

Building Facades and Digital Twins

Benefits and Limitations

David Schnerch, PhD, PE

Learning Objectives



1. Understand the state-of-the-art in using digital technology and digital twins to assess building facades to determine and quantify maintenance and repair requirements.
2. Identify the advantages of automated approaches for collection of data to establish the condition of a building at a point in time and to determine the rate of deterioration based on multiple surveys.
3. Determine what limitations there are for the use of photographic-based techniques in recognizing detrimental or hazardous facade conditions.
4. Illustrate, through the use of case-studies, various types of facade failures with discussion on the appropriateness of inspection methods to minimize risk.

Why are Facade Inspections Important?

December 10, 2024



Preventative Maintenance



Materials used to construct facades deteriorate
Facade inspections are part of the process to establish what **preventative maintenance** a building requires

Also used to evaluate the useful lifespan of facade components

Rate of deterioration can be affected by ages of materials, deferred maintenance, and the configuration of the facade components



Safety



Boston, Chicago, New York, Philadelphia, Pittsburgh, San Francisco (among others) have facade ordinance inspection requirements

Inspection to be performed under the direction of a licensed architect or professional engineer

If left unaddressed, potential unsafe conditions can expose public to safety hazards



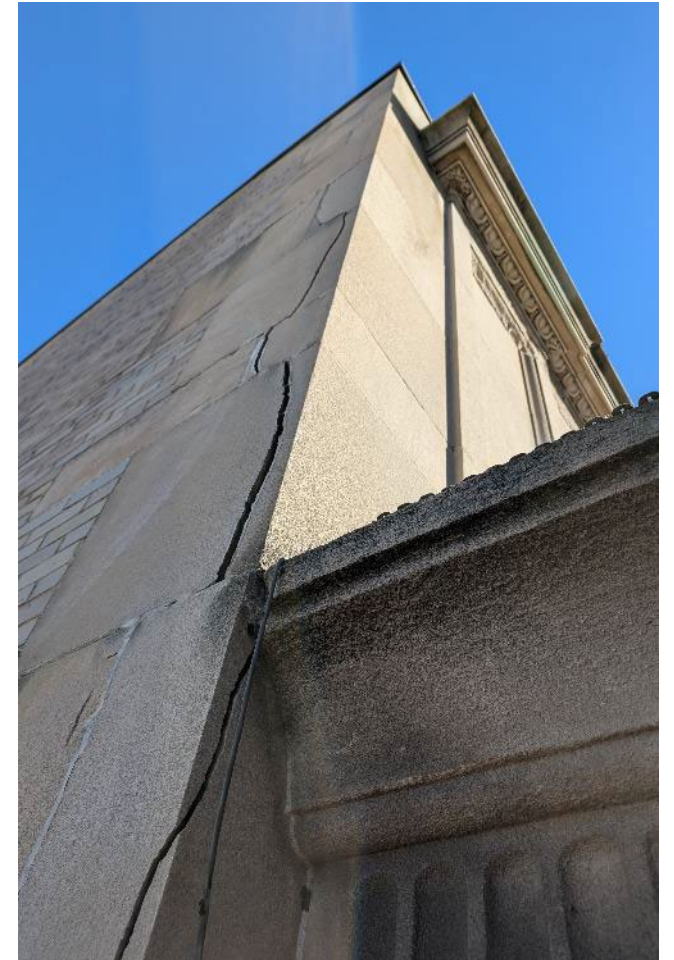
Facade Inspection Guidelines



Rules for performing the facade ordinance survey differ by jurisdiction

ASTM E2270 Standard Practice for Periodic Inspection of Building Facades for Unsafe Conditions provides guidance

General inspection (more than 6 feet away, no remote devices or optical magnification) or Detailed inspection (visual and tactile possibly including probing or NDT to observe concealed conditions).



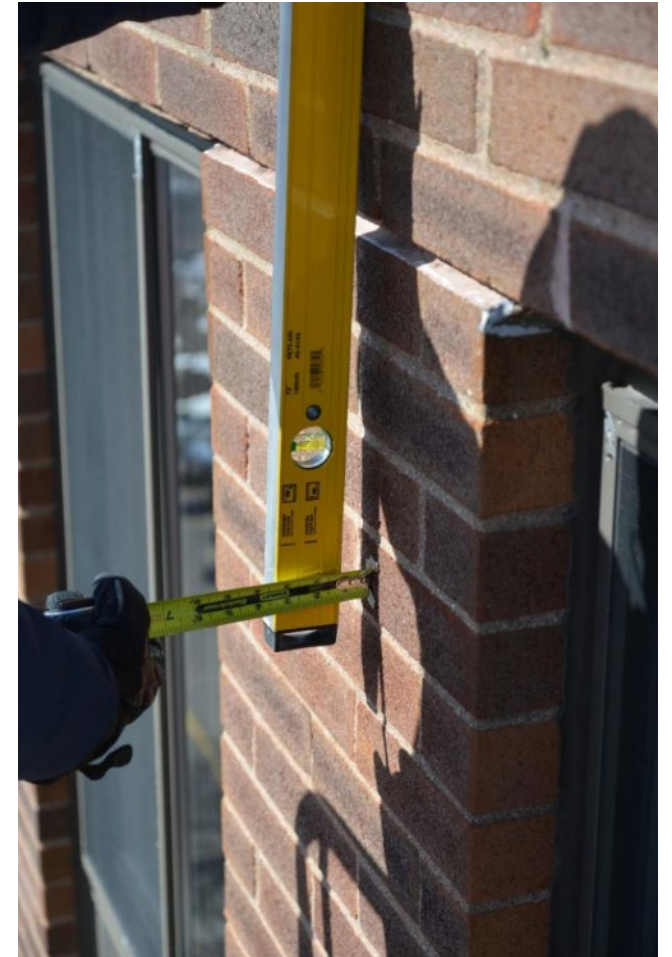
Unsafe Conditions and General Maintenance



Facades may exhibit various indications of distress or deterioration, such as cracking, bowing, or spalling

Some conditions that are **not visually apparent** can also result in leaks, distress, or potential detachments

Some types of facade systems are more vulnerable to problems than others



General and Detailed Inspections



Inspections may be performed from the ground using binoculars and telephoto binocular equipment and from grade

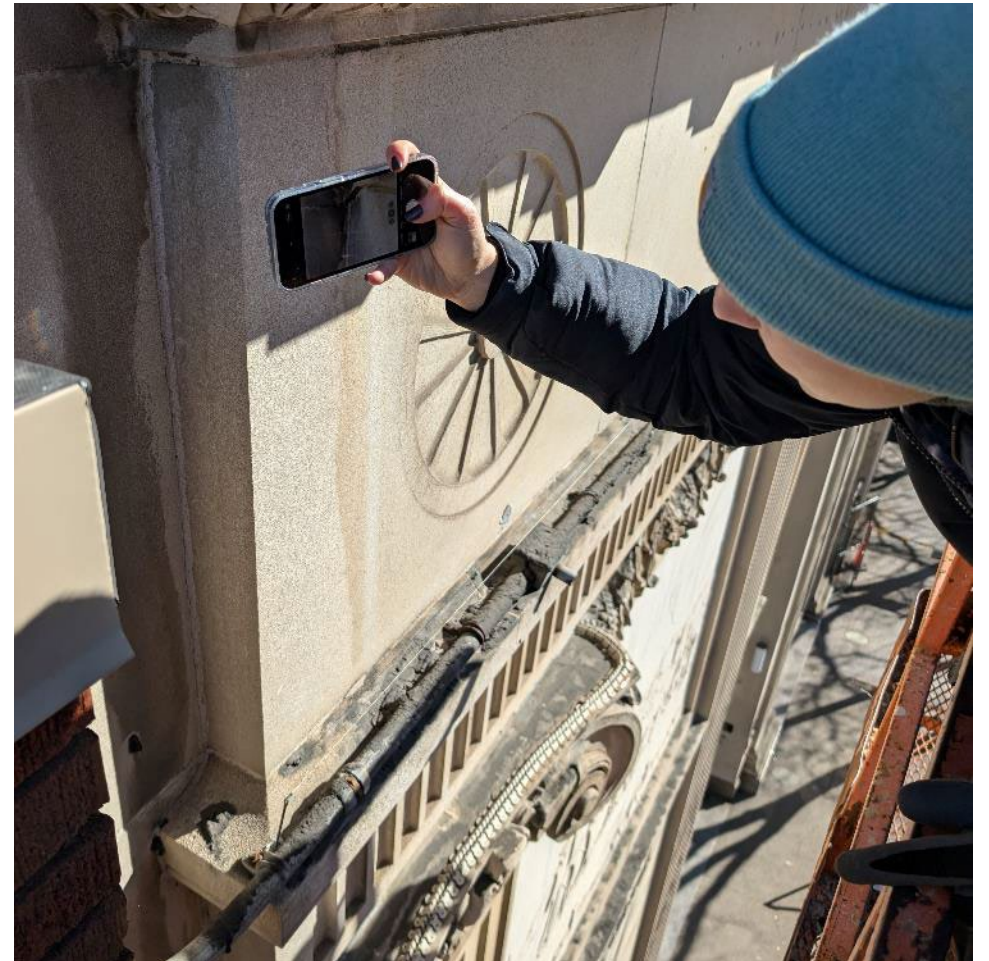
This may be combined with some means of access to allow tactile evaluation, including probing and NDE



Visual Evaluation

We mostly rely on our eyes together with photographic equipment to assess the condition of facade materials

We look for differences in color, surface roughness, discontinuities, or separations to infer the condition of the material



Lighting

Sufficient light is needed for visual observation or photography

Cross lighting can provide information on surface flatness



Tactile Evaluation



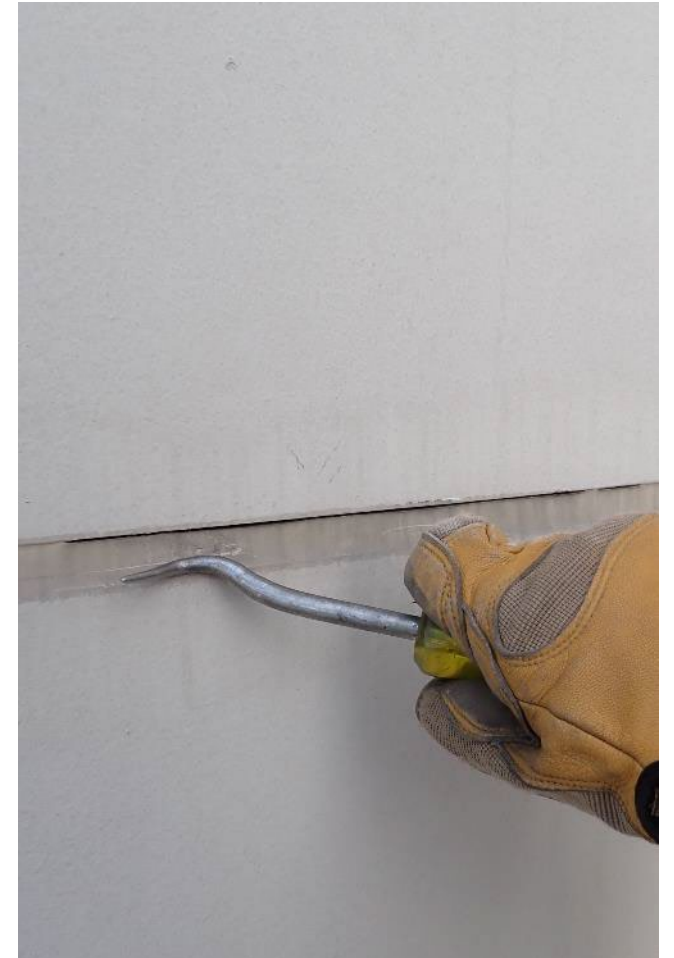
Pushing against a material can give an indication of its ability to function or give an indication of below-surface distress

Examples:

- Mechanical sounding of stone or concrete materials

- Probing of sealant joints to assess adhesion

- Evaluate looseness of components



How Can Technology and Use of Digital Twins Help ?

December 10, 2024



Technology and Use of Digital Twins



New technologies can improve our ability to assess distress and deterioration of facades and reduce the inefficiencies associated with the data collection process while facilitating the owner's desire to minimize costs for assessments and repairs.

- Vantagepoint
- Data Management
- Time

Vantagepoint

With traditional methods, limited to inspection from grade, adjacent roofs, or close-up using access equipment sUAS (or drones) allows greater opportunity to inspect facade component from the best vantagepoint

ASTM E2270 states that horizontal surfaces that can collect water (like sills) be viewed from above where possible





Vantagepoint – Point Cloud

Photogrammetry allows images to provide measurable data

Specialized equipment (LIDAR) provides additional accuracy

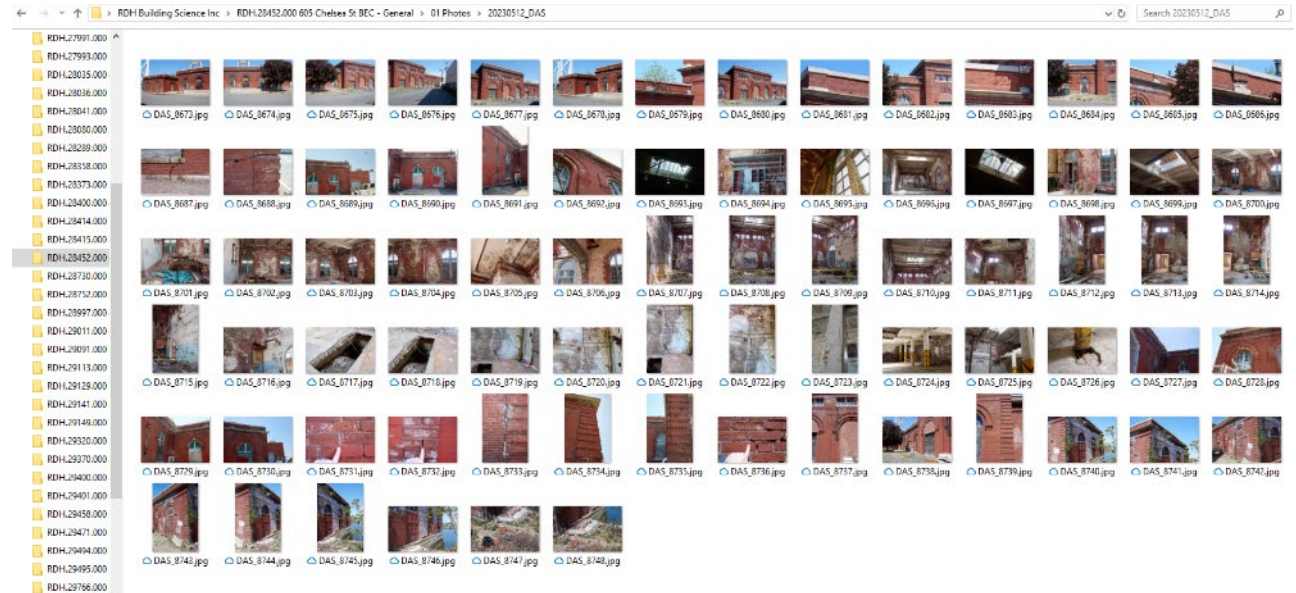
With sufficient resolution, out-of-plane conditions may be assessed



Data Management - Standard



Used to use folders with photographs and separate field sheets to document where photographs were taken



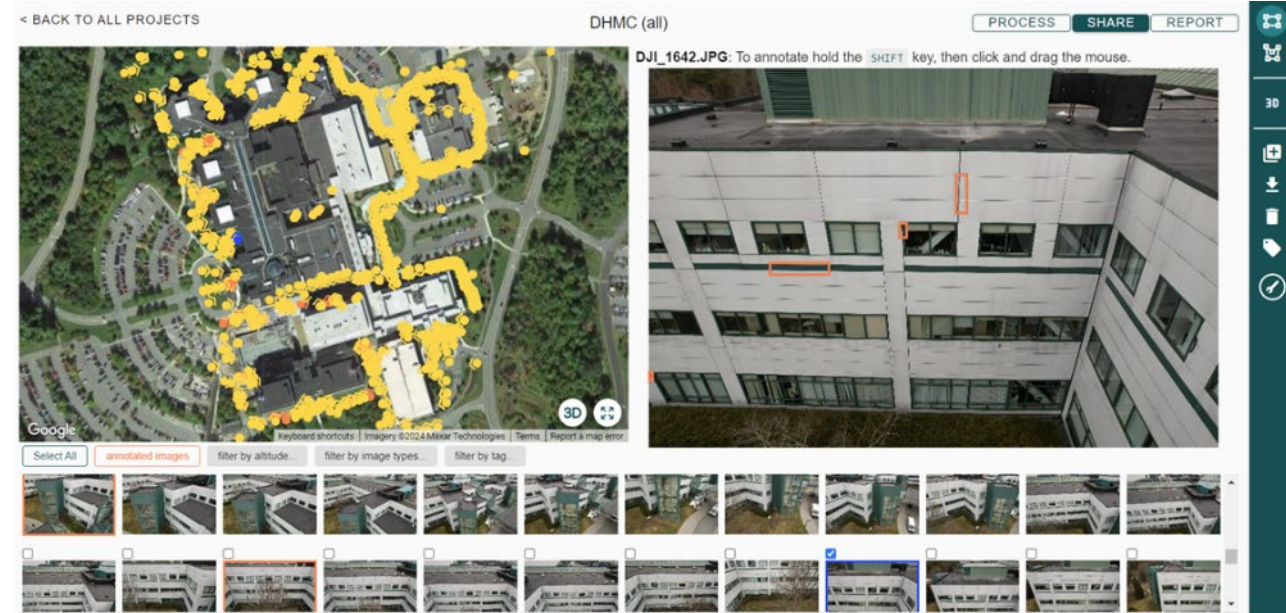
Data Management – Digital Twin



With use of a Digital Twin, information is now organized around the model

Contextual information and detailed information is readily available

Quality of the model is not paramount, because it is the index for our documentation



Repeated Inspections

With automated flight paths, data can be collected and maintained in a way that creates a permanent record of the observed conditions at multiple points in time

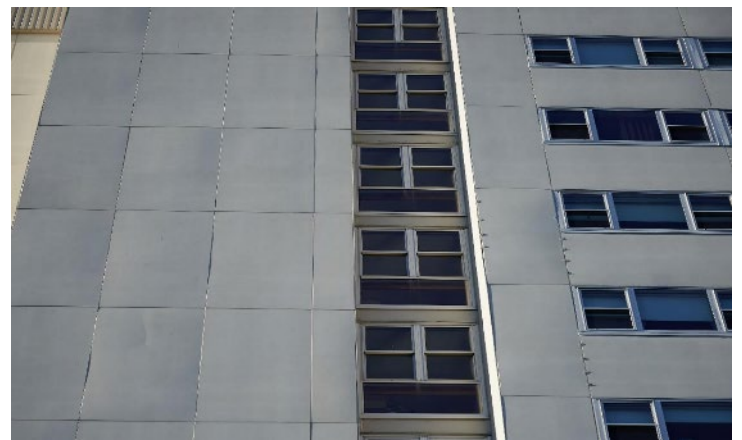
Also allows layering of different types of data sets like LIDAR or IR with visual



Time

Understanding the rate of deterioration is difficult with a single assessment because it relies on experience

Digital twin allows repeated inspections to be performed such that changes in extent or magnitude of distress can be determined

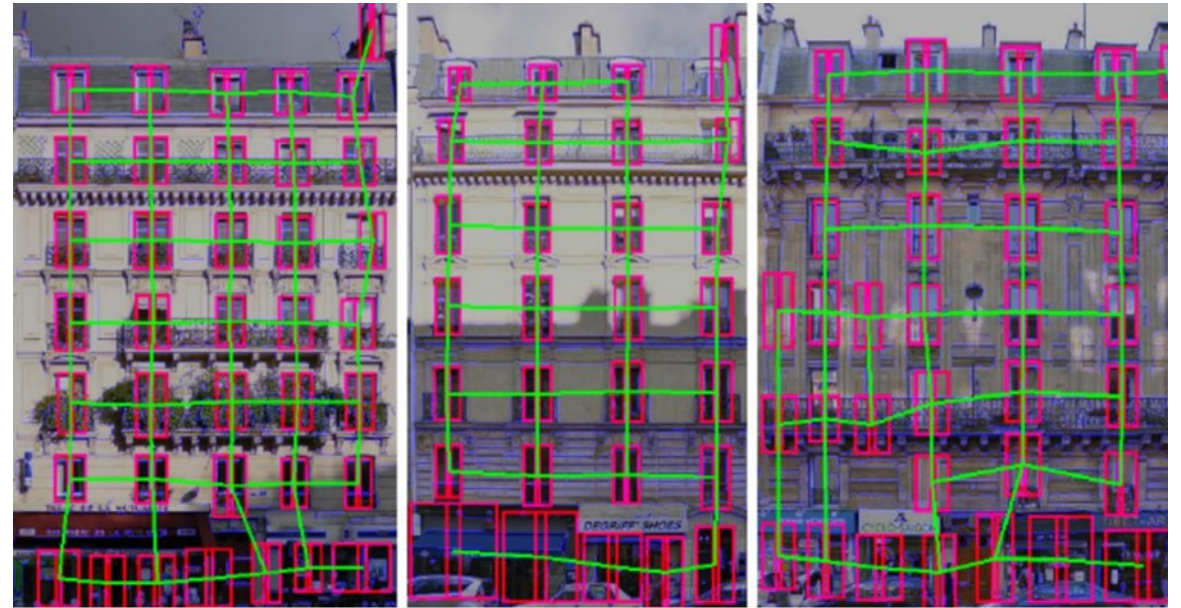


Quantification

Quantification may include the number of instances of a condition or a unit measure

Important to capture all of the known areas and predict areas that will be problematic at the time repairs are performed

Square foot precision not likely necessary



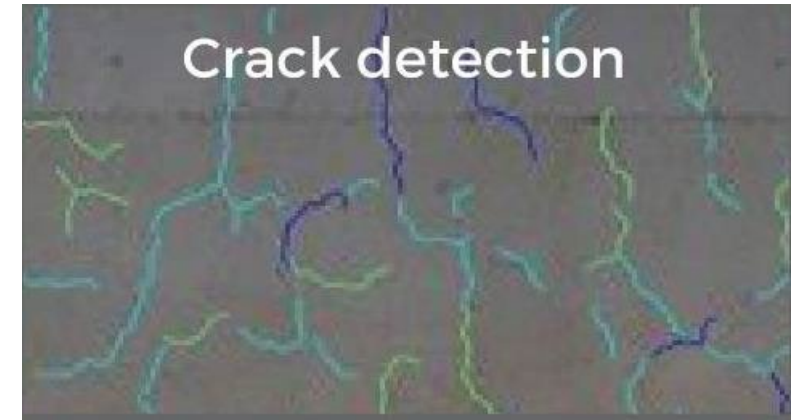
AI

AI is in the early stages of adoption

Requires significant training

Featureless surfaces difficult

Should the software manufacturer
be the beneficiary of training?



Benefit

By simplifying facade condition assessments have opportunity to **find problems early**

Together with regular maintenance intervals, overall maintenance costs can be reduced



Preventive maintenance costs markedly less than repairing extensive damage or building failures

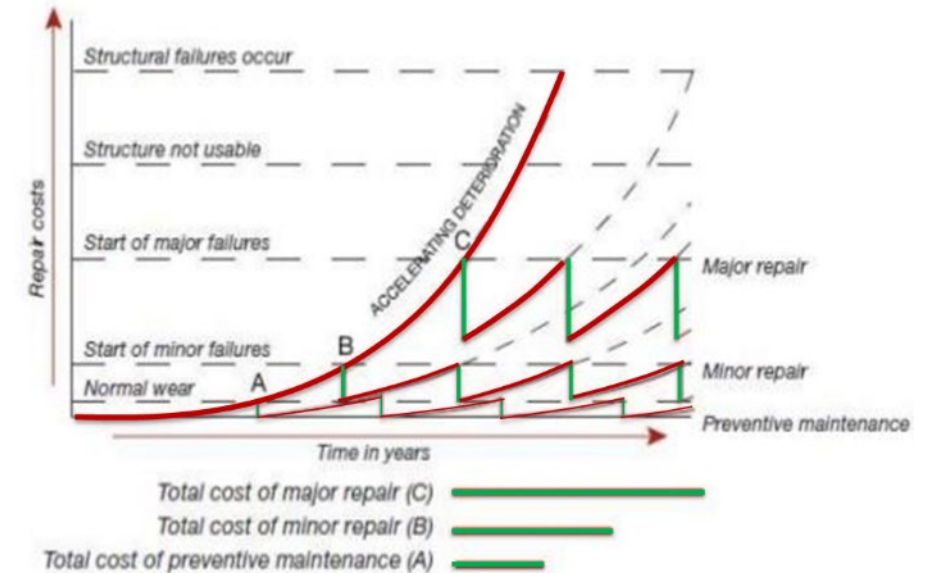


Diagram from *Preventive Maintenance of Buildings*, Van Nostrand Reinhold, New York, 1991.



Why Should We Not Only Rely on Visual Inspection?

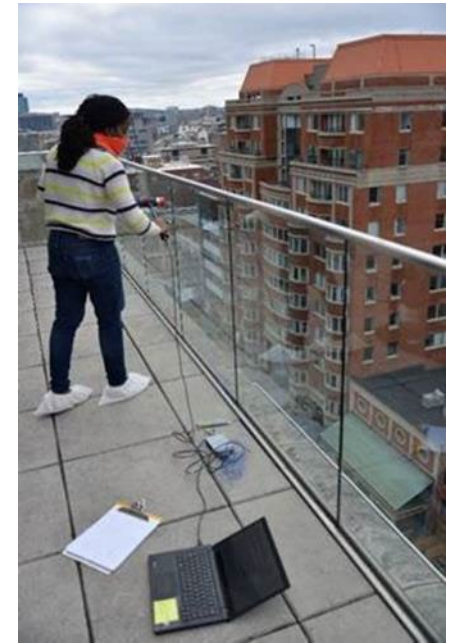
Close-Up Inspection

Ordinances typically require some portion of close-up inspection

Important to assess materials using tactile methods – **Not all distress is visually observable**

Next stage is to include data from tactile evaluation into digital twins

Modal hammers paired with GPS are one potential means of accomplishing this





Case Study

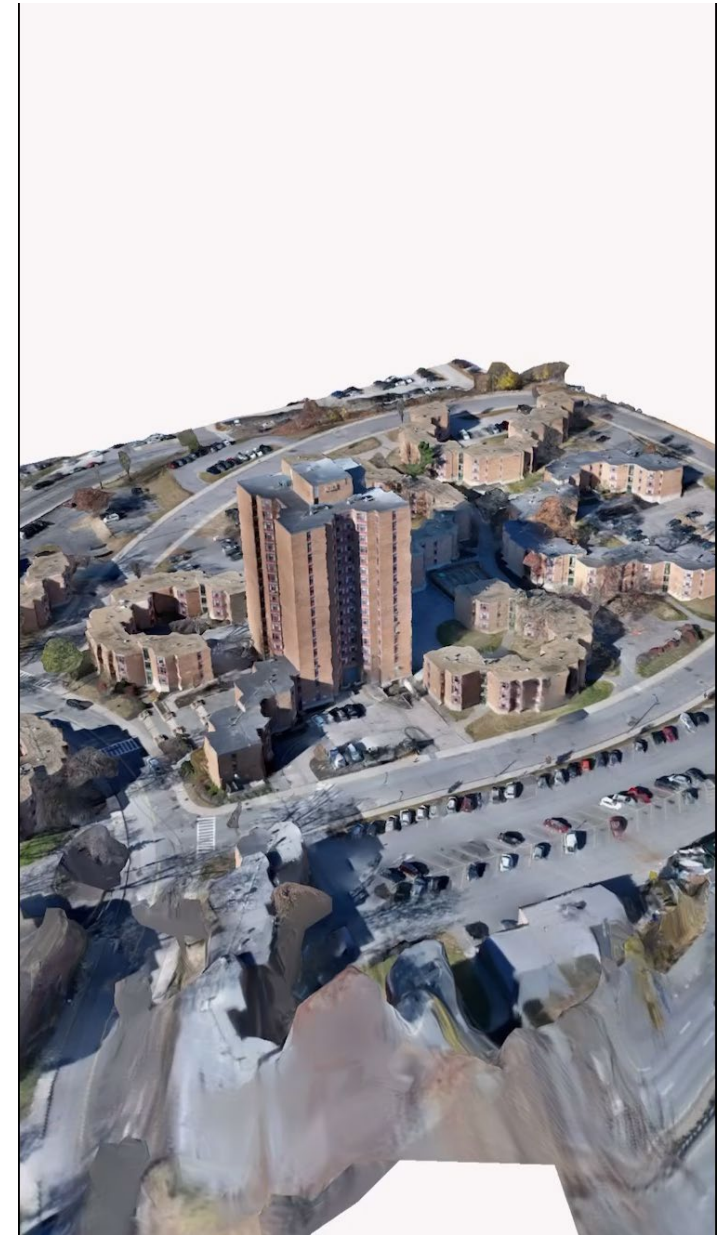
December 10, 2024

Case Study – Plumley Village

Plumley Village is a residential complex constructed circa 1970

Current property owners requested a comprehensive condition assessment of the facades and roofs

Consists of one 16-story tower and fifteen 3-story buildings

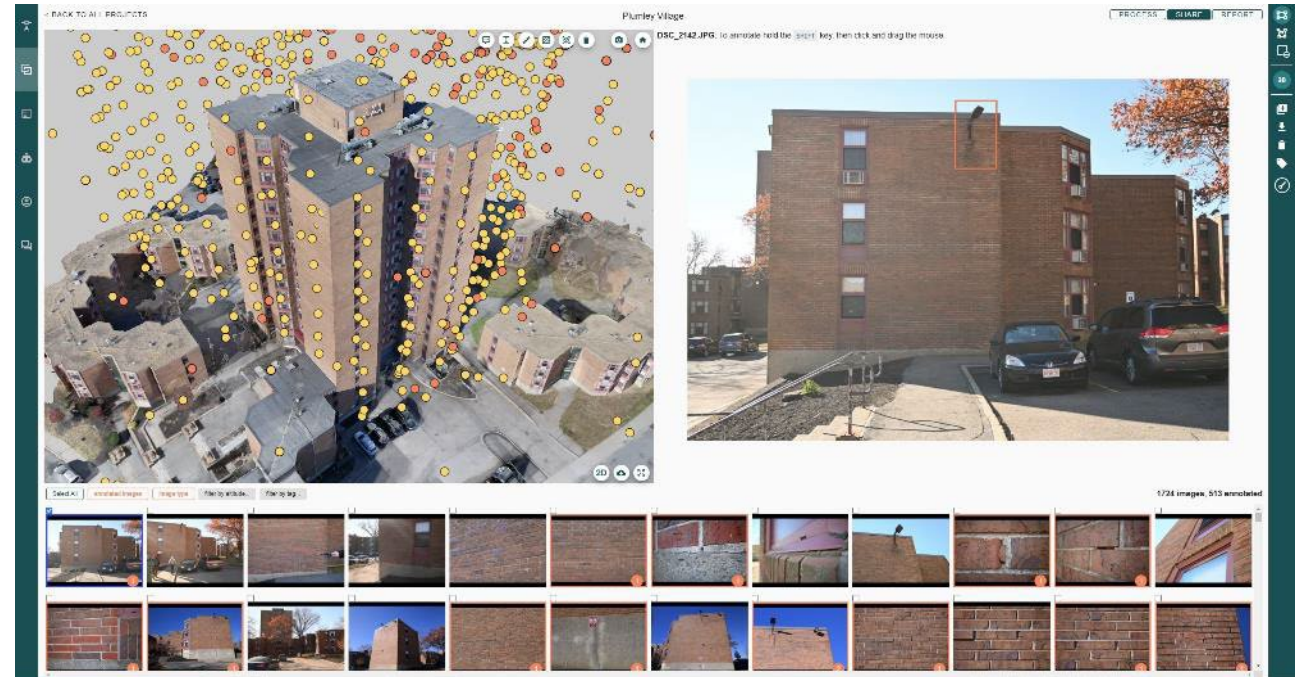


Case Study – Plumley Village



Used combination of traditional photographic methods and drone survey

Both ground-based photographs and drone were integrated into a single model

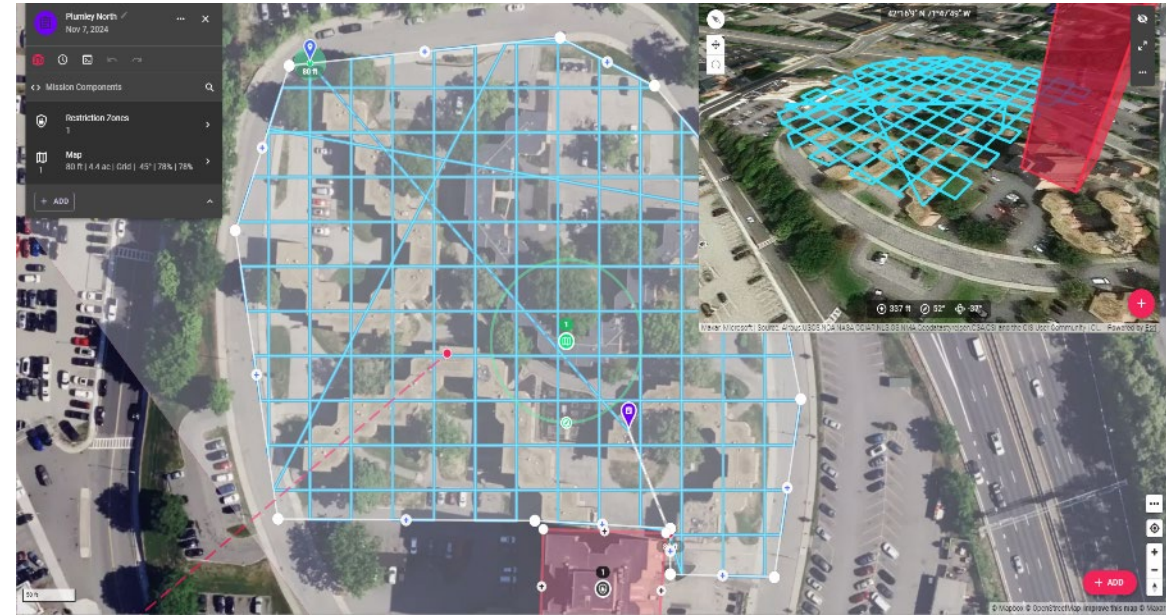


Case Study

Automated flight paths consisted of mapping and facade missions

Mirrorless cameras were used to document conditions close-up on the facades and roof

Flight tracks and geotagged photographs archived for future comparison

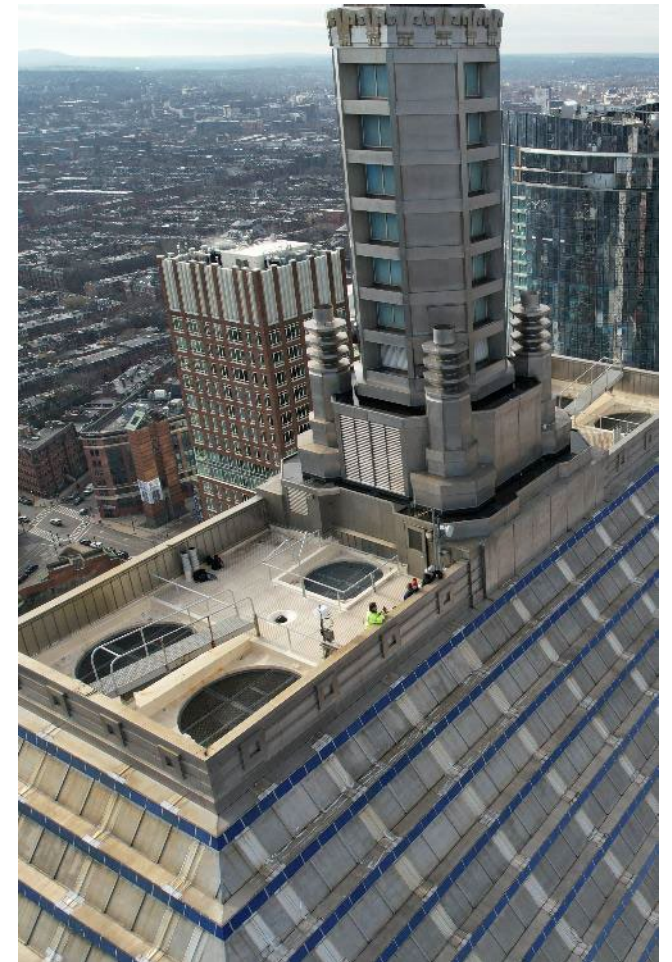


Summary

Digital techniques and digital twins can improve the quality of facade condition assessments and allow data to be managed in a way that allows rates of deterioration to be assessed

AI and quantification will allow automation of some manual tasks

Tactile inspection is still important – with digital techniques we can better optimize close-up inspections



Questions?



David Schnerch, PhD, PE
dschnerch@rdh.com

RDH Building Science