# Research, Building Science and Architecture

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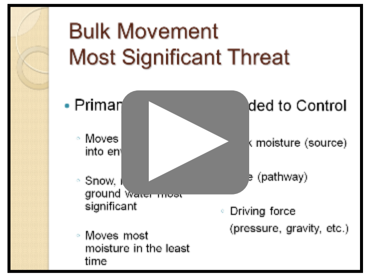


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# Course Description

The subject of the webinar is building science and research on buildings, and how building science has been accepted within the architecture community. The webinar will draw heavily on writings and examples from throughout the 20th century, with particular emphasis on research before and after World War II. It will track how the architecture literature of the time described the integration of science and research into architecture. It will touch on the variety of research, including behavioral, health, history, and technology.

The principal example will be the science and research that led to prescriptive measures of moisture control such as vapor barriers and attic ventilation. The webinar will trace how these measures were introduced (by an architect!), codified, applied, challenged, and changed over time. The example will be used to illustrate how architects participate in the research process, and how they apply the products of research.



# Learning Objectives

1. Review what building science is, viewed from within building science and from within architecture
2. Discuss how building research is conducted, and how it is applied.
3. Review how building science leads to an ordered body of knowledge, and to prescriptive measures.
4. Discuss how architects participate in the research process, and apply the products of research.

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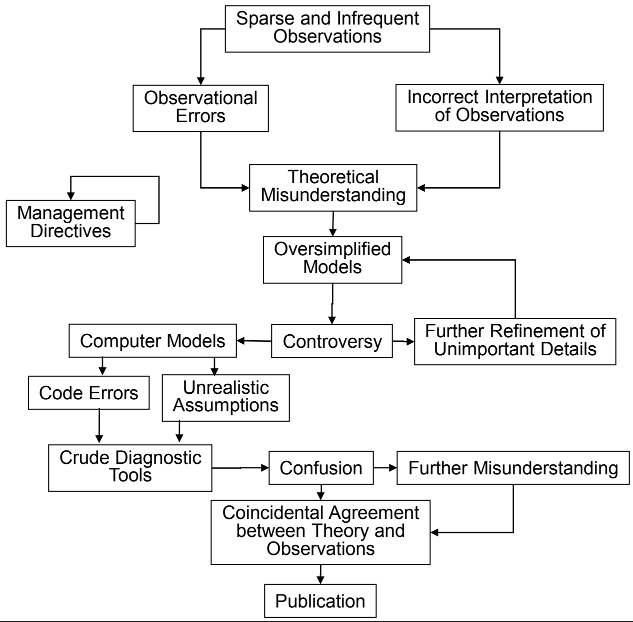
## Research, building science and architecture

William B. Rose
University of Illinois

## *Building Science* *tribute to Larry Palmiter*




## Ok, that's not building science

- Aim of this webinar:
  - Review what building science is, and how it is viewed from within itself and from outside
  - Discuss the roles of research in architecture and in building science
  - Answer: what is "an ordered body of knowledge"?
  - Discuss the process and product of building science research
  - Give an example of research applied to architecture and construction

## Origins of "building science"?

- Buildings…go way back
- Materials, tools, techniques…go way back
- Scientific method…goes way back
  - Francis Bacon: avoid four common errors (idols)
  - Mandate of science: don't be wrong, be right.
- Structures, acoustics, lighting…go way back
- Use of the term "building science"? Post World War II.
  - More common in the British Commonwealth than in the US.

PROCEEDINGS
OF THE
UNIVERSITY OF ILLINOIS
CONFERENCE ON
ARCHITECTURAL EDUCATION
FEBRUARY 21, 22, 23, 1949

## Max Abramovitz, 1949

ABRAMOVITZ: Such a research program would be one of the greatest aids to the profession that could possibly happen. Actually, I am very concerned that the science of building is going to disappear. I wonder if you realize how very few men are left today who are expert in building science. They are very rare and they are passed around among the large offices. You have to dig them out of their holes and revive them. One of them in our office is eighty years old. He passed out the other day and we had to pump stuff into him to get him going again because we couldn't spare him. It sounds like a joke, but we also have one who gets drunk every third day, but we can't fire him.

We have talked about design for the past two days and it is of vital importance. But once you get into working drawings, specifications, and

## What is building science?

- What was Max Abramovitz referring to?
- Science applied to buildings
- Broader definition: all physical, chemical and biological processes affecting buildings
  - Structures, lighting, acoustics, technology, controls, mechanicals, etc.
  - Human behavior? Social behavior?
- Narrower definition: Heat, air and moisture transport in buildings. “Hygrothermal” building science.
- Corresponds to European use of the term “building physics”.

## Who’s in charge of Building Science?

- NIBS, National Institute of Building Science
  - Building Enclosure Councils, joint with AIA
- CIB, Congrès International de Bâtiment
- SBSE, Society of Building Science Educators
- ASHRAE, American Society of Heating Refrigerating and Air Conditioning Engineers
  - Handbook chapters: Fundamentals on Heat, Air and Moisture Transport, Applications on Building Envelopes
  - Repository of the building science knowledge base
- Others…

## ASHRAE Handbook

- An ordered knowledge base regarding building mechanical systems and enclosures.
  - Equations (F25)
  - Tables (F26)
  - Examples (F27)
  - Applications (A39)
  - References
  - Index


- Knowledge in, knowledge out
- Handbook lags research by 4 years
- Practice lags handbook by 4+ years
- Codes lag practice by…

- Discussion: Has post-modernism relegated text to the “old school”?

## Building Science and architecture?

- Cowan, Henry J. (Department of Architectural Science, Sydney, 1979) “Architectural Science and Post-Modernism” *Architectural Science Review* 23:1.
  - “…many thought that the outcome of the Second World War would be decided by superior scientific knowledge, and the prestige of science and engineering had possibly never been as high before or since. RIBA had had a Science Group for some years, but it now came to be treated as an important committee. In 1941 it produced a report which caused a number of architecture schools after the war to introduce specialist courses in building science, supported by building science laboratories…”

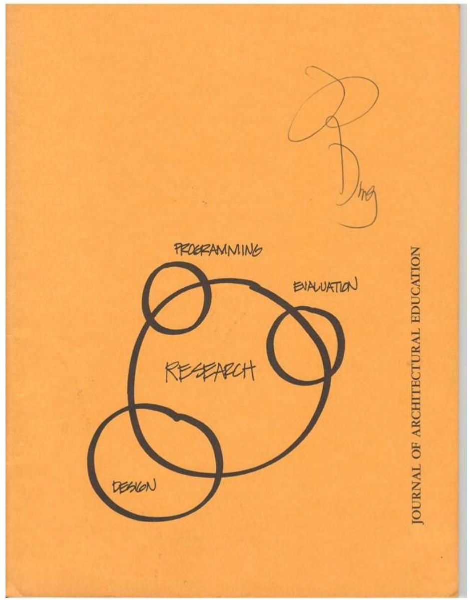
## The architecture/engineer discussion is never dispassionate Cowan argues:

- Modernism promised technical improvements, but did not deliver
  - “Perhaps the extreme case was the house Mies van der Rohe designed for Dr. Elizabeth Farnsworth in 1946 near Plano, Illinois. The four walls were glass from floor to ceiling, and there were no roof overhangs or sunshades. After its completion in 1950 Dr. Farnsworth described the house as unfit for human habitation and started legal proceedings against the architect. Although she lost the case, she altered the house so extensively to improve the thermal environment that it ceased to be the visual masterpiece Mies had designed. The house has since been demolished.”
- Post-modernism promises technical improvements
  - “It is no longer possible to emphasize the lightness of the structure with an unshaded glass wall, and create an acceptable interior thermal and luminous environment by the expenditure of large quantities of energy.”

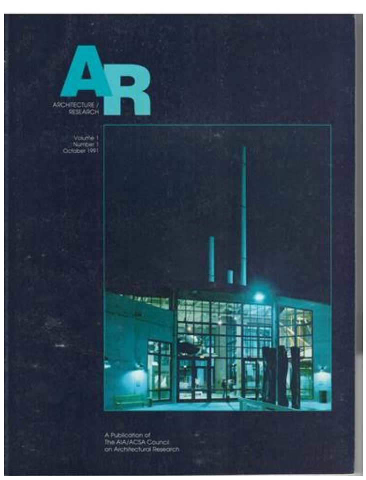
## Farnsworth house, today

- Moral: avoid grandstanding

## What about research?




## Architectural Research has a history…




AR
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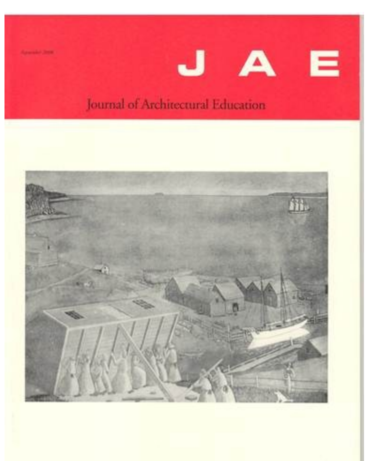
Volume 1
Number 1
October 1991



A Publication of
The AIA/ACSA Council
on Architectural Research

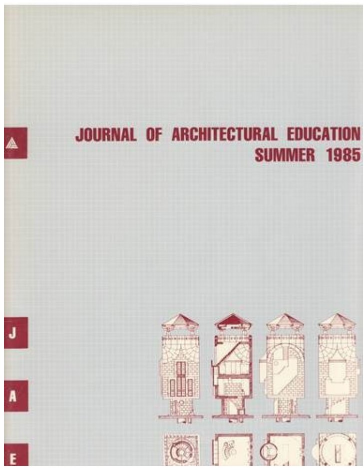
## Example: Architectural Science Review

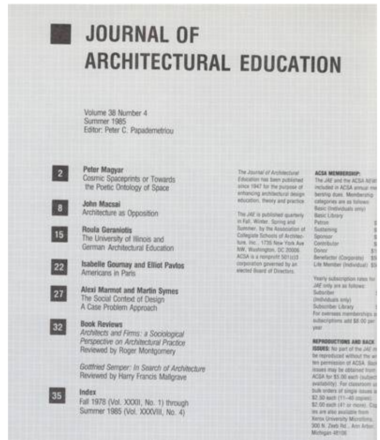

## Journal of Architectural Education




September 2000 **contents**

## Older JAE



JOURNAL OF ARCHITECTURAL EDUCATION

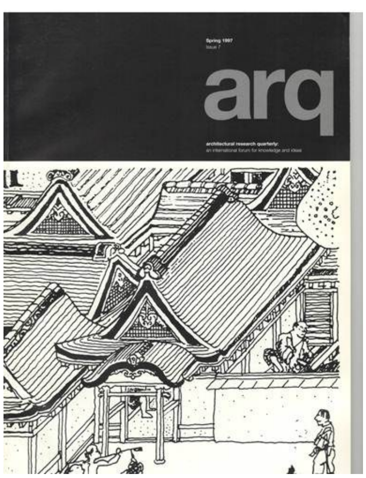
Volume 38 Number 4
Summer 1985
Editor: Peter C. Papademetriou



The *Journal of Architectural Education* has been published since 1947 for the purpose of enhancing architectural design education, theory and practice.

The *JAE* is published quarterly in Fall, Winter, Spring and Summer, by the Association of Collegiate Schools of Architecture, Inc., 1735 New York Ave NW, Washington, DC 20006. ACSA is a nonprofit 501(c)3 corporation governed by an elected Board of Directors.

## Architectural Research Quarterly



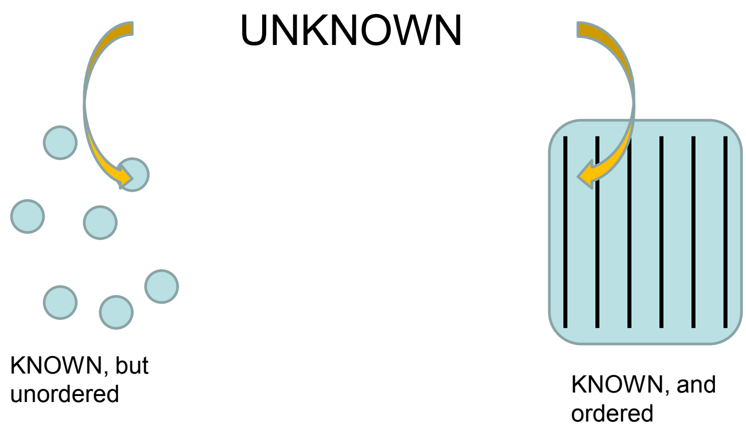

arq: Vol 2: spring 1997
contents

# contents



- History, technology, theory, education, cultural studies, opinion, perception, individual and social behavior, etc.

## My impression of two research models




## Why do research?

- Good reasons
  - Natural curiosity, glory of the chase, turning unknowns into knowns
  - Being part of a research community
  - Making a contribution to the knowledge base
  - Advancing the arts (profitably)
  - Setting policy
- Not so good reasons
  - Promotion and tenure
  - Making money
  - Seeking confirmation of (arbitrary?) findings
  - Delaying management decisions
  - Grandstanding

## Good research involves…

- Context and community
  - Research agenda is developed collectively, it is not arbitrary
  - Peer review, by recognized peers
  - Contributes to an accepted knowledge base
  - Funding
- Method
  - Avoids error (recall Francis Bacon)
  - Tests a hypothesis
  - Makes assumptions explicit
  - Derives conclusions consistent with data and method

## Problems with research in buildings…

- Degrees of freedom
  - Every building is different
  - How to select a sample which represents the population?—assume restrictions to the degrees of freedom.
  - We represent mean values, maybe variance. We can report significance only with severe simplifying assumptions.
  - Is building research even possible?
- Starting assumptions
  - Linear no-threshold assumption in health studies
- Confirmation bias
  - Why do research once policy is established?

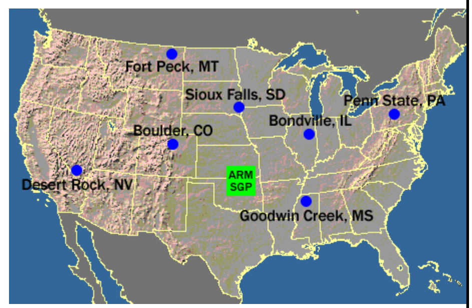
## Time for an example of research and its building science context…

## White roofs, wet roofs

Got a call about moisture problems in the desert…

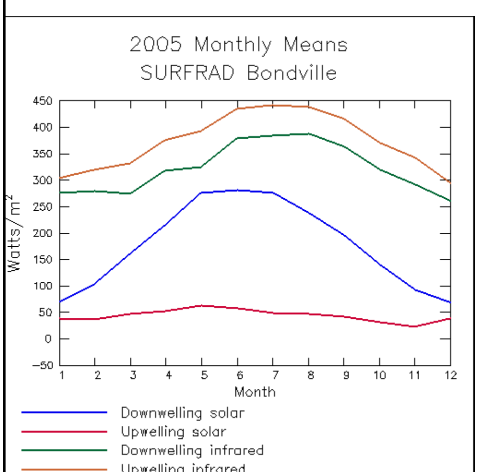
## Radiation measurements: SURFRAD network (NOAA)

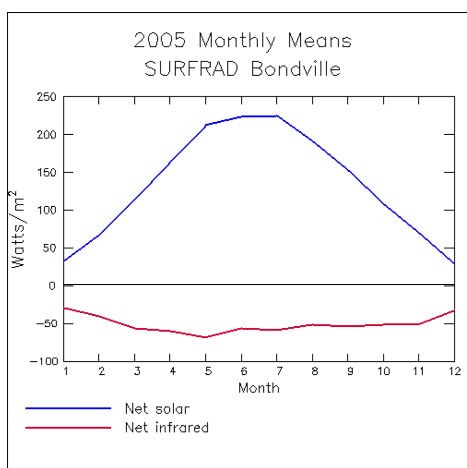
Desert Rock NV site.



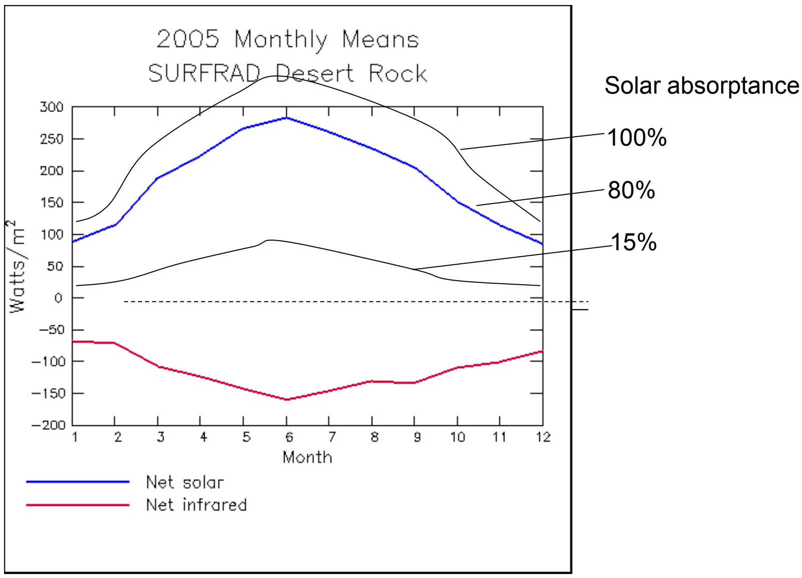

SURFRAD Sites.

## Solar and infrared net fluxes, Bondville IL



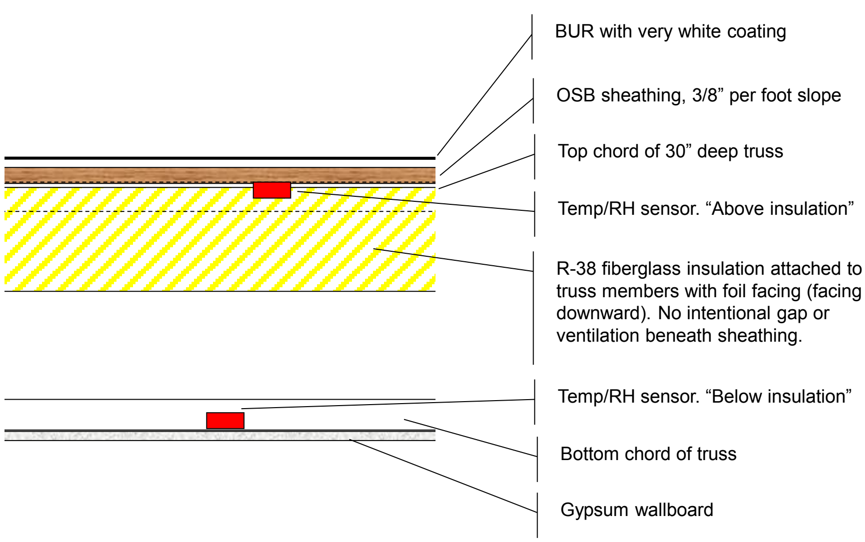
## Net fluxes, Desert Rock NV



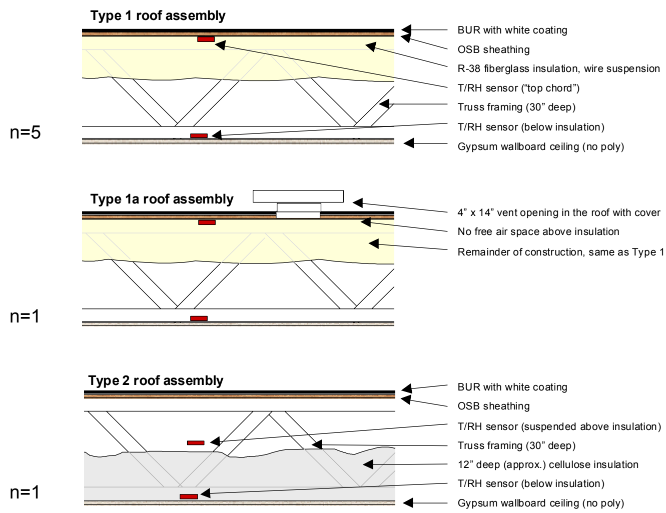

## Notes

- For roofs with low solar absorption, heat loss to the sky may be much greater than heat gain from the sun.
- The sky temperature varies by angle from zenith. Sky temperature at the horizon approaches ambient outdoor air temperature.
  - White roof with parapets sees the coldest part of the sky.

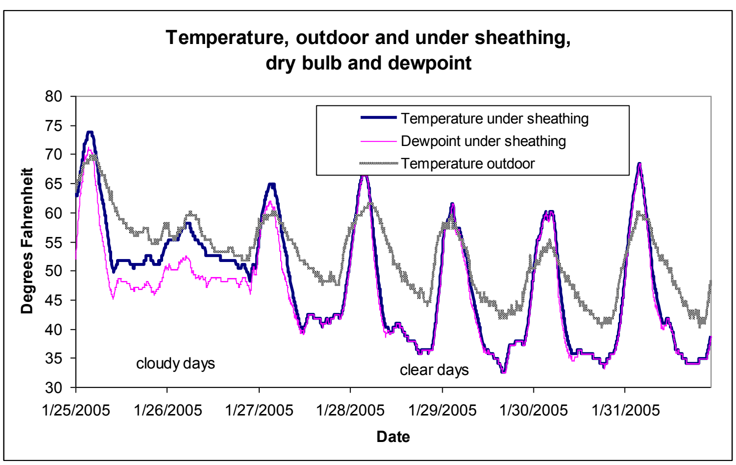
## Type 1 construction



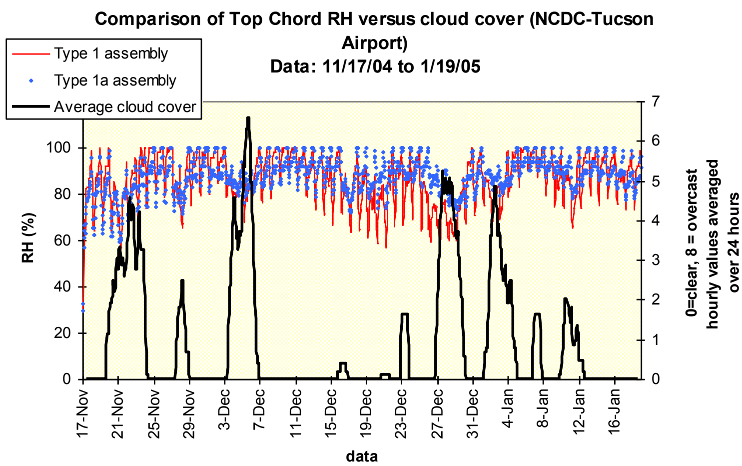
# Three types of roof assemblies



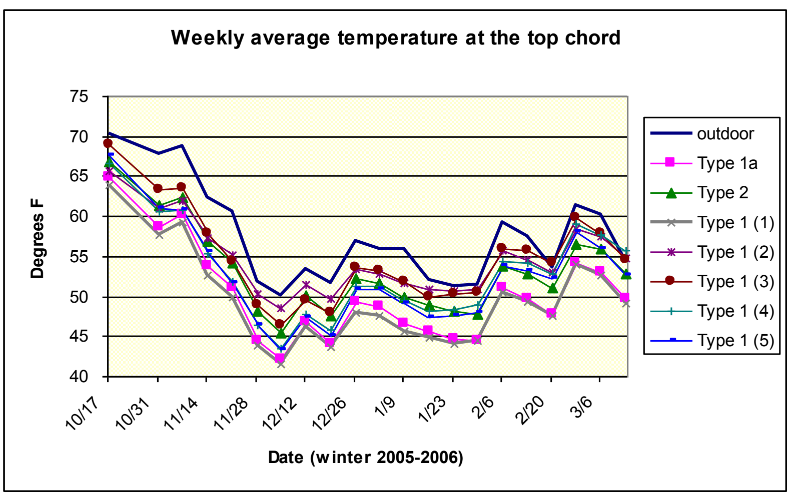

# Underside of the sheathing was cold and wet. Type 1 construction, worst case.



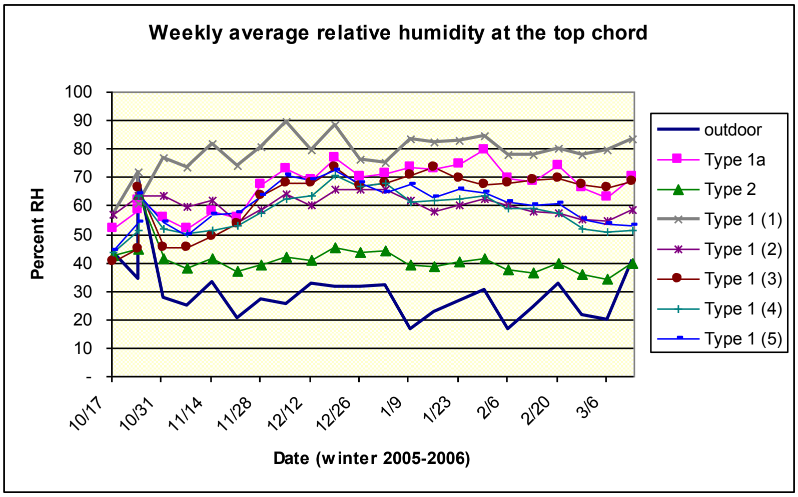
# Cloud cover effect



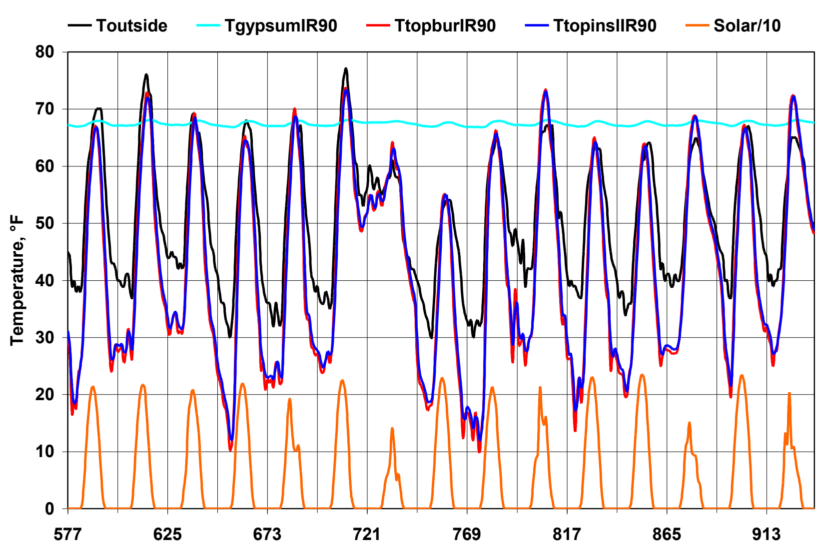

# Temperature depression at the top chord



## Relative humidity at the top chord




## Modeled values, Tom Petrie, ORNL



## Conclusions from the research

- For analysis purposes (and for design) solar radiation and sky radiation must be distinguished.
  - They should not be lumped, as with sol-air temperature
  - Fund NOAA for more extensive radiation survey.
- Any blanket recommendation for white roofs should be revisited.
  - Concerns in other climates have been expressed.
  - Classic case: building science must resolve competing interests—durability and energy efficiency
- Client had several options for remediation.
  - "Desert tan"

## Reference


- Rose, W.B. 2007. "White roofs and moisture in the US desert Southwest", Proceedings *Thermal Performance of the Exterior Envelopes of Whole Buildings X*. US Department of Energy, Oak Ridge National laboratory.


## Acknowledgement


- The presenter would like to acknowledge Tucson Electric Power, especially Linda Douglas-Worthey, for their generous participation in this project, and for the expert contributions of their staff.

## What does this example teach us?

- Research arises from an expressed need.
- The method was pretty good. The data were reliable and repeated. The observations complied with the measured values, which complied with modeled.
- Practice is not immediately affected, which is a good thing.
  - Recall the lag time between research—knowledge base—policy—practice.
- Radiant effects have been refined in the Handbook

## General Conclusions

- The idea of building science arose post- World War II. It accompanied Modernism, and carried a promise of technological progress
- It exists today as a coherent and independent field of study, with a strong community, funding, demand, and delivery.
- Building research contributes to practice (despite difficulties) and to the building science body of knowledge.
- Research and policy are in a continual dance
- Compliant design may not perform. Performing design may not comply.
- Relation of building science to architecture and architecture education must continue to be discussed.

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