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Sustainable construction criteria to evaluate the thermal indoor climate - further development of the BNB assessment tool and practical implementation

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This abstract comprises
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2 Figures

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Content

1 Objective

Although the existing profiles 3.1.1. and 3.1.2 in the "Assessment System for Sustainable Construction of Federal Buildings in Germany (BNB)" provide the necessary criteria for the assessment of thermal comfort in winter and in summer, there are still uncertainties in practice for the application of the verification processes. Indeed, available evidence for certification appears to be of very different quality depending on the person performing the assessment. The data consigned for the certification do not always provide sufficient information for a meaningful proof of thermal comfort in a building.

The goal of this research is to further develop the existing profiles for thermal comfort in winter and in summer of the Assessment System for Sustainable Construction of Federal Buildings 3.1.1 / 3.1.2 to be more sophisticated and adapted to the practical application. Outcome of this research should be used as an aid for planning, construction, operation and use of federal buildings. Therefore, the profiles in this work are considered as a tool for the improvement of the indoor climate in practice.

2 Implementation of the research work

2.1 Determination of the thermal comfort quality levels

A fundamental question for thermal comfort assessment in the BNB profile is to choose the quality category that a federal building should reach. Regarding high thermal comfort, it is undisputed that category I in DIN EN 15251 would be better than category II, but the requirement of a higher level of comfort is usually related to higher energy consumption (high operating costs). Also, it often demands a mechanical system (high investment costs). Therefore, suitable targets for the quality level I in the profiles should be determined under consideration of the energy consumption, the feasibility in practice and the thermal comfort. During the determination process of the quality level or of the target limit, inconsistencies in standards and guidelines have been identified, which are highlighted and discussed in the report.

2.2 Operative temperature in summer

In the respective research, it is still controversial which operative temperature can still be regarded as comfortable in summer. DIN EN 15251 provides two different comfort areas depending on the existence of mechanical cooling systems in a building. 26 °C is specified as the upper operative temperature limit for buildings with mechanical cooling systems, while higher temperatures than 26 °C are still permitted in buildings without a mechanical cooling system (optional method in DIN EN 15251, so-called adaptive model). In contrast to the DIN EN 15251, the BMVBS (Federal Ministry of Transport, Building and Urban Development) "climate policy" in 2008 distinguishes the application of two models depending on whether the user can influence the indoor climate (type A → Adaptive model) or not (type B → 26 °C). However, the new national annex to DIN EN 15251 provides a uniform temperature curve for all buildings depending on the hourly outdoor temperature. Basically, the climate policy formulates the most flexible requirements, because the adaptive model can be applied to most buildings independently of the existence of a mechanical cooling. This can be explained by the desire of the federal government to operate federal buildings generally without the use of a mechanical cooling system, or with minimal cooling energy when mechanical cooling cannot be avoided. However, the different comfort areas are not clearly proven scientifically yet, depending on whether the users have influence on the indoor climate or not. On the other hand the differences in the comfort areas caused by the use of mechanical cooling system is internationally investigated and acknowledged. Therefore, the following upper limit for temperature is proposed for the thermal comfort requirement in the new profiles, considering the energy goals of the federal government and thermal comfort requirements:

Without mechanical cooling → Optional method (Adaptive model) according to DIN EN 15251

With mechanical cooling → upper limit for temperature according to the national annex in DIN EN 15251, so that the indoor temperature is allowed to be up to 28 °C at a warm ambient temperature over 32 °C; which may lead to energy savings as well.

2.3 Indoor humidity in winter

In addition to the assessment of the operative temperature in summer, the requirements for indoor humidity are not clearly defined in the standards. According to the DIN EN 15251, a humidification or dehumidification is only needed in special buildings such as museums or production buildings. However, the same standard requires an air flow volume, with which an office building in Germany cannot avoid a low level of humidity without additional humidification in winter. This often causes dry mucous membranes or irritated eyes in office buildings.

On the other hand, the previous profiles (BNB 3.1.1 /3.1.2) only evaluate the indoor air humidity according to DIN EN 15251 in buildings with humidification or dehumidification, but the most frequent complaints of dryness occur in practice in buildings with a mechanical ventilation system without humidification, for which no clear limits are defined in DIN EN 15251. While the windows practically are rarely opened in winter and the level of humidity is relatively high in buildings without a mechanical ventilation system, the high air change rate in buildings using a mechanical ventilation often results in a dry indoor air due to the cold and dry outdoor air in winter in Germany. Therefore, the lower limit (25%) should be evaluated for all buildings with mechanical ventilation systems.

2.4 Radiant temperature asymmetry

According to DIN EN ISO 7730, the predicted percentage of dissatisfied (PD) caused by radiant temperature asymmetry should not exceed 5% for category A and B. The PD is calculated based on the plane radiant temperatures of the opposite half-spaces (e.g. left to right). VDI 3804 provides guideline values for the practice for minimum and maximum surface temperature because there are few tools in the practice for the calculation of the plane radiant temperature. These reference values in VDI 3804 are also adopted in the existing BNB profiles. As more and more radiant heating or cooling systems are being used in practice for indoor conditioning, a more detailed analysis of the radiant temperature asymmetry is required. A calculation tool for the estimation of radiant temperature asymmetry was developed based on DIN EN ISO 7726 and the quantitative evaluation according to PD is included in the new BNB thermal comfort specification.

3 Results and Summary

3.1 Summary of the important changes in the proposed BNB thermal comfort profile

General

- A summary of the two profiles (winter and summer) in a document
- From a discrete to an interpolated scoring system
- Proposal for the consistent certification documentation as an attachment

Operational temperature

- No discrete quality levels according to categories (I, II, III or IV) as in the DIN EN 15251
- Assessment of degree-hours outside the comfort temperature lower limits (in winter) and upper limits (in summer)
- Upper limit for comfort temperature in summer: for buildings with mechanical cooling systems → upper limit for temperature according to national annex in DIN EN 15251
- Upper limit for comfort temperature in summer: for buildings without mechanical cooling systems → optional method in DIN EN 15251 (adaptive model)
- Determination of the position for the calculation of the mean radiant temperature (1m distance and in the middle of the facade)
- Load calculation is permitted for the certification in all buildings with sun protection
- Additional requirement for the calculation of the mean radiant temperature in the case of the calculation of the operative temperature in the centre of a room, or in the case of the certification using load calculation
- Additional requirements for the calculation of the mean radiant temperature in case of the application of radiant heating / cooling
- Documentation of the applied boundary conditions for zonal thermal building simulation in the appendix

Draft

- Tightening the requirement from 20% DR to 15% DR

Radiant temperature asymmetry

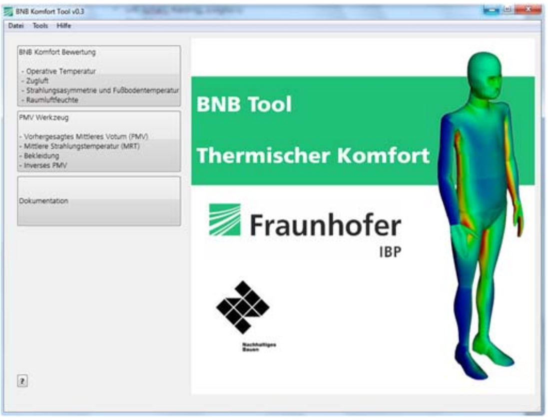
- No VDI 3804 guideline values
- Calculation of PD (Percentage of Dissatisfied) according to DIN EN ISO 7730 and evaluation of the radiant temperature asymmetry with PD

Evaluation of indoor air humidity

- Quantitative assessment in buildings with HVAC systems
- Implementation of allowed frequency of discrepancy: 7% of the working time for winter and summer period respectively

3.2 BNB Tool Thermal Comfort

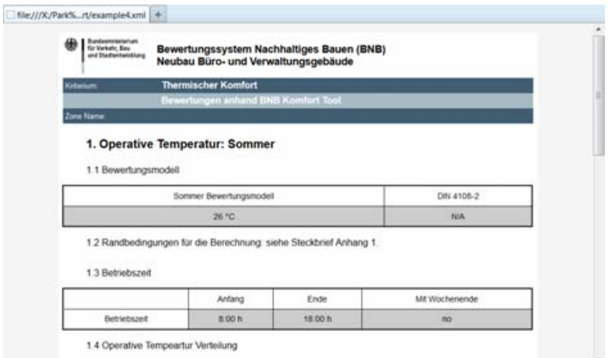
The new proposed BNB profiles require more transparent and quantitative assessments than the existing ones. This can result in more effort for the planner in the certification process. Therefore, a tool "BNB Tool Thermal Comfort" with user-friendly GUI (Graphical User Interface) was developed for the steady-state calculation or to quickly assess the thermal comfort in buildings based on data from the building simulation (one year). The results can be exported as *.xml* file including all required input data. In addition to the certification the tool can be used as a planning and decision-making tool for thermal comfort by giving practical advice to engineers, project managers and building owners.



Picture 1:
BNB Tool Thermal Comfort.

With the tool, the frequency distribution of the temperature in winter and summer on weekdays can be analysed during the operational period. Draft risk (DR), radiant temperature asymmetry and mean radiant temperature can be calculated with the tool. The indoor humidity is determined dynamically based on the input of volume, moisture production (occupancy rate), ventilation rate and moisture recovery rate. The calculation of the indoor air humidity in the tool is based on a moisturemass balance, which deviates from a detailed simulation, which would also consider moisture buffering.

After completion of the input, calculation and evaluation of the data, the assessment scores will be awarded in the tool according to the BNB profiles 3.1.1. / 2 using linear interpolation. The output file (. xml) can be viewed in a web browser and saved as *.pdf* or can be opened in Excel for further processing, if needed.


file:///X:/Park%...rt/example4.xml

Bewertungssystem Nachhaltiges Bauen (BNB)
Neubau Büro- und Verwaltungsgebäude

Kriterium: Thermischer Komfort
Bewertungen anhand BNB Komfort Tool
Zone Name:

1. Operative Temperatur: Sommer

1.1 Bewertungsmodell

Sommer Bewertungsmodell	DIN 4108-2
26 °C	N/A

1.2 Randbedingungen für die Berechnung: siehe Steckbrief Anhang 1.

1.3 Betriebszeit

	Anfang	Ende	Mit Wochenende
Betriebszeit	8:00 h	18:00 h	no

1.4 Operative Tempeartur Verteilung

Picture 2:
Export Format as *.xml* file.

In addition to the BNB assessment tool, PMV calculation and an inverse calculation tool of the PMV have been developed for practical use. The inverse PMV calculation is useful for the estimation of an unknown parameter (e.g. operative temperature) for a known PMV value.

3.3 Information Brochure: Thermal comfort for planning practice

In addition, a brochure entitled "Thermal comfort for planning practice" has been composed to define the important decisions regarding thermal comfort in the building process and to show a precise procedure for the practice.
The brochure includes the following topics:

- Thermal comfort in summer
  - Thermal comfort versus energy efficiency?
- Ventilation: air quality, indoor humidity and draft
  - Issues of mechanical ventilation
  - Issues of window ventilation
- Radiant temperature
  - Cold windows
  - Radiant heating / cooling
  - Radiant temperature asymmetry
  - Solar radiation

List of pictures