SUBLime

Sustainable Building Lime Applications via Circular Economy and Biomimetic Approaches

Marie Skłodowska-Curie Actions

European Commission | Horizon 2020 European Union funding for Research & Innovation

OPEN PhD POSITIONS in European Training Network

We are looking for dedicated and highly motivated Early Stage Researchers (ESR), who will join our team to craft the future of lime mortars/plasters in new construction and conservation of the built heritage.

SUBLime description (4 years ETN project starting February 2021)

Lime is one of the earliest industrial commodities known to man and it continues to be one of the essential building blocks of modern Society. Often unseen, it is an enabling material essential in many industries and value chains e.g. steel. The global lime market is anticipated to approach the value of 44 Billion Euros by the end of 2026 and resulting in various growth opportunities for key players. The SUBLime network aims to develop the most advanced technology in lime-based materials modelling and characterization for industrial use that will go beyond the limitations of existing solutions in new construction and conservation in the built heritage. It is dedicated to recruit and train fifteen PhD students in multiple scientific and engineering fields towards a better understanding and development of sustainable innovations in both added functionalities and sustainability aspects in lime mortars and plasters, strongly based on novel biomimetic and closed loop recycling approaches, thus embedding the circular economy approaches. The project covers the main features of lime-based applications analysis, including material characterization, numerical non-linear modelling of multiphysics behaviour, functionality and sustainability in lime use and performance-based design. These new developments include capacities such as: self-cleaning, hydrophobicity, self-healing, enhanced CO_2 capture capabilities, and considers closed-loop recycling. The cross-disciplinary approach throughout the SUBLime value chain, leveraging the knowledge of the academic (6) and industrial members (11), such as lime producers, mortar/plaster/block producers and end-users for the prioritization of industry needs, will dramatically increase the transfer of scientific knowledge to the lime-consuming industries in the EU.

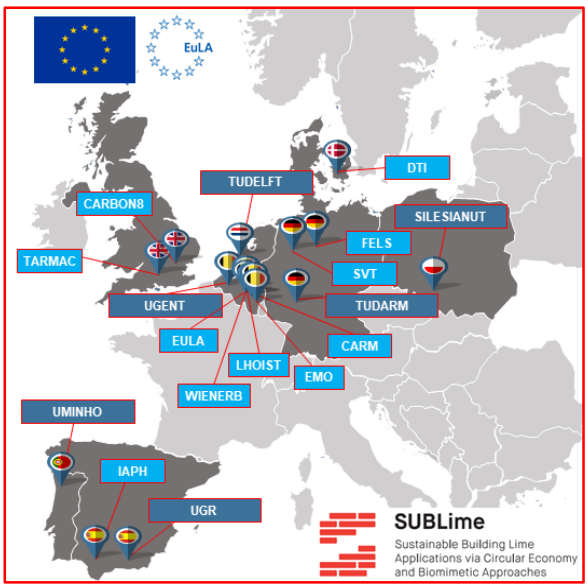
SUBLime – Sustainable Building Lime applications via Circular Economy and Biomimetic Approaches

⇨ **6 Academic Partners:**

- University of Minho (PT) (Coordinator)
- University of Granada (ES)
- TU Delft (NL)
- Ghent University (BE)
- Silesian University of Technology (PL)
- Technische Universität Darmstadt (DE)

⇨ **11 Industrial Organizations:**

- European Lime Association (BE)
- Lhoist (BE)
- Wienerberger (BE)
- Instituto Andaluz del Patrimonio Histórico (ES)
- Fels (DE)
- Tarmac (UK)
- Carbon8 (UK)
- European Mortar Industry Organization (BE)
- Carmeuse (BE)
- Danish Technological Institute (DK)
- Sievert (DE)



15 available PhD positions: 3 years' studies hosted by different Academic Partners

- **Original research projects, within a Marie-Sklodowska-Curie Innovative Training Network**
- **Participate in worldwide training workshops**
- **Visit other network partners during secondments**
- **Very attractive fellowships**
- **Excellent opportunities to enhance your career prospects**

Academic Partners	PhDs
UMINHO (PT)	4
UGR (ES)	2
TUDELFT (NL)	2
UGENT (BE)	3
SUT (PL)	2
TUDa (DE)	2

Highly specialised Universities and worldwide leading Industrial Partners training network

The SUBLime (SUstainable Building Lime applications via Circular Economy and Biomimetic Approaches) network is firstly dedicated to educate/train researchers in multiple scientific and engineering fields aiming a better understanding and development of sustainable innovation solutions for lime mortars/plasters in new construction and conservation of the built heritage. The project covers the main features of lime-based applications in the masonry construction (both joints and plastering mortars), including material characterization, numerical non-linear modelling of multi-physics behaviour, functionality and sustainability in lime use, all within a framework of performance-based design. Innovations are focused in both added functionalities and sustainability aspects in lime mortars and plasters, strongly based on novel biomimetic and closed-loop recycling approaches. SUBLime introduces and develops new sustainable solutions with added functionalities such as self-cleaning, (super-) hydrophobicity, self-healing or enhanced (catalysed) CO_2 capture capabilities, and considers closed-loop recycling. As an example, at the end of life (EoL) of a building, unlike cement, lime has compatible strength to allow the masonry to be separated and fully recycled.

The recruited Early Stage Researchers (ESRs) will take advantage of the most sophisticated experimental and analytical techniques, as well as numerical tools, to model, design and predict the behaviour of lime-based applications and leveraging the knowledge of the academic and industrial members of this network. Being trained in scientific, technical and soft skills, by direct involvement in the development of novel building lime technologies, these ESRs are the next generation of highly employable scientists and engineers in this sector and related areas.

The research training in the SUBLime network is structured to take full advantage of intensive cooperation between academia, lime producers, mortar/plaster/unit producers, and end-users. This cross-disciplinary approach throughout the SUBLime value chain will dramatically increase the transfer of scientific knowledge to the lime industry in the EU, ensuring social, environmental and product progress.

The main scientific objective of the SUBLime network, in the context of lime-based applications in construction, is to develop/transfer biomimetic-based sustainable technologies targeted to reduce CO_2 emissions, to support current and future needs of society, by using advanced computational and experimental multi-scale strategies. The focus is on new construction and conservation of the built heritage.

Eligibility Criteria

Early-stage researchers (ESR) are those who are, at the time of recruitment by the host, in the first four years (full-time equivalent) of their research careers. This is measured from the date when they obtained the degree which formally entitles them to embark on a doctorate, either in the country in which the degree was obtained or in the country in which the research training is provided, irrespective of whether or not a doctorate was envisaged.

Conditions of international mobility of researchers: Researchers are required to undertake trans-national mobility (i.e. move from one country to another) when taking up the appointment. At the time of selection by the host organisation, researchers must not have resided or carried out their main activity (work, studies, etc.) in the country of their host organisation for more than 12 months in the 3 years immediately prior to their recruitment. Short stays, such as holidays, are not taken into account.

English language: Network fellows (ESRs) must demonstrate that their ability to understand and express themselves in both written and spoken English is sufficiently high for them to derive the full benefit from the network training.

Benefits and Salary

The successful candidates will receive an attractive salary in accordance with the MSCA regulations for early stage researchers. The exact salary will be confirmed upon appointment and is dependent on the country correction factor (to allow for the difference in cost of living in different EU Member States). The salary includes a living allowance, a mobility allowance and a family allowance (if married or with children). The guaranteed PhD funding is for 36 months (i.e. EC funding, additional funding is possible, depending on local Supervisor). In addition to their individual scientific projects, all fellows will benefit from further continuing education, which includes internships and secondments, a variety of training modules as well as transferable skills courses and active participation in workshops and conferences.

Recruitment Commitee

The Recruitment and Skill Progress Committee (RSPC) establishes well-defined recruitment criteria to be used by all partners and ensure fairness of selection, in accordance with the Charter & Code for researchers. The pre- and final selection is made in a collective, open, transparent and merit-based process, led by the RSPC. The candidates apply for a maximum of three specific ESR projects and list their order of preference. The supervisors provide the names of their preferred candidates to the RSPC, which in turn produces a short list of candidates. As such, a limited number of fellows will be invited to be interviewed, during which, each preselected candidate will have to give a presentation. All preselection and final recruitment will be in line with the European Charter for Researchers. The recruitment strategy of SUBLime fully complies with the Code of Conduct definition of merit.

Key Dates

- **Deadline for applications: 14/09/2020**

How to apply

The application should contain the following documents (**all provided in English language**):

- ETN-SUBLime ESR application form (download it here) to be filled
- Curriculum Vitae
- Cover letter: Refer to ETN-SUBLime project and ESRs Recruitment procedure, indicate clearly the ESR positions to which you are applying with your order of priority (maximum of three). Argue your motivation to apply for these specific ESR position(s). Discuss in bullets your skills which are specifically adapted to the chosen topic, and provide supporting evidence to your arguments.
- Certificate of Master's Degree (or equivalent) with transcript of records
- Proof of English proficiency
- Recommendation letter(s) from previous supervisors or employers
- List of publications, if applicable
- Manuscript of listed publication, if applicable
- Work experience certificates, if applicable

All official certificates should be provided in their original European language or with an associated official English translation for non-European documents.

In case of open questions, please contact the main supervisor of the ESR you are looking for (see tables below)

All documents should be send by email to: applications@sublime-etn.eu, with the subject: [SUBLime] – recruitment ESR. Application should be sent until the deadline presented in this document. For more information please check www.sublime-etn.eu/job/.

Contacts

General Coordinator	Deputy Coordinator	Project Manager	Chair of Recruitment and Skill Progress Committee (RSPC)
Prof. Paulo B. Lourenço	**Prof. Miguel Azenha**	**Dr. João Pereira**	**Prof. Nele De Belie**
ISISE – Institute for Sustainability and Innovation in Structural Engineering University of Minho Department of Civil Engineering Azurem, 4800-058 Guimaraes Portugal pbl@civil.uminho.pt	ISISE – Institute for Sustainability and Innovation in Structural Engineering University of Minho Department of Civil Engineering Azurem, 4800-058 Guimaraes Portugal miguel.azenha@civil.uminho.pt	ISISE – Institute for Sustainability and Innovation in Structural Engineering University of Minho Department of Civil Engineering Azurem, 4800-058 Guimaraes Portugal jpereira@civil.uminho.pt	Ghent University Department of Structural Engineering and Building Materials Technologiepark-Zwijnaarde 60 9052 Gent, Belgium Nele.DeBelie@UGent.be

Available positions

Open! Click here for more details.	**ESR1** **TUDELFT**	Start date: **May 2021**	Duration: **36 months**	Lead Supervisor: **Prof. Guang Ye** **G.Ye@tudelft.nl**

Extending a microstructural simulation framework towards lime-based materials

Objectives: The objective is to build up a numerical model which can simulate the chemical reaction process, and microstructural formation of lime-based materials. The generated microstructures will be used as input for predicting the physical and transport properties of lime-based materials, and act as a tool for designing new generation of sustainable/functional lime mortars/plasters. The focus will be mainly in the development of reaction kinetics model which will consider the chemical composition of lime, liquid to powder ratio and reaction temperature. In the kinetics model the volume fraction of reaction production (mainly calcium hydroxide), unreacted lime and capillary pores will be simulated explicitly. In the microstructure simulation, as a start point the existing cement hydration and microstructure model HYMOSTRUC3D developed at TUDELFT will be extended for the simulation of lime-based materials. Based on the reaction kinetics model developed above, the physical and chemical process, i.e., the dissolution, nucleation and growth of lime will be simulated by coupling ion transport and thermodynamics, where Lattice Boltzmann methods will be employed to deal with ions transport, while Phreeqc will be employed to simulate the chemical reaction and thermodynamics. In the end a comprehensive microstructure of lime mortar can be

obtained, including the pore structures, pore solution chemistry, crystal phases and amorphous phases. The models will be implemented in a commercial software as an external user subroutine (or API programming), allowing the industrial partners to use them for their simulations.

Open! Click here for more details.	ESR2 TUDELFT	Start date: May 2021	Duration: 36 months	Lead Supervisor: **Prof. Guang Ye** **G.Ye@tudelft.nl**

From microstructural features to estimation of physical/mechanical properties at micro-scale and meso-scale (paste and mortar level)

Objectives: The objective is to upscale the microstructural properties from paste level to meso-scale in mortar level to study the physical and mechanical properties of lime-based mortar. The physical and mechanical properties include water permeability, moisture and ion transport, creep and shrinkage. More specifically, three tasks are defined: a) Simulation of the mortar structure: lime mortar is a composite material consists of bulk (lime) paste, sand and interfacial transition zone (ITZ) between lime paste and sand. The lime paste in micro-level will be upscaled by volume average method in meso-scale at mortar level. The simulated mortar structure will be used as input to simulate physical/mechanical properties mentioned above. This simulated mortar structure will be also used to predict the elastic modulus, tensile behaviour and crack development in mortar level; b) Estimation the transport properties of lime-based paste and mortar: in micro-level the percolation phenomenon of microstructure of lime paste is studied and the representative elementary volume (REV) of lime paste and mortar will be determined. The simulation results will be validated using experimental results; c) Shrinkage and creep properties of lime-based paste and mortar: this task will investigate the volume stability (creep and shrinkage) of lime-based paste and mortar and to develop models for predicting shrinkage induced cracking and estimating the creep for applications in practice. The different type of lime, water/lime ratio and curing condition will be considered in the design of shrinkage and creep experiments.

Open! Click here for more details.	**ESR3** **UGranada**	**Start date:** **May 2021**	**Duration:** **36 months**	**Lead Supervisor: Prof. Carlos Navarro** carlosrn@ugr.es

Lime-based mortars and plasters with added functionality: a biomimetic approach

Objectives: The objective is the development and testing of novel methods to add extra functionalities to lime-based mortars and plasters via a nanoparticle-based, biomimetic strategy. Lime-based mortars and plasters are exposed to water/humidity and pollutants/dirt accumulation that can ultimately lead to soiling and degradation, hampering their long-term durability. To avoid these problems, two strategies will be tested and validated here. One involves the modification of the surface properties (wettability) via the application of nanoparticles that can be integrated in the fresh mix or applied afterwards on the set material surface. Such nanoparticles can impart nano- and microrugosity, fostering a transition from a Laplace regime to a Cassie-Baxter regime leading to enhanced hydrophobicity or even superhydrophobicity. This strategy is based on nature, which through million years evolution have designed (super)hydrophobic structures, such as the Lotus leaves which through hierarchical nano- and microstructures enable extreme hydrorepellency. To enhance surface protection nanoparticles will also be applied along with polydimethylsilane (PDMS). Specific nanoparticles with known photocatalytic activity, e.g., anatase (TiO2), will be also tested for self-cleaning functionality. Interestingly, such nanoparticles could also contribute to surface rugosity, thereby potentially playing a dual functional role: self-cleaning and (super)hydrophobicity, aspects that need to be explored and validated.

Open! Click here for more details.	**ESR4** **UGranada**	**Start date:** **May 2021**	**Duration:** **36 months**	**Lead Supervisor: Prof. Carlos Navarro** carlosrn@ugr.es

New CO_2 capture solutions on lime-based mortars

Objectives: Lime-based mortars and plasters naturally set and harden by carbonation, contributing to the long-term effective mineral sequestration of atmospheric CO_2. However, little is known on the mechanisms and kinetics of this process. This precludes the design and implementation of effective methods to speed up this setting reaction and to optimize CO_2 mineral capture. Here we plan to conduct a detailed research of the mechanisms and rate-controlling steps of lime carbonation. For this task we also will explore the possibilities of using lime-rich industrial waste materials (e.g., carbide lime or other alkaline wastes such as bottom - or fly-ash from carbon power plants) as a binder and/or additive (with pozzolanic activity) for CO_2 capture and utilization. Means to accelerate the carbonation process will also be explored by using a biomimetic approach. Overall, the main objectives are: (a) Gain a better understanding on mechanisms and kinetics of lime-binders carbonation; (b) Evaluate the possibility of using waste lime (e.g., carbide lime) and other industrial Ca-rich alkaline wastes as an alternative to hydrated lime for the design and application of lime-based mortars and plaster with the added-value of enhanced CO_2-capture and utilization; (c) Gain insight on the mechanisms and effects of natural enzymes such as carbonic anhydrase for the acceleration of the carbonation (setting via CO_2 mineral capture) of lime-based materials; (d) Explore the possible application of Zn-based MOFs as a biomimetic strategy for the accelerated CO_2 capture and setting via carbonation of lime-mortars and plasters.

Open! Click here for more details.	**ESR5** **UGent**	**Start date:** **May 2021**	**Duration:** **36 months**	**Lead Supervisor: Prof. Nele De Belie** Nele.DeBelie@UGent.be

Self-healing in lime based mortars

Objectives: Both analytical science and practical experience have indicated that providing lime mortars with an early strength avoids failure due to environmental conditions such as frost or strong solar radiation. Instead of expensive and/or toxic chemicals, the rapid hardening of lime mortars will be obtained through bacterial CO_2 production and calcium carbonate precipitation. When cracks do occur in lime-based mortars, they possess an autogenous healing capacity, which is a well-known phenomenon, but the conditions have not been the focus of much research until now. Parameters affecting the self-healing capacity (lime composition, water and CO_2 concentration, temperature, among others) will be studied as a basis, and measures for improvement proposed. Application of bacteria that induce precipitation of calcium carbonate at the interface of building stone and lime mortar/plaster may change the surface roughness and improve the bond due to the compatibility between the precipitate and the lime and reduction of the sorption characteristics of the stone. In addition, bacteria will be added into lime mortar, to induce $CaCO_3$ precipitation in occurring microcracks, and their viability will be studied after various time spans. Brick-mortar assemblies with bacteria at the interface or in the mortar, will be loaded to study revival of bacteria and healing of microcracks. Need for protection of bacteria, and use of spores instead of vegetative cells will be considered. Water availability during carbonation of the lime can be tailored by addition of superabsorbent polymers.

Open! Click here for more details.	ESR6 UGent	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Nele De Belie Nele.DeBelie@UGent.be

New possibilities of recycling and new admixtures in lime-based mortar

Objectives: To enhance the sustainability of the construction industry, the construction and demolition waste should be recycled, as far as possible in high value applications. The overall quality of recycled concrete aggregates is generally lower than that of natural aggregate, due to the mortar that remains attached to the natural aggregate. Studies on the use of recycled concrete aggregates in concrete show that various mechanical and durability properties can be improved, if the attached mortar can be separated better from the recycled aggregates. When using a classic recycling process, exhibiting only one crushing action by a jaw or impact crusher, approximately 50 wt% of recycled aggregates and 50 wt% of recycled sand extremely high in filler (<63 µm), can be obtained. To improve this sand quality, the fines can be further separated from the sand. Another possible source of fines is washing sludge from aggregates production. The fines induce a high water and admixture demand in concrete, may have a higher content of SO3, etc., making their use difficult. These fines, however, could find a positive use in lime mortars. Since they come as fines, the need to grind them as raw materials is omitted. Furthermore, the lime mortar could benefit from the unreacted cement and/or uncarbonated calcium silicate hydrates that are present, as nuclei for the further hydration reactions. To compensate for the water demand and to improve the mortar's performance, the combination with various types of (new) admixtures will also be investigated.

Open! Click here for more details.	ESR7 UMinho	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Miguel Azenha miguel.azenha@civil.uminho.pt

Fresh properties and early age behaviour of lime-based mixtures for masonry

Objectives: To understand and describe the current practices of construction of lime-based mortars in the European area, with focus on actual industry testimonials, and with focus on application processes and the relevant important properties at both fresh stage and early hardened stages. To gather a representative set of materials and promote the necessary experimental research that confirms the differences felt within Europe in this concern, and make a systematization. The breadth of the study on existing practices that is already very challenging, will be further widened by a connection with the increasingly important field of digital fabrication, by targeting specific studies towards the feasibility of lime-based mortars in such context. It is expected that very positive insights are brought about in this unexplored field, in view of the acknowledged improved fresh properties of mortars in lime binders included. This ESR7 will also interact directly with other ESR's operating in the scope of WP2 and WP3, with teamwork being conducted towards the adequate tailoring of the mixes in view of the important fresh and early age properties.

Open! Click here for more details.	ESR8 UMinho	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Miguel Azenha miguel.azenha@civil.uminho.pt

Industry oriented experimental techniques for lime based materials and structures

Objectives: This plan has two fundamental objectives: (a) to innovatively apply and adapt experimental techniques to lime-based mortars and structures in ways that make them feasible for in-situ application, and not just on research; (b) to deploy the original techniques developed, together with standard technologies, in order to execute systematic verification of the feasibility of mortar mixes studied within the consortium in view of the validation of the tables of Eurocode 6 for masonry mortars. This will allow a directly applicable and validated framework to be deployed in industrial context, with significant added value for future constructions in terms of quality control and performance requirements satisfaction assurance. Specific efforts will be done to allow information to be attained in-situ from expedite medium-to-low-cost systems that allow generalization in actual construction practices. Three main lines will be pursued in such concern: 1) advanced used of knowledge on UPV measurement; 2) retailoring the EMM-ARM (Elasticity Modulus Measurement through Ambient Response Method) for application in lime mortars to study the very early stiffness kinetics; 3) Deploy cyberphysical systems based on development boards.

Open! Click here for more details.	ESR9 TUDa	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Eduardus Koenders koenders@wib.tu-darmstadt.de

Cradle-to-grave sustainability of novel lime-based materials

Objectives: to quantify improvements in Environmental and Economic sustainability indicators of SUBLime innovative solutions in comparison to current lime-based mortars and plasters. LCA analysis will include baseline scenario and following Innovative solutions: a) use of lime waste materials such as paper mill Ca(OH)2 sludge or carbide lime (a by-product of the acetylene industry), taking into account impacts of purification steps versus avoided impacts of landfilling and related environmental hazards; b) novel biomimetic metal-enzymes as carbonation accelerators, increasing CO_2 capture and reducing greenhouse gases; c) hydrophobic and self-cleaning lime-based mortars and plasters and self-healing mortars with increased durability, which through increased service life reduce use of raw materials and creation of waste; d) use of recycled fines from the construction industry in lime-based applications, reducing the need for virgin raw materials; e) Life cycle inventory data will be obtained from existing databases as well as from the lime producers and EULA. The functional unit will comprise multiple criteria: a volume of the mortar/plaster material as well as including functional specifications such as strength, thermal properties. Open source (e.g. Open LCA, CCaLC, Bees) and commercial (SimaPro) tools will be used.

Open! Click here for more details.	ESR10 UGent	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Veerle Cnudde Veerle.cnudde@ugent.be

3D multi-scale structural characterization and long-term performance related to efflorescence

Objectives: Characterize the 3D microstructure of the current lime-based mortars and the new generation of lime-based mortars and plasters using multi-scale high resolution X-ray imaging. Experimentally the product's performances will be validated with special attention towards efflorescence and salt damage. This ESR will be in close collaboration with the other ESR's as the microstructural characteristics can be used as a tool for the modellers and the 3D imaging can serve as an input for validation. The composition of the newly developed mortars (binder, additives, grain size) is known to influence greatly the efflorescence. Other important elements are the variability of the pore structure of the mortar during hydration and carbonation, and the change once in contact with porous bricks. Efflorescence will be tested using an accelerated efflorescence test. The interest of this test is that it involves a series of wetting-wicking cycles under specific climatic conditions on a combined specimen of mortar and brick. The actual test can be preceded by an accelerated carbonation of the mortar, which would allow testing the mortar at various ages. This study will be complemented by dynamical monitoring of physical changes inside the mortars during salt efflorescence using dynamic X-ray imaging and ESEM.

Open! Click here for more details.	ESR11 UMinho	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Paulo B. Lourenço pbl@civil.uminho.pt

Thermo-physical and short term mechanical properties of lime-based mortars: upscaling from micro to macro scale

Objectives: The objective is to bridge the gap between knowledge generated at the micro and macro scales, towards the prediction of actual mortar behaviour, acting as a construction material. This ESR focuses mainly in thermo-physical and short term mechanical properties, such as: thermal conductivity, specific heat, moisture diffusion, compressive/tensile strength, bond (e.g. brick vs mortar) and E-modulus. This work will be focused on strategies for upscaling properties obtained at the microstructural level to larger scales, using two distinct approaches: (a) a fully numerical approach based on lattice models or finite element models that upscale the REV's throughout the scales; (b) a fully or semi-analytical strategy based on extending standard procedures such as the Mori-Tanaka or other schemes for homogenization. At the larger scales, 3 particular challenges are expected: (a) the need to consider Interface Zone between the matrix and the aggregates, which still remains difficult in other materials that have been subject of significant research in the past (e.g. cement-based mortars); (b) the inherent challenges to upscaling from mortar-brick towards masonry behaviour; (c) issues related to understanding and being able to predict efflorescence of salts on masonry units, with salts coming from the mortars. The models will be implemented in a commercial software as an external user subroutine (or API), allowing the industrial partners to apply them.

Open! Click here for more details.	ESR12 SilesianUT	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Jan Kubica jan.kubica@polsl.pl

Bridging from micro to macro scale on durability and long term mechanical properties including irreversible expansion

Objectives: The objective is to bridge the gap between knowledge generated at the micro and macro-scales, towards the prediction of long term behaviour of lime-based and/or modified mortars as well as masonry taken as composite material in relation to the durability, mainly characterized by in-plane deformations and crack resistance. The focus will be mainly in methods of micro and macro modelling of mortar-brick long term behaviour including shrinkage, creep and plastic deformations and prediction of changing of thermal conductivity, moisture diffusion, compressive/bending/tensile strength, bond strength, E-modulus, shear modulus and Poisson's ratio. The following are expected: (a) the determination of main mechanical properties changes connected with delayed effects (creep, shrinkage) for lime-based mortars and masonry (b) development of strategies for upscaling properties (scale effects) obtained at the microstructural level to larger scales (macro scale), mainly analysed masonry as 2D structures (orthotropic body), and representative for masonry walls. This work will be carried out in three ways: (a) experimental tests on long-term behaviour and properties of materials; (b) fully numerical FEM models that upscale the REA's (Representative Element Area) throughout the scales, (c) analytical or semi-analytical methodology based on modification of the material properties and/or analytical calculation methods for masonry as homogenized material.

Open! Click here for more details.	ESR13 UMinho	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Graça Vasconcelos graca@civil.uminho.pt

Large scale testing & simulation - shrinkage & expansion

Objectives: The objective is to understand clearly the benefits of the developed mortars in real case applications, with a focus on shrinkage and expansion. It is well known that the shrinkage behaviour is strongly dependent on moisture states, restraint and strain capacity of the binder. An important interplay with creep is also known, bringing further complexity to the problem. Additionally, irreversible expansion is a much relevant detrimental effect on clay bricks and tiles, which depends much on moisture uptake and mortar stiffness. This activity of this ESR will be linked with all other ESRs, benefiting from the knowledge and tools developed at lower scale. The work will focus on an experimental campaign, including masonry wallets on uniaxial compression, expansion / shrinkage of masonry wallets, expansion of clay units and wall testing under restrained movement (or indirect loading). Tests on mortar shrinkage from other ESRs will be used in the analysis. After validation of the experimental results with a FEM meso-scale and a homogenized model, parametric studies will be carried out to provide estimates of natural periods for masonry buildings, behaviour factors and overstrength ratios for masonry elements and buildings, design rules masonry joints, all with the newly developed mortars.

Open! Click here for more details.	ESR14 SilesianUT	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Jan Kubica jan.kubica@polsl.pl

Behaviour of masonry made of lime-based mortars based on large scale testing & simulation – subsoil settlements & earthquake

Objectives: The objective is to study the behaviour of masonry made of different types of units (clay and/or Ca-Si solid bricks and the widest being in use hollow blocks) and lime-based and/or modified mortars subjected to in-plane horizontal and vertical shearing forces produced by seismic actions and cyclic loads or irregular vertical displacements (e.g. irregular settlements) with and without some delay influences (creep and shrinkage). Based on the experimental investigations of larger specimens (with and without plastering) and some specimens in real scale (masonry walls one storey height and length up to 4.5m) the load-bearing capacity as well as in-plane deformations and crack resistance will be analysed. This project will be carried out in three ways: (a) determination, based on physical and mechanical properties of lime-based mortars, the bond strength of mortars to masonry units and its self-healing or crack resistance enhancement also by addition of different types of short flexible fibres; (b) prediction of behaviour of masonry larger scale elements under horizontal cyclic loads or statically vertical shearing based on numerical simulations, validated by large scale test data; (c) analytical or semi-analytical methodology based on modification of the material properties and/or calculation methods for masonry large structures taken as homogenized material. The theoretical models will be implemented in a commercial software or incorporated into calculation procedures.

Open! Click here for more details.	ESR15 TUDa	Start date: May 2021	Duration: 36 months	Lead Supervisor: Prof. Eduardus Koenders koenders@wib.tu-darmstadt.de

Cradle-to-cradle sustainability of lime based constructions systems

Objectives: To compare Environmental, Economic and Societal sustainability indicators between the current and the SUBlime innovative technologies for lime-based construction unit. Life cycle inventory data will be obtained from existing databases as well as from the lime producers and EULA. Based on cradle-to-gate inputs from ESR9, ESR15 will widen the LCA scope to consider in a more advanced approach the following life phases of the construction unit: a) construction phase: current versus digital fabrication technologies; b) use phase: models for CO_2 capturing, service life, operation, maintenance and retrofitting of lime-based constructions; c) end-of-life processes: where lime-based components are separated from bricks and used in closed loop recycling. The LCA will consider the predicted long-term performance of elements at construction scale under real exposure conditions, by collaboration with ESR12, 13 and 14 on service life and CO_2 capture predictions.

More details about SUBLime project, requirements for the candidates and recruitment procedure: www.sublime-etn.eu/jobs/