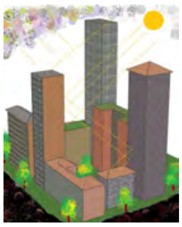
Urban Albedo Computation in high latitude locations: an experimental approach



Heat Risk in London Group
12th June 2018

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Kent | Brunel University London | Loughborough University | EPSRC Engineering and Physical Sciences Research Council

Project aims & objectives

- Incorporate *accurate* calculation and prediction of urban albedo in the planning and design process
- Investigate experimentally the impact of urban fabric on urban albedo, using on London as a case-study
- Develop a catalogue of urban albedo for various materials and geometrical configurations
- Develop an urban albedo calculator, an empirical model to predict changes in urban albedo in relation to changes in urban fabric and solar altitude

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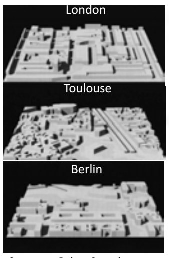
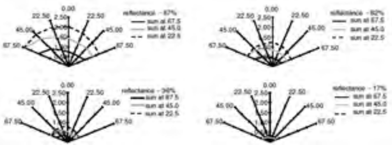
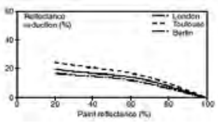
Radiation absorption and urban texture



Steemers, Baker, Crowther, Nikolopoulou, Dubiel (1998) "Radiation absorption and urban texture", *Building Research and Information*, Vol. 26.



Measured distribution of reflected light for the London model for three sun-angles and four different paint reflectances



Reduction in hemispherical reflectance compared with flat plane

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Advisory Group

- Greater London Authority (GLA)
- Ibstock Brick Limited
- SWECO UK Limited
- CIBSE - Resilient Cities Special Interest Group
- Adaptation and Resilience in the Context of Change network
- London Climate Change Programme (LCCP)
- European Cool Roof Council (ECRC)
- Michael Bruse: ENVI-MET
- Leading Academics
  - ✓ Sue Grimmond, Reading
  - ✓ Anna Mavrogianni, UCL

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Project tasks

Task 1: Urban survey and 3D scanning

Task 2: Experimental model

Task 3: Weathering

Task 4: Urban albedo calculator

Task 5: Urban modelling and simulation

Task 6: Dissemination and outreach

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Task 1
Urban survey and 3D scanning

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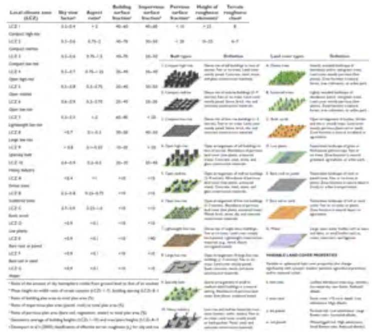
Field surveys

- 50 locations (100x100m) within the Greater London area
- Collection of information on building block typology, canyon geometry, surface characteristics and ground level surface albedo.
- Starting point:
  - ✓80 locations in Greater London studied in terms of UHI in 2002[1]
- Survey locations to include:
  - ✓Urban and semi-urban areas
  - ✓Commercial, residential and mixed-use areas
  - ✓Variation in geometry and building materials
  - ✓Areas within or close to Opportunity Areas[2]
  - ✓Areas with higher average surface temperature profile[3], as modelled with LondUM[4] for the period 26 May 2006 - 31 Aug 2006.

[1]Richard Watkins, The impact of the urban environment on the energy used for cooling buildings, PhD Thesis, Brunel University, June 2002
[2] https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/opportunity-areas/opportunity-areas
[3] https://data.london.gov.uk/dataset/london-s-urban-heat-island
[4] Jonathon Taylor, UCL Institute for Environmental Design and Engineering

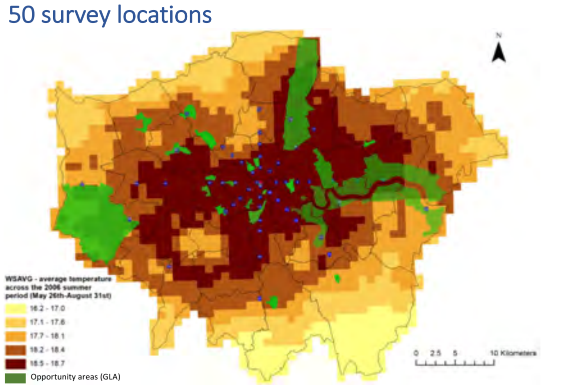
Survey protocol for characterisation of urban geometry

- The study uses the local climate zone (LCZ) system developed by Stewart & Oke[1]
- New sub-zones will be developed for cases that are not represented in the existing LCZs



[1]ID Stewart & TR Oke, Local Climatic Zones for Urban Temperature Studies, Journal of American Meteorological Society, Dec 2012.

50 survey locations



Three areas to be modelled

- Selection criteria based on surveys to date:
  - ✓ Residential, commercial and mixed-use area
  - ✓ Representative building height, materials and façade finish
  - ✓ Buildability

Stanley Terrace (residential)

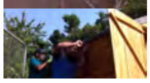
Bishopsgate (commercial)

Mina Road (mixed use)

Task 2
Experimental model

Experimental site

- 20x20m tarmac field located in the UKC campus, Canterbury
- Site preparation
  - ✓ Fencing
  - ✓ Shed to house data logger and provide materials storage



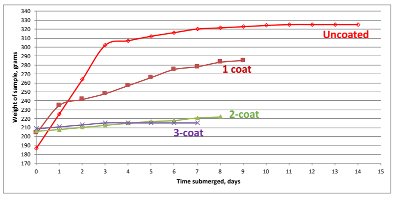
Experimental model – Inceptive concept

- The physical model will be built to 1:10 scale at the UKC campus using an area of 5m radius
- Use of plywood boxes to allow uncomplicated adjustment of model dimensions
- Materials to be attached onto the boxes.
- The initial concept for 300 x 300 x 300mm boxes, 11 mm thick, made in the University workshop, succeeded the use of no nail 250 x 250 x 250mm boxes, 4mm thick, prefabricated and sewn together with cold rolled annealed steel.

Cost & time efficiency →

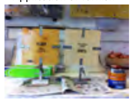
Experimental model – water absorption test

- Four samples (box lids) were submerged in water to assess the absorptivity of the original plywood compared to that with 1 coat, 2 coats and 3 coats of satin yacht varnish.
- The results from this intensive test showed that at least 3 coatings are required as for the plywood to retain its original weight.



Uncoated sample: bend due to water absorption

Application of varnish



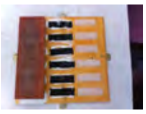
Submerged in water

Experimental model – attaching materials test

- Tests commenced using the most common and heaviest material to be used in the model, bricks.
- As it is the surface characteristics that matters, the study uses brick slips, instead of bricks. These are provided by IBSTOCK.

	building block	red brick slip	lime brick slip	brown brick slip
Height (m)	0.250	0.215	0.215	0.215
Width (m)	0.250	0.065	0.065	0.065
Depth (m)	0.250	0.018	0.018	0.018
Weight (kg)	1.385	0.709	0.600	0.812

- Different velcro-like materials and adhesives were tested to assess the strength of the bond between brick slips and plywood as well as how this evolves in water.



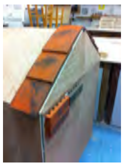

Experimental model – final concept

- Plywood sheets (9mm thick) are attached onto columns comprised of plywood boxes to represent the walls.
- Materials are attached onto these plywood sheets rather than boxes.
- Plywood boxes are used for structural support and adjusting the size of the buildings.






Experimental model – prototype








Data acquisition

- Measurements to commence in July 2018.
- A pyranometer will be suspended 1m above the roof of the tallest block (i.e. 3m high equivalent to 10 storeys) at the centre of the model.
- Additional pyranometers will be placed above the roof (0.5m), above the ground (approx 0.25m) and on wall surfaces at critical positions to capture reflected radiation.
- Pyranometers will be connected to data loggers placed in a nearby monitoring room.
- Model will be equipped with probes to measure soil and air moisture at critical locations as well as surface temperature.
- A weather station close to the model will gather weather data during the measurement periods.
- Different equipment configurations have been explored.