

French Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes one of the PhD subjects proposed by the French Polytech network. The network is composed of engineering schools/universities. The document also provides information about the supervisor.

Supervisor information	
Family name	AMZIANE
First name	Sofiane
Email	sofiane.amziane@uca.fr
Web reference	https://scholar.google.com/citations?user=6w5ykSAAAAAJ&hl=fr&oi=ao
Lab name	Institut Pascal
Lab web site	https://www.institutpascal.uca.fr/
Polytech name	Polytech Clermont
University name	Clermont Auvergne University
Country	France

PhD information	
Title	Sino-French urban cooling strategies for mitigating urban heat islands: integrated modelling, passive solutions and climate-resilient urban design
Main topics regards to CSC list (3 topics at maximum)	V-10 Ecological variation of environment and ecological design V-11 Change of world climate and climatic forecasting VI-4 Intelligent construction

Required skills in science and engineering	Background in civil engineering/building physics, urban climate, energy or materials science; skills in heat and mass transfer, microclimate modelling, data analysis and tools such as Python, GIS, ENVI-met, COMSOL or TRNSYS.
---	--

Subject description (two pages maximum including biblio)

Urban heat islands are becoming a major challenge for dense metropolitan areas exposed to climate change. They increase outdoor heat stress, cooling energy demand and health risks during extreme summer periods. The phenomenon is commonly explained through the urban energy balance, in which radiation trapping, heat storage in mineral surfaces, anthropogenic heat release and reduced evapotranspiration increase urban temperatures compared with surrounding rural areas [1,2]. Recent studies on urban climates also show that climate change requires adaptation strategies to be assessed across several scales, from materials and surfaces to districts and building energy demand [3].

The proposed PhD will develop an integrated Sino-French research framework to analyse, model and compare urban cooling strategies against urban heat islands. Shanghai provides a relevant Chinese case study because the city has connected low-carbon development, sea-level rise adaptation, flood protection, digital climate governance and urban heat island mitigation in its planning framework [4,5]. In France, urban cooling policies and operational guidance also emphasise the need to prepare cities for more frequent heatwaves while limiting dependence on active air-conditioning [4,5]. The Sino-French comparison will make it possible to test solutions under contrasted urban densities, climates, governance frameworks and material practices. Within this framework, Tongji University, Shanghai, through Prof. Hui Li and his research team, will act as the Chinese academic partner for the Shanghai case study. The Chinese partner will support the identification of a relevant urban study area, the discussion of local climatic, urban and material data and the interpretation of cooling strategies adapted to the Chinese context. The collaboration will include regular scientific exchanges, supervision support, possible mobility of the PhD student and contributions to joint publications.

The scientific originality lies in a multiscale approach linking material properties, urban morphology and microclimate response. At the surface scale, the work will investigate albedo, porosity, water retention, thermal inertia, evapotranspiration and moisture buffering. Cool pavements and reflective surfaces can reduce heat storage and surface temperature, but their efficiency depends on optical properties, ageing, soiling, maintenance and urban geometry [6,7]. For permeable pavements, recent work shows that the cooling effect is not governed by porosity alone, but also by near-surface water availability, capillary transport and absorption properties [8,9]. This thesis will address three scientific questions : which thermal and hydric parameters control the real cooling potential of urban surfaces ; how water availability, urban morphology and climate limit passive cooling efficiency ; and whether the same solution performs similarly in Shanghai and French urban contexts.

A specific contribution will be the development of an integrated multiscale modelling framework, able to compare scenarios between Chinese and French urban contexts. The model will integrate climate data, urban geometry, surface and material properties, vegetation parameters, water availability and building energy

response. It will be used to simulate present and future heatwave conditions and to compare reflective pavements, permeable and water-retentive surfaces, bio- and geosourced coatings, green roofs, green façades, shaded urban corridors and hybrid combinations. When available, the modelling approach will be supported by experimental or in situ data from monitored surfaces, façades or urban test areas.

The project will also address low-carbon and moisture-active materials. Bio- and geosourced materials are relevant because they may contribute to passive cooling through thermal inertia, moisture buffering and reduced environmental impact. Previous work on raw earth envelopes has shown the interest of hygrothermal characterisation at material, wall and building scales for understanding the relationship between material behaviour, climate solicitation, comfort and energy demand [10]. This background will be extended from the building envelope to the urban microclimate scale.

The assessment will be multicriteria and will include thermal benefit, water demand, embodied carbon, maintenance, ageing, durability, cost, urban integration and possible side effects such as humidity transfer, loss of reflectance or clogging. The expected outcomes are : (i) a Sino-French database of urban cooling solutions and physical parameters ; (ii) an integrated modelling methodology coupling materials, microclimate and building energy response ; (iii) a comparative assessment for Shanghai and French urban context ; (iv) design guidelines for climate-resilient and low-carbon urban districts and (v) the development of a structured Sino-French academic collaboration involving French supervision and Chinese scientific support, with then objective of promoting joint publications, academic exchanges and future research projects on climate resilient urban design.

References

- [1] Oke, T.R. The energetic basis of the urban heat island. *Quarterly Journal of the Royal Meteorological Society*, 108, 1-24, 1982.
- [2] Oke, T.R., Mills, G., Christen, A., Voogt, J.A. *Urban Climates*. Cambridge University Press, 2017.
- [3] Masson, V., Lemonsu, A., Hidalgo, J., Voogt, J. Urban climates and climate change. *Annual Review of Environment and Resources*, 45, 411-444, 2020.
- [4] UNESCO. Climate change education and urban climate action in Shanghai: low-carbon development, sea-level rise adaptation and urban heat island mitigation, 2024.
- [5] Shanghai Municipal People's Government. *Shanghai Master Plan 2017-2035: Striving for the Excellent Global City*, 2018.
- [6] Santamouris, M. Using cool pavements as a mitigation strategy to fight urban heat island: a review. *Renewable and Sustainable Energy Reviews*, 26, 224-240, 2013.
- [7] Wang, C., Wang, Z.-H., Kaloush, K.E., Shacat, J. Cool pavements for urban heat island mitigation: a synthetic review. *Renewable and Sustainable Energy Reviews*, 146, 111171, 2021.
- [8] Seifeddine, K., Amziane, S., Toussaint, E., Ouldboukhite, S.-E. Review on thermal behavior of cool pavements. *Urban Climate*, 51, 101667, 2023.
- [9] Seifeddine, K., Amziane, S., Toussaint, E. Experimental investigation of physical characteristics to improve the cooling effect of permeable pavements. *Construction and Building Materials*, 345, 128342, 2022.
- [10] Belarbi, Y.E., Ferroukhi, M.Y., Issaadi, N., Poullain, P., Bonnet, S. Assessment of hygrothermal performance of raw earth envelope at overall building scale. *Energy and Buildings*, 310, 114119, 2024.