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SECOND DRAFT

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PROPOSED METHOD FOR CALCULATING THERMAL DISCOMFORT

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Introduction

The treatment of comfort in the evaluation of building design by thermal simulation is at present rudimentary. Some programs assume that comfort set points are always met, and just calculate the heating or cooling plant size required. Others allow temperatures to diverge from the set point because of limited plant capacity, or to free float, but only record the number of hours above set point, or exceptionally produce a histogram of frequency of occurrence of different temperatures. None produce anything like a rating or index of (dis)comfort, or any measure to facilitate a trade off between comfort and costs of heating and cooling.

When evaluating the thermal performance of proposed or existing buildings by simulation, there is a need for a measure of discomfort suitable for rating existing buildings or ranking competing design proposals. In particular, it should be appropriate for weighing the relative importance of rare episodes of extreme temperatures against more frequent but much milder excursions from ideal comfort conditions. For example, a building with large windows and overhangs to protect against summer overheating may have good conditions in summer and winter, but may suffer overheating in spring and autumn when the sun is low in the sky. An alternative design with small windows may have acceptable but never very pleasant conditions throughout the year. The challenge is to derive a measure (objective function) capable of making a fair comparison between such competing designs, or to provide a rating of an existing building.

The measure should have a number of desirable properties:

1. it should be weighted according to the number of people affected, for example there may be five people in the North facing office and twenty in the South facing one, and the amount of time that they are affected.

2. It should reflect the fact that discomfort is small within a few degrees of the optimum temperature, and then increases increasingly steeply as one moves away from this most comfortable (ideal) temperature.

3. It should reflect the fact that (hot) discomfort increases much more rapidly with body core temperatures above the ideal than (cold) discomfort increases as one moves to core temperatures below the ideal.

4. It should reflect the purpose of the evaluation, for example in evaluating different office designs it should ideally reflect the impact on productivity.

Yilmaz[5] used Gagge's discomfort model[8] to evaluate alternative designs.

Carroll[2], in a detailed analysis, used the squared difference between the actual and preferred temperature as the index of discomfort.

Crawford and Woods[4] also used the squared difference objective function for discomfort, adding it to the energy cost. Modelling intermittent occupancy in a lightweight house, they showed how comfort at the beginning and end of the occupied period could be traded for energy cost savings.

David Fisk, in an unpublished BRE N note[9], examines control algorithms for space conditioning, and argues for an objective function based on minimisation of the mean square error, or on the covariance of the error.

A related publication by Fisk[10] develops these ideas, and reviews thermal comfort criteria for temperature fluctuations about neutral, relating the mean square error to both the PPD and the probability of occupants taking unprompted action to change their environment.

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