SIMCO
DURABILITY ENGINEERING

Optimized Bridge Preservation Strategies

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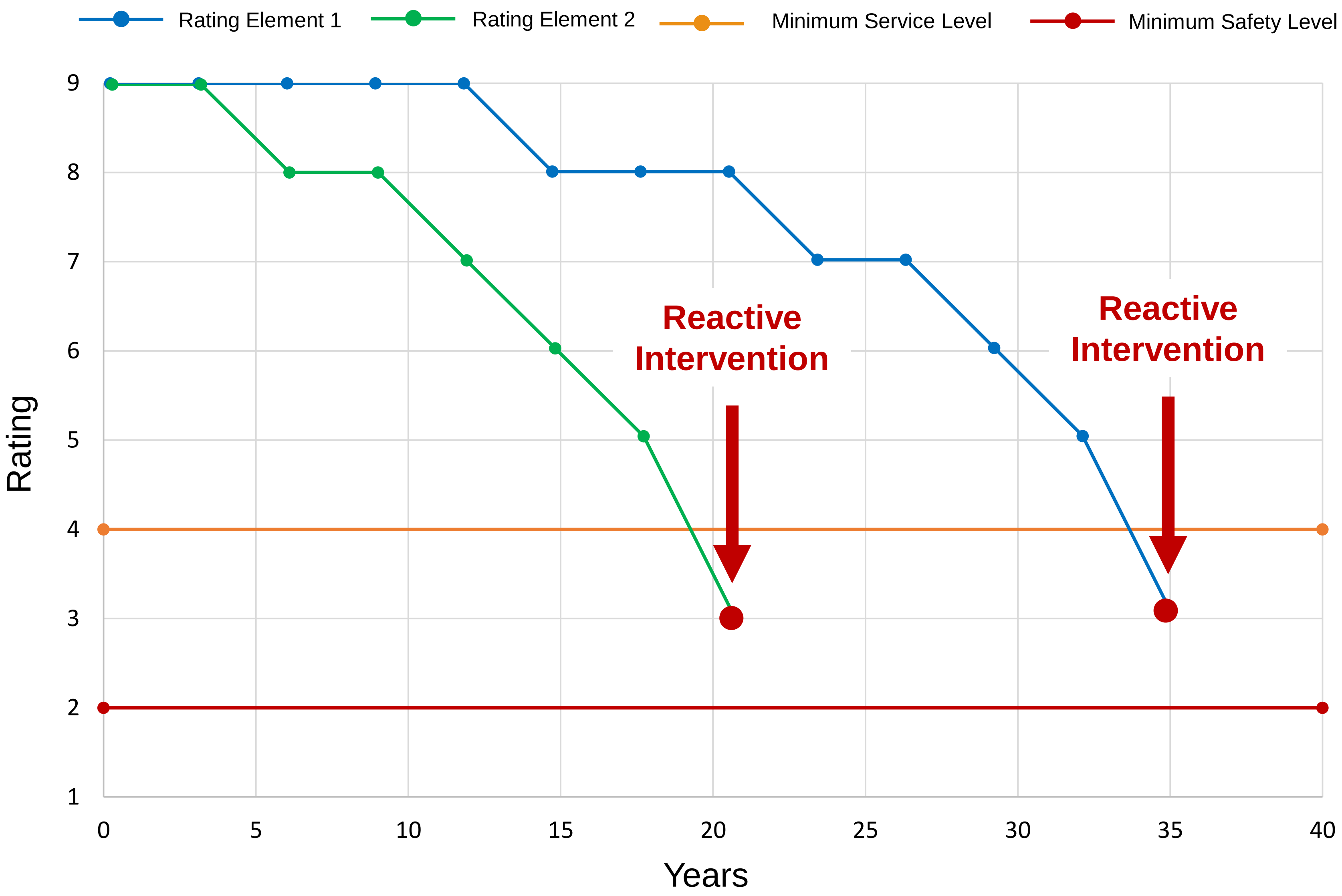
Agenda

- Limitations of current condition assessment approach on repair performance
- Durability analysis
- Proposed approach for preventive and durable repairs

Background

Traditional Inspection Approach



Limitations of the Current Approach

Elementary inspections provide:

- Only a part of the story
  (much is going on under the surface)
- After-the-fact information
  (damage can hardly be mitigated)
- No insight on future deterioration
- No information on sections of the structure that are not accessible
- Signs of deterioration when they become evident
- Reactive interventions with standard procedures give mixed results

Durability of Concrete Repairs

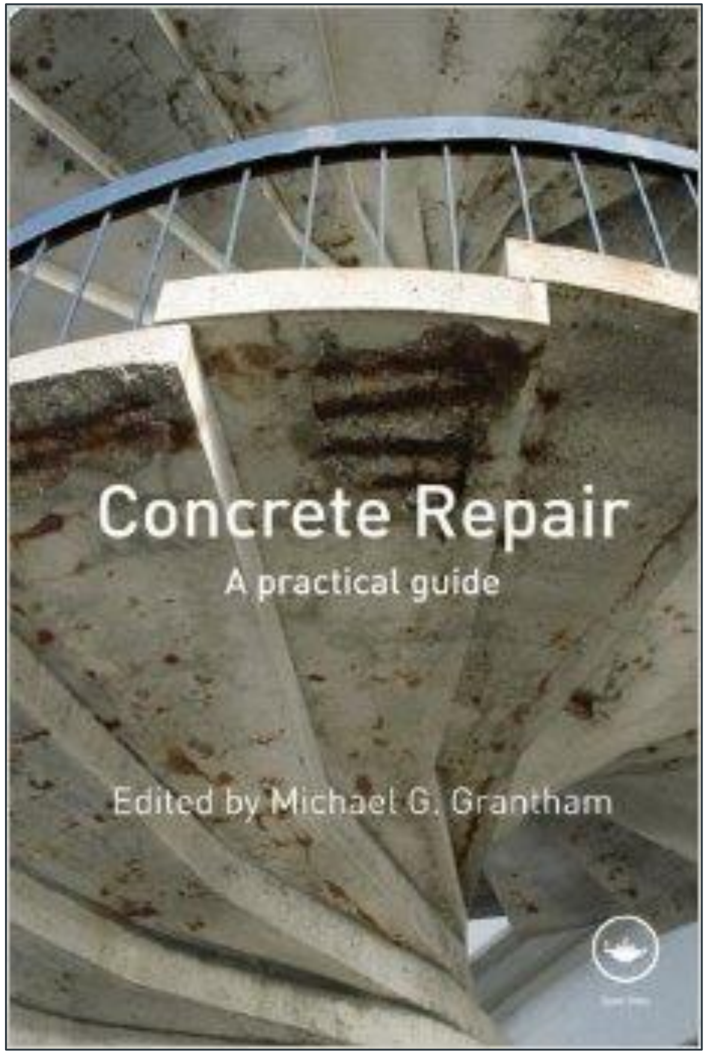
50%

of repairs
do not extend
service life

Causes

- Inappropriate design
- Poor installation
- Inadequate materials

Recent European Studies



Tilly, G.P., (2014), *Durability of Concrete Repairs*, in Concrete Repair – A Practical Guide, Edited by M.G. Grantham.

Degradation	Successful
Corrosion	50%
AAR	20%
Freeze-Thaw	25%
Cracking	65%
Wear & Leaching	80%
Faulty Construction	80%
Other Damage	45%

Performance & Durability of Concrete Repairs

Durability Analysis

What is Durability?

ACI Definition

- Durability - the ability of a material to resist weathering action, chemical attack, abrasion, and other conditions of service.

ACI 365 – Report on Service Life Prediction

- Durability - the ability of a material or structure to resist weathering action, chemical attack, abrasion, and other conditions of service, and maintain serviceability over a specified time or service life.
- Service life - an estimate of the remaining useful life of a structure based on the current rate of deterioration or distress, assuming continued exposure to given service conditions without repairs.

What Affects the Service Life of a Structure?

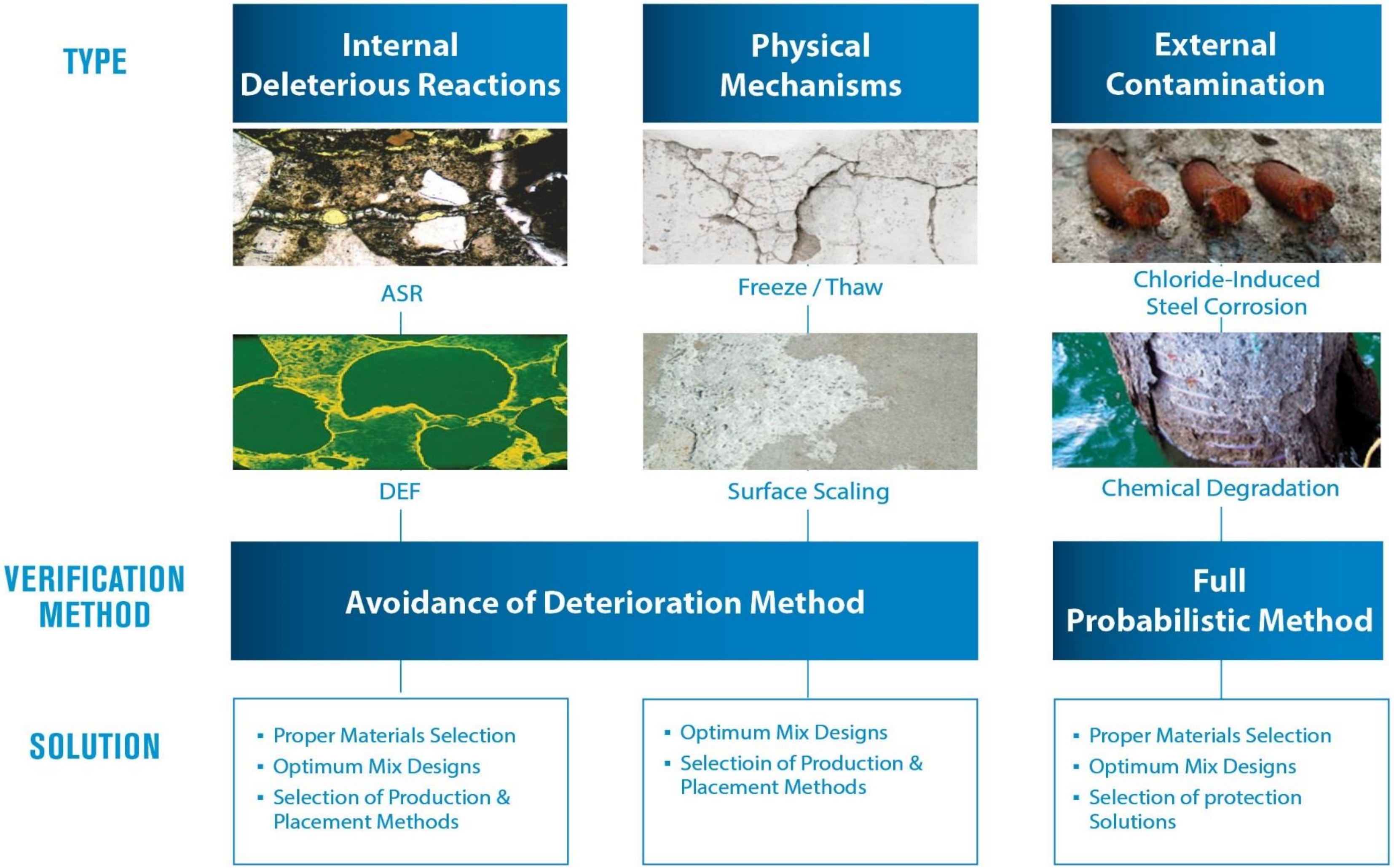
- Design and geometry
- Materials
- Environment
- Maintenance

Concrete Degradation Mechanisms

Root cause within the concrete triggered by action of the environment

Root cause outside the concrete, caused by the action of the environment

Avoidance and Prediction of Degradation



Methodology

Objectives of the Proposed Approach

- Remain objective and simple by leveraging existing data and current practices
- Reduce the total cost of ownership by generating quantitative and reliable information about future performance using innovative technologies
- Assess consequences of deferred inspection using a risk-based approach maintenance and repairs

Optimized Preservation Strategy

For Existing Structures

Evaluate the Current Condition

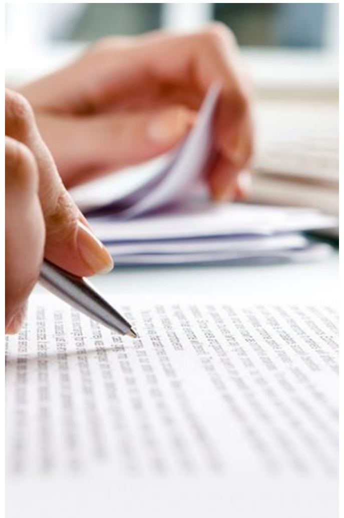
Determine the Residual Service Life

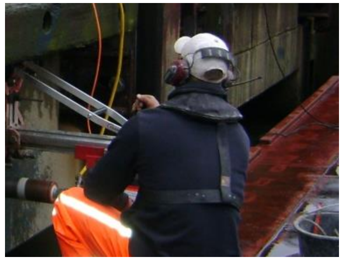
Prioritize the Right Interventions

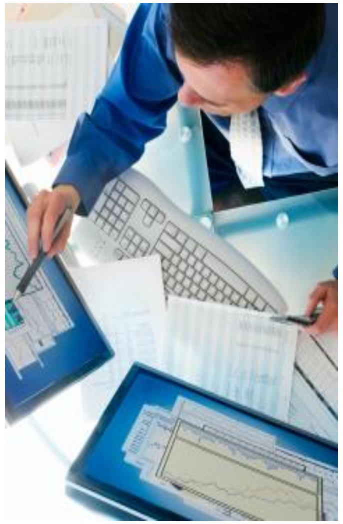
LONG-TERM DURABILITY PLAN WITH MINIMUM CAPITAL INVESTMENT

Prevention-Oriented Approach

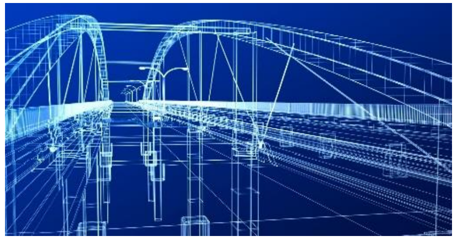
Review of Existing Documentation & Determination of Service-Life Criteria → **Visual Inspection, On-Site Observations & Core Extraction** → **Concrete Characterization** → **Determination of Exposure Conditions & Modeling** → **Evaluation of Residual Service Life, Selection of Optimum Repairs & Final Recommend-ations**







Durability Design vs Structural Design



Design(Geometry)

Exposure Conditions

Local Materials

Service-Life Calculations

Determination of Loading and Resistance

- Different exposure zones: shoulders, center, drains, joints, underside, substructure…
- Different elements: deck, beams, piles, piers, caps, abutments…
- Variable ambient conditions: deicing, seawater, groundwater, direct exposure, spray, intermittent exposure…
- History: pavement, repairs, overlays
- Assessment of the concrete (new, repair or existing) resistance to applicable degradation mechanisms (freeze-thaw, ASR, chloride-induced corrosion, abrasion…)

New or Repair Concrete Optimization

- How to get the required service life under existing conditions? How can the resistance exceed the loading?
- By designing the concrete to:
  - Improve resistance to external contamination (Cl^-, SO_4^{2-})
  - Reduce the hydration temperature and risk of cracking
  - Reduce shrinkage and risk of cracking
  - Improve physical compatibility of repairs
  - Improve chemical compatibility of repairs (AAR)
  - Improve abrasion resistance
  - Improve freeze-thaw resistance
  - Improve chemical resistance

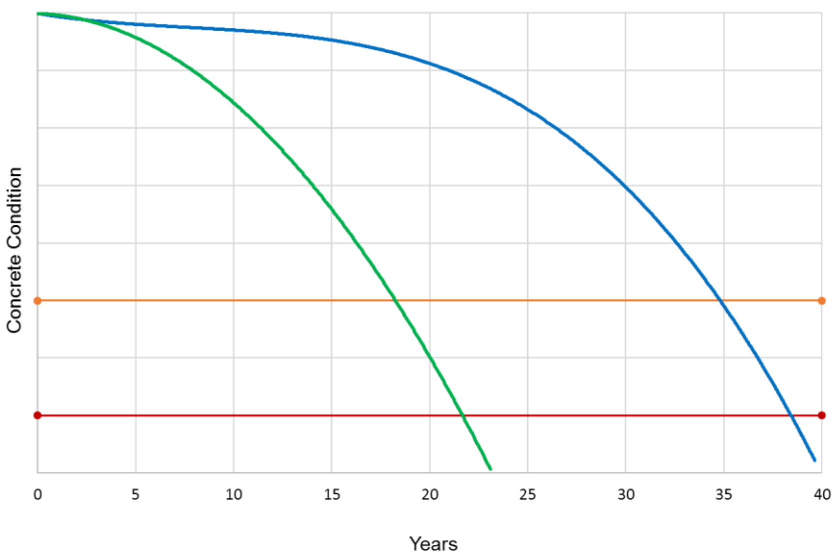
Modeling of Degradation

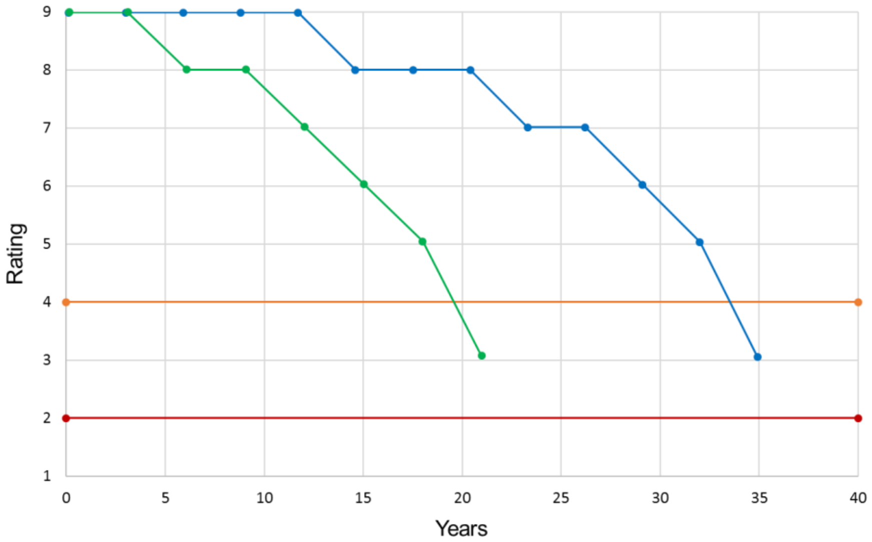
- Validation process: reproduce current situation based on past history to predict future performance

- Past history: year built, years in service, previous repairs and maintenance
- Current condition: concrete properties and state of contamination
- Future performance: change in condition with planned repairs and maintenance

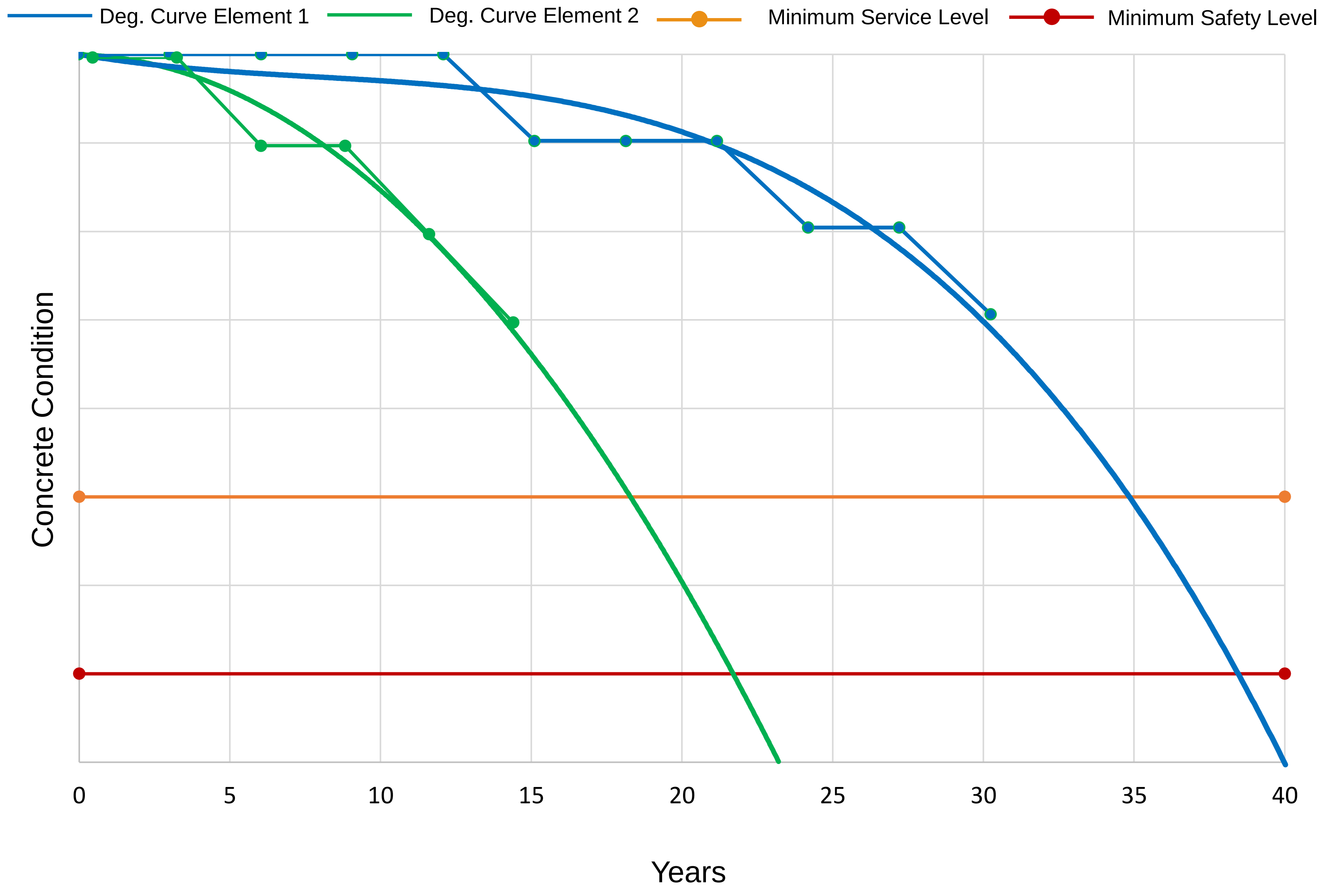
Modeling of Degradation

Modeled degradation ⟷ Observed degradation





Modeling of Degradation



Questions to Answer

What is the current condition?

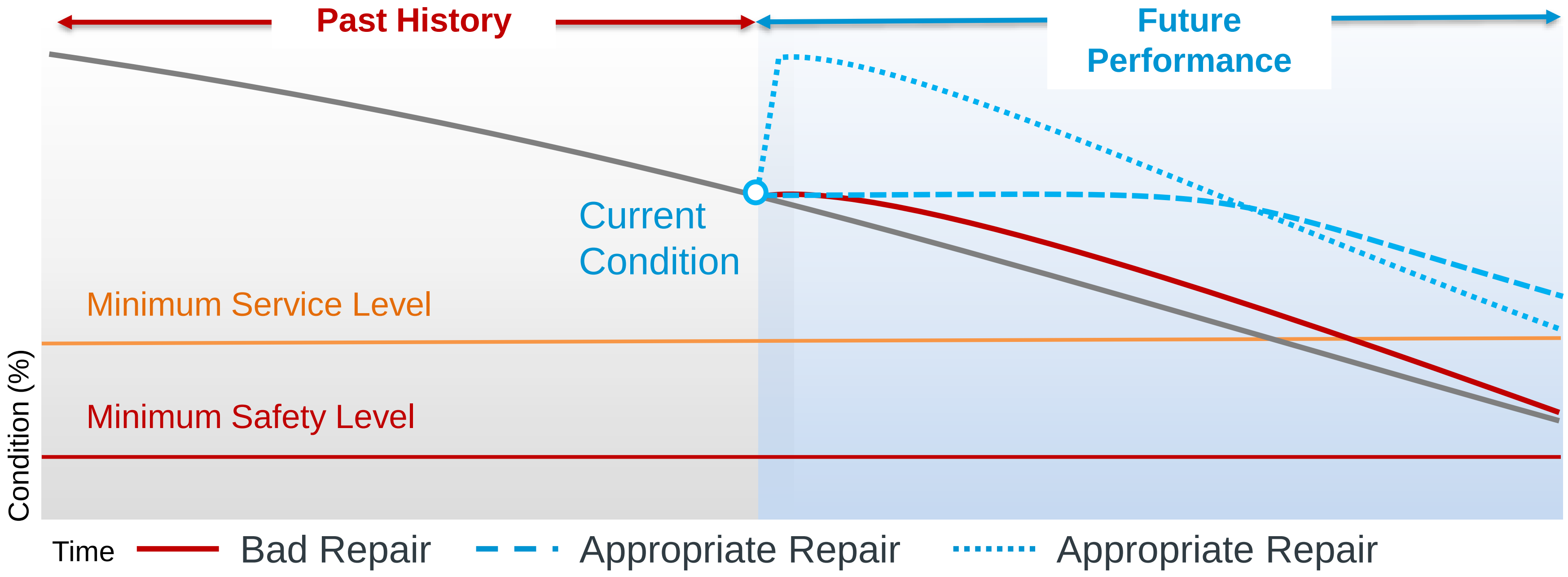
- **Visible degradation**
- **Hidden degradation**

What is the residual service life?

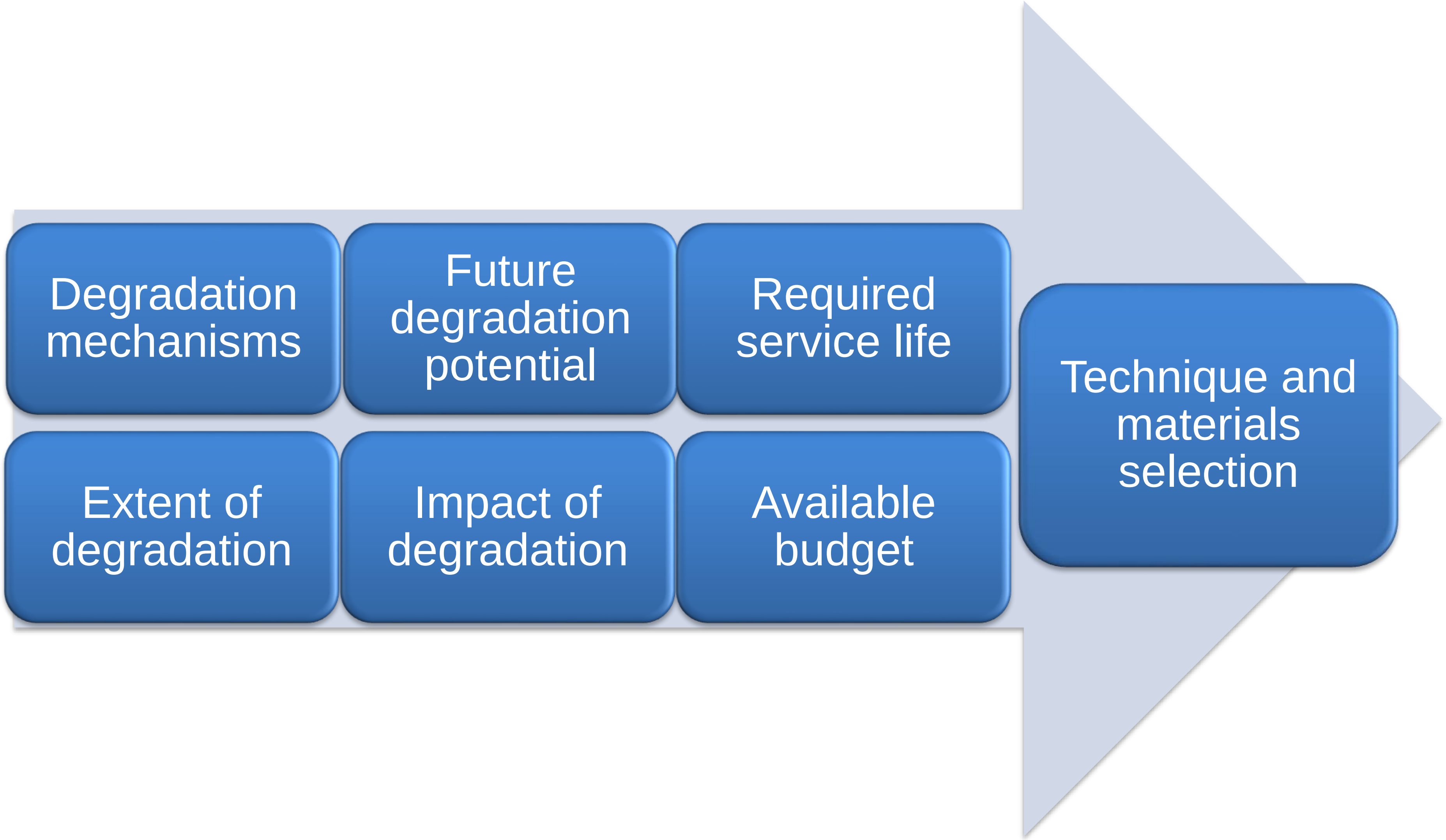
- **If nothing is done**
- **If repairs are implemented**

What actions to take and when to intervene?

- **LCCA**
- **Most cost-effective solution**



Optimized Preservation Strategy



Optimized Preservation - Benefits

Optimal Management of Assets

- Insight into the future condition of structures
- Prioritization of interventions
- Centralized management system of structure data

Increased Safety of Structures

- Identify most critical elements
- Prediction of future degradation from actual data
- Flag situations requiring interventions

Improved Control of Costs

- Better inspection planning
- Selection of most cost-effective interventions and timing
- Improved budget planning

Conclusions

What to Remember

Better estimate of how and when to intervene

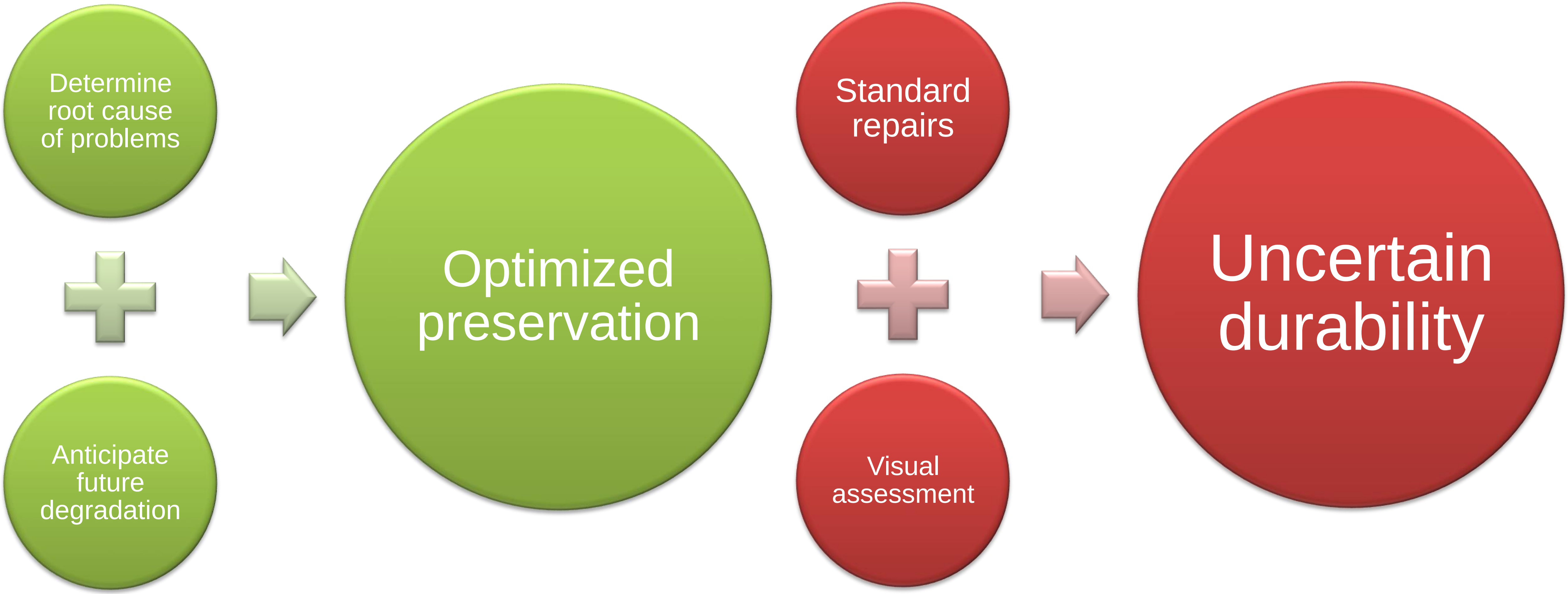
Minimize closures, demolition and interventions

Reliable information

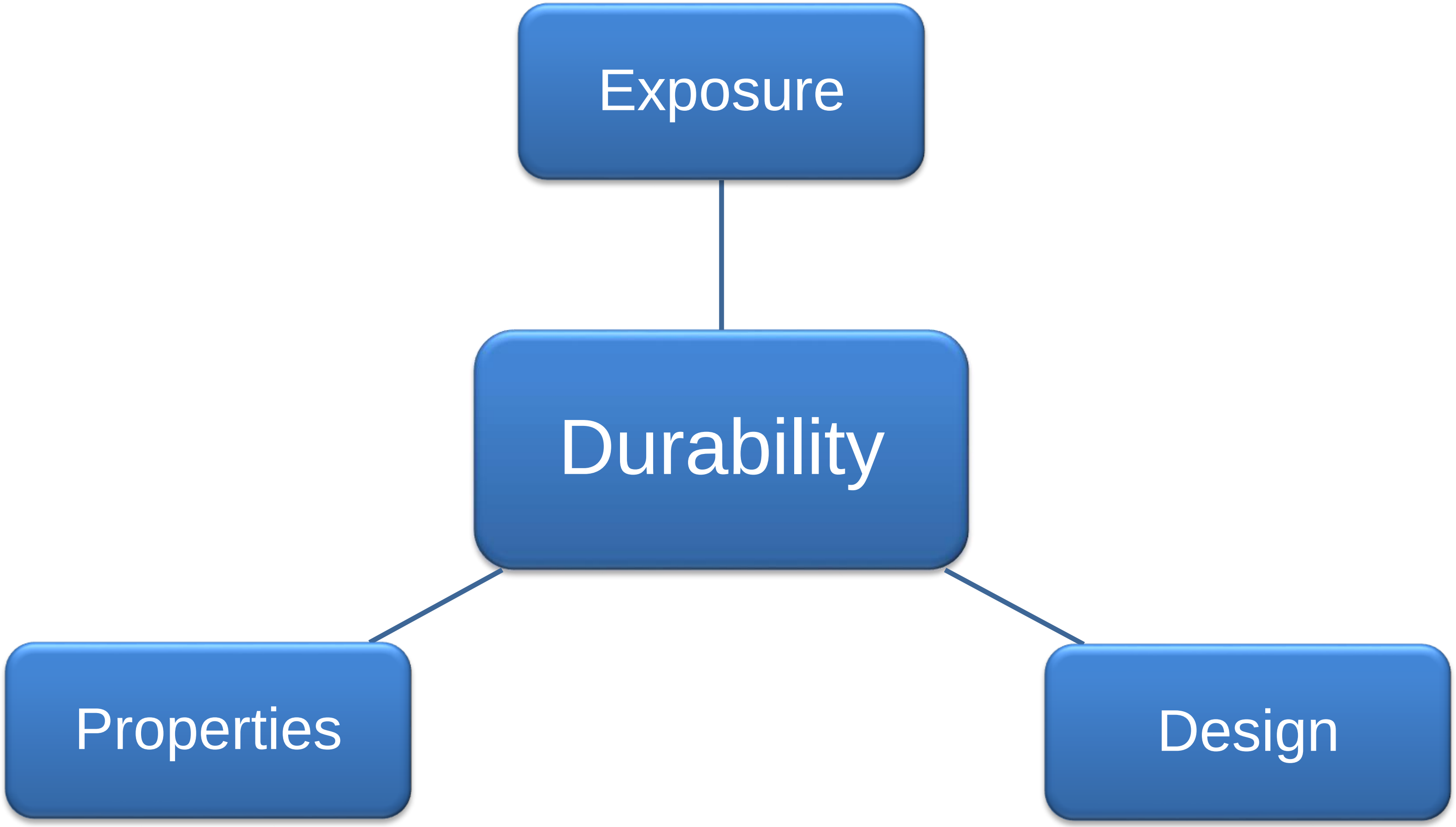
Ensure long-term durability at lower overall maintenance

Prioritize interventions and make best use of available budgets

What to Remember



What to Remember



What to Remember

Testing for concrete properties

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Testing for exposure conditions

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Current and future degradation evaluation based on scientific principles

Thank you!

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