Approach for Future Foundation Reuse

Actions Required Today to Enable Sustainable Redevelopment Tomorrow

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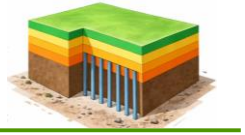
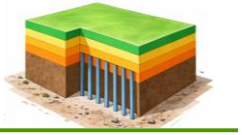


Future Foundation Reuse

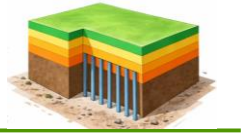
- Foundations should not be demolished with buildings
- They should be designed as long-term infrastructure
- Start treating foundations as reusable assets

- Content of this presentation:
  - Why? How? Who? When?



Future Foundation Reuse

- Why?



Foundations are Reusable Assets

- Foundations often have a *technical* lifetime much longer than the *economical* lifetime of the superstructure.
  - Technical lifetime is often more than 100 years
  - Commercial/office buildings typically economic life of 30 to 50 years
    - Requiring major upgrades, redevelopments to remain market competitive
  - Future developments in transportation will impact infrastructural works
- Current engineering practice rarely anticipates the reuse of foundations beyond the first building cycle
- As a result, foundations that remain structurally and geotechnically sound are frequently demolished and replaced, leading to unnecessary material consumption, cost, and embodied carbon emissions

Why?

Economical vs Technical life time

Opened in 1977
30.000 m² offices.
IBM-office, Ministry of Housing and Spatial Planning, 1977

Why?

Economical vs Technical life time

2024

Why?

Economical vs Technical life time

Why?

Technical lifetime

Royal Palace on the Dam, Amsterdam
13.659 timber foundation piles
constructed around 1665

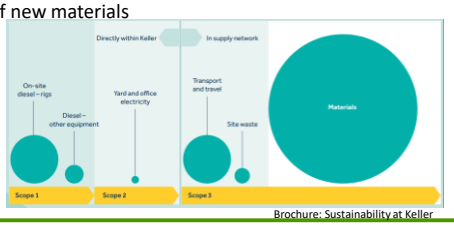
The Waag (St. Anthoniespoort), Amsterdam
built in 1488, the oldest non-religious building and sits on medieval timber foundation piles.

Foundation replaced in 2014 by 148 grout-injected screw piles

Why?

CO_2 Impact of Foundations

- Carbon emissions of new foundations
  - Diesel of pile driving rig and other site machinery
  - Transport of employees and materials to and from site
  - Production and delivery of new materials
- Materials in Scope 3



Brochure: Sustainability at Keller

Why?

CO_2 Impact of Foundations

Impact Foundation on environment-impact

MPG (**Environmental Performance of Buildings**) calculates the environmental impact of a building's materials.

The score is given in euros per square meter of gross floor area per year (€/m²/year).

Foundation and basement are 30% to 60% of that impact (ABT)

MPG constructie: €0,30
Fundering en kelder: 29%

MPG constructie: €0,41
Fundering en kelder: 60%

MPG constructie: €0,34
Fundering en kelder: 56%

Why?

Mismatch Technical and Economical lifetime

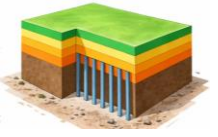
- Mismatch in lifetimes:
  - Reduce the technical life time of the foundation
  - Use the foundation over multiple superstructures

Design time	**50**	**years**
Economical lifetime		
Commercial/offices	30-50	Years
Housing	50+	years
Infrastructures	?	
Technical lifetime foundation	100+	years

Why?

Future Foundation Reuse

- How?



Mismatch Technical and Economical lifetime

- Design foundations for **multiple life cycles**
- When feasible:
  - Sufficient reserve capacity to accommodate future changes in use
  - Robust detailing that allows for load redistribution
  - Reliable as-built data
  - Geometries that facilitate future assessment and testing
- No overdesign
  - Balance initial material use with long-term adaptability and sustainability

How?

Main Question

- What actions are required **today** in design, construction, testing, and documentation
- To enable reliable reuse of foundations in **future** redevelopment projects?
  - Replacement superstructure
  - Redevelopment
  - Extended use (past the design time)
  - Change of function, change of pile loads
  - Topping up, vertical extension, adding rooftop floors
  - Maintain/repair foundations to avoid problems and extend technical life time

How?

No future uncertainties about what is built now

- All must ensure that:
  - Pile lengths, diameters, and installation records are accurately documented
  - Locations of the deep foundations are well registered, including the definition of the reference points
  - Soil investigation data and interpretations are archived in accessible digital formats
  - Construction deviations and anomalies are recorded
- Anno 2026: digital storage in cloud-based systems
  - Standardized (software in 2075 will be different…)
  - Can BIM be the platform?

How?

Role of BIM in Foundation Reuse

- Acts as a long-term digital container for foundation information
- Stores geometry, pile test results, soil parameters, and design assumptions.
- Supports future engineers in assessing capacity and reliability
- Reduces uncertainty in reuse feasibility

How?

Designing for Testability and Inspectability

- To assess the suitability of foundations for reuse, foundation piles should be accessible for visual inspection and testing
- Engineers should therefore consider future testability during design
  - Avoiding unnecessary obstruction of pile heads
  - Providing accessible zones or inspection openings where feasible
  - Designing basements and pile caps in a way that allows localized exposure
  - Foundations should be detailed to allow future load testing, even under an existing superstructure

How?

Test and monitoring of existing foundation



How?

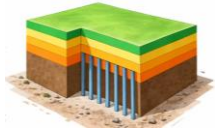
Performance-Based Assessment of Existing Foundations

- When a superstructure reaches the end of its economic life, engineers should prioritize **performance-based assessment** methods over analytical redesign
- Observed service performance - such as settlement, cracking, and structural alignment - combined with targeted testing, provides a far more reliable basis for decision-making than reapplying conservative design models.
- Pile load testing is central to this approach, as it:
  - Directly measures actual load–displacement behavior
  - Reduces uncertainty in pile capacity
  - Verifies both geotechnical and structural performance in the as-is condition
  - Mobilizing hidden safety

How?

Future Foundation Reuse

- Who?

Who?

Role of Stakeholders in Enabling Foundation Reuse

- Successful reuse of existing foundations requires coordinated action by multiple stakeholders throughout the life cycle of a structure
- Foundation reuse cannot be achieved through technical measures alone; it depends equally on asset management, engineering practice, and construction execution
- Owners and developers, engineers and designers, and contractors each play a distinct and essential role in reducing uncertainty and preserving foundation value for future reuse.

Who?

Owners and developers

- Owners and developers are the primary asset holders and play a central role in enabling foundation reuse
- They control design ambition, documentation, maintenance, and long-term data storage
- To make foundations available for reuse, owners must take responsibility for the quality, completeness, and correctness of foundation-related information throughout the asset's life cycle.
- From an economic perspective, owners and developers benefit the most from foundation reuse through reduced construction cost and time, lower embodied carbon emissions, and improved sustainability credentials
- Foundations should be recognized and quantified as long-term assets during sale, redevelopment, or refurbishment decissions.

Who?

Engineers and designers

- Engineers and designers translate circular economy ambitions into safe and practical foundation solutions
- This requires adoption of **multi-life-cycle design** principles, performance-based assessment methods, and uncertainty reduction through testing **as-is**
- Education, professional training, and design codes must evolve accordingly.
- Engineers should not be evaluated solely on minimizing initial construction cost
- Their contribution to sustainability—through reduced material use, lower carbon footprint, and improved reuse potential—should be explicitly recognized and **rewarded**

Who?

Contractors

- Contractors determine the actual quality and reusability of foundations, by translating design intent into **as-built reality**
- Deviations between as-designed and as-built foundations must be systematically documented
- By recording installation methods, sequences, site conditions, and deviations, contractors significantly reduce uncertainty and preserve foundation value for future reuse.

Who?

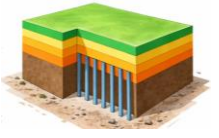
Regulatory Authorities

- Shape the regulatory framework for foundation reuse
- Current approval processes focus on new-build compliance and may unintentionally **discourage** reuse
- Recognize **proven performance and testing results**, such as pile load tests
- Stimulate foundation reuse by updating standards, promoting uncertainty reduction through testing and documentation, etc.

Who?

Future Foundation Reuse

- When?



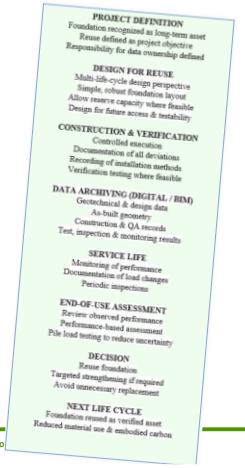
Resumé

- Foundations often have a much longer technical lifetime than buildings, bridges and other superstructures
- Reuse of foundations can significantly reduce CO_2 emissions and material use
- Future reuse requires actions during initial design and construction
- Testing, documentation and monitoring increase reuse reliability
- BIM and long-term data storage are critical for future assessment
- A lifecycle approach is needed to enable sustainable redevelopment

When?

And today? Plan for action!

- What must we do today?
- See the framework in the paper



When?

What must we do **today** to enable foundation reuse **tomorrow**?

Action **now**: Design foundations for a second life

- 1. Design for reuse
  - Plan foundations with sufficient robustness and flexibility to accommodate future building adaptations
- 2. Test & verify performance
  - Implement pile testing, monitoring, and verification to ensure long-term reliability
- 3. Preserve knowledge in BIM
  - Store geometry, soil parameters, load tests, and design assumptions in digital models for future engineers
- 4. Enable future assessment
  - Provide documentation and access so foundations can be reassessed rather than demolished

When?

Foundations often outlive buildings —
our design decisions **today** determine whether they become **waste** or **future** assets

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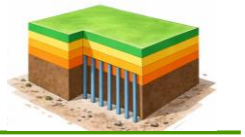

And then?