Research on Satisfaction of Building Indoor Personnel

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Abstract. In the operation stage, current green buildings gradually take energy conservation into consideration, a trend resulting in a phenomenon that environmental control system neglects suitability of indoor personnel. This article summarizes the advantages and disadvantages of several existing indoor thermal comfortability evaluation indicators by selectively analyzing common factors that affect personnel satisfaction, including personnel factors, indoor environmental factors, space factors, design factors, equipment factors, construction and property factors, and work factors. By combining the questionnaire to screen first-level impact factors, this article provides a basis for exploring a new multi-method-based evaluation method of intersection satisfaction.

1. Introduction
The equipment control mode often adopts a method oriented to maintain a certain physical environment index of the building. However, since thermal comfortability of the human body is a comprehensive reflection of human physiology and psychology and an effect of multiple factors, pure physical information collection and calculation cannot replace the real human feelings and thereby weakens users’ appeal to the built environment. Aiming to strengthen the “People Oriented” in building commissioning, we refer to common comfortability evaluation standards and sort out the factors affecting personnel satisfaction. By screening out the most influential factors through questionnaires and using data research and regression analysis methods, we study those factors’ weight on the satisfaction index, so as to analyze the impact mechanism of personnel satisfaction and establish a parameterized feature library of satisfaction influencing factors applicable to different public and commercial building control scenarios. This article is the first stage of research. The goal is to determine the key influencing factors and provide references for future control research based on body comfortability.

2. Research Background
With the development of Chinese green buildings, the construction of settlements has increasingly emphasized the value of user experience, and incorporated more elements into the design and construction of green buildings, such as comfortable, energy-saving, environmentally friendly, and
people-oriented concepts. The basic research on the satisfaction of building interior personnel discussed in this article stemmed from the development of two key technologies: objective evaluation of user satisfaction of green building environment and cost control and rapid modeling of operating strategies. Establishing a strategized database of key methods of dynamic control system oriented to satisfaction evaluation can make green building operations more people-oriented. In order to acquire the data of personnel’s satisfaction more accurately, it is essential to establish a new model combining with existing indicators. The following summarizes the traditional thermal environment satisfaction indicators.

Table 1. The traditional thermal environment satisfaction indicators

| Index                               | Proposal time | Proposer                  | Scope of application                                                                 | Advantage                                            | Disadvantage                                                                 |
|-------------------------------------|---------------|---------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------|
| Effective Temperature (ET)          | 1923          | Houghton, Yaglou etc.     | 1℃<ET<43℃                                                                           | Easy to apply, Supported by data                     | Overestimated the influence of humidity in high/low temperature zone        |
| Effective Temperature* (ET*)        | 1971          | Gagge etc.                | Dress lightly, with little activity, and low wind speed                               | Radiation, convection and evaporation are taken into account | Small scope of application, affecting large-scale use                       |
| Standard Effective Temperature* (SET*) | 1971          | Gagge etc.                | Same as above, within the temperature range where there is no shivering             | Correlated with the body’s cold and hot feelings     | Complicated calculation, Difficult to be precise in mutual influence of parameters |
| Operation Temperature (OT)          |               |                           | Low wind speed, as a supplement to PMV                                               | Wide range of applications                           | Medium accuracy                                                             |
| Predicted Mean Vote Index (PMV)     | 1972          | Fanger                    | In a stable thermal equilibrium for a long time, the average skin temperature should be close to a level suitable to comfortability | Objective and comprehensive for 6 elements included | -2<PMV<2 Distortion occurs outside the range, Some factors are not considered |

3. Screening and Selection of Influential Factors of Satisfaction

Existing studies on indoor environment satisfaction mostly focus on thermal, sound, light environment and indoor air quality[1]. Factors affecting satisfaction are limited and basically only reflected in thermal comfortability; meanwhile, architectural Spatial attributes are rarely included. This research attempts to break through the limitation of traditional building environmental comfortability evaluation that only based on thermal comfortability index, analyze the connotation of satisfaction index, formulate scientific and reasonable data collection methods and complete sample survey of commercial building environmental parameters (heat, sound, , Light, humidity, noise, orientation, usage habits, spatial layout, etc.).

By reading a large number of related materials and combining the comprehensive feedback of human psychology and physiology, we have summarized the seven major affecting factors, namely, personnel attributes, space factors, architectural factors, indoor environmental factors, interior design
factors, property factors and equipment factors. These seven factors include multiple impact elements as listed below.

![Diagram of Personnel Satisfaction Factors](image)

Figure 1. Personnel satisfaction factor

We analyzed each element. For example, in terms of personnel attributes, according to Pantavou [2] and others, the correlation between height, weight and satisfaction is low. Thus, elements are included except those mentioned before. In terms of space factors, AncaD. Galasiu [3] et al. found that people have a good impression of natural lighting. Within such environment, the satisfaction of the environment will be significantly improved. Therefore, he orientation and the height are considered. There are limited researches about correlation of vision and depth. Research on indoor environmental quality and evaluation of comfortability needs the comprehensive consideration of effects of heat, sound, light, air quality and other factors [4]. The items listed in indoor environmental factors are all considered. By using of DIALux software, Zhang Yanmei and others find appropriate intensity of light has a significant impact on the performance of cognitive tasks’ output, and natural light is more advantageous than artificial lighting in terms of personnel work efficiency and health. Users have a preference for natural light psychologically and physiologically [5]. Fanger et al. found that temperature and humidity affects the comfortability, moreover, lower air temperature and humidity will make people feel fresher. CO2, as the main indoor pollutant, is often used as a monitoring indicator of indoor ventilation efficiency and personnel density [6]. For the last two items, interior design factors are considered, not property factors.

4. Questionnaire

In order to filter out the factors that have the greatest impact on satisfaction, we conduct a questionnaire surveys and analyze 211 valid responses. The number of male to female is close, and the age span is large. As shown in Figure 2, people who are sensitive to hot and cold temperatures accounts for 34% of total respondents. As shown from Figure 3, undergraduates accounts for 67%, high school and below accounts for 20%, and postgraduate and above accounts for 13%. Generally speaking, respondents are highly educated.
In this survey, of all respondents, 53% is employed; students are secondly. Most of the interviewees works in indoor environment, which is also our survey goal. We investigate the comfortability of indoor environment and get the following results.

In indoor temperature survey, more than 90% of respondents use air-conditioning in their offices, of which central air-conditioning accounts for 50%. In the comfort survey, 63% of the respondents felt comfortable, and 14% felt too cold or a little hot. It is worth noting that the feet and legs of the human body are most likely to be too cold or too hot in practice.

Nearly 48% and 15% of the respondents said that the indoor environment is dry and very dry, indicating that most office environments have insufficient humidity. In the survey on air quality satisfaction, only 4% of the respondents claim that the office air was fresh; 36% of the respondents could clearly smell the peculiar smell. Light satisfaction test reveals that 54% of the interviewees consider that the current light is more comfortable, and those who are dissatisfied with the lighter sit toward east or north, or whose cubicle is far away from the window and facing against window. Humans prefer natural lighting conditions. 86% of the respondents said natural lighting is more comfortable. In the acoustic environment survey, 73% of the respondents were satisfied with indoor noise, while less than 20% were satisfied. Therefore, we should pay attention to noise elimination measures in interior design in the future. In order to study the impact of environmental awareness on satisfaction, only 4% of the interviewees are not concerned about energy conservation and environmental protection, and only 2% of the respondents say that they have no environmental protection behaviors. This shows that most of the people in China are possess of sense of
environmental protection. 36% of the respondents say that they would take the initiative to save energy, the largest proportion of environmental protection behaviors is to avoid energy waste, and 63% of the respondents said they are willing to make concessions for environmental protection.

The study summarized five important influencing factors. From Figure 5, they are ranked as follow: air environment, light environment, thermal environment, acoustic environment, and energy-saving awareness. Most interviewees are quite satisfied with the current indoor environment, and 8% are dissatisfied with the environment.

5. Summary
Thermal comfortability is a comprehensive reflection of people’s physiology and psychology, and is a comprehensive effect of multiple factors. Establishing a building indoor environment control system based on human thermal comfortability will achieve the human-oriented architectural design concept. Through the survey, we find that most people are satisfied with the room temperature, people prefer natural lighting conditions, and the noise sources are different from office areas and number of people. Although respondents’ awareness of energy conservation is generally strong, their concessions to environmental satisfaction are limited. In the future improvement of environmental control, the deviation of energy usage habits caused by personal factors can be used in key applications. Respondents ranks impact factors as follows: air environment>light environment>thermal environment>acoustic environment>energy-saving awareness. The next step will be to analyze the satisfaction of different types of people in the actual environment on this basis, and complete the adjustment and control with the help of person portrait technology. The system has practical significance for the evaluation of indoor personnel satisfaction.

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