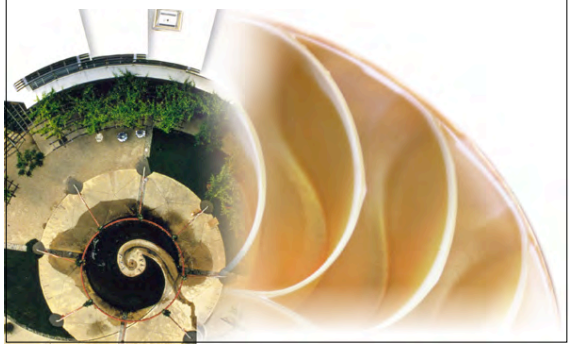
Architectural Sailing

ARCH 331/431 Spring 2008
Lecture 13



announcements 5/13/08

Final Exam Alternate Time:

Wednesday, 6/11

4:30 - 6:20

SMI 304

Final Exam Assigned Time:

Friday, 6/13

4:30 - 6:20

Gowan 201

announcements 5/13/08

Assignment 4: Shading Model Studies

EXTENSION - DUE NEXT WEEK

Available on the Course Website (due in sections next week)

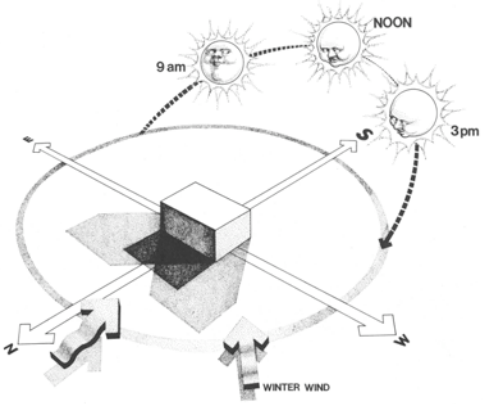
Wednesday, May 14 • 6:30 in Architecture 147

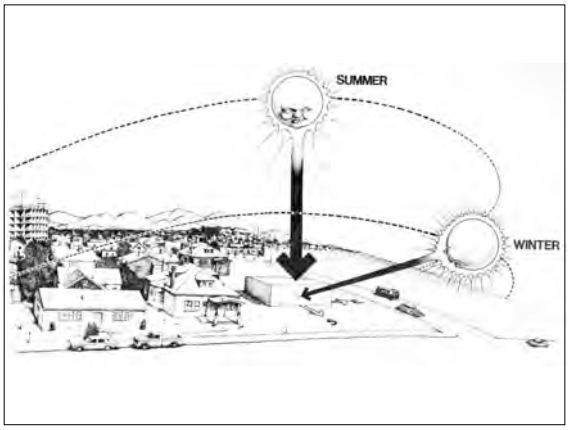
Glen Murcutt

Materiality and Continuity

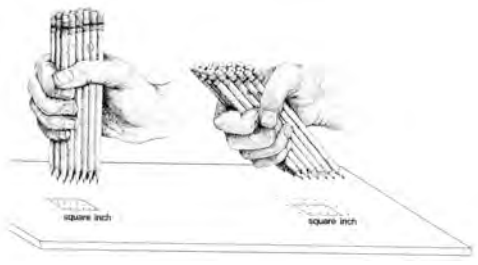
Sun Angle Calculators

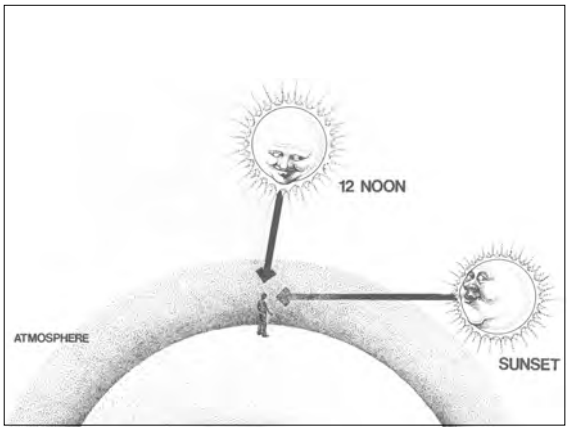
http://www.sbse.org/resources/sac/index.htm





Angle of Incidence





Solar Radiation: Horizontal and Vertical Surfaces

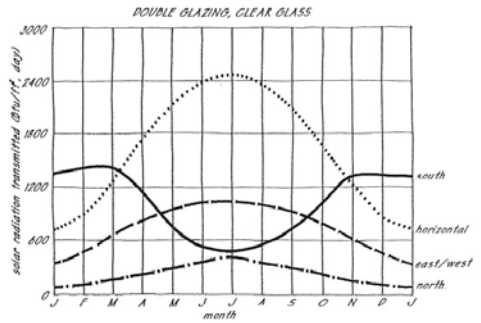
Solar radiation

thermal energy measured in

Btu/h sf
or
Watts/m^2

both direct + diffuse sunlight

The effect of orientation on glazing



Solar Radiation: Horizontal and Vertical Surfaces

MEEB 10th Appendix C: Solar Data

TABLE C.15

			Seattle	Phoenix	Denver
Heating Degree Days			4684	1552	6016
January	Solar Insolation BTU/day ft²	HS	262	1021	840
		VS	378	1462	1465
July		HS	2248	2486	2273
		VS	1299	964	1053
Year (avg.)		HS	1056	1371	1570
		VS	857	1326	1334

HS = Horizontal Surface

VS = Vertical South

Palmetto House

Florida Keyes

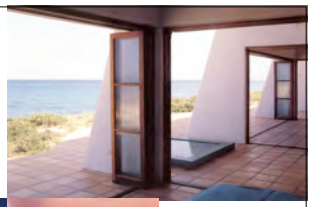
Jersey Devil

Architectural Solutions to Environmental Adaptation
- LOCATION
- FORM
- METABOLISM

Casa Mariposa

Baja California, Mexico

Jersey Devil



ECS Objectives - Towards Sustainability
- RESOURCE CONSERVATION
- HUMAN HEALTH, COMFORT AND SAFETY
- HUMAN DELIGHT

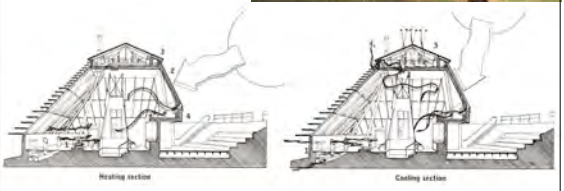
Montessori Island School

Tavernier, Florida

Jersey Devil

Energy and Form Sustainability

Architectural Means of Environmental Adaptation



Spring Lake Visitor Center • Obie Bowman • Santa Rosa, CA

Thermal Building Types

Envelope Dominated

- typically small buildings
- low internal heat gains
- space heating determined by heat loss through the envelope.
- relatively high balance point temperature

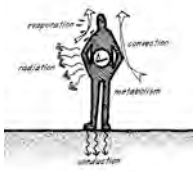
Internal Load Dominated

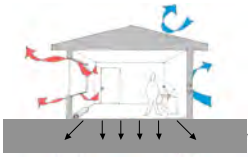
- typically large buildings
- high internal heat gains
- space cooling requirements determined by heat gains from people, lights and equipment within the building
- relatively low balance point temperature

Balance Point Temperature

Thermal Equilibrium between Inside and Outside

$Q_{losses} = Q_{gains}$ or $Q_{out} = Q_{in}$





Envelope ("skin") losses

Infiltration ("lung") losses

Perimeter ("feet") losses

Balance Point Temperature

Thermal Equilibrium between Inside and Outside

$Q_{in} = Q_{out}$

$Q_{gains} = Q_{losses}$

$Q_{gains} = Q_{free} + Q_{purchased}$

Q_{free} = people + lights + equipment

$Q_{purchased}$ = purchased heat (boiler, furnace, etc.)

$Q_{losses} = UA \times (T_{in} - T_{outside}) = UA \times \Delta T$

balance point temperature — thermostat setting — a building's "thermal fingerprint"

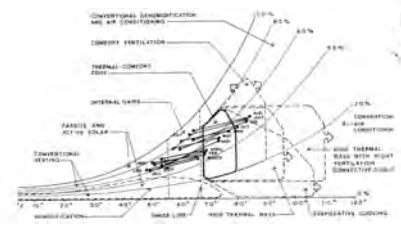
Balance Point Temperature: $T_{balance\ point} = T_{in} - Q_{gains} / UA$

Internal heat gains

Climate Design Priorities (5)

Southern Coastal California

- Open the building to the outdoors since temperatures are comfortable most of the year.
- Protect from the summer sun.
- Keep the heat in and cold out in the winter.
- Use natural ventilation for summer cooling.
- Let the winter sun in.
- Use thermal mass to flatten day-to-night temperature swings in the summer.



Architectural Sailing

MECHANICIAL HEATING | MECHANICAL VENTILATION AND COOLING

OUTSIDE TEMPERATURE 45 55 68 78 85 95

INSIDE TEMPERATURE RANGE

CLOSED HEATING | OPEN | CLOSED COOLING

OUTSIDE TEMPERATURE 45 55 65 75 85 95

Balance Point Temperature

"Change-over" Temperature*

*natural ventilation rule-of-thumb assumes interior temperatures are typically 3°F **higher** than outside air temperatures when natural ventilation is effective, due to people, lights and equipment.

Closed Heating Mode Strategies

MECHANICAL	ARCHITECTURAL
• Active Solar	• Thermal Mass: Heat
• Furnace/Boiler	• Direct Gain: Sun

Closed Cooling Mode Strategies

ARCHITECTURAL	MECHANICAL
• Thermal Mass: "Coolth"	• Ceiling Fans
• Evaporation: Water	• Chillers

Seattle 2-hour temperatures

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
12 midnight	37	40	42	45	50	56	60	60	56	49	42	38
2	37	39	40	43	49	54	58	58	54	48	42	37
4	36	38	39	42	47	53	56	57	53	47	41	36
6	35	37	39	41	46	52	55	56	52	46	40	36
8	36	39	40	43	48	54	57	58	54	47	41	37
10	41	44	47	51	57	62	67	67	62	54	46	41
12 noon	44	48	51	55	61	67	72	72	67	58	49	44
2	45	50	53	57	64	70	75	75	69	60	51	45
4	44	48	52	56	62	68	74	74	68	59	50	44
6	42	46	48	52	59	64	69	69	64	55	47	42
8	40	43	45	48	54	60	64	64	60	52	45	40
10	38	41	43	46	52	57	61	62	57	50	43	39

CLOSED/Heating: 66.0%

OPEN/"Sailing": 32.6%

CLOSED/Cooling: 1.4%

Balance Point = 55° F

Change-over Temperature = 75° F

Seattle 2-hour temperatures

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
12 midnight	37	40	42	45	50	56	60	60	56	49	42	38
2	37	39	40	43	49	54	58	58	54	48	42	37
4	36	38	39	42	47	53	56	57	53	47	41	36
6	35	37	39	41	46	52	55	56	52	46	40	36
8	36	39	40	43	48	54	57	58	54	47	41	37
10	41	44	47	51	57	62	67	67	62	54	46	41
12 noon	44	48	51	55	61	67	72	72	67	58	49	44
2	45	50	53	57	64	70	75	75	69	60	51	45
4	44	48	52	56	62	68	74	74	68	59	50	44
6	42	46	48	52	59	64	69	69	64	55	47	42
8	40	43	45	48	54	60	64	64	60	52	45	40
10	38	41	43	46	52	57	61	62	57	50	43	39

8am to 6pm

CLOSED/Heating: 55%

OPEN/"Sailing": 42%

CLOSED/Cooling: 3%

Balance Point = 55° F

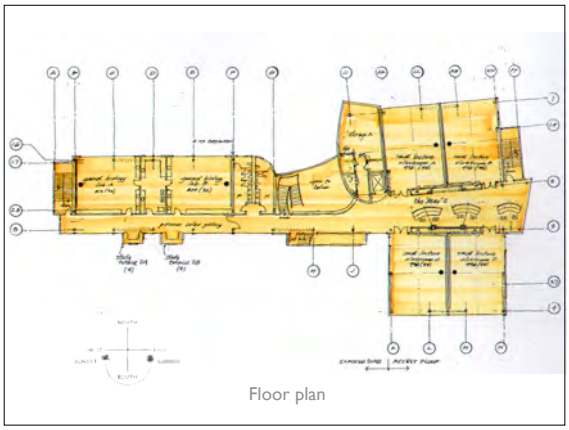
Change-over Temperature = 75° F

The Kirsch Center for Environmental Studies at De Anza College is the lead demonstration building for energy innovation and sustainability in the California Community College System.

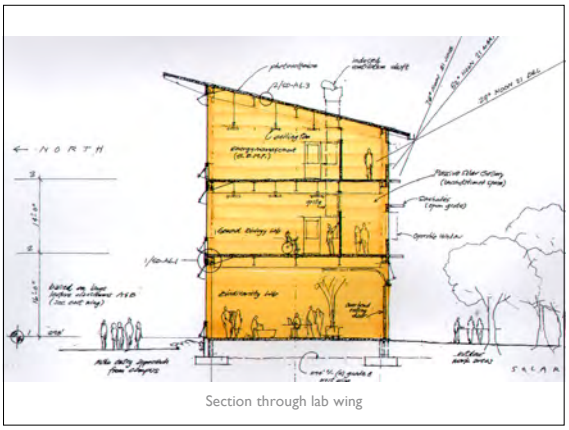
View from the south-west

Site plan

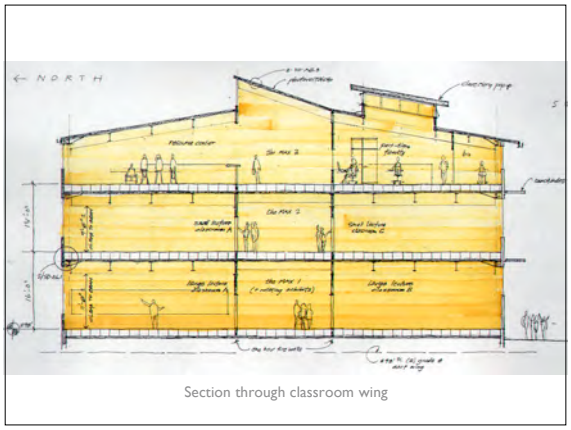
South elevation



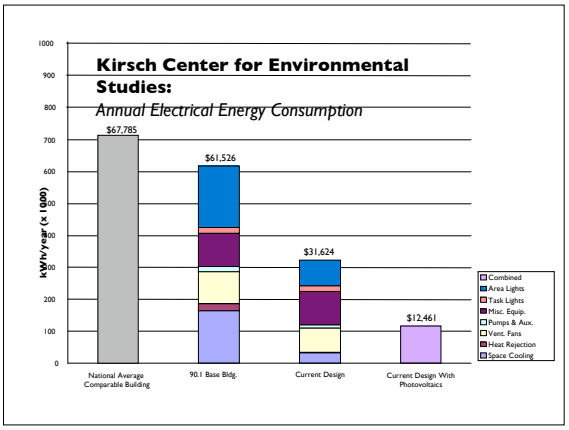
Floor plan

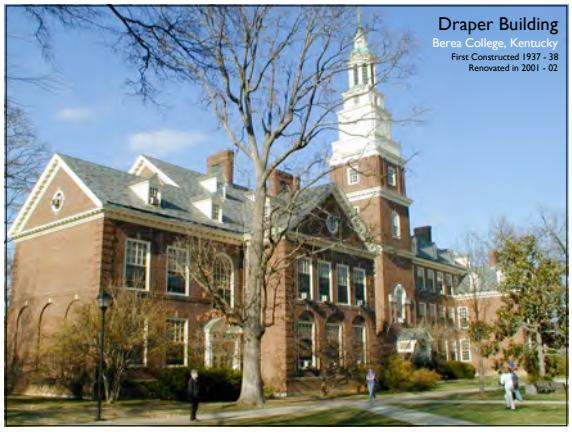


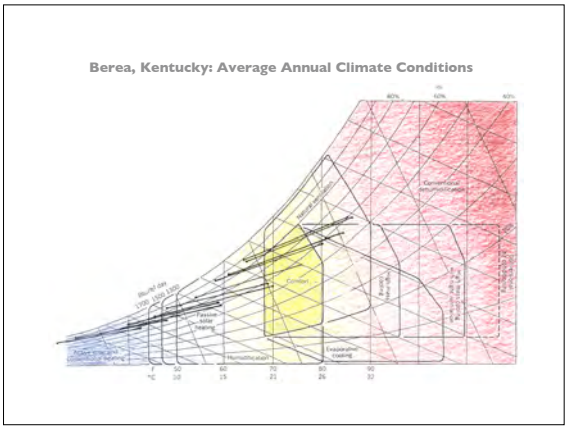
Section through lab wing

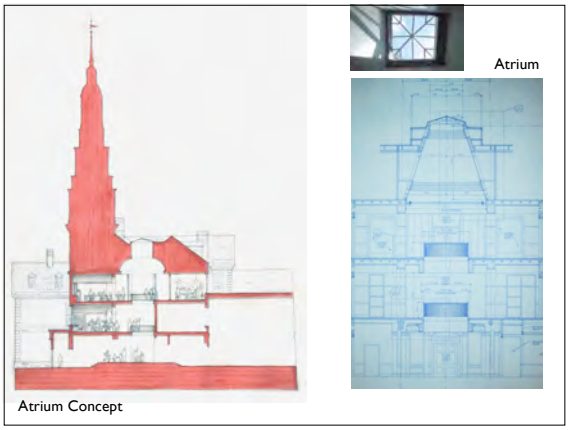


Section through classroom wing

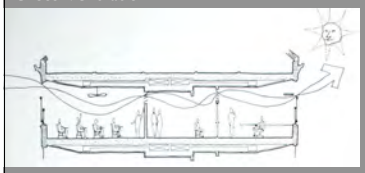




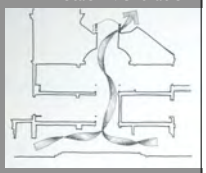




Cross Ventilation

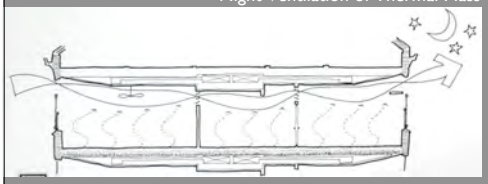


Stack Ventilation



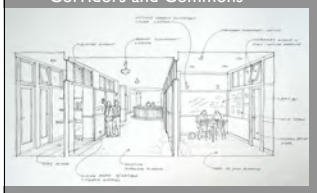
- Double-hung windows
- Transom windows between perimeter rooms and corridors
- Integrated passive and mechanical systems

Night Ventilation of Thermal Mass



Economizer-mode cooling

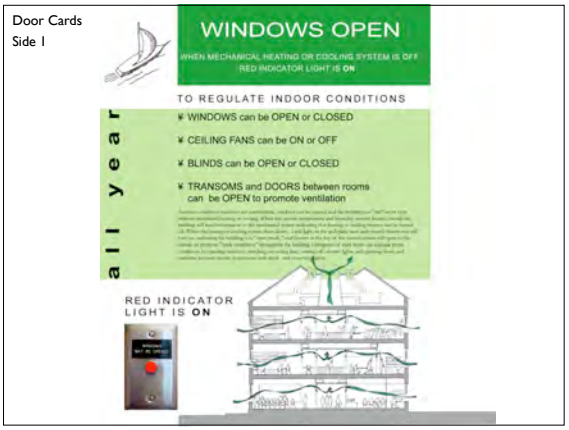
Corridors and Commons



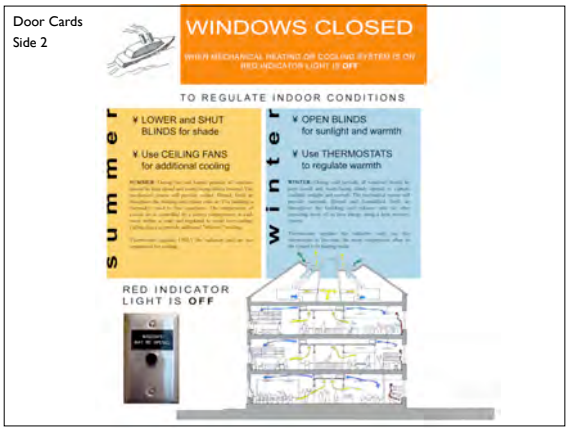
Office Concept

- Transparancy
- User-controlled switches: lights, ceiling fans, radiators, windows and transoms
- Places to gather, study, and connect to the network

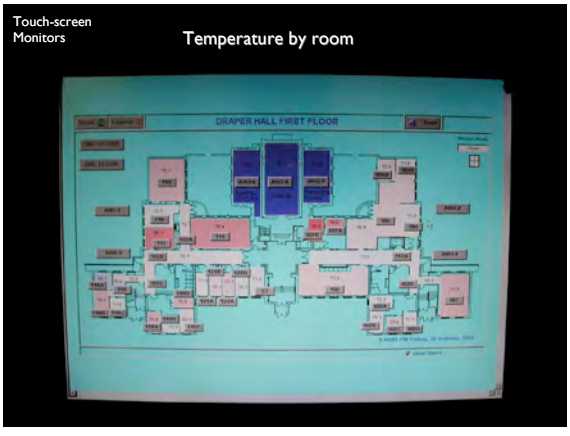
Door Cards
Side 1



Door Cards
Side 2



Touch-screen
Monitors



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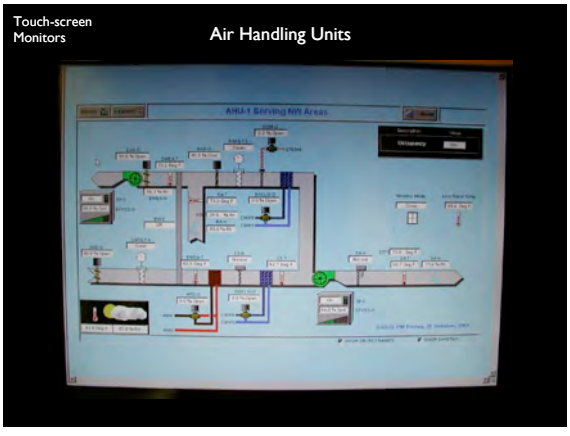
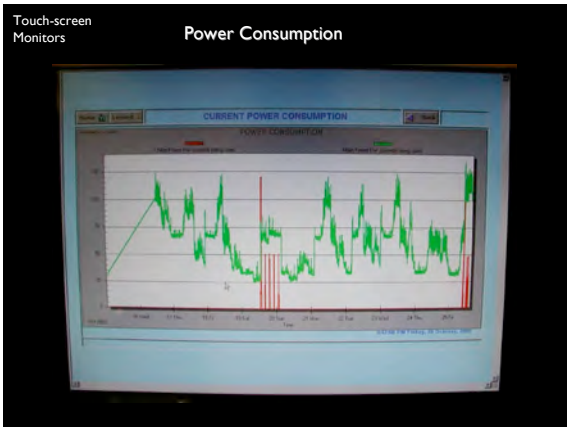




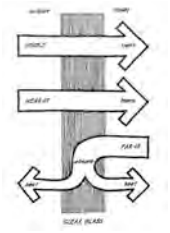
Fundamental Criteria for Passive Solar Design

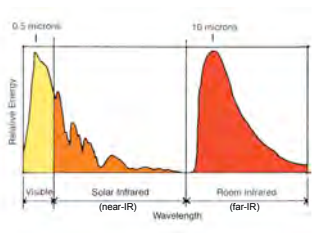
1. Insulation
- Keep the Heat In and Cold Out

2. Glass
- Window Area and Solar Access

3. Mass
- Heat Capacity and Quantity of Materials
- Location and Distribution of Materials

2. Glass
Greenhouse Effect





3. Mass
Thermal Mass:

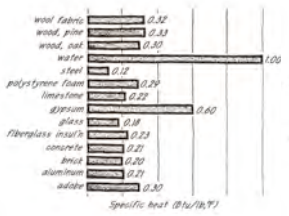
HEAT CAPACITY
The capacity of a material to store heat for a given temperature change

↓

Specific Heat
and
Volumetric Heat Capacity

Specific Heat

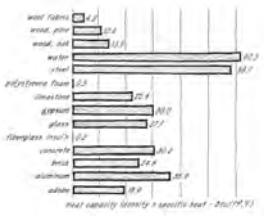
*Heat Capacity by **Weight***



Thermal Mass = SH x Mass

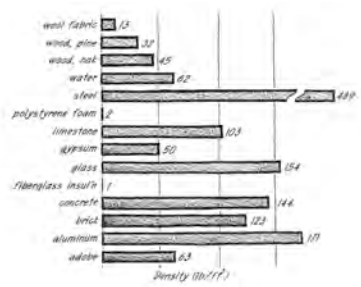
Volumetric Heat Capacity

*Heat Capacity by **Volume***



Thermal Mass = VHC x Volume

Density



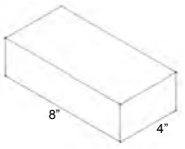
Heat Capacity

The capacity of a material to store heat for a given temperature change

Material	Specific Heat BTU/lb °F	Density lb/ft³	VHC BTU/ft³ °F
Water	**1.00**	**62.0**	**62.0**
Concrete	**0.20**	**120.0**	**24.0**
Wood	**0.50**	**27.0**	**13.5**
Air	**0.24**	**.075**	**.018**
Steel	**0.12**	**489**	**58.7**

Heat Capacity

The capacity of a material to store heat for a given temperature change



Volume = 72 in³
= .0417 ft³

Weight = 5 lbs

Mass

Thermal Mass = SH x Density x Volume

VHC

TM = VHC x Volume

TM = 24 BTU/ ft³ °F x .0417 ft³ = **1.0 BTU / °F**

TM = Specific Heat x Mass

TM = .20 BTU/ lb °F x 5 lbs = **1.0 BTU / °F**

Q = TM x dT

Passive Solar Systems

DIRECT GAIN

INDIRECT GAIN

- Trombe Wall
- Sunspace
- Roof Pond