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Modular breathing panels for energy efficient, healthy building construction

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Abstract

The paper presents the state-of-the-art and the science underlying a new generation of modular breathing wall systems, and their implementation in new and refurbishment building projects. Examples of how these new breathing wall systems are being implemented in the UK and in other countries will be briefly outlined.

Keywords: Breathing; Building; Carbon reduction; Dynamic insulation; Energy efficiency; Filtration; Indoor air quality; Modular breathing panel; Urban pollution

1. Introduction

In conventional construction the walls comprising the outer shell (envelope) of the building typically comprise an external rain screen, an insulation layer, and an internal wall surface. A modular breathing wall panel has been developed that replaces conventional insulation with dynamic insulation, but leaves the rest of the wall virtually unchanged. This new approach to breathing wall construction forms the basis for a distributed ventilation air supply system where the wall functions as a supply source, heat exchanger and filter of airborne pollutants. Outdoor air is drawn into the building using

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active and/or passive means, and as it passes through the breathing wall panels it is pre-heated (or cooled), and filtered very efficiently.

It will be shown that the dynamic *U*-value of the resulting breathing wall system decreases as the air flow is increased, allowing the building to be ventilated at higher levels than would otherwise be possible without cost penalty. Combined with the filtration of incoming air, this means that very healthy indoor environments can be achieved even in the polluted urban environment of a large city such as London, New York, or Shanghai. The air exhausted will be cleaner than that taken in to ventilate the building, which also means that a breathing building of this type will clean the local environment. Implemented at scale, this holds the promise of self-cleaning urban environments in future, offering significant benefits to the inhabitants and helping to combat global pollution.

2. The environmental building system

Dynamic insulation describes a method of supplying fresh filtered ventilation air to indoor spaces that brings us close to the natural ventilation ideal. Instead of bringing fresh air into the building at roof level using ducted air distribution as in conventional Heating, Ventilation and Air Conditioning (HVAC), air is drawn directly into the building through an air-permeable, dynamically insulated envelope. The use of a large wall area to provide ventilation means that the flow velocity can be reduced by a factor of 100 or more compared to that in a conventional HEPA filter. This method of ventilation enables conduction heat loss recovery for enhanced energy efficiency, cleans-up the air by transforming relatively sparse fibrous insulation material into a highly effective filtration unit, and significantly reduces the size, complexity and cost of plant required. Successfully deployed, it paves the way for a new type of energy efficient ‘breathing’ building in polluted urban environments that also cleans-up the outdoor environment, thus reversing the age-old trend of buildings as net polluters of the environment.

The science that underpins the performance of fibre-based dynamic insulation media has been established and is well-understood. Mathematical models have been developed to calculate dynamic *U*-value as a function of flow velocity, and the initial particulate filtration efficiency and life as functions of particle size, fibre diameter and packing density. The models have been validated and calibrated in laboratory and field trials.

Fundamental research on dynamic insulation was undertaken in an EPSRC-funded project at the University of Aberdeen on the use of diffusive and dynamic insulation for combined heat recovery and ventilation in buildings [1–4]. Further research and field studies into breathing wall systems using dynamic insulation, including the particulate filtration performance and service life of fibre-based dynamic insulation, have been undertaken since then [5–7]. The Environmental Building Partnership Ltd (EBP), a recently formed spin-out company, has been created to promote and disseminate the results of research in partnership with developers, architects, engineers, manufacturers, contractors, research organisations and governments worldwide.

In dynamically insulated buildings the building fabric is used as a counter-flow heat exchanger through which the movement of air from outside to inside is controlled by careful balance of internal and external air pressures. This is one of the benefits of a new