



Department of Civil,  
Environmental and  
Geomatic Engineering

# CAVE AND PEARL AT UCL



# WANT TO CHANGE THE WORLD? YOU'VE COME TO THE RIGHT PLACE.

## An introduction to Civil, Environmental and Geomatic Engineering (CEGE) at UCL

From wildfire smoke and heatwaves to air pollution and viral pandemics, our warming and increasingly urbanised world is affecting our health in new and challenging ways, yet research into how we manage these effects through building design and policymaking is still in its infancy.

At CEGE, we want to facilitate ambitious and groundbreaking research that helps us answer the most pressing questions of our age.

How do human brains and bodies respond to events in real-time?  
How is our health affected by wildfire smoke when mixed with polluted city air and can masks help mitigate its impact? How can we design building

ventilation systems that minimise the negative impacts of poor air quality on our health? How do we reduce the energy demands of our public spaces – such as schools, hospitals, and entertainment venues – while maintaining environments where we can play and work while feeling safe and comfortable? How do we enable safe e-scooter use in cities? And, how does creativity change our perspectives of the world?

We emphasise creativity, communication, and collaboration across academia, industry and public policy, and our award-winning next-generation facilities in East London are at the heart of that approach.

# CAVE



Deepening our understanding  
of airborne and climate hazards





Today, our buildings, people, and culture are subject to an extraordinary array of environmental challenges, from viral outbreaks and air pollution to wildfires and global warming. CAVE has been created to study how to mitigate these threats through deepening our understanding of airborne and climate hazards.

CAVE allows researchers across science, arts, humanities, medicine, and engineering to focus on protecting people from airborne pathogens, pollution, and wildfire smoke as they move around the air in complex public indoor environments, from theatres and restaurants to doctor surgeries, and multi-floor offices and shopping malls to

airports and transport systems. To achieve this, CAVE has two building ventilation systems, which enable researchers to have complete control over ventilation and temperature in the experimental chamber. CAVE's large size – over 200m<sup>2</sup> and 9m high, the size of a two-storey building – allows for full scale indoor environments to be

built inside the laboratory space; in effect it is a building within a building, and each is set up and controlled separately.

In CAVE, realistic buildings can be simulated at full scale, using real components from the construction industry and testing them with people in the space, subject to various

airborne threats, and/or under a range of thermal conditions. By controlling the temperature in the experimental chamber within a range of -4 to 40°C, researchers can observe, for example, how minor and major shifts in thermal comfort might impact individuals and how to improve thermal conditions in an optimal way.

At CAVE, researchers can also study multifactorial problems, such as how temperature might worsen disease outcomes, how to limit disease transmission, how building ventilation can be made more energy efficient, and how to protect people in their homes from external airborne hazards.



**“CAVE is a hugely exciting laboratory as it allows us to carry out transformative work into solving air quality problems and ventilation challenges in buildings. The work done at CAVE informs how we protect people in buildings and on public transport from air pollution, airborne diseases, and chemical threats, and even how to better protect art from environmental problems such as humidity, chemicals, and dust.”**

Dr Liora Malki-Epshtein, Director of CAVE



**“The vision of CAVE and PEARL is to enable researchers to create a better world where people can thrive in their built environment, whether outdoors or indoors, in a safe, equitable and healthy way.”**

Professor Jose Torero Cullen,  
Head of Department of CEGE



# CAVE AND PEARL: TWO UNIQUE SPACES TO MAKE THE WORLD A BETTER PLACE

Computer modelling and virtual and augmented reality can be useful when exploring new concepts in civil engineering but they're no match for testing with real people when it comes to mitigating the environmental challenges we currently face and building a better world for all.

CAVE (Controlled Active Ventilation Environment) and PEARL (Person Environment Activity Research Laboratory) are two new highly innovative people-centred research spaces located side by side at our Dagenham East site.

The great strengths of CAVE and PEARL lie in their versatility. Neither is constrained by just one type of environment or experiment. We can research how parks protect residents from urban pollution, how to tailor buses for those with sensory processing difficulties, and how to reduce fire deaths in buildings by improving evacuation protocol.

Together, the two centres provide a vast full-scale testing facility, where researchers can simulate a host of scenarios using life-size replicas of physical environments – buses, doctor surgeries, theatres, and multi-floor offices – and study how individuals interact with the space around them, right down to the air they breathe and temperatures they experience. This can be done without the risks that the same experiments would present in real-life settings.

Each centre has been built in line with UCL's Sustainability Strategy and bold ambition to be a net zero carbon institution by 2030. PEARL is UCL's first net zero carbon building, with the export of surplus energy from solar panels expected to make it carbon negative.

We have a rigorous ethical framework in place, which guides our work when conducting research with people, especially those with disabilities, as we seek to inspire stakeholders to create safer and more inclusive public spaces that are future proof in terms of meeting the needs of their users.

# PEARL



Examining how  
people interact with  
their environment



PEARL is a massive space – around 10m high and 4,000m<sup>2</sup>, the size of a football pitch – in which we can create life-sized environments – a railway station, high street, town square, for example – under controlled conditions, so that we can examine how to make these complex socio-technical environments safer, healthier and more sustainable, and more inclusive and user-friendly.

We can develop disaster response protocols in the face of massive explosions, make tube travel in crowded conditions a less stressful experience, reduce light pollution in cities, and inspire building layout designs that are frictionless for people with disabilities. Our pioneering work with e-scooters led us to create a unique identifiable sound for the transport which alerts other road-users to their approach.

Much of our understanding about how cities work is based on assumptions about how people respond to, use and act in the environment. Many of these assumptions are valid, but often the models we use don't represent what actually happens.

PEARL allows us to study in detail how people actually interact with the environment and each other, by enabling us to test detailed differences in the environment – such as space, colour, lighting, fog, sound, smell, and/or a combination of these – under controlled conditions, using eye trackers, brain scanners, and motion detectors, so that we can obtain rich data for use in the design and improvement of real urban systems.

Research from PEARL has improved fire safety and disaster response plans, how green spaces help those with autism, bus stop design, e-scooter safety, footway surface design, and more, helping scientists scale up logic from small studies to applied research at the human and building level.







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At CAVE and PEARL, we are extremely open to collaboration, and encourage those within the communities of engineering, urban planning, behavioural science, the performing arts, health and medicine to get in touch to discuss how we could work together.

**CAVE**

[ucl.ac.uk/civil-environmental-geomatic-engineering/controlled-active-ventilation-environment-cave](http://ucl.ac.uk/civil-environmental-geomatic-engineering/controlled-active-ventilation-environment-cave)

**PEARL**

[ucl.ac.uk/person-environment-activity-research-laboratory](http://ucl.ac.uk/person-environment-activity-research-laboratory)

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**“PEARL approaches the challenges of how people live in an environment in a totally new way. It is a unique facility where we fuse science, arts, humanities, and engineering knowledge to transform our understanding of how people and the environment interact with each other.”**

Professor Nick Tyler, Director of PEARL





