



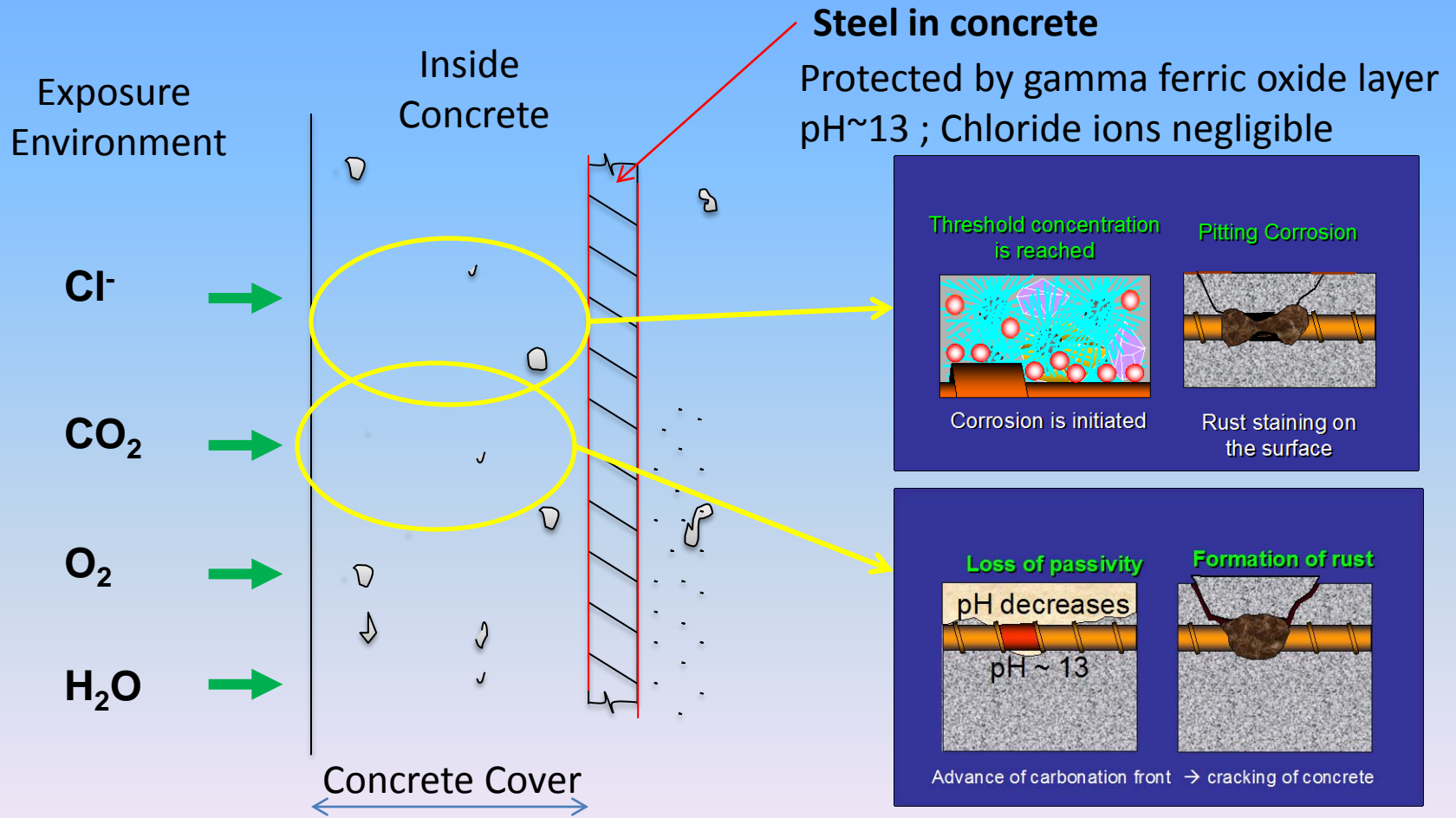
Climate change & concrete infrastructure

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Basheer

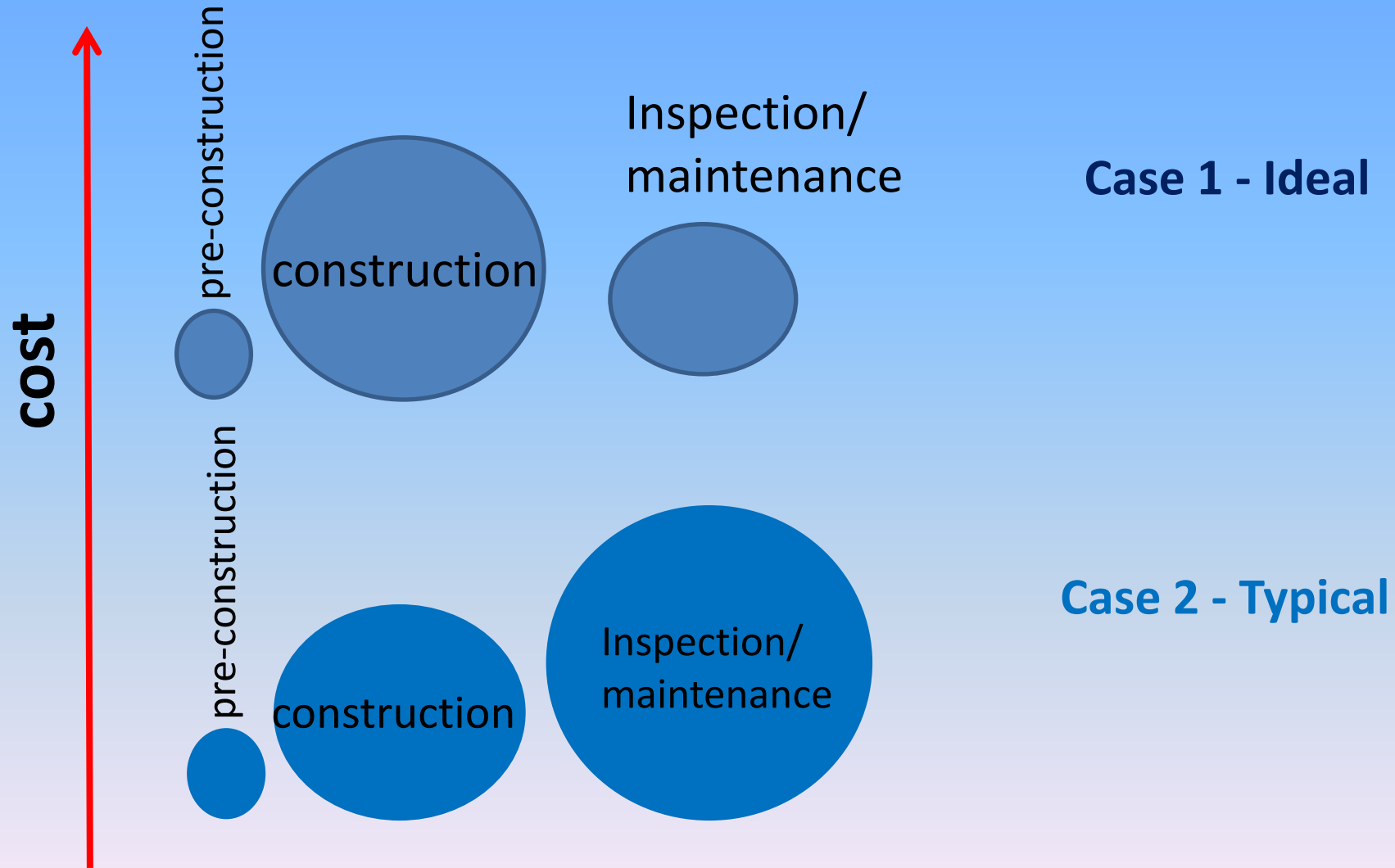
Layout of presentation

- Deterioration of structures & the role of exposure environment
- Economics of infrastructure management
- Performance of built infrastructure in changing climate – example carbonation
- Concluding remarks & further research

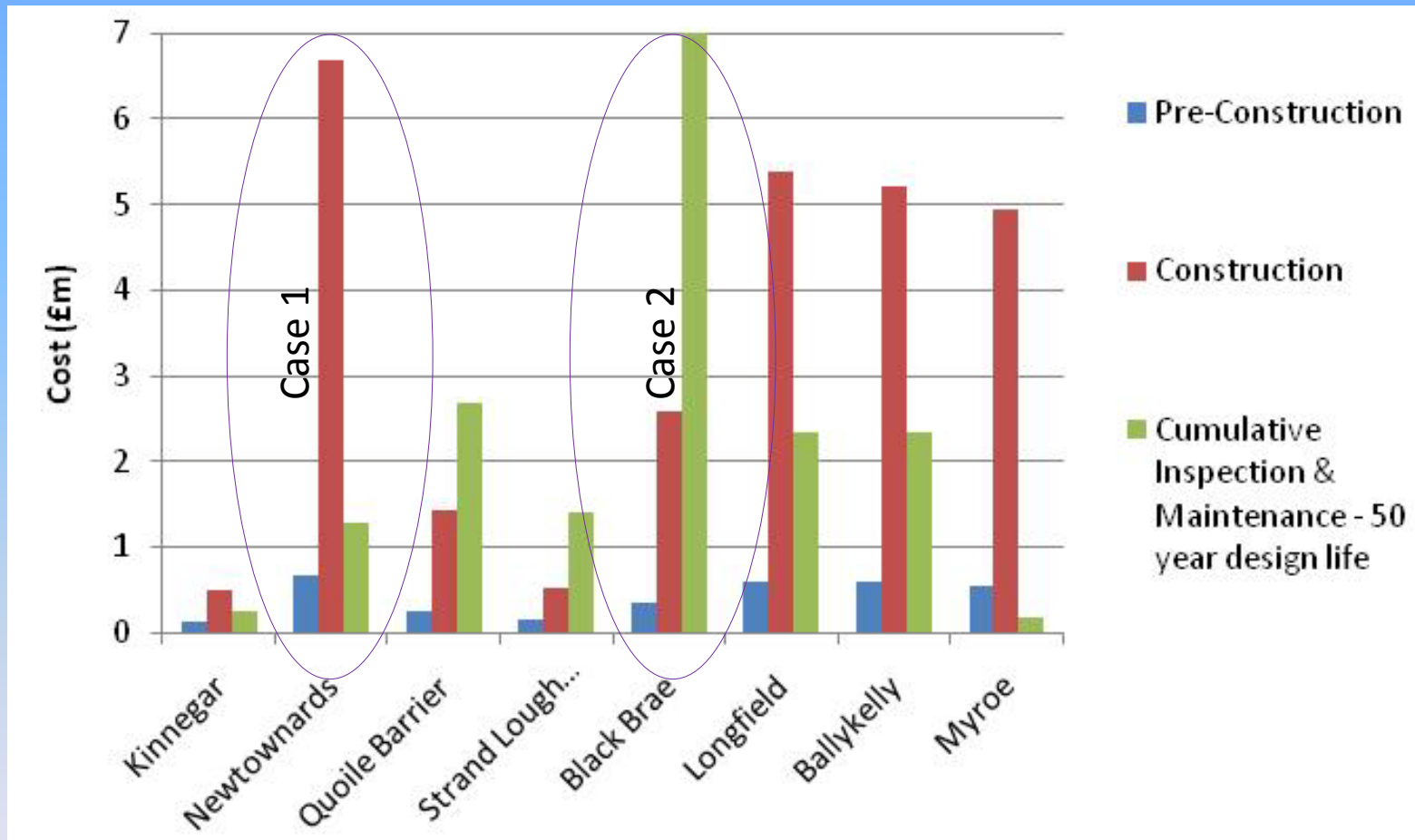
Why do structures deteriorate?



Life cycle thinking...



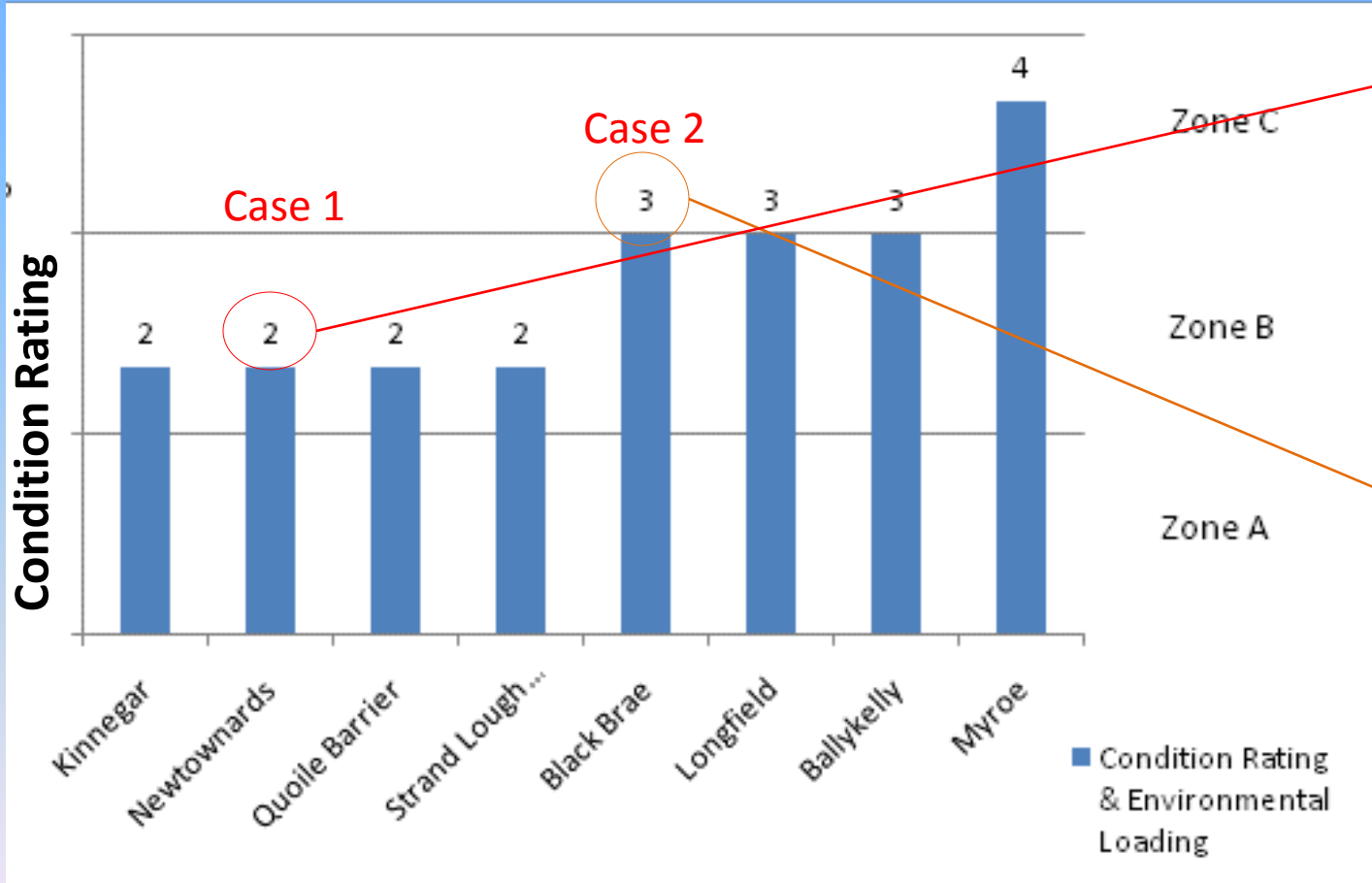
Life Cycle Costing



Cost analysis for a 50 year period. Future costs are all brought to present value

Role of environmental loading

Condition rating of structures and the role of exposure environment



Rating 2

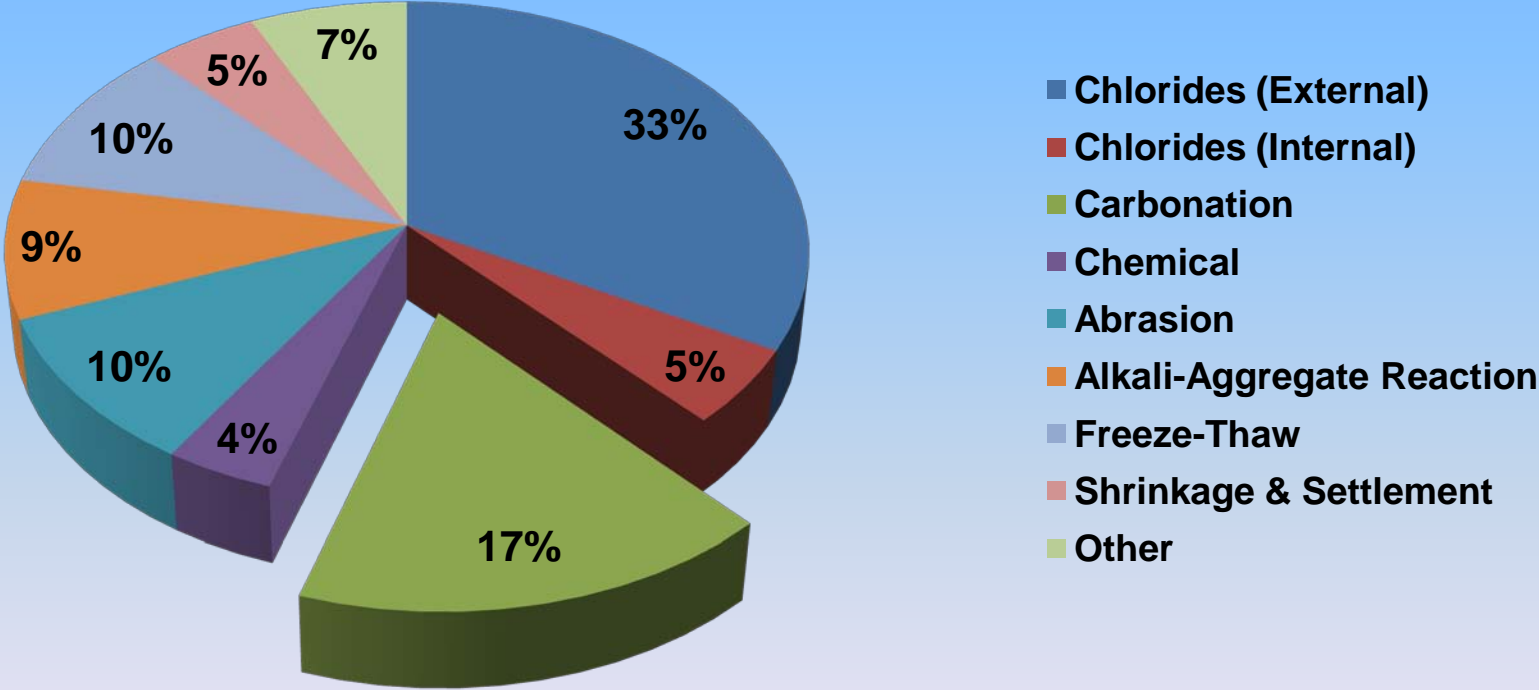


Rating 3-4



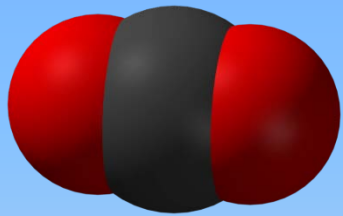
Zone A = Mild; Zone B = Moderate; Zone C = Harsh)

Causes of deterioration of structures

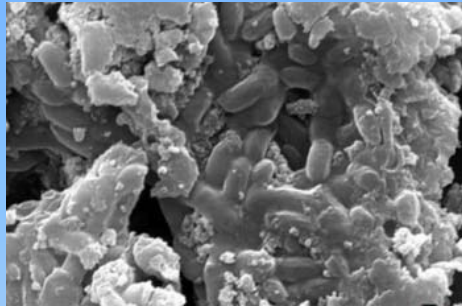


Carbonation

Carbonation of Concrete

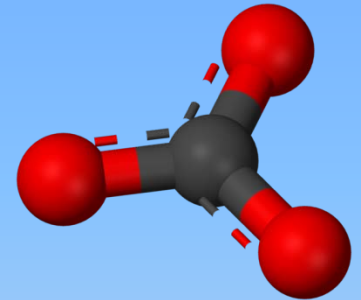


CO_2



Cement matrix

Calcium hydroxides + others



Carbonates

-
- **Atmospheric Concentration**
 - Diffusion & Binding
 - **Relative Humidity & Temperature**

- **Ionic concentrations**
- Rate of hydration
- Construction related

Positives and Negatives of Carbonation

- Damages

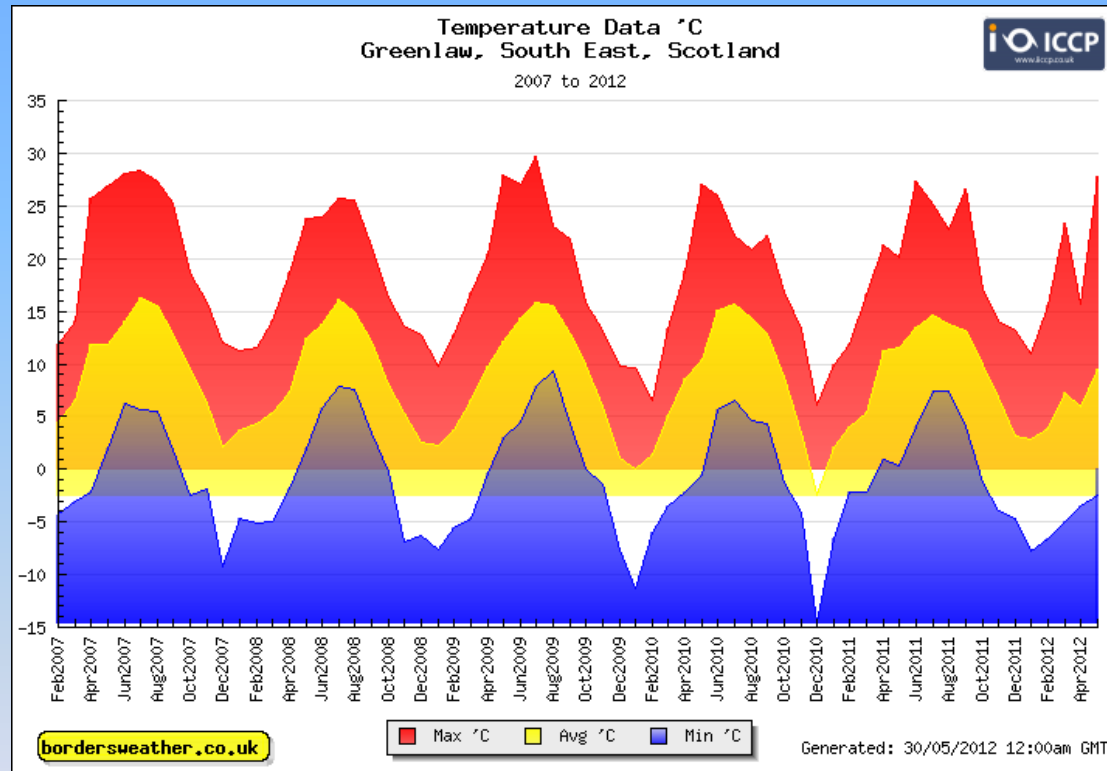


- Positives

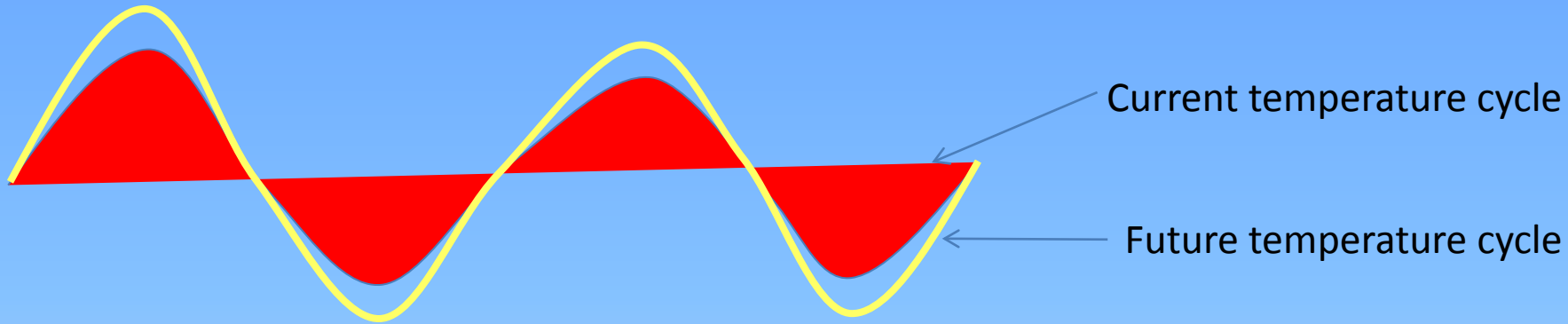
Densification of concrete & Carbon capture

Absorption of CO₂ over the life time of concrete
~ 30kg/m³

Climatic variables - Temperature



Climatic variables - Temperature

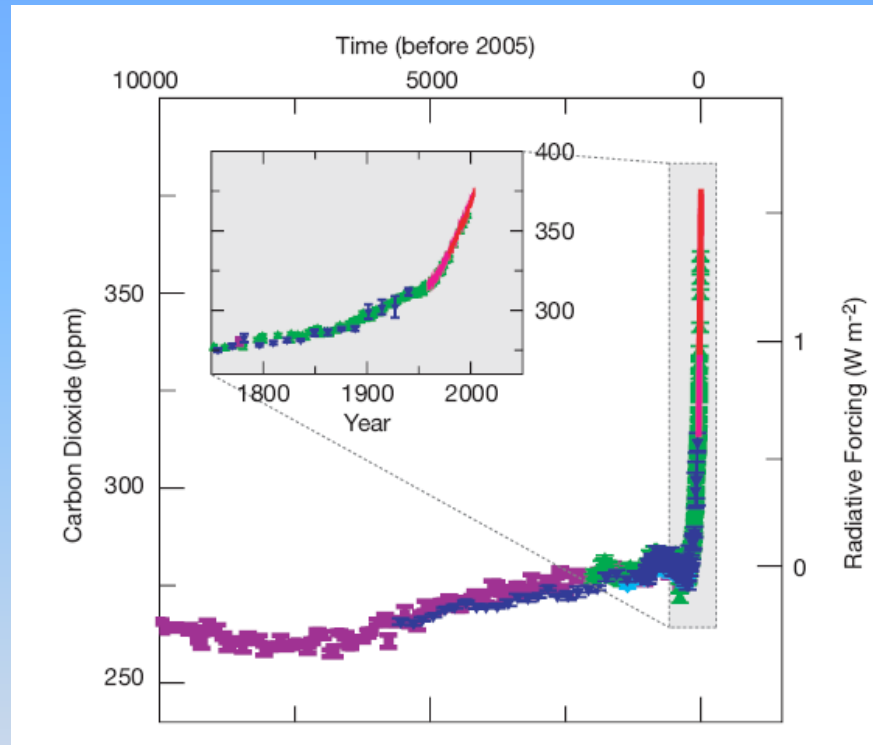


Affects the diffusion process

Affects the binding capacity

Brings in other deterioration factors

Climatic variables – CO₂ concentration



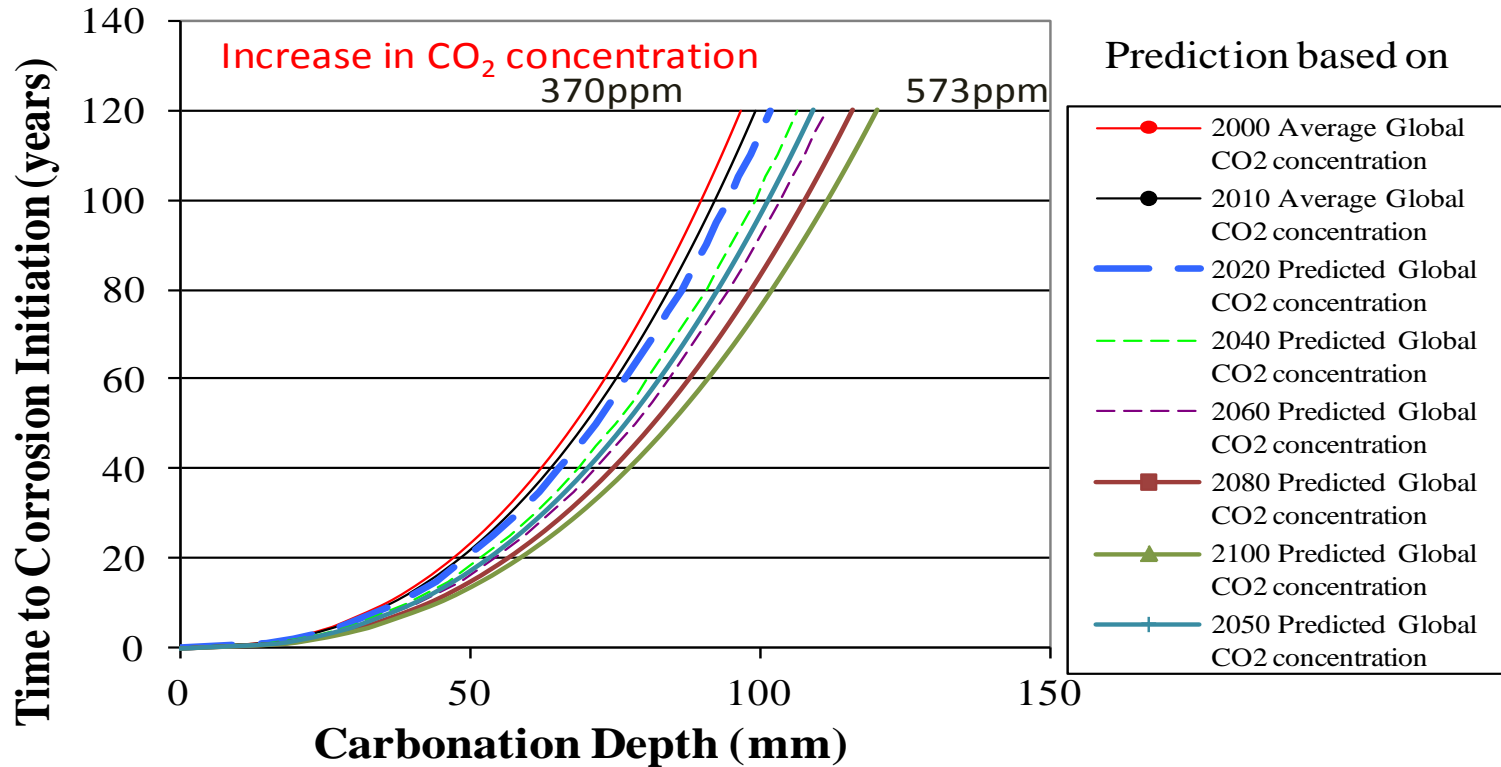
CO₂ Increase

- From 1962 – 1971 \longrightarrow 0.89ppm annual increase
- From 2002 – 2011 \longrightarrow 2.07ppm annual increase

Climatic variables – others

- Relative humidity
- Prolonged summers & winters
- Rising sea level/salinity/Pressure/Wind
- Micro climates

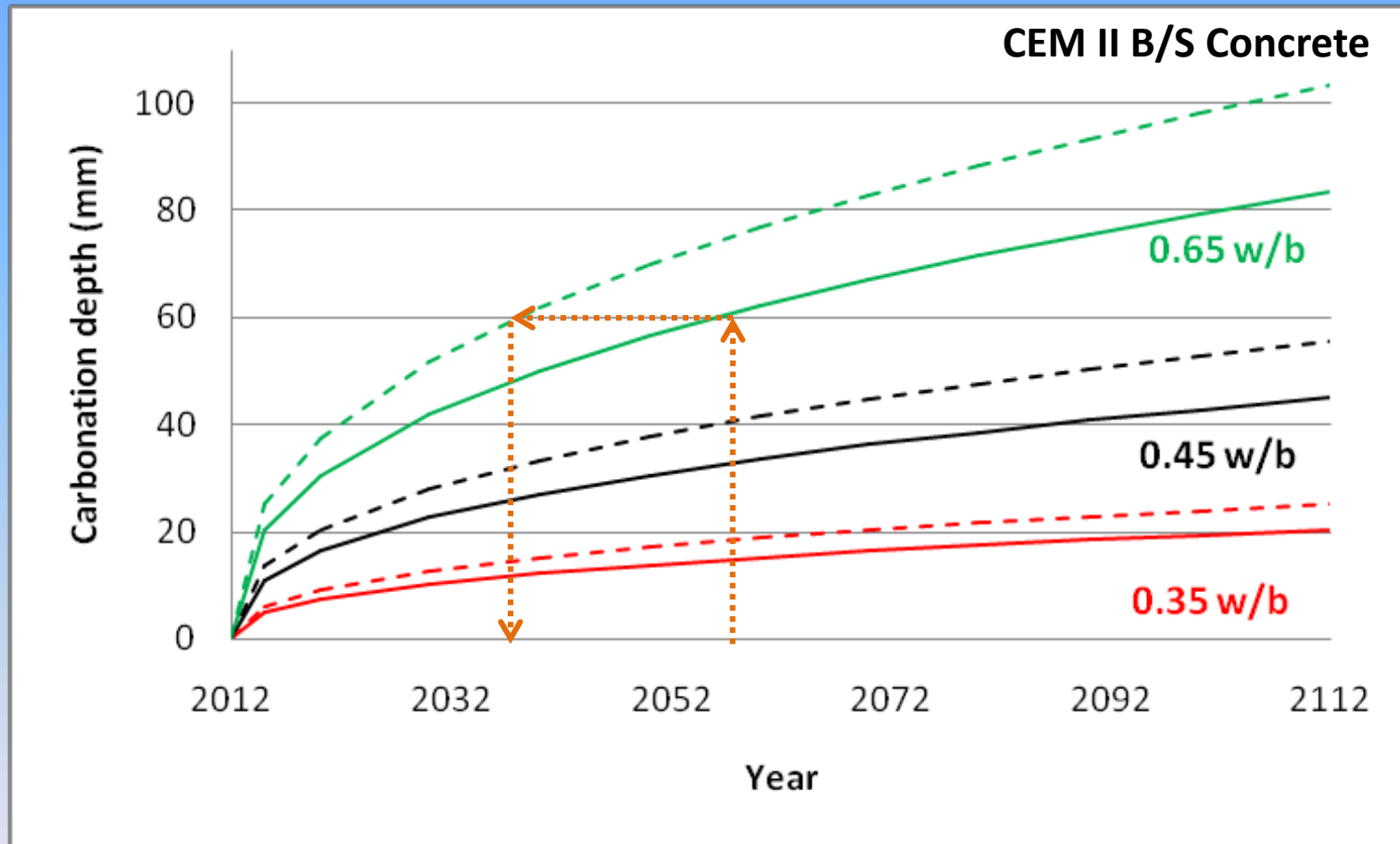
Effect of the increase in CO₂ concentration



Normal Portland cement concrete, 0.50 w/b, Exposure Class XC3

CEM I Concrete

Effect of climatic variations – CO₂ concentration & temperature

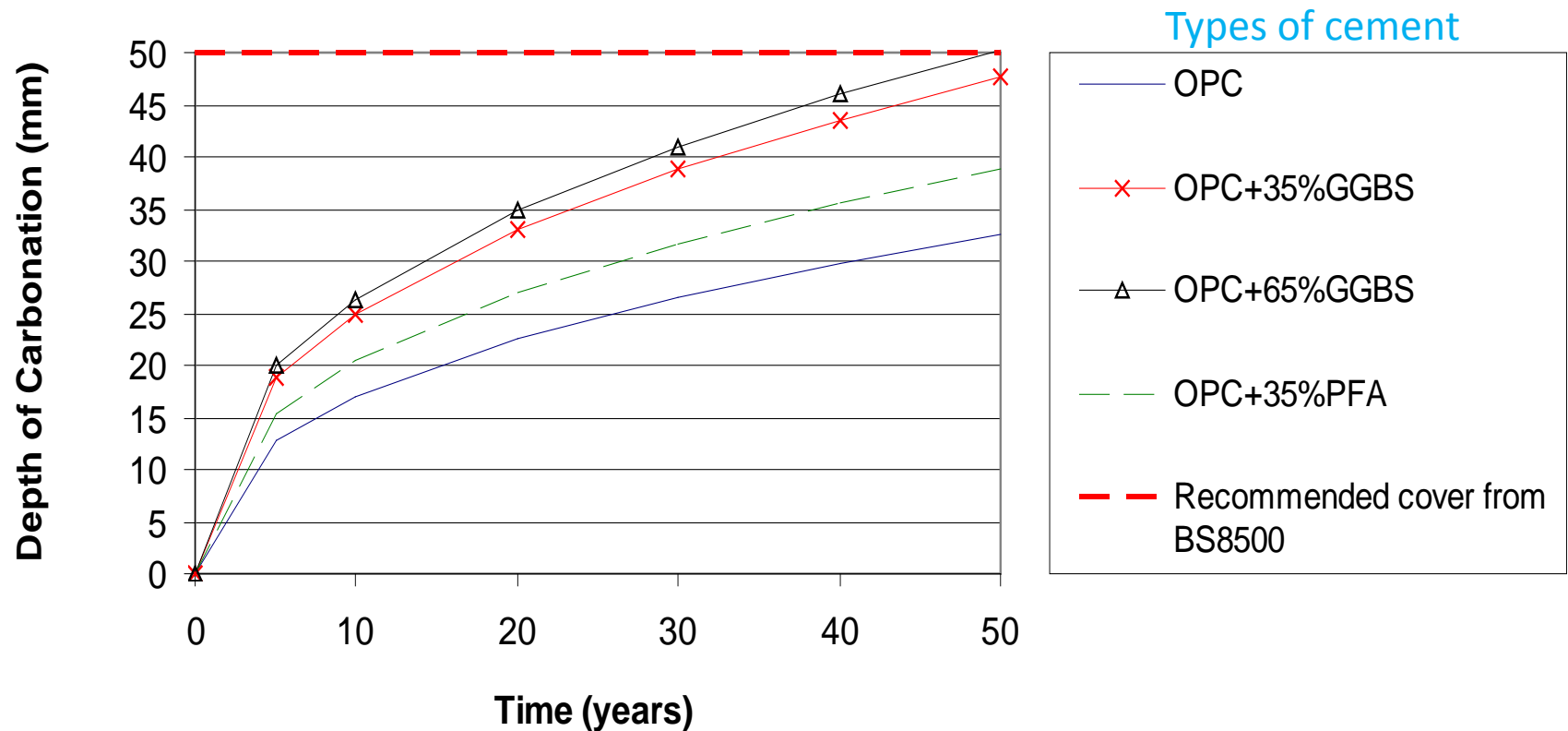


— Current climate (394ppm & 14°C)

- - - Future climate (600ppm & 19°C)

Is current specification satisfactory?

Graph showing how the concrete mixes performed following the guidelines in BS8500 for intended working life of 50 years - Current Conditions



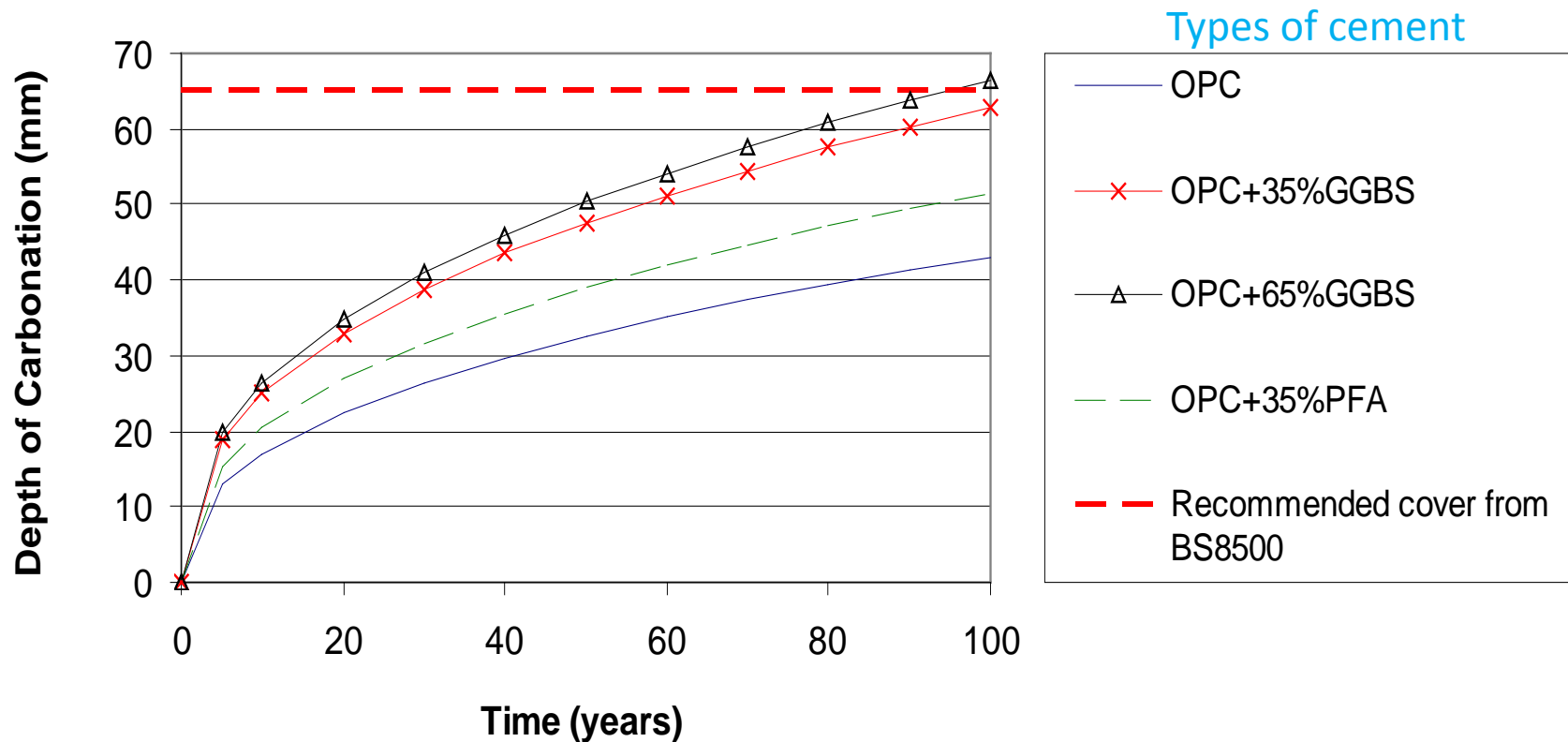
0.6w/b concrete

Current climate (394ppm, 10°C)

50 years

Is current specification satisfactory?

Graph showing how the concrete mixes performed following the guidelines in BS8500 for intended working life of 100 years- Current Conditions



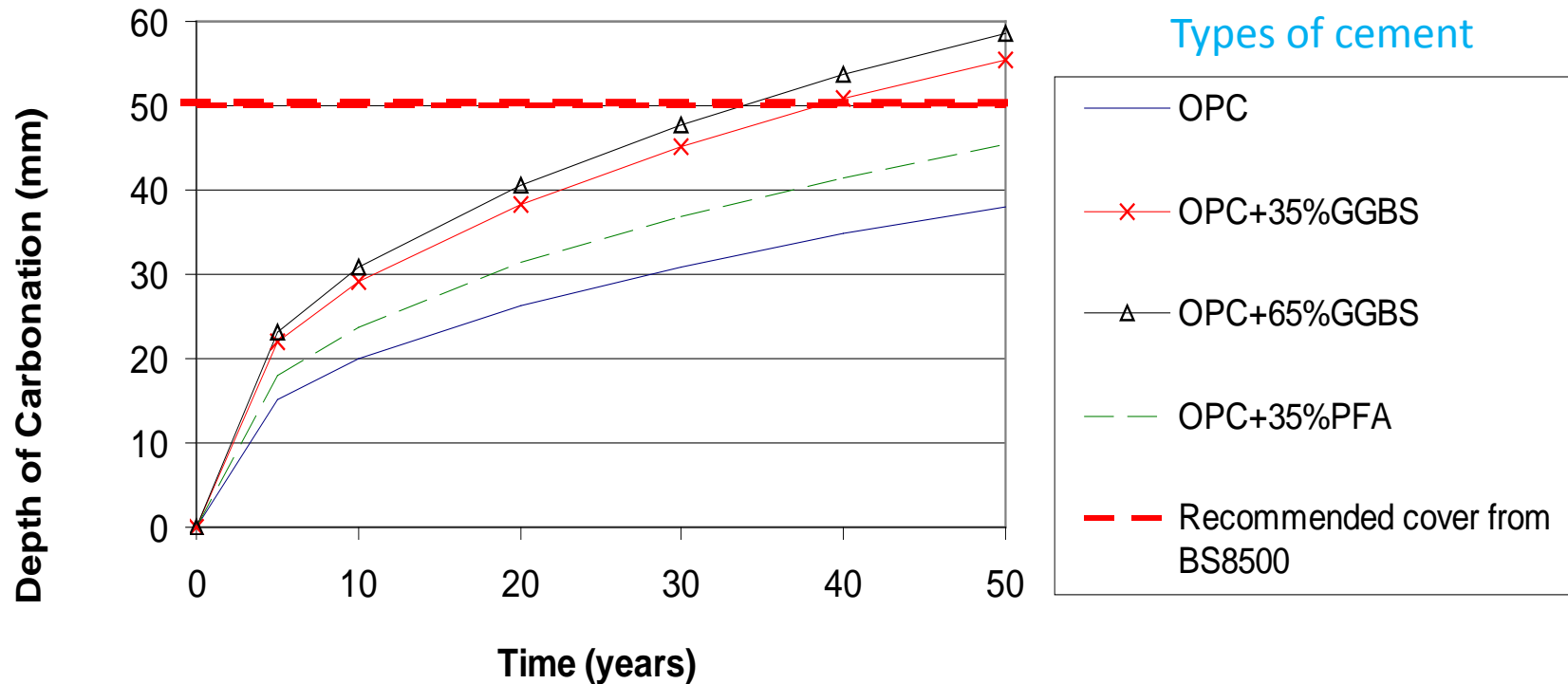
0.6w/b concrete

Current climate (394ppm, 10°C)

100 years

Is current specification satisfactory?

Graph showing how the concrete mixes performed following the guidelines in BS8500 for intended working life of 50 years using Climate Projections



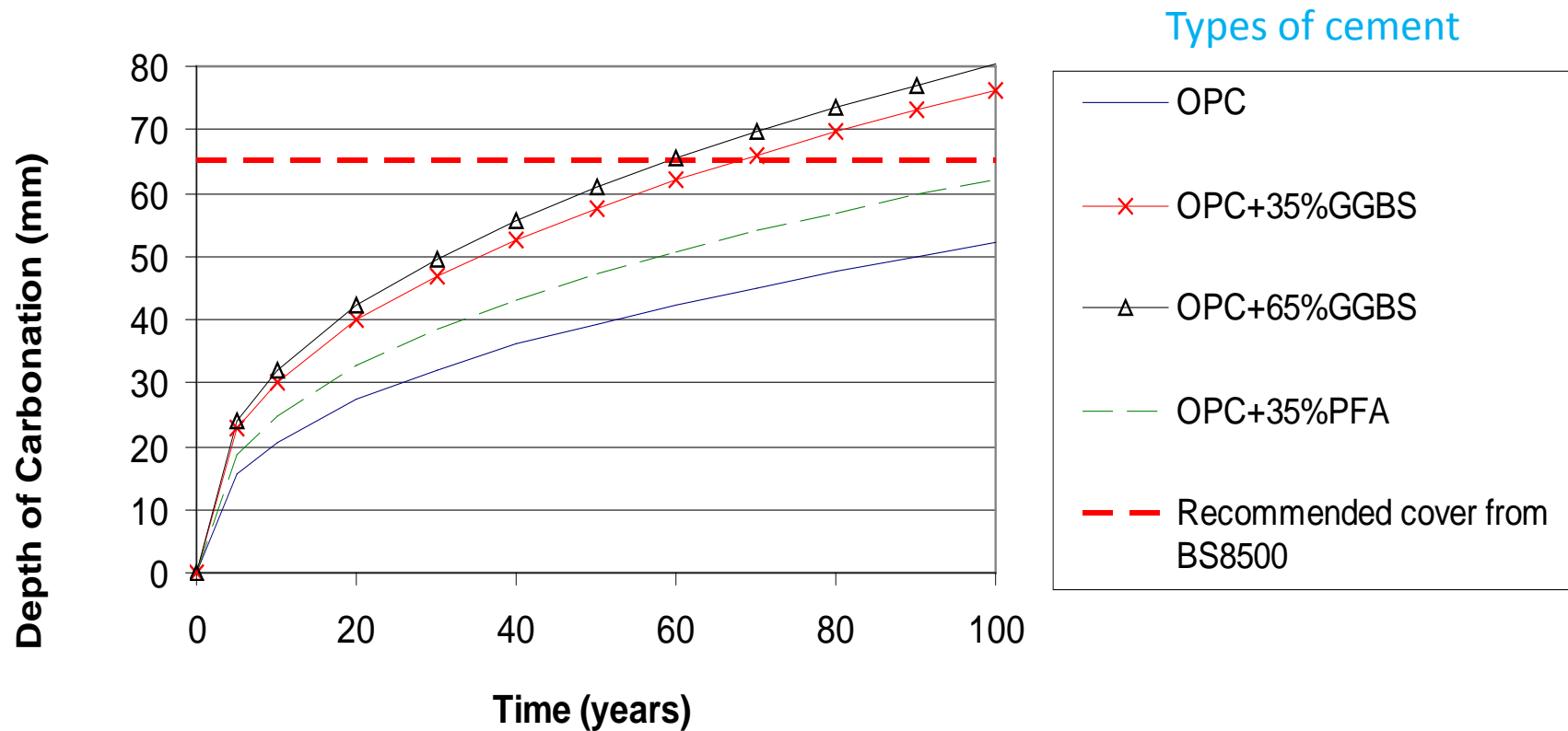
0.6w/b concrete

Future climate (500ppm, 11.5°C)

50 years

Is current specification satisfactory?

Graph showing how the concrete mixes performed following the guidelines in BS8500 for intended service life of 100 years using Climate Projections



0.6w/b concrete

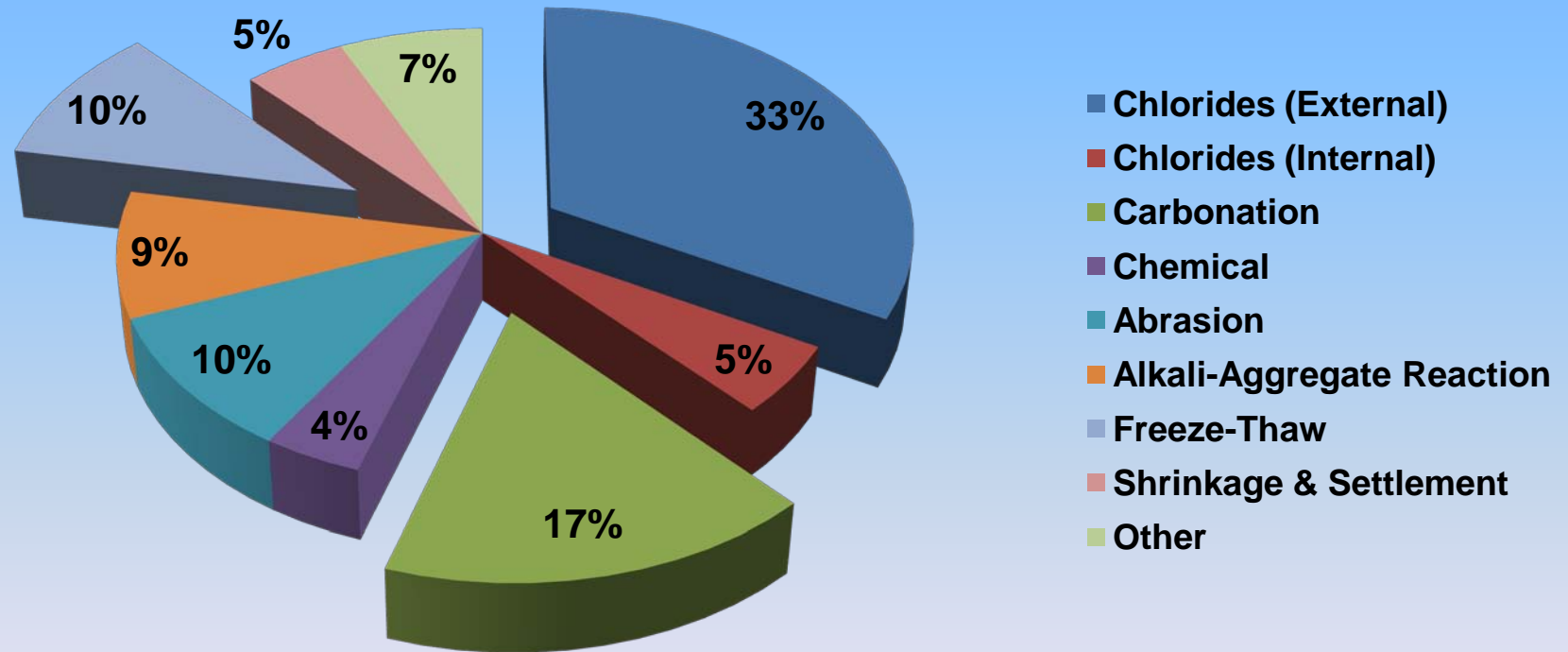
Future climate (500ppm, 11.5°C)

100 years

Concluding remarks

- Climate change will have a significant effect on the carbonation process and therefore this needs to be taken into consideration while designing/specifying new structures.
- More money will need to be spend maintaining existing structures subjected to carbonation.
- Other environment related loading could aggravate the concrete deterioration resulting in significant drain on the economy.

On going research



On going research

- Developing exposure locations across the world with the help of research partners
 - Highlands, Scotland
 - Donegal Coast, Ireland
 - Lisboa, Portugal
 - St. Nazaire, France
 - Hangzhou Bay Bridge, China
- Quantifying the impact of climate change on infrastructure: Performance Monitoring and Cost/Performance predictions
 - **domestic buildings and large civil infrastructures**
- Developing more adaptive maintenance strategies for asset managers