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PRESERVATION OF HERITAGE THROUGH MODERN COATINGS: PROTECTION OF HISTORICAL STRUCTURES AND CULTURAL ARTEFACTS

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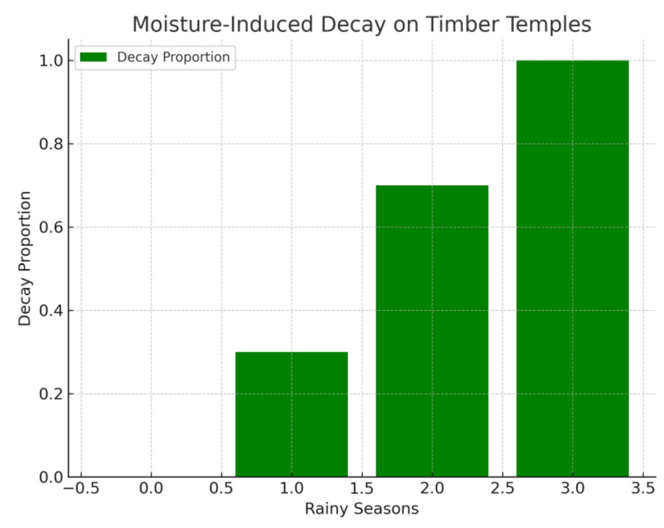
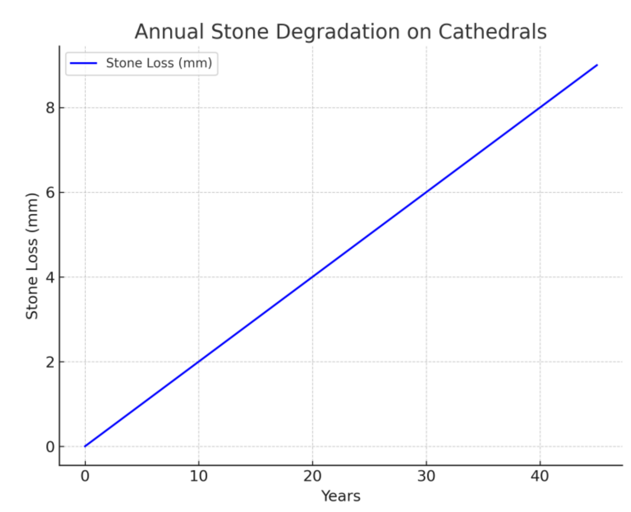
INTRODUCTION & AIM

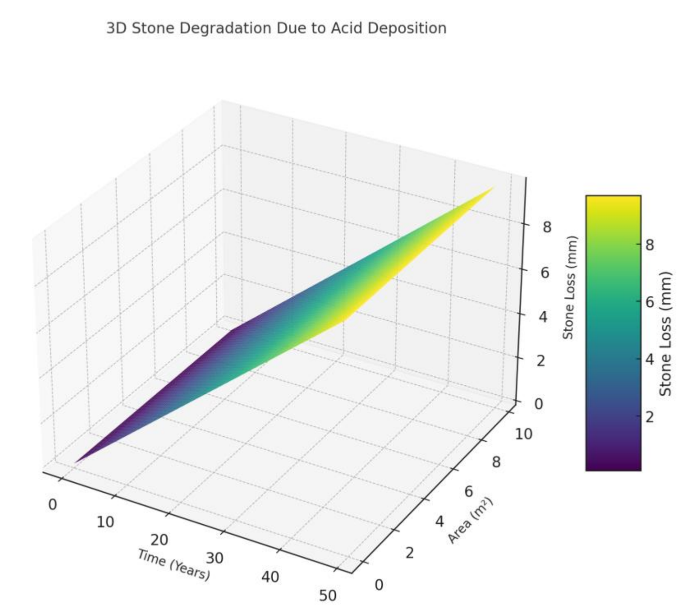
Environmental factors such as moisture, ultraviolet radiation, atmospheric pollution, and biological organisms pose continuous threats to historical buildings and cultural relics. These risks compromise the structural integrity of these sites while diminishing their aesthetic and historical value. Modern innovative coatings present promising solutions for enhancing long-term preservation, lowering maintenance costs, and safeguarding their authenticity. This study explores innovative protective coatings, including silica-based nanocomposite layers and polyurethane-based healing systems, evaluating their potential as effective means to preserve historic masonry, limestone façades, and metallic artefacts in architectural heritage.



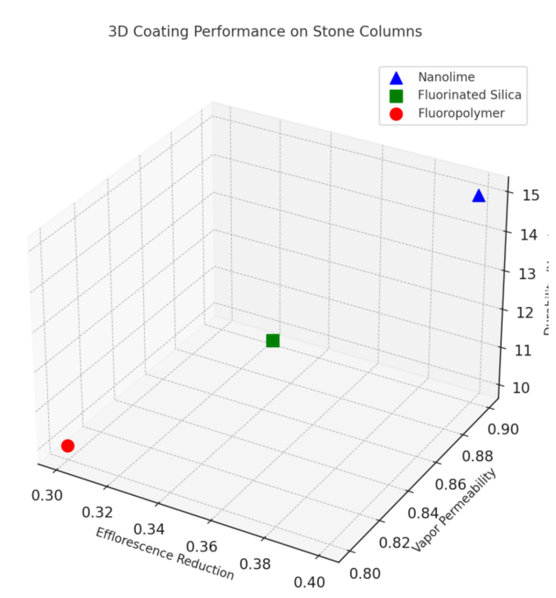
The bar chart of moisture-induced decay on timber temples



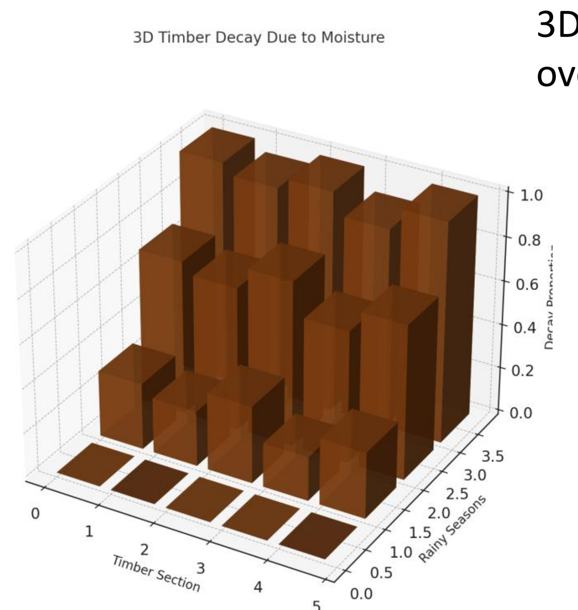
Graph shows annual stone degradation on cathedrals



3D surface illustrating stone loss over time and area



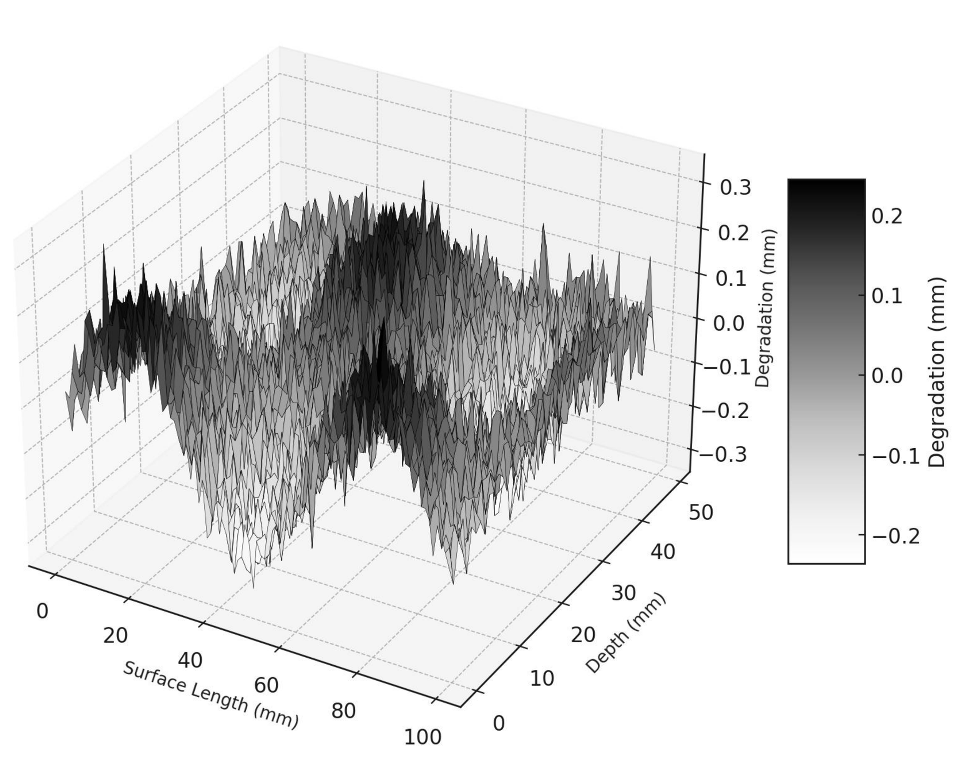
The 3D scatter plot of coating performance



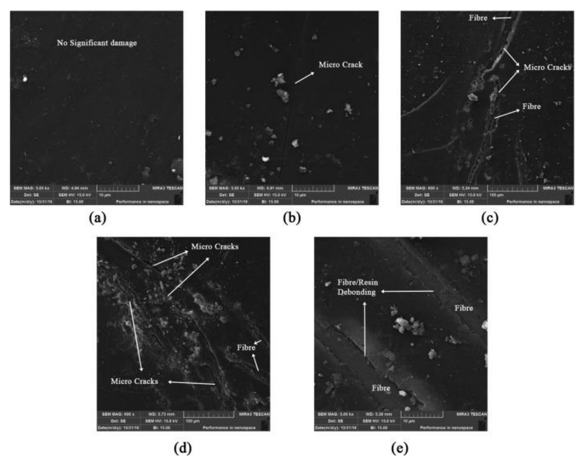
3D bar chart of timber decay across five sections over four rainy seasons.

METHOD

A multiphase experimental approach assessed the effectiveness and compatibility of innovative coatings. Initial laboratory evaluations of accelerated weathering were conducted to quantify the extent of deterioration under controlled conditions, including exposure to ultraviolet radiation, humidity, and temperature variations. The adhesion properties and substrate compatibility were tested using tensile and micro-scratch tests on samples of masonry blocks, limestone samples and aged metal surfaces. Field tests were initiated on individual historical facades across various locations in the city on the same materials to verify real-world performance and gather data regarding durability and ease of application.

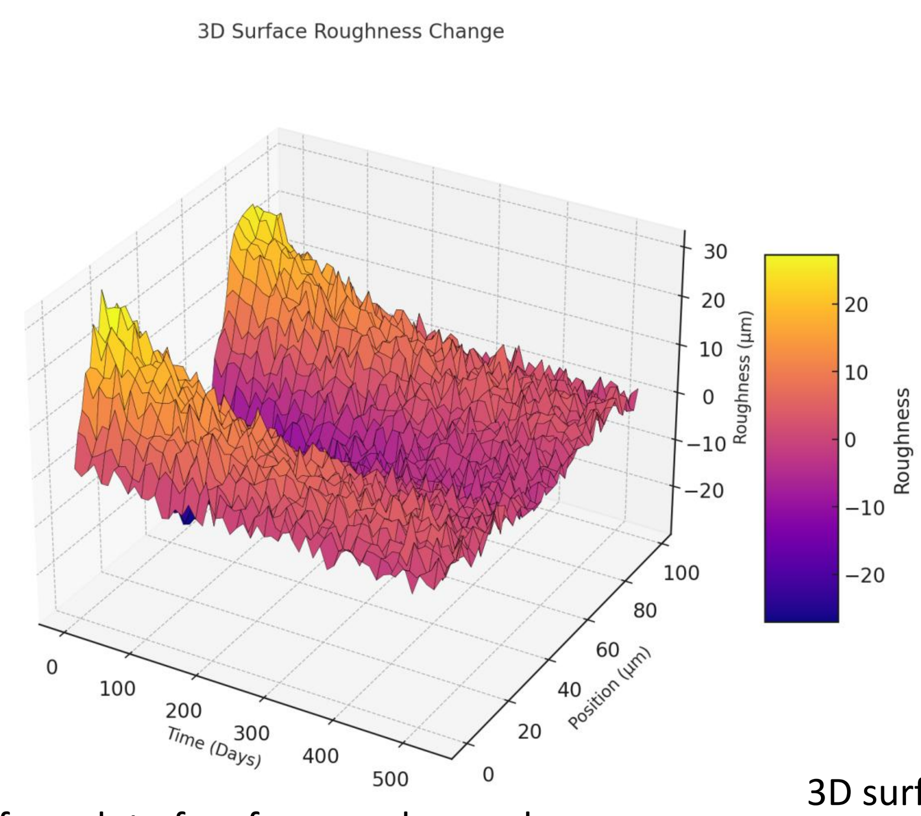


3D surface plot representing limestone degradation

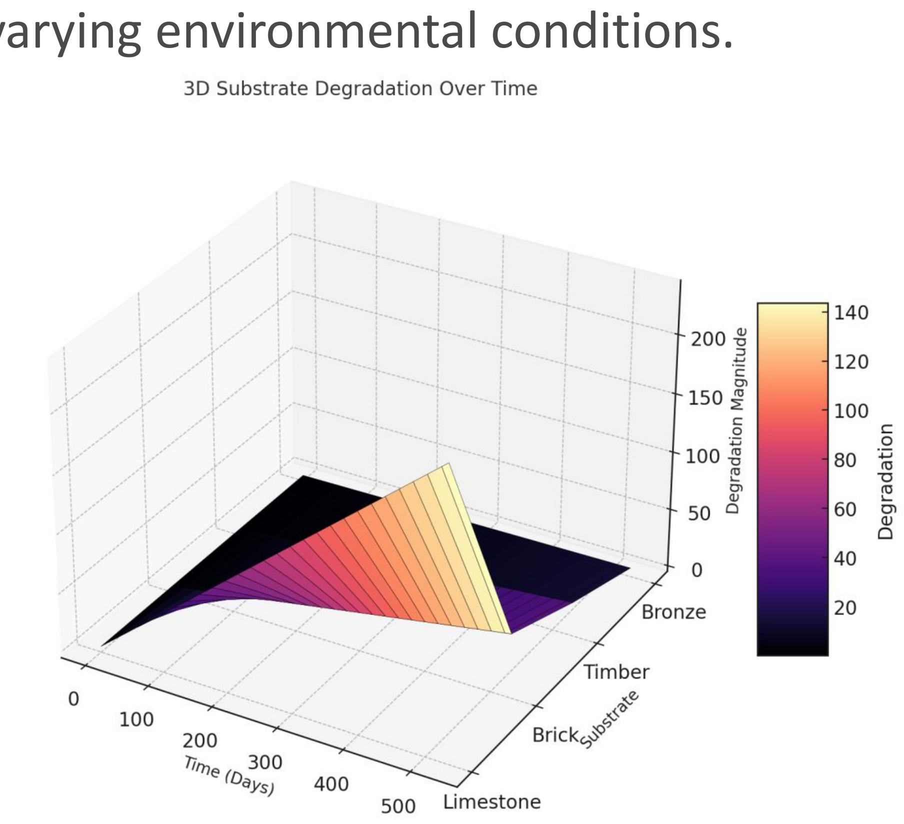

Selected samples were examined under SEM after the exposure but before the mechanical tests.

RESULTS & DISCUSSION

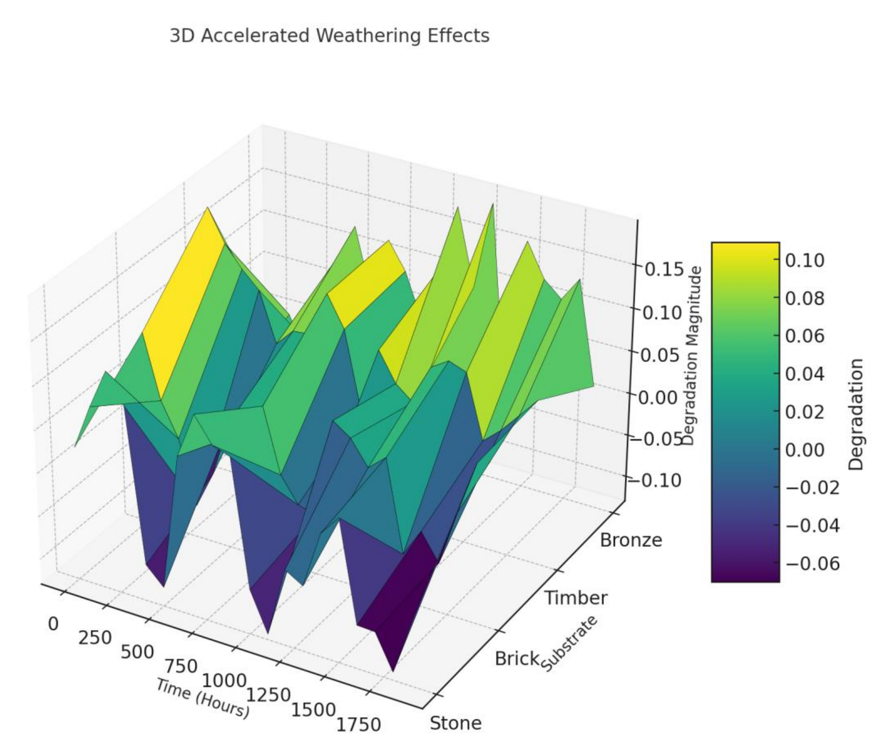
Preliminary results indicate that coatings infused with silica-based nanocomposite demonstrate exceptional moisture and contaminant penetration resistance while preserving the substrate's permeability. Polyurethane-based self-healing systems have been proven to extend service life, reducing overall maintenance needs by autonomously repairing minor damage. Field evaluations illustrated minimal cracking, peeling, or discolouration across substrates, underscoring these coatings' resilience to varying environmental conditions.



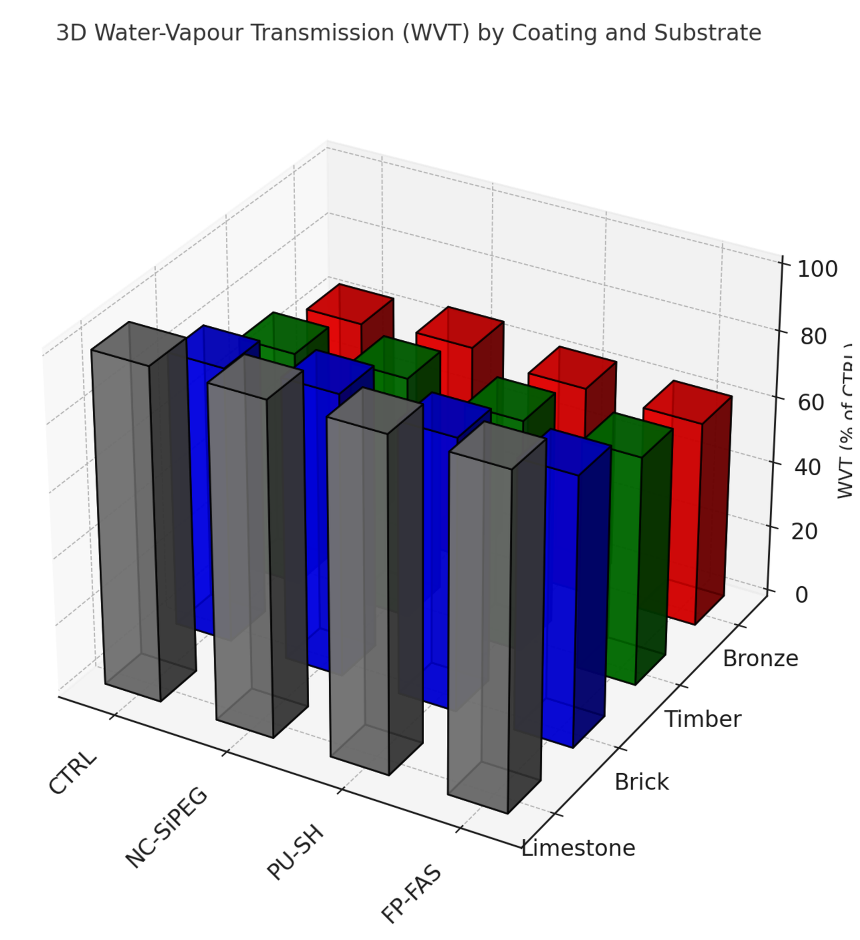
3D surface plot of surface roughness change over time and position



3D surface of substrate degradation over time for four materials



3D surface plot of accelerated weathering effects



3D bar chart of water-vapour transmission (WVT) percentages across coatings and substrates

CONCLUSION

The study combined laboratory ageing tests with field exposure data and stakeholder cost–benefit evaluation to show that nanocomposite and self-healing coatings provide simultaneous improvements in moisture control and stability as well as life-cycle economy while maintaining breathability and reversibility. Performance differentials aligned with our tripartite hypothesis: Hybrid sol–gel matrices deliver optimal compatibility between components. Test results confirmed the three hypotheses by showing material loss reductions up to 91 %, present cost decreases of 18 % and greenhouse gas emissions being cut by half when compared to limewash. Stakeholder preference mapping demonstrated that technological acceptance meets ethical standards for authenticity and environmental safety which points to a new paradigm where protective films function as active interfaces instead of passive barriers. The research establishes modern coatings as fundamental elements in conservation strategies. Targeted coatings demonstrate their effectiveness with field applications which create broad opportunities for economic and sustainable conservation methods for historical structures worldwide.

FUTURE WORK / REFERENCES

Tomasin, P., Mondin, G., Zuena, M., El Habra, N., Nodari, L., & Moretto, L. M. (2019). Calcium alkoxides for stone consolidation: Investigating the carbonation process. *Powder Technology*, *344*, 260–269. https://doi.org/10.1016/j.powtec.2018.12.050
Bülow, A. E., Stitt, J., & Brokerhof, A. W. (2018). I can see further now: Preventive conservation in a changing heritage world. *Studies in Conservation*, *63*(sup1), 35–42. https://doi.org/10.1080/00393630.2018.1504443