The transient 3D hygrothermal model: LECTUS

Simulating conditions in beds over space and time

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Aims

The project aims to develop a model to predict house-dust mite populations in dwellings accurate enough to determine the impact of modifications to building fabric, services and occupant behaviour.





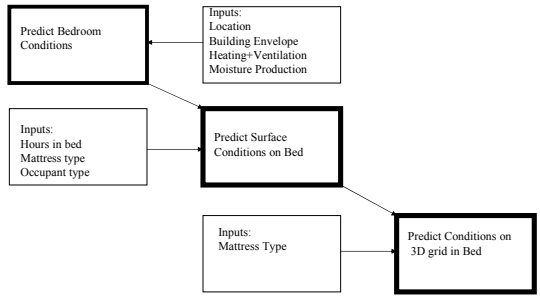



Predict conditions mites are exposed to in a given bed

•Predict on an hourly basis the temperature and Humidity on a 3D grid in the bed

•Use this data as an input to mite population model

Methodology



Bedroom conditions

Use commercially available building simulation models to model the building environment

Not attempting to produce new model, use the best models available

EnergyPlus, Tas

Inputs of simulation

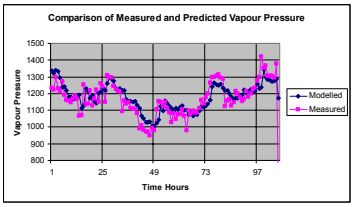

Heating schedule


Ventilation schedule


Moisture production


Surface finish

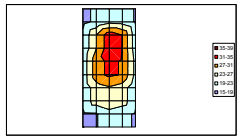
Can you model internal humidity?



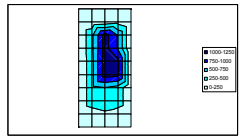
Empirical Model of Conditions on Mattress Surface

Define the boundary conditions on the mattress using empirical relationships from experimental work in test bed

Temperature

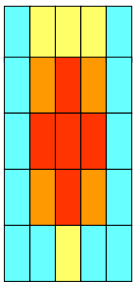


Vapour Pressure



Divide surface of bed into zones

Temperature



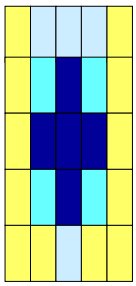
34 C

28 C

23 C

Room

Vapour pressure excess



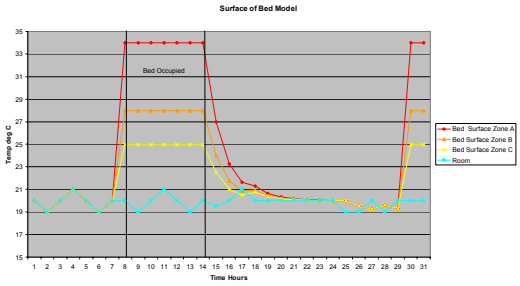
1000 Pa

800 Pa

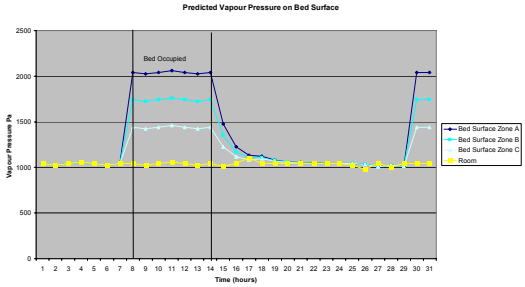
400 Pa

Room

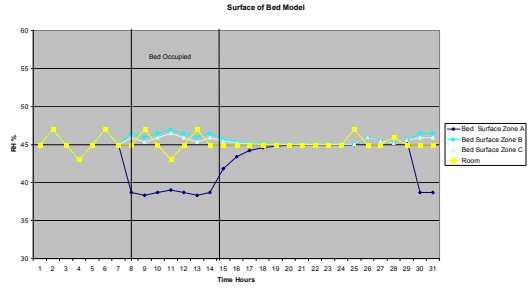
Predicted temperatures



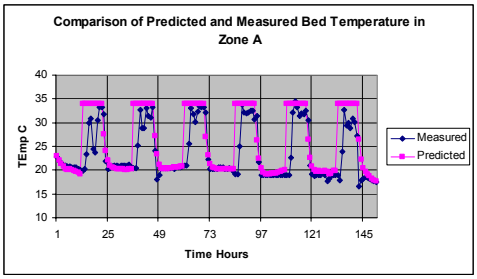
Predicted vapour pressure



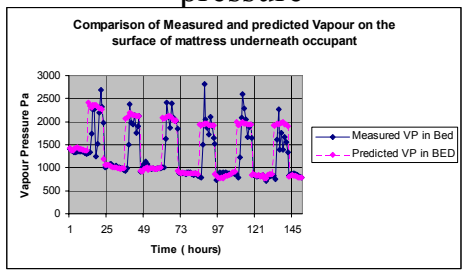
Predicted relative humidity



Real bed v model: Temperature



Real bed v Model: Vapour pressure

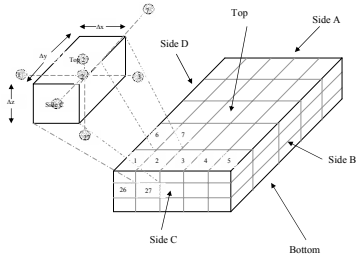


Predicted conditions within mattress

3D transient heat conduction and vapour diffusion model
- Boundary conditions imposed on the six faces of mattress
- Surface boundary condition predicted by surface model
- Bottom and sides at room condition

- Predict temperature and RH on 100 node grid

3D model of mattress

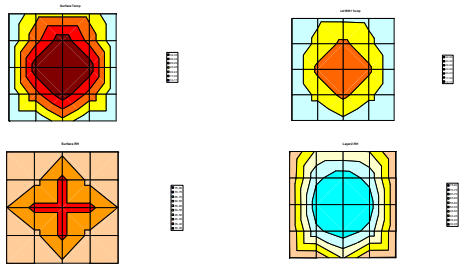


Gauss Seidel iterative solution

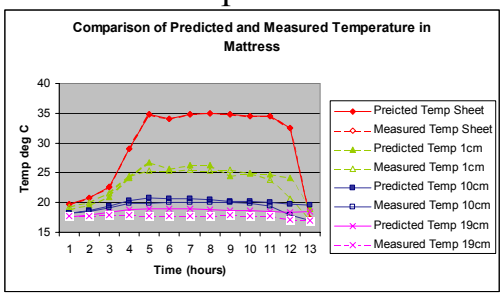
$$T_i^{p+1} = \frac{\Delta\tau}{C_i}\left[\sum_j \frac{T_j^p - T_i^p}{R_{ij}}\right] + T_i^p$$

$$V_i^{p+1} = \frac{\Delta\tau}{\xi_i}\left[\sum_j \frac{V_j^p - V_i^p}{Z_{ij}}\right] + V_i^p$$

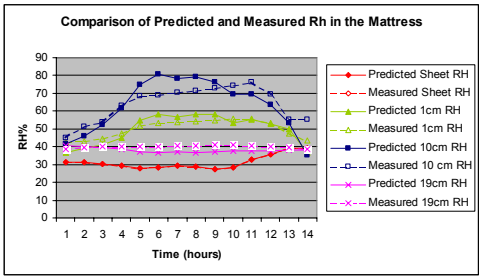
Predictions of Model



Model tested against test Bed: temperature



Model tested against test bed: RH



Input to Population model

The results of the simulation are formatted into a text file which can be input into the population model:

x, y, z, t, Temp, RH

Summary

•Developed a flexible, modular model, to predict the bed environment on an hourly basis
•Could be easily modified for pillows, duvets and floors

•Further validation is needed
•Sensitivity testing
•User friendly interface
•Model occupant as a source of heat and moisture