Abstract

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Mixed-Mode Cooling Design of Office Buildings in Arid Climates

Contemporary recognition of climate change and global warming has brought building energy consumption into focus and office buildings are considered the most significant commercial building energy consumer. Mixed-Mode/hybrid cooling is an innovative approach that promotes energy and carbon emission savings while maintaining a satisfactory indoor environment. Such systems maximise the use of passive cooling strategies, operate low energy cooling strategies alternatively and depend on active cooling strategies only when strictly required. Although arid climates cover nearly a third of the earth land area, research into mixed-mode strategies has focussed mostly on European applications and temperate climate zones. This research tests the performance of different mixed-mode cooling strategies for office buildings in arid climates, examines their potential to reduce energy demands and carbon emissions, and proposes a design methodology and guidance for architects. Four cities have been identified to represent the diversity of arid climate conditions and a prototypical office building design has been optimised for best thermal, ventilation and daylight performance to suit these locations. Different active, passive and mixed-mode cooling strategies have been simulated for the prototypical design with different internal gains in the four representative arid cities. Performance evaluation criteria and control algorithms appropriate for mixed-mode systems have been applied. The simulation results were evaluated in terms of thermal comfort and indoor air quality before any energy savings were considered. Five optimal designs have subsequently been proposed as the most suitable mixed-mode cooling strategies for office buildings in arid climates. A design flowchart has been developed to determine the most appropriate design according to key weather parameters. Bioclimatic analysis methods were tested to determine which was the most accurate in identifying the most effective passive cooling strategies for integration in a mixed-mode scheme for a given location. Results of these bioclimatic analysis methods were compared with the building energy simulation results in order to determine the most useful method. A comprehensive methodology has been developed to guide the design of mixed-mode office building in arid climates. This methodology includes the most effective bioclimatic analysis method along with the mixed-mode design flow chart. The validity of the proposed methodology has been tested with a modern Egyptian office building design. This research shows that mixed-mode ventilation could save about half of the plant energy consumption compared to common active systems. Savings due to the application of mixed-mode strategies that include low energy cooling technologies such as radiant, evaporative and ground cooling could exceed 90% of the plant energy consumption. Mixed-mode cooling strategies are therefore very attractive and should be considered in the design of office buildings in arid climates.