DOE Thermal Mass Research leading up to the thermal mass credit tables found in the International Energy Conservation Code

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Outline of DOE Thermal Mass Research

- History
- Experiments
  - NIST test huts
  - New Mexico test huts
  - ORNL Joint Institue Dormitory
- Modeling
- Simplified tool development
- IECC Thermal Mass Credit Tables
- Whole Wall Thermal Performance Calculator

In 1981 DOE was asked by industry to answer three key technical questions

- **What is the effect of exterior envelope thermal mass on the annual energy requirements to heat and cool residential buildings (Thermal Mass Effect)?**
- **Can the thermal mass effect be accurately predicted for specific residences?**
- **Once the first two questions are answered what code changes and building design tools are needed to implement these findings in the field?**

Thermal Mass Research Review Panel

- Francisco Arumi-Noe, U of. TX
- George Barney, PCA
- Peter Billings, National Forest Products Assoc
- Jean Boulin, DOE
- Doug Burch, NIST
- K Callahan, NCMA
- T.J.Cardenas, Log Home Council
- Bill Carrol, LBNL
- Ken Childs, ORNL
- Jeff Christian, ORNL
- Richard Dixon, State of Florida
- Joe Hagan, Celotex
- Bion Howard, NAHB
- Merle McBride, Owens Corning
- David Robertson, New Mexico
- Martha Van Geem
- Steve Szoke, Brick Institute of America
- George Walton, NIST
- Bruce Wilcox, Berkeley Solar Group

Time Line

- Thermal Mass Assessment 1982-83
- Thermal Mass Research Review Panel 1982-86
- 5 yr plan 1983
- Experiments
  - Test Huts
    - NIST
    - NMERDI
  - Real Building
- Data consistency and model validation 1983-85
  - BLAST (LBNL) 1984-85
  - DOE2.1 (ORNL & LBNL) 1983-85
  - DEROB (University of Texas) 1983-85
  - TARP (NIST) 1985

Continuing time line

- 100 Comparisons of model vs measurements
- Predicted floating temperatures

- **Calibrated Model data base generation and analysis 1985**
  - Six U.S. climates
  - Typical real U.S. residential single family building
  - Five different wall configurations
  - R-value of exterior wall
  - Heat capacity of exterior wall
  - 2000 Blast runs
  - Building operation parametric analysis
  - DOE 2.1 agrees with BLAST

DOE fulfills objectives completes project

• Design Tools	1986-88
• Code Change	1988
• DOE successfully fulfills program objectives	1988
• Summary Technical ASHRAE Paper Presented	1991

Approach

- **Experimental Test Data**
  - Multiple Sites
  - Test Huts and Real Building
  - With and Without Windows
  - With and Without Insulation
  - Heating and Cooling Season

- **Data Consistency and Model Validation**
  - Multiple Models
  - Multiple Analyst
  - Grid of Cross Checks

Approach – cont.

- Simulation Data Base Development and Analysis
  - Theoretical Parametric Analysis
  - Cross Check of Blast with DOE 2.1
- Empirical Nonlinear Model
  - Developed and Validated with Different Models
  - Fractional Factorial Design
- Personal Computer Program
  - Validated with Test Cell Data
  - Reduces Problems of Defining "Typical Construction and Operation"
  - Enhance Acceptance
- Change Building Codes and Standards

Products

- Provided an Extensive Measured Data Base Using 20 ft by 20 ft Test Houses Near Gaithersburg, MD, and Near Santa Fe, NM
- Performed Data Consistency Tests Using Blast, Derob, and DOE 2.1
- Developed an Extensive Simulated Data Base Using The Calibrated Model Blast and a 1200 ft^2
- Developed a Simplified Empirical Model for Use By Contractors to Estimate the Energy Savings of Thermal Mass
- Developed PC Program
- Published 2 dozen Technical Papers and Public Reports
- Presentations to ASHRAE, ASTM, CABO, State of Florida, and HUD
- Contributing to ASHRAE Handbook of Fundamentals
- Changed MEC now IECC

Thermal Mass Benefits as part of the Whole Wall Thermal Performance today

- dynamic hot box results
- 3-D computer model prediction
- Material thermal property data
- 1-D Equivalent wall DOE2 BDL file
- Compliance data consistent to Model Energy Code Approach
  - used ASHRAE 90.2 building
  - all “typical operating parameters” as defined for ASHRAE 90.2 data base