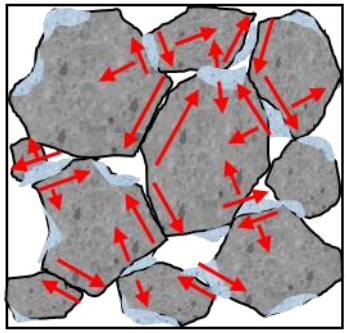
# Permanent Deformation>> Durability is an issue



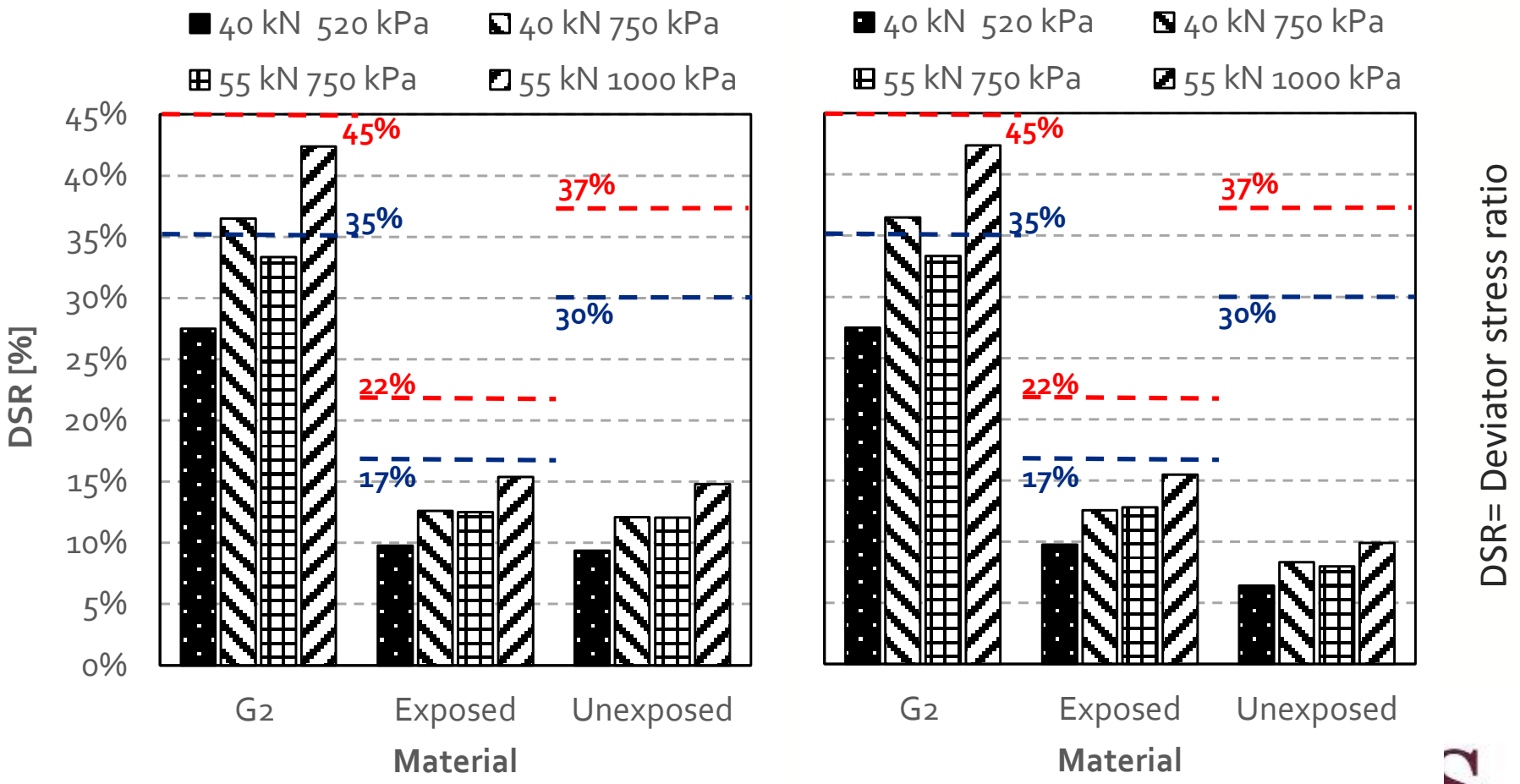
# Permanent Deformation>> Exposed >> 0 month



## **Defining Boundaries** >> Summary

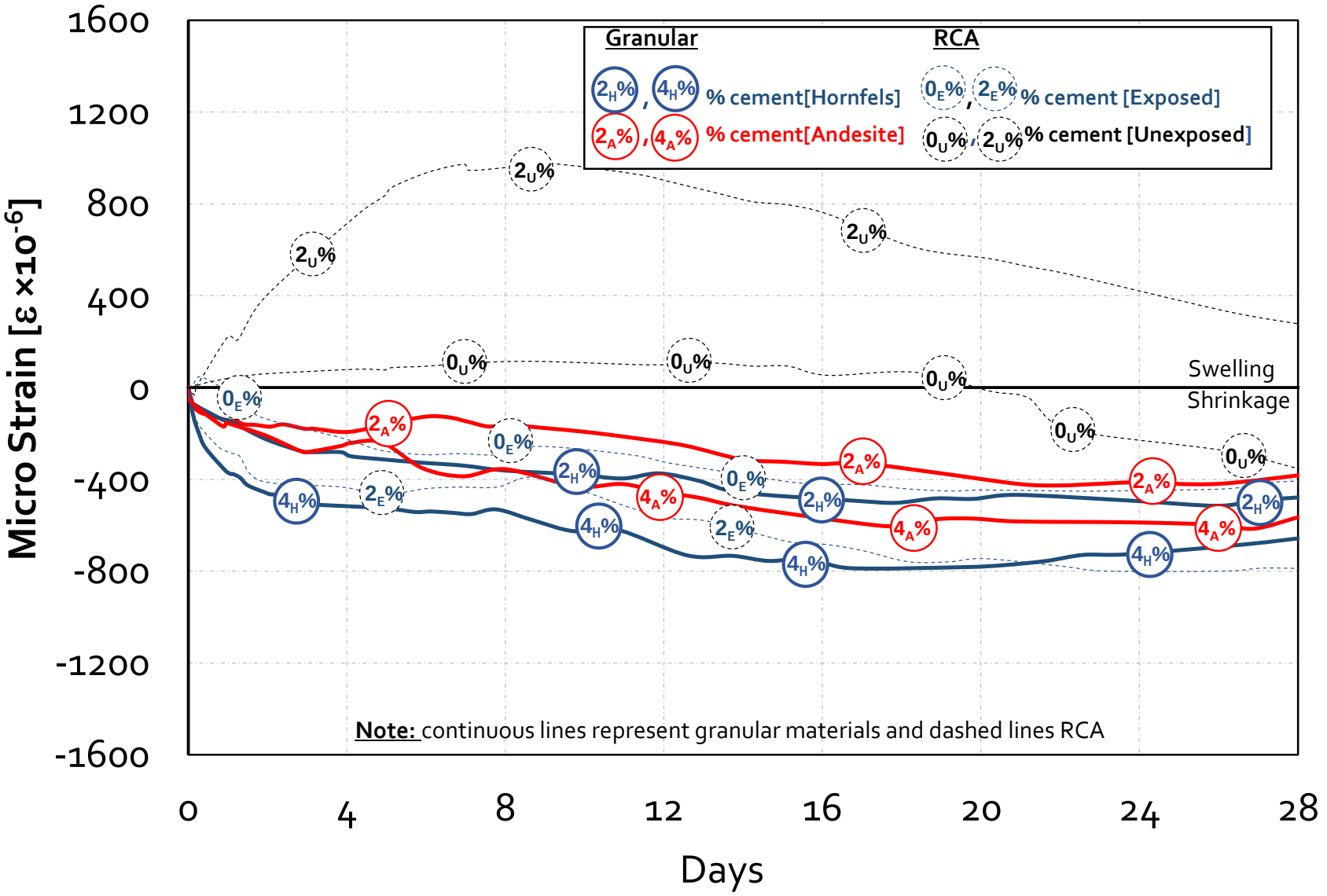
| | Exposed 0 month | Unexposed 0 month | Exposed 1 month | Unexposed 1 month |
|---|---|---|---|---|
| Processing + self-cementation |  |  |  |  |

# **Pavement Analysis** >> Pavement 2 >> DSR comparison

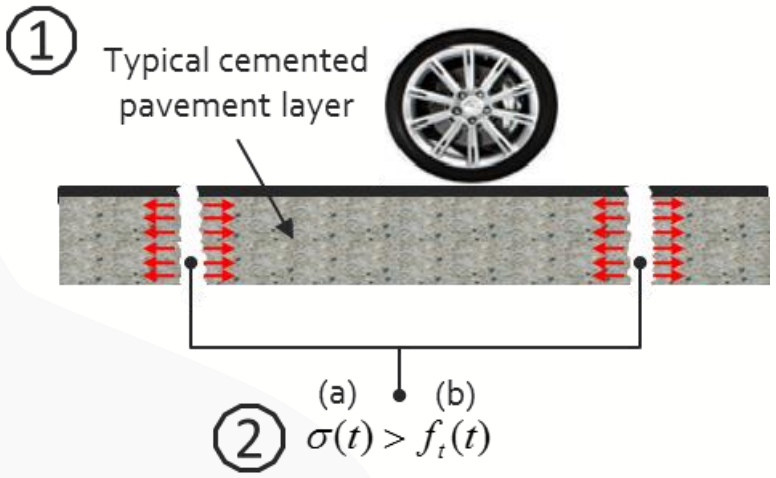


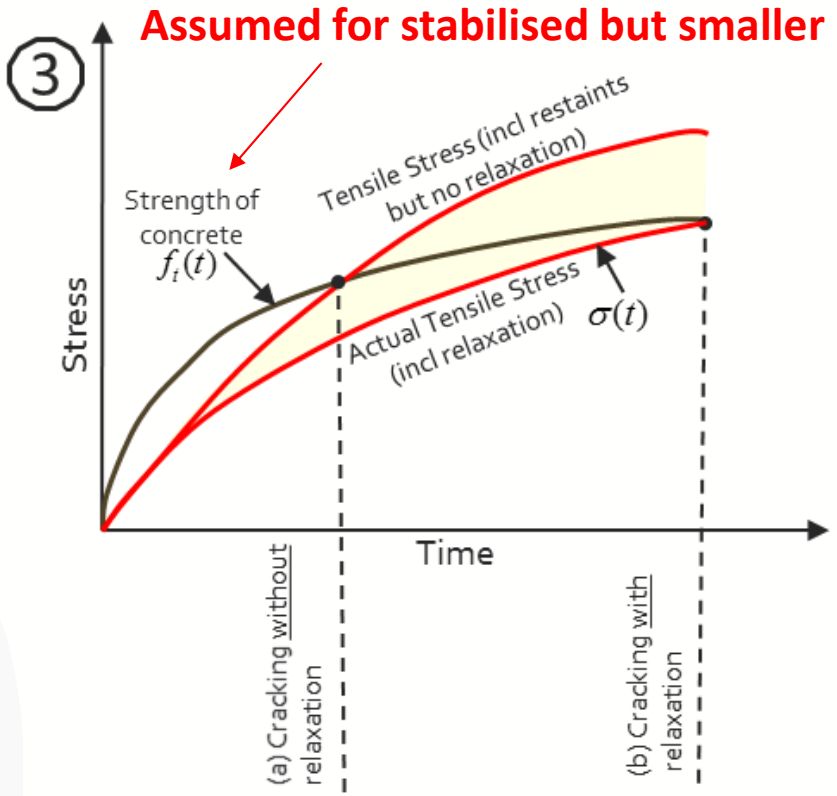
# Shrinkage

# **Shrinkage** >> Experimental Data



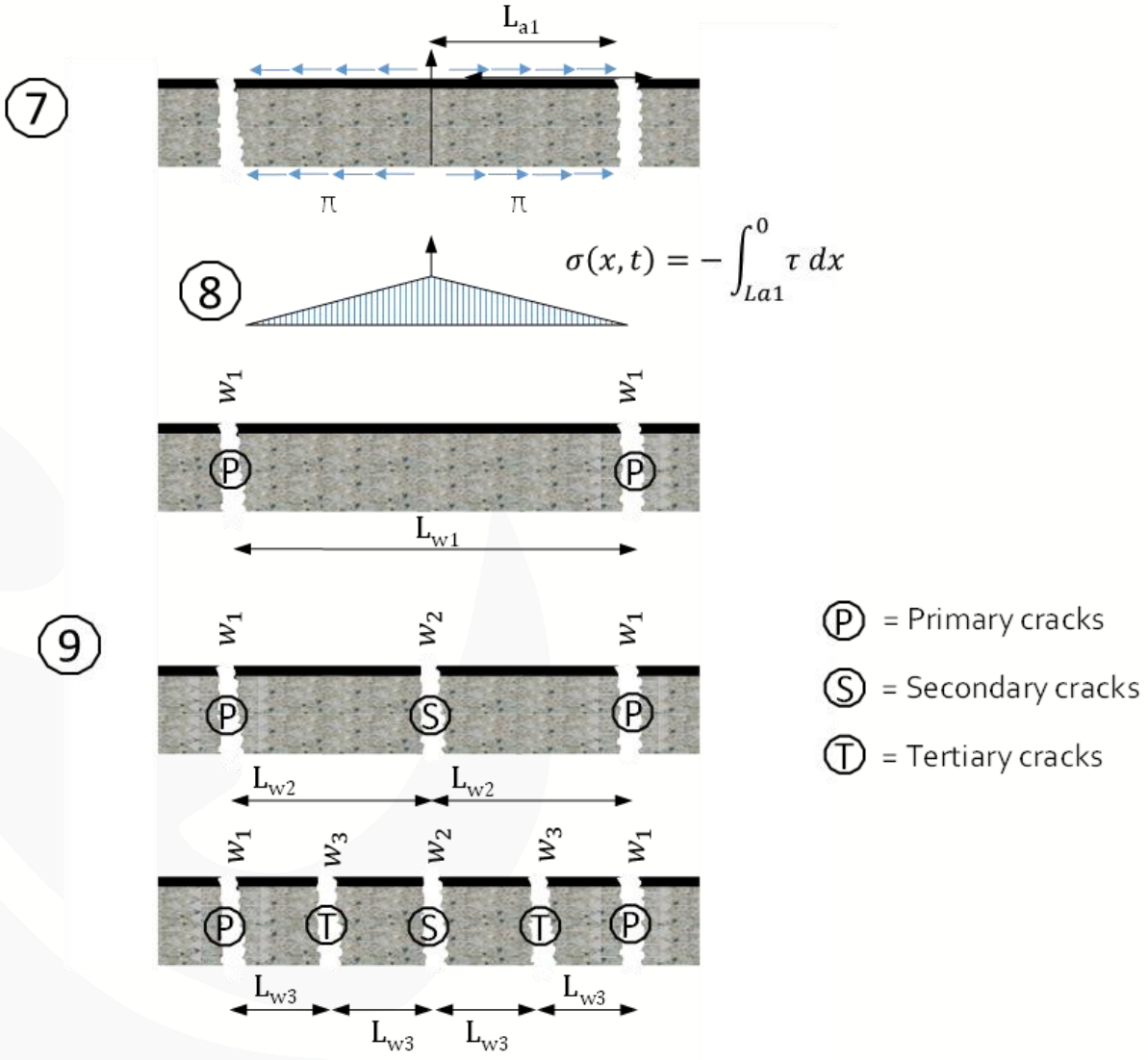
# **Shrinkage** >> Theory



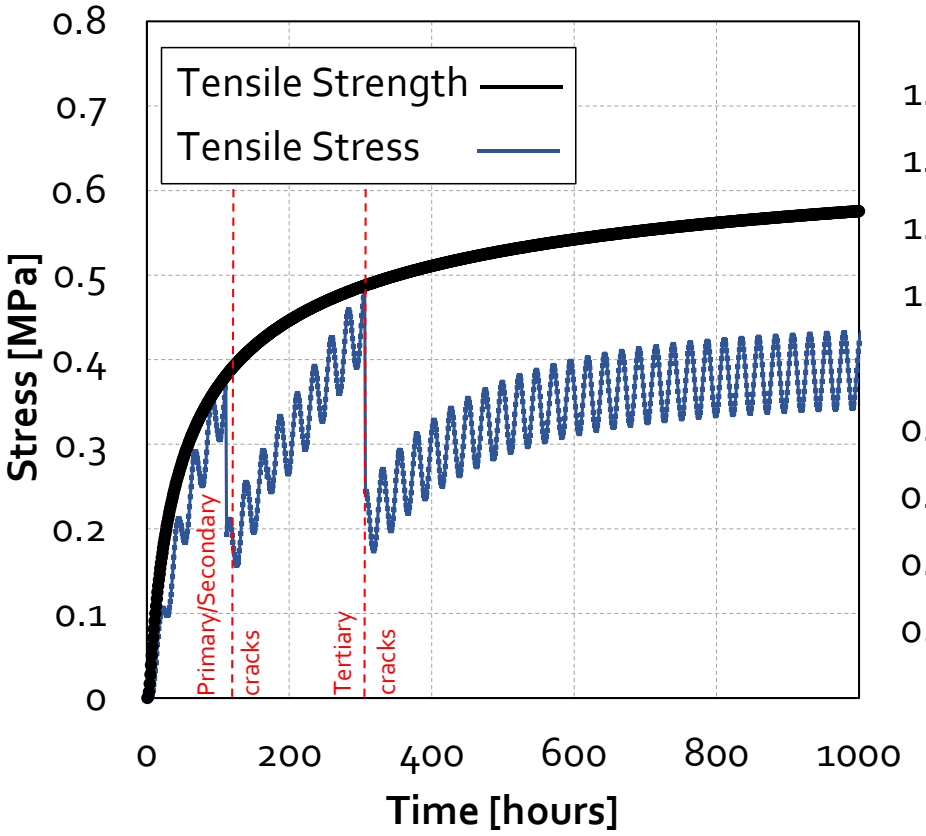



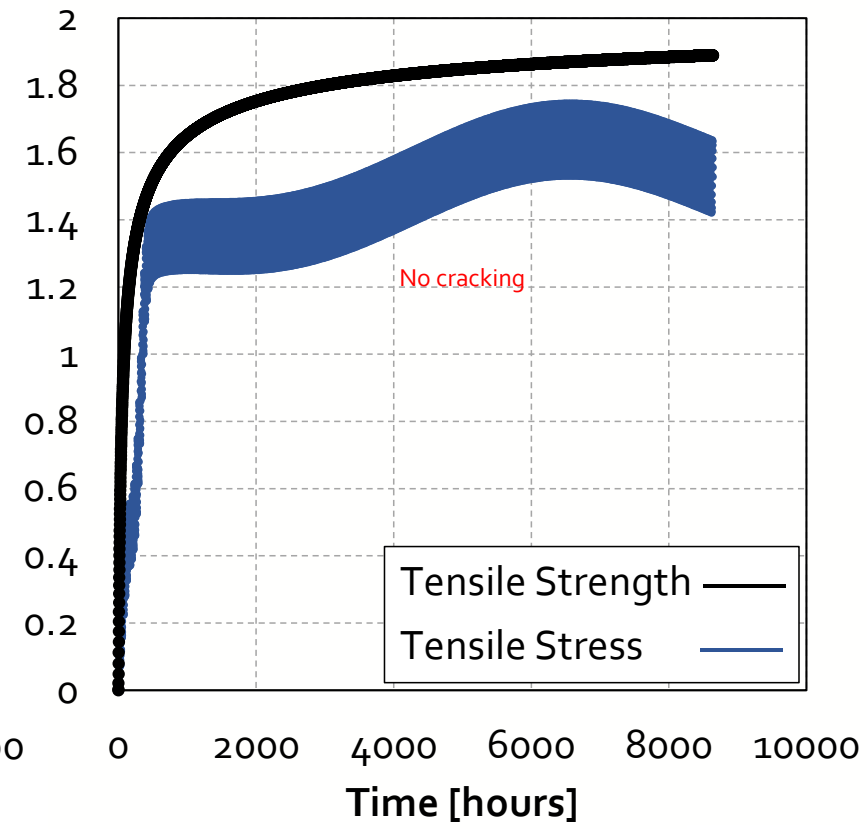

4 $\sigma(t) = \varepsilon(t) \cdot R(t) \cdot E(t)$

# **Shrinkage** >> Houben Model

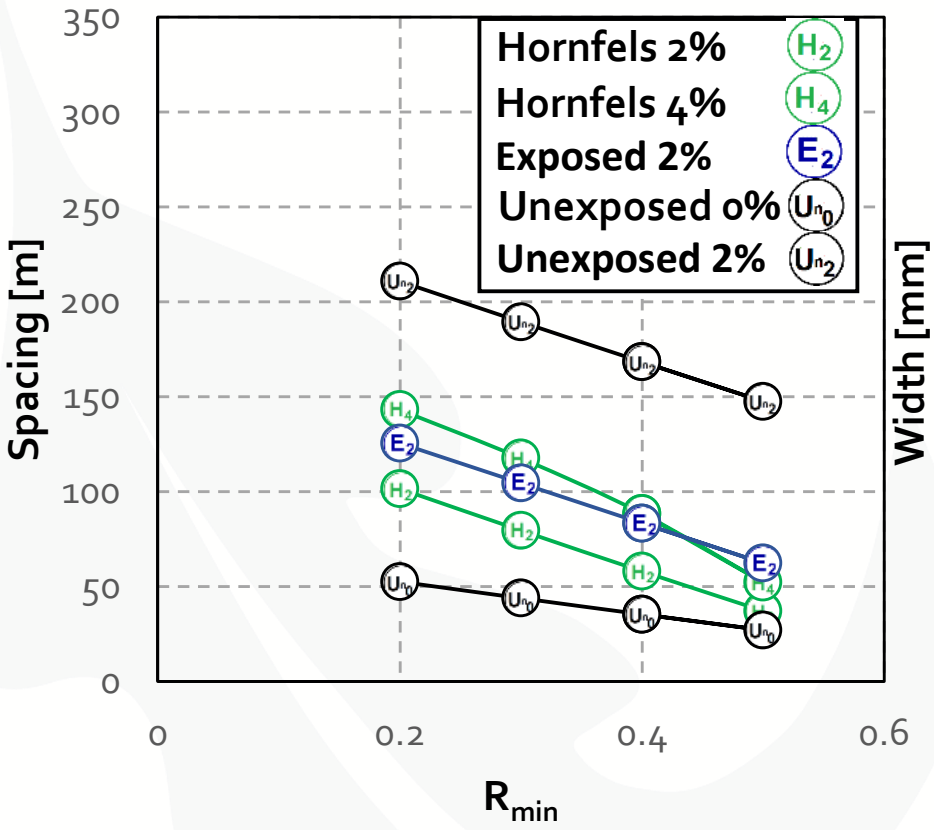


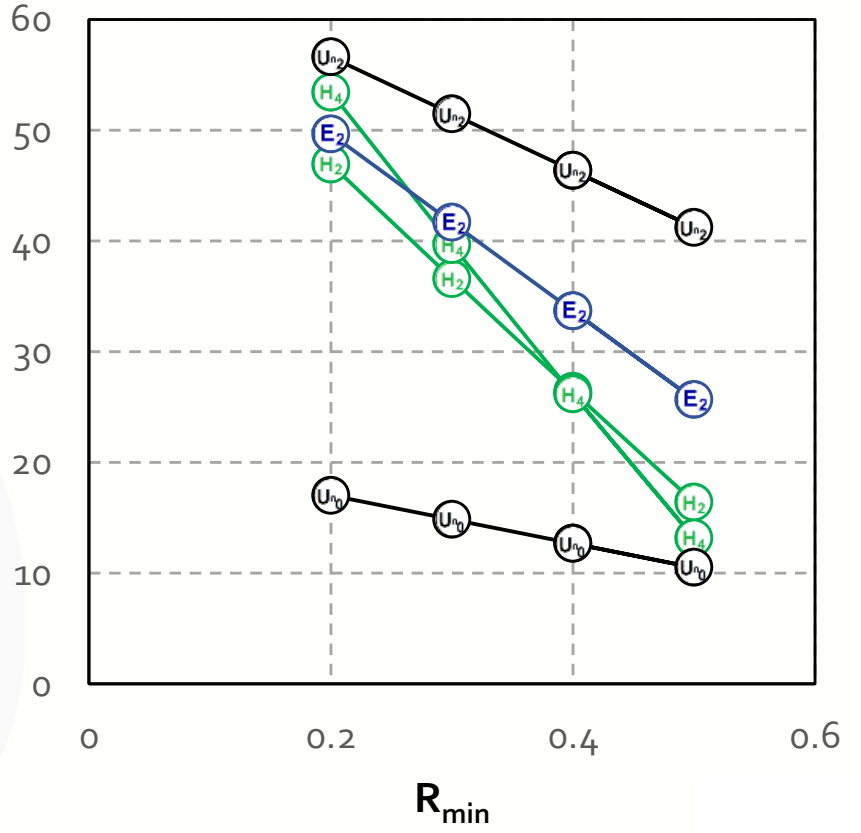
# **Shrinkage** >> Houben Model >> Typical Output



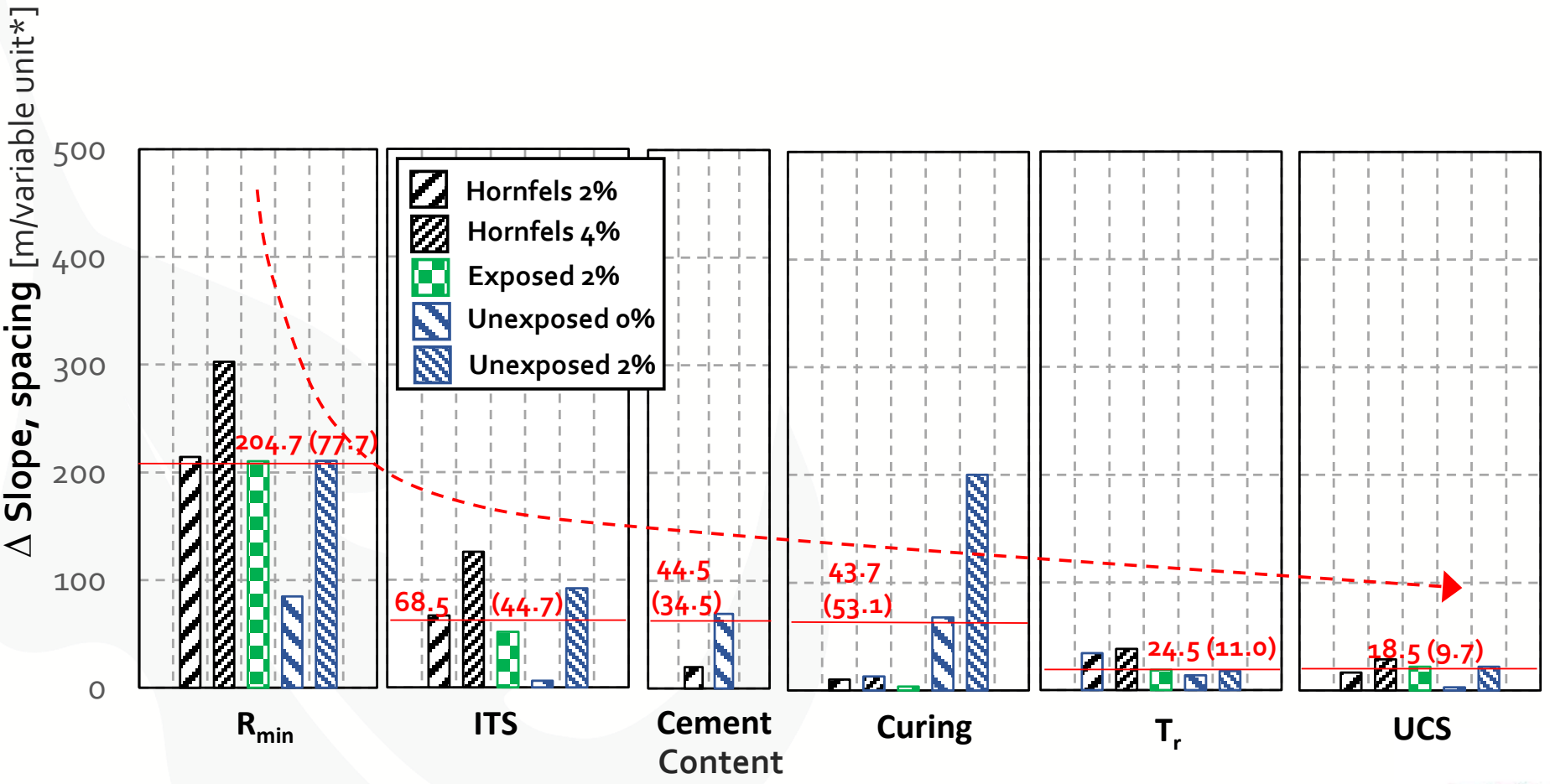



# **Shrinkage** >> Sensitivity analysis >> Empirical Models >> $R_{min}$



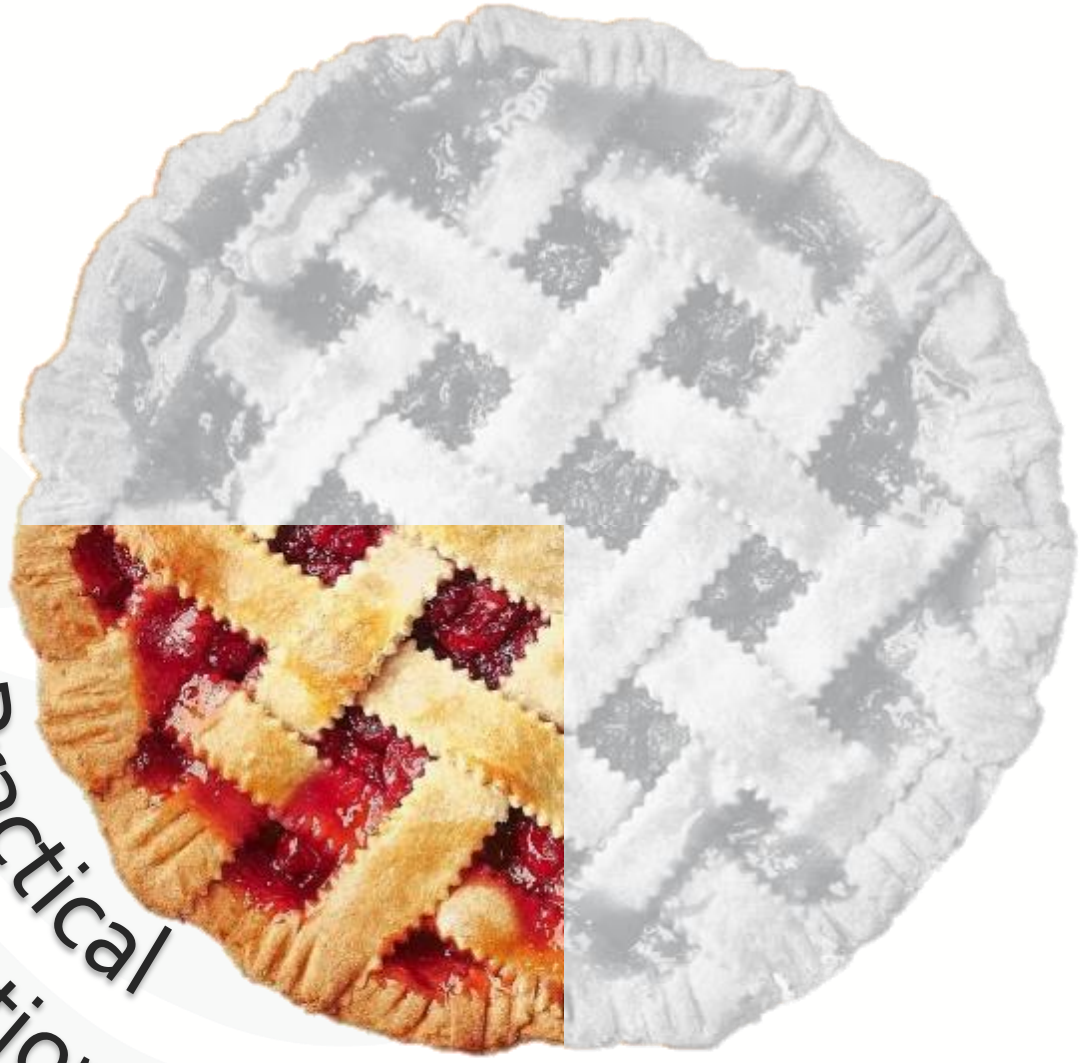



# **Shrinkage** >> Sensitivity analysis >> Ranking Variables




* measured against unit of x axis

# Practical Considerations



# Proposed guidelines

| | In-situ/ immediate construction [Unexposed] | Stockpile [Exposed + Unexposed] | Stockpile [Exposed] |
|---|---|---|---|
| Processing sampling | ✓ |  | ✓ |
| | ✓ | | ✓ |
| | ✗ | | [✓] |
| | Turning and wetting of stockpiles preferred | | |
| Sampling | ✗ | ✓ ✓ | [✓] |
| Testing | Immediately | Mix design to be rechecked before construction | No significant material response change |
| | Testing frequency to be developed | | |

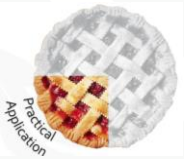
# Conclusions


- Response of material changes
- Origin of self-cementation varies


- Bound and unbound response
- Limits on stress ratio for Unexposed


- RCA susceptible to carbonation
- Moisture addition important


- RCA susceptible to shrinkage
- Cement must be added to mitigate shrinkage
- Less cement needed



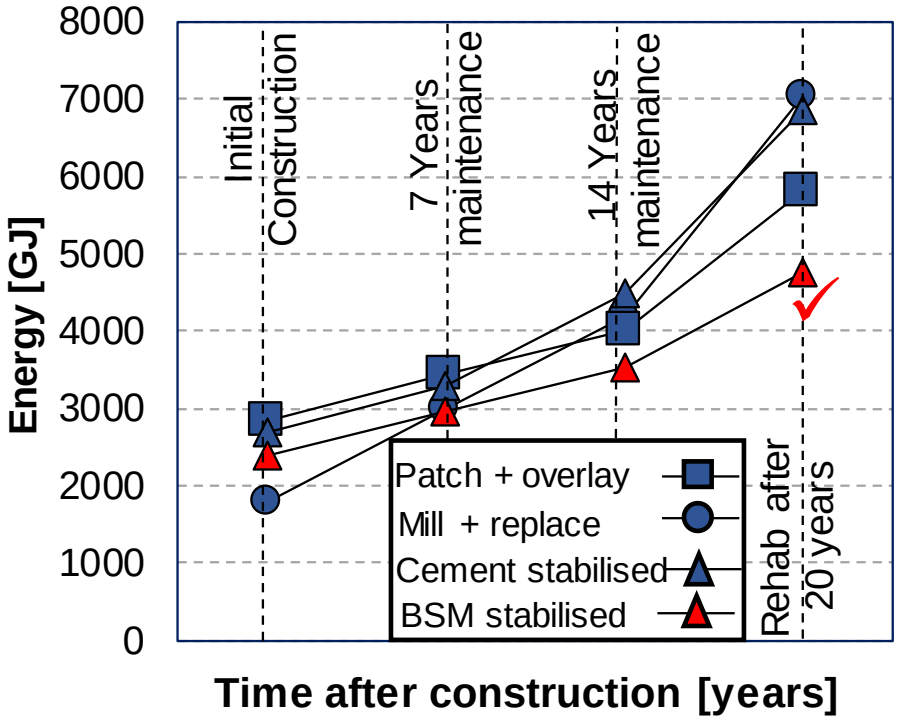

- Unbound form, performs superior to conventional materials

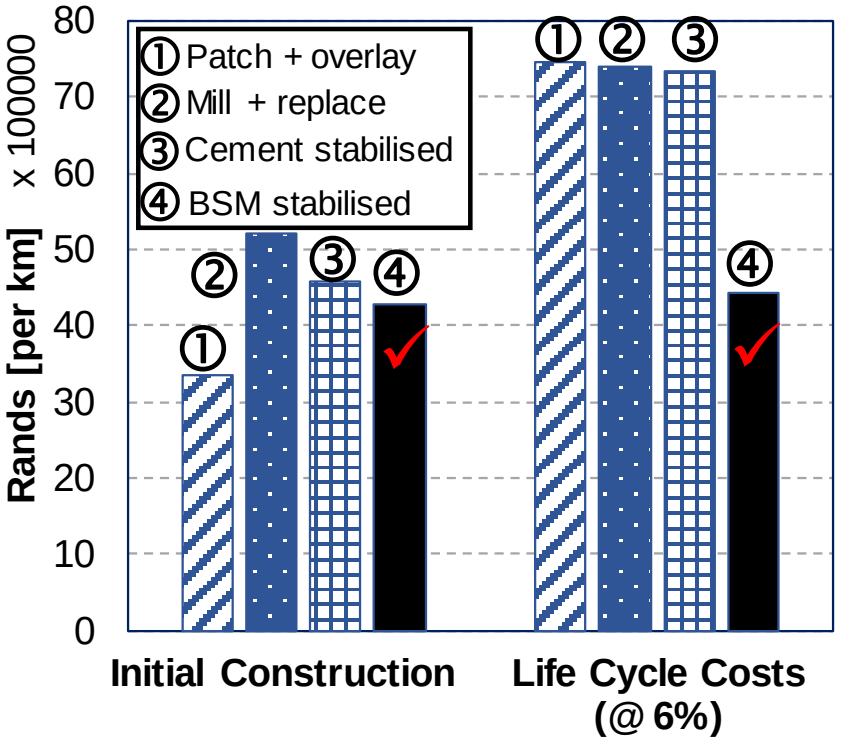
## The way forward

- **Uptake of RCA and RCM in the next five years will be significant**

- **Trial sections are being built in the next few months.**

# The way forward




Collings and Jenkins (2015)

## The way forward

- **Uptake of RCA and RCM in the next five years will be significant**

Watch this space

- **Flexibility of using material in other applications**

# THANK YOU