Project Call for 2022 ERBE Cohort

MaREI Supervisor	Prof Jamie Goggins
Institution	NUI Galway
Co-Supervisor & Institution (if known – please note this is not a requirement at application stage):	Dr Ajitanshu Mishra (National University of Ireland, Galway), Co-supervisor with expertise in sustainable building materials from UCL or Loughborough University
PhD Proposal Title:	Cost-effective and low-embodied carbon self-healing smart materials for retrofitting heritage buildings
Alignment with ERBE Themes: (200 words max – please specify if the project aligns with 1 or more of the ERBE Themes)	The requirement of research attention towards heritage preservation and reduce energy consumption is well aligned with ERBE CDT Programme research themes. The proposed project aligns with the Technology and system performance theme but will also will address aspects of the flexibility and resilience, and comfort, health and well-being themes.

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PhD Proposal Abstract: (500 words max)	The requirement of research attention towards heritage preservation and reduce energy consumption is well aligned with ERBE CDT Programme research themes. Mortar and building material deterioration is a serious concern for architectural heritage conservation. The utilisation of bacteria for self-healing in concrete is common; however, self-healing capacity of historical lime-based mortars is less investigated. The controlled activation of bacteria for long term healing effect in architectural heritage preservation will be first time investigated. This proposal aims to produce compatible advanced functional building materials that provide repair, long lasting protection and strengthening along with energy-efficiency to the heritage structures without compromising with their sovereignty. This aim will be achieved by development of functional materials with novel encapsulation and immobilization methods and low-cost nano-coatings. The encapsulation and immobilization methods will allow controlled activation of bacteria over a period. The controlled activation of bacteria will result long term strengthening and self-repairing post retrofitting of the structures with these functional mortars. The suitable naturally available strains of Bacillus cohnii, Bacillus pseudofirmus, Bacillus alkalinitrilicus and Ectomycorrhizal fungi will be cultivated/purchased for inclusion in functional repair materials. The most suitable type and proportion of microorganism and method of inclusion will be determined for maximum compatibility over a period. A high compatibility will be further achieved by applying low cost nano coatings on laboratory models developed after characterization of historical building material. The ultrasonic testing will be performed along with mechanical, colorimetric testing and examination of mutual interaction and cohesion between old and new material. The efficiency of functional repair healing method in/on the laboratory samples will be evaluated over a period. The cracks in historical sample and the prepared models, bacterial suspension diffusion assessment will be performed. The experimental part of the proposal will provide data about the performance of the developed functional building materials during extreme loading conditions and energy-efficiency. A finite element model will then be developed and validated using the experimental data, allowing examination of conditions that are not examined experimentally. Finally, a simplified model for predicting the time-temperature variation, load-bearing ability, thermal and residual stresses in functional building materials will be developed and validated. The project should result in the development of functional building repair materials that will allow historical and current structures to heal themselves in the long-term, preserving their aesthetic and functional properties and make them energy-efficient. The project will be addressing one of the most significant

	challenges associated with European architectural heritage conservation; thus, it should have a significant technological, social, and economic impact.

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PhD Proposal Summary for inclusion in Student Call Document: (300 words max – please note the student will be indicating their order of preference for all submitted proposals; please ensure this summary includes a project overview & introduction to the supervisor & institution)	Mortar and building material deterioration is a serious concern for architectural heritage conservation. The utilisation of bacteria for self-healing in concrete is common; however, self-healing capacity of historical lime-based mortars is less investigated. The controlled activation of bacteria for long term healing effect in architectural heritage preservation will be first time investigated. This PhD project aims to produce compatible advanced functional building materials that provide repair, long lasting protection and strengthening along with energy-efficiency to the heritage structures without compromising with their sovereignty. This aim will be achieved by development of functional materials with novel encapsulation and immobilization methods and low-cost nano-coatings. The encapsulation and immobilization methods will allow controlled activation of bacteria over a period. A high compatibility will be further achieved by applying low-cost nano-coatings on laboratory models developed after characterization of historical building material. Laboratory testing and numerical modelling will be used to evaluate the performance of the materials. The project should result in the development of functional building repair materials that will allow historical and current structures to heal themselves in the long-term, preserving their aesthetic and functional properties and make them energy-efficient. The project will be addressing one of the most significant challenges associated with European architectural heritage conservation; thus, it should have a significant technological, social, and economic impact. Prof. Jamie Goggins is a chartered engineer with more than 20 years of experience. He is an Established Professor in NUI Galway, Director of Research & Innovation in the School of Engineering and Principal Investigator and member of the Executive Management team of the SFI MaREI Centre. His core technical expertise is in developing sustainable and resilient structures for buildings and energy infrastructure. He has been principal investigator on over 50 research projects (total project value >€85M).