CONFIDENTIAL

Research Report

Underfloor Plenum Air Conditioning Systems for Office Buildings in Hong Kong – Preliminary Study

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Executive Summary

The University of Hong Kong was commissioned by AET Flexible Space (Hong Kong) Ltd to undertake a preliminary research study to investigate the major issues affecting the design and performance of underfloor plenum air conditioning (UPAC) systems in office buildings in Hong Kong. Investigations have been carried out to study the characteristics of the UPAC systems and develop key information for the analysis of air flow patterns and energy and thermal performance.

It is found that a well-designed UPAC system can provide improved thermal comfort, ventilation and indoor air quality, and occupant satisfaction and productivity at first costs and energy use similar or lower than conventional ceiling-based systems. It also has the potential to be applied effectively in new and existing buildings. The flexibility and ability to allow individual control are the key benefits of UPAC systems. To design and implement a successful UPAC system, the underfloor approach should be integrated with architectural planning, structural design and building services requirements at early design stages.

Among the four basic air distribution methods in the plenum-based systems, the floor supply and floor return method is found to be a good compromise between the ventilation efficiency, individual controllability and the space flexibility. A good air distribution system is essential for a better air quality with the minimum energy consumption. The floor supply and ceiling return system does not display the conventional displacement ventilation system performance, in particular it fails to deliver a better efficiency than all other three methods studied when the heat source (cooling load) is distributed uniformly in the three-dimensional room. It is recommended that the Archimedes number should be kept to be less than 0.1 in a floor supply and floor return system to avoid short-circuiting, based on the work done in this project.

The present study on energy and thermal performance has indicated that UPAC systems can have energy consumption about 19% lower than that a typical VAV system. Studies in other countries have suggested possible savings as high as 20-25%. The major energy savings come from the energy reduction in fans, cooling and heating. Further energy and operating cost savings can also be achieved by using the concrete floor slab in a thermal storage strategy and by night venting of the floor plenum, but further research is needed to optimise and quantify this effect for the climatic conditions in Hong Kong. As fan energy use is an important component of the total energy consumption, measures to reduce it through air volume control, proper configuration, and good plenum design should always be considered.

Further research areas identified and recommended for future development of the research are:

- Develop simulation tools for systematic study and design of UPAC systems.
- Study how UPAC systems can be used effectively in building retrofits.
- Model the building fabric thermal storage using CFD and thermal simulation techniques.
- Study air flow and heat transfer inside the underfloor plenum.
- Investigate how UPAC systems can be integrated with the building envelope for ventilation.