PROCEDURE FOR ASSESSMENT OF PLANE RADIANT TEMPERATURE DISTRIBUTION IN OCCUPIED SPACES

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INTRODUCTION

Here is presented a description of the implementation of a procedure for calculation of plane radiant temperature indoors. Plane radiant temperature (t_{pr}) is the uniform surface temperature of an enclosure in which the incident radiant flux on one side of a small plane element is the same as in the actual environment, [1, 2]. It is used to assess both the mean radiant temperature and the radiant temperature asymmetry, which is the difference between the plane radiant temperatures (t_{pr}) on two opposite sides of a small plane element.

MATHEMATICAL MODEL

The ISO 7726 standard provides a method for calculating the plane radiant temperature and the radiant temperature asymmetry. [2]
The plane radiant temperature can be obtained from the surface temperatures of the surroundings and the angle factor between a small plane element and the surrounding surfaces. The angle factor is a function of the shape, size and relative position of the surface with respect to the person. [3, 4]
When estimating the plane radiant temperature, the following equation can be used:

$$T_{pr}{}^4 = T_1{}^4 F_{p-1} + T_2{}^4 F_{p-2} + \ldots + T_N{}^4 F_{p-N}$$

where: T_{pr} – the plane radiant temperature in Kelvins; T_N – the surface temperature of surface N in Kelvins and $F_{p\text{-}N}$ – the view factor between the small plane element and surface N

IMPLEMENTATION

For implementing the procedure the software package Matlab is used. The area of the walls of the room under consideration is divided into square cells with dimensions 5x5 cm.
Information for the coordinates and the temperature of every cell of the wall is recorded. The mass center of the person, who occupies the room, is represented as a cube with dimensions 5x5x5 cm. The developed program calculates the angle factor between the person's center of mass and the center of each cell of the wall, using surface to surface approach. The plane radiant temperature is then calculated as the mean value of the surrounding temperatures, weighted according to the magnitude of the respective angle factors. The flow of radiation energy that comes from the six possible directions of the room is calculated separately. That flow is denoted as: x+, x-, y+, y-, z+, z-. For example, y+ will stand for the t_{pr} of a small plane element with normal collinear with the positive direction of the Y-axis.

RESULTS

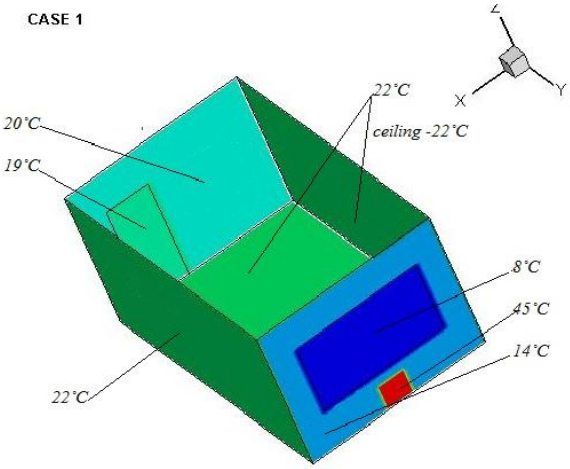
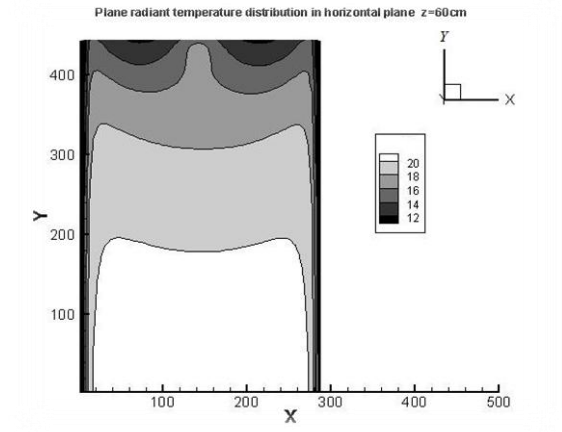
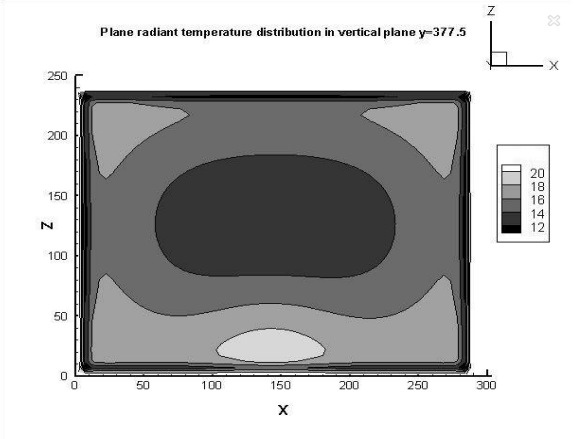


Figure 1 presents results for the t_{pr} distribution in horizontal (X-Y) and vertical (X-Z) plane of a room with dimensions 290x460x240 cm. The given results were calculated for the case of y+ and temperatures of the room's walls as given in the figure above.



t_{pr} distribution for horizontal plane z=60cm



t_{pr} distribution for vertical plane y=377.5cm

Figure.1 *Temperature of the walls of the room under consideration and Plane radiant temperature distribution in two planes*

CONCLUSION

Radiant temperature asymmetry is one of the parameters that have to be considered when estimating the thermal comfort. The described procedure presents a tool for calculating the t_{pr}, based on computing the angle factor between two small plane elements. Compared to the ISO7726 standard, this procedure is able to calculate the t_{pr} distribution in different planes and thus provide more detailed information about the radiant temperature asymmetry.

REFERENCES

[1] DS/EN ISO 7730: Ergonomics of the thermal environment – Analytical determination and interpretation of thermal comfort using calculation of the PMVand PPD indices and local thermal comfort criteria, 2006

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[3] John H. Lienhard IV, John H. Lienhard V*; A Heat Transfer Text Book Third Edition* – page 536 – page 544, 2004

[4] Lílian Dobrowolski de Carvalho Augusto, Bruno Giacomet and Nathan Mendes; *Numerical Method for Calculating View Factor between Two Surfaces* , 2007 [PDF]