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Optimal implementation of green structures for mitigating urban heat island effects

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Dense urban areas are facing increasing climate-related risks due to the disruption of natural ecosystems. Climate change and the multiplication of mineral, impervious and dark surfaces inside cities contribute to creating artificial microclimates –called urban heat islands– characterized by significant air temperature differences with the surrounding countryside. The revegetation of public places and buildings seems an efficient solution for urban cooling during summer. The lack of quantification of green infrastructures' environmental benefits also affects their implementation and their overall environmental footprint assessment. In addition, current technical solutions employed to vegetate dense urban spaces are rarely adaptable to existing buildings and need major works to be carried out.

Hence, elastic gridshells (large-span doubly-curved lattices) in composite materials are proposed as innovative supports for climbing plants. This type of vegetated structure, which is light and cost-effective, displays an interesting potential for mitigating urban heat island effects. It allows a high geometric versatility to suit different urban configurations and can be planned as a temporary or a long-term solution.

Monitoring of real green infrastructures is required to evaluate their related cooling effect, and particularly the latent heat flux provided by the plants and the soil (i.e. evapotranspiration). For this purpose, an experimental vegetated gridshell prototype has been built in the courtyard of Ecole des Ponts ParisTech (Champs-sur-Marne, France). It has been designed to withstand high mechanical stresses due to various loading cases (weight of the plants, snow and wind loads, accidental actions). "Tree-shaped", it is also easy to duplicate and to connect when large urban spaces are to be covered. The collected thermo-hydric data can then be compared with numerical simulations of heat flows carried out around the structure. Combined with multi-fractal tools, it allows the assessment of the cooling effect through scales. In parallel, a life-cycle analysis that takes into account the thermal benefit attributed to the green structure is performed. In future works, various grid typologies and geometries will be analysed to enhance the thermal and structural performances of the vegetated gridshell, hence reducing costs and materials. The ultimate goal of this research is to develop an effective tool connecting models (structure, fluid dynamics, life-cycle analysis) that assesses the global environmental impacts of such structures. It could be used for city planners to meet environmental targets thanks to resource-efficient blue and green infrastructures.