空調・建物の統合シミュレーションを用いた、設計・施工段階における不確かさによる空調システム性能への影響

The Variation Estimation of Building Performance due to Uncertain Variables in the Design and Construction Phase Using an Integrated Building Simulation

東京大学 赤司研究室 修士過程2年　野村暁里

背景

空調システムを構成するパラメータの中には、設計・施工段階では確定しないものがある（Table1）。これまで、これらのパラメータはその性質から、設計段階では考慮しない、またはある仮定の元で簡易的・固定的にしか考慮されてこなかった。本研究はこれらパラメータの影響による、空調システムの性能の幅の定量化を目的とする。

手法

既往研究[1,2]で構築された、詳細な物理モデルによる自動制御を組み込んだ空調・建物の統合システムシミュレーションを用いた（Fig.1）。

研究成果[3]

- 設計段階で確定しない不確かな変数として、施工段階で決定するダクト圧力損失係数、運用段階で決定する給気ファンの下限INV周波数のそれぞれに幅をもたせた、計9条件（Table 2）で、夏・冬の各代表日について計算した。
- 低負荷での運転時間がより長く（Fig.2-3）、ファンの下限INV周波数の影響の大きかった冬季は、夏季より以上に性能の増減幅がより大きかった。その幅はベースケース比で、エネルギー消費量-4.2%～+6.2%、システムCOPにして-4.7%～+2.8%であった（Fig.4-5）。

Background

Some of the parameters that compose an air conditioning system are not fixed in the design and construction phases (Table 1). Therefore, these parameters have not been considered in the design phase or have been given only in a simplified or fixed manner under a certain assumption. This study quantified the range of variability in the performance of an air conditioning system caused by these uncertain parameters.

Methods

The detailed integrated system simulation of a building and an air-conditioning system with automatic control, which was developed in previous studies[1,2], was used (Fig.1).

Results[3]

- Two uncertain parameters were selected: 1) the duct pressure loss factor obtained after the construction phase, and 2) the minimum inverter frequency of the SA fan determined in the operation phase. Calculations were performed for nine conditions (Table 2) with a respective range for each parameter, for a typical summer and winter day.
- In winter, the operation hours at low load were long (Fig.2-3) and the impact of the minimum INV frequency of the SA fan was significant, which resulted in the large range of performance. The range was -4.2% to +6.2% in energy consumption and -4.7% to +2.8% in system COP compared to the base case (Fig.4-5).

Table 1. Determination of parameters in air-conditioning systems

	Design	Construction	Operation
Building structure (External envelope, stories…)	◎	→	
Device selection (Fans, dampers, chillers…)	◎	→	
*Duct system	△	◎	→
*Control logic	○	○	◎
*Parameters in control logic	△	○	◎
*Actual operating conditions	×	×	○

*Uncertain parameters in the design phase

◎: Completely determined　○: Roughly determined

△: Tentatively determined (or default values)　×: Not determined

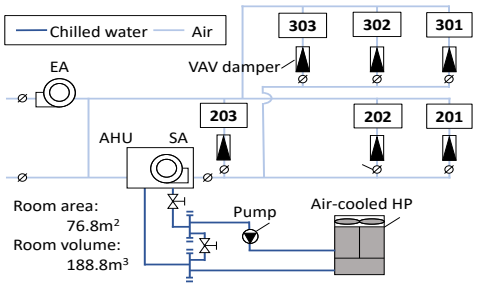

Fig. 1. Target system

Table 2. Case study conditions

	Minimum SA fan inverter frequency		
Pressure loss coefficient	20Hz	25Hz	30Hz
0.8 Cr	1-a	1-b	1-c
1.0 Cr	2-a	2-b (Base case)	2-c
1.2 Cr	3-a	3-b	3-c

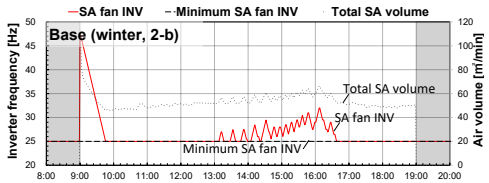

Fig. 2. The result of the base case (2-b) (SA fan inverter frequency and air volume)

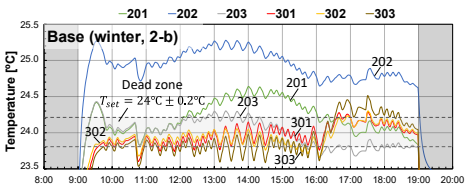

Fig. 3. The result of the base case (2-b) (Room temperature)

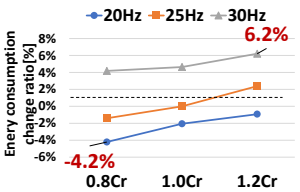

Fig. 4. Energy consumption change ratio

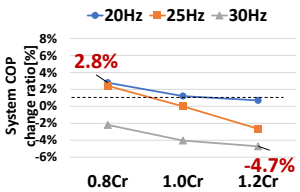

Fig. 5. System COP change ratio

References

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