

NATURAL MATERIALS FOR THERMAL INSULATION

MULCH AND LAVA-ROCK CHARACTERIZATIONS

Aurélien P. Jean^a, Craig Adams^b, Mario A. Medina^b, Frédéric Miranville^a

^a Physics and Mathematical Engineering Laboratory for Energy, Environment and Buildings, University of Reunion Island, France

^b Civil, Environmental and Architectural Engineering Department, The University of Kansas, USA

aurelien.jean@univ-reunion.fr

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Summary

I – Context

II – Experimental design

III – Experimentation

IV – Results

V – Discussion

VI – Conclusion

I – CONTEXT

Project

- Location : Kansas University (USA),
- Topic : Sanitation technologies for developing nations,
- Goal : Find available and inexpensive insulation.

I – CONTEXT

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Objectives

- Mulch and lava rock thermal conductivities,
- Usefulness as building insulation.

II – EXPERIMENTAL DESIGN

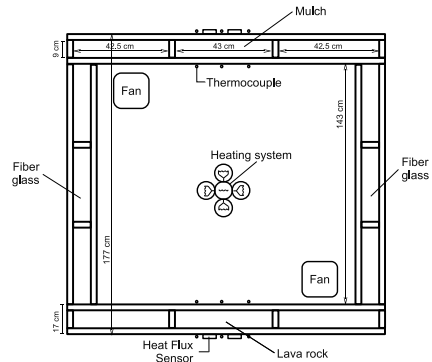


Fig. 1 : Instrumented reproduction of the original design

II – EXPERIMENTAL DESIGN

Conception

- Scale : one
- Partitions : wood
- Heat source : bulb lamps
- Homogeneity : Air fans

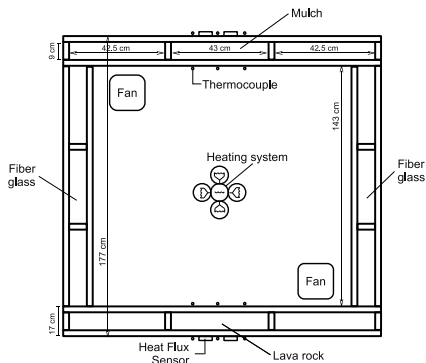


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Instrumentation

- Thermocouples (type T)
- Heat flux sensors
- Sampling : every minute

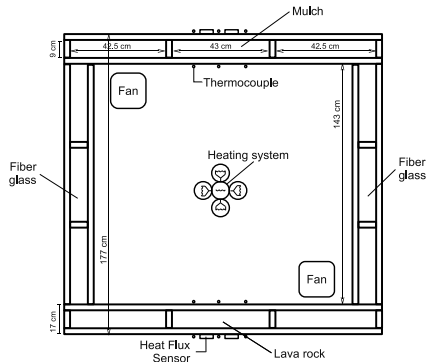


Fig. 1 : Instrumented reproduction of the original design

III – EXPERIMENTATION

Filled partitions



Fig. 2 : Mulch and lava-rock in the partitions

III – EXPERIMENTATION

Filled partitions



Fig. 2 : Mulch and lava-rock in the partitions

Time

- Time to steady state : 20 hours
- Total duration : 50 hours

IV – RESULTS

Raw data

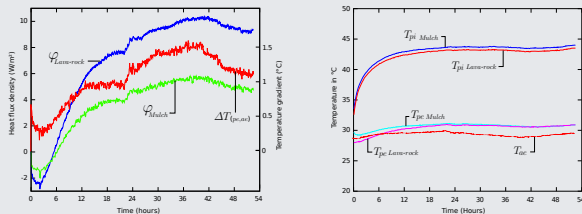


Fig. 3 : Heat fluxes and temperatures through the partitions filled with mulch and lava-rock

IV – RESULTS

Raw data

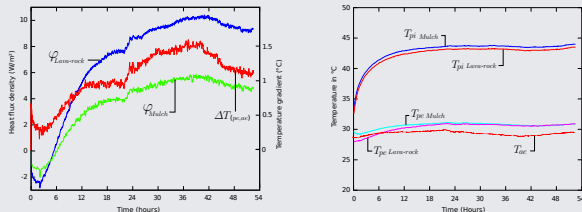


Fig. 3 : Heat fluxes and temperatures through the partitions filled with mulch and lava-rock

Numerical treatment

- Steady state : 7h duration (34h to 41h)
- Linear regression : slope ≈ 0 and std < 0.6

IV – RESULTS

Numerical treatment

- $R_{Partitions}^*$: FOURIER's equation
- $R_{Samples}^*$: Additive property

R^* : equivalent resistance.

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Results

	Conductivity $\lambda_{x,y} [W.m^{-1}.K^{-1}]$	Resistance $R [m^2.K.W^{-1}]$
Mulch	$0.48 \cdot 10^{-1} \pm 1 \cdot 10^{-3}$	$1.93 \pm 2 \cdot 10^{-2}$
Lava-rock	$1.29 \cdot 10^{-1} \pm 3 \cdot 10^{-3}$	$0.710 \pm 7 \cdot 10^{-3}$

$\lambda_{x,y}$ defines the thermal conductivity into the horizontal plane



V – DISCUSSION

Characteristics comparison

- $\lambda_{mulch} \approx \lambda_{bulk\ hemp}$
- $\lambda_{lava\ rock} \approx \lambda_{hemp\ brick}$ (for a density of $25\text{ kg}\cdot\text{m}^{-3}$)
- Mulch to Lava-rock \Rightarrow +70% thickness
(identical insulation) +235% mass

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Usefulness as thermal insulation

- $R_{mulch} > R_{air} > R_{lava\ rock}$
- Mulch : useful
- Lava-rock : (less) useful

$$R_{air} \approx 1.0\text{ m}^2\cdot\text{K}\cdot\text{W}^{-1}$$



VI – CONCLUSION

Resume (conductive level)

- Mulch : $0.48 \cdot 10^{-1} \pm 1 \cdot 10^{-3} \text{ W.m}^{-1}.\text{K}^{-1}$
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- Mulch should be preferred to lava-rock as building insulation

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Perspectives (dynamic level)

- Need for the densities and calorific capacities
- Material chosen after behavior prediction (simulation)

THANK YOU FOR YOUR ATTENTION

Annexes

