Condensation risks in bulk insulation in hot and mixed climates

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• The research presented here shows some interim insights into a project entitled “Bulk insulation in hot and mixed climates” being undertaken for ICANZ http://icanz.org.au

• Our research and simulation team includes:
  – Exemplary Energy
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  – University of Tasmania
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• Specialised climate data is supplied by our Bureau of Meteorology, selected and formatted by Exemplary Energy www.exemplary.com.au
Presentation Outline

• Methodology and Problems Encountered
• Climate analysis
• Component analysis
• Component simulation – THERM
• Component simulation – JPA and WUFI
• Conclusions and Progress
• Questions
Methodology and Problems Encountered

• Variations between AS and ISO Standards and industry practice
• Software limitations for simulations (e.g. assumption of still, trapped air in all voids when cavities are often well ventilated)
• Climate data with unhelpful units of humidity measurement (e.g. Relative Humidity in % and Absolute Moisture Content in g/kg dry air)
• Uncertainties and imprecisions in long term measurement of humidity; generally as Wet Bulb Temperature unadjusted for measured wind speed
• Internal temperatures for Regulation purposes and actual values in practice
Climate Analysis

• The research covers three specific climates
  – Darwin (hot humid monsoonal)
  – Brisbane (subtropical, coastal)
  – Eastern Sydney (warm temperate, coastal)

• Climate files selected were RMY-C

• RMY = Reference Meteorological Year

• C = indicative months selected with a strong weighting for temperature and humidity (over solar and wind speed)
Climate Analysis

Eastern Sydney (warm temperate, coastal)

- Used RMY-C climate file but could use immediate past weather data
- Real Time Years (RTYs) to end of last month
- RTYs for Sydney (Macquarie University or CBD) and associated Weather and Energy Index published monthly by Exemplary Energy

Climate Analysis - Eastern Sydney

Summer week around the hottest day
Climate Analysis - Eastern Sydney

Winter week around the coldest morning
Climate Analysis - Internal

• Internal conditions are indicated in the National Construction Code (NCC) and mandatory for compliance simulations
  — Residential – NatHERS (www.nathers.gov.au)
  — Section J – JV3 Energy Verification
    NCC Section J - Verification Methods JV3 (d)(i)(D)

• Actual internal conditions vary widely with occupant and management preferences
Climate Analysis - Internal

• Darwin (hot humid monsoonal)
  – NatHERS - Heating: 20.0°C, Cooling: 26.5°C
  – NCC - Heating: 18.0°C, Cooling: 26.0°C

• Brisbane (subtropical, coastal)
  – NatHERS - Heating: 20.0°C, Cooling: 25.5°C
  – NCC - Heating: 18.0°C, Cooling: 26.0°C

• Eastern Sydney (warm temperate, coastal)
  – NatHERS - Heating: 20.0°C, Cooling: 24.5°C
  – NCC - Heating: 18.0°C, Cooling: 26.0°C
Component analysis

• **Australian Standards**
  – AS/NZS 4859.1:2002 - Materials for the thermal insulation of buildings - Part 1: General criteria and technical provisions

• **International Standards**
  – ISO 6946:2007, Building components and building elements - Thermal resistance and thermal transmittance - Calculation method
  – ISO 10211 (2), Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations
  – ISO 14683 (4), Thermal bridges in building construction — Linear thermal transmittance — Simplified methods and default values
  – ISO 15242:2007 - Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration
Component simulation – THERM

What is THERM?
- thermal modelling software for walls, roofs, window frames...in fact anything solid, plus entrapped gases such as air
- Public domain, free, developed and supported by Lawrence Berkeley National Laboratory, University of California
- At the heart of 10 million window energy ratings in USA, Canada, Australia and many other countries
- windows.lbl.gov/software
Modelling walls and roofs with THERM 7.4.3

THERM capabilities:
- 2-D heat transfer calculation using ‘finite element’ method
- Calculate overall R-values, U-values, surface and interstitial temperatures and temperature gradients, condensation risk (provided dew point of the air is known separately)
- One layer or many
- Conduction, convection and radiation
- Computational algorithms are compliant with ISO 15099:2003 (international heat transfer standard)
Modelling walls and roofs with THERM 7.4.3

THERM limitations:
- Steady state analysis, *i.e.* a snapshot in time (not dynamic) and not accounting for thermal mass effects
- Does not evaluate moisture transfer
- Does not calculate wind-driven or fan-forced air flows
- But *does* calculate buoyancy-driven air movement and circulation caused by temperature differences
Modelling walls and roofs with *THERM 7.4.3*

**However...**

- THERM *can* be used in situations of wind-driven or thermally forced air flow *IF* those characteristics are known and can be pre-calculated and input to THERM as ‘special’ boundary conditions.
Component simulation – JPA

- JPA Designer SAP 2012 (9.92) [www.techlit.co.uk](http://www.techlit.co.uk)
- Like THERM, Steady State is assumed; but
- Water vapour transmission and condensation is accounted for; and
- The analysis can include thermal bridging.
Component simulation – JPA
Component simulation – JPA

In real buildings, short term transient effects are significant and need to be accounted for.
Component simulation – WUFI

- Considers transient and seasonal effects; but
- It is also 1-Dimensional; but
- It has a high-end 2 Dimensional option.
Component simulation – Ideal

The ideal software will account for:

- Roof Spaces and Envelope Components;
- Northern Spaces and Envelope Components;
- Eastern Spaces and Envelope Components;
- Western Spaces and Envelope Components;
- Southern Spaces and Envelope Components;
- Façade Systems;
- Passive Ventilation Systems; and
- Passive and wind-driven aspiration of air spaces within Components (e.g. the cavity in brick veneer construction).
Conclusions and Progress

• Analysing condensation risks in bulk insulation in hot and mixed climates on a theoretical basis has its challenges.

• Studying moisture and condensation issues in buildings by simulation alone has its limitations; but we anticipate overcoming them as a part of this study.
Questions

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