

# VEGETALIZED COMPLEX PARTITION (VCP)

## IMPACT OF A GREEN ROOF UNDER A HUMID TROPICAL CLIMATE, COMPARISON BETWEEN HONG KONG AND REUNION ISLAND

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## SUMMARY

I – Introduction

II – Experimental design

III – Experimentation

IV – Results

V – Discussion

VI – Comparison : Hong Kong  
and Reunion Island

VII – Conclusion

# I – INTRODUCTION

## Definition

*"A Vegetalized Complex Partition (VCP) defines every partitions in which there is a living vegetation layer, regardless of its position into the complex"*

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## Context

- 1977 : First publication,
- Since 1977 : Rising knowledge,
- Few studies under humid tropical climate.

# I – INTRODUCTION

## Humid tropical climate

- Summer: Isolation (as expected),
- Winter : Heat loss amplifier (not expected).

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Results published by JIM & TSANG (2011).

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## Objectives

- Impact of a VCP on a building thermal field,
- Check if the heat loss happen with an extensive VCP.

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Results obtained in Reunion Island (humid tropical climate).

## II – EXPERIMENTAL DESIGN

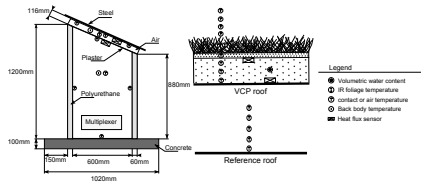


Fig. 1 : The Isotest small scale building and its two roof configurations : reference and VCP.

## II – EXPERIMENTAL DESIGN

### Conception

- Scale : 1/3 (Isotest),
- Isolated and hermetically sealed,
- Slop : 24°,
- VCP : Steel, lava-rock, Zosya<sup>t</sup> (1mm, 80mm, 40mm).

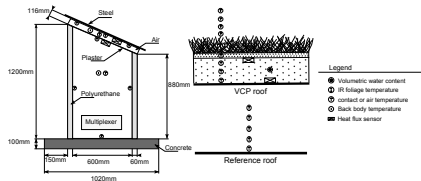


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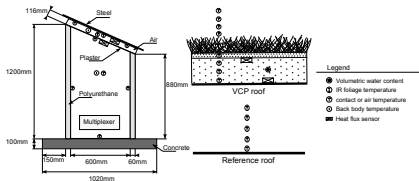
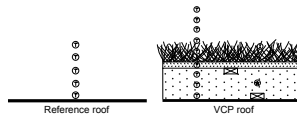
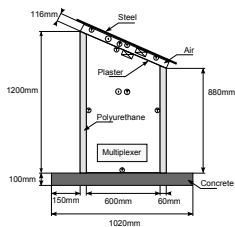


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### Instrumentation

- Thermocouples (type T),
- Infrared sensor,
- Heat flux sensors,
- Reflectometric sensor,
- Sampling : every minute.

# III – EXPERIMENTATION



## Legend

④ Volumetric water content

① IR foliage temperature

② contact or air temperature

⊙ Back body temperature

■ Heat flux sensor

# III – EXPERIMENTATION

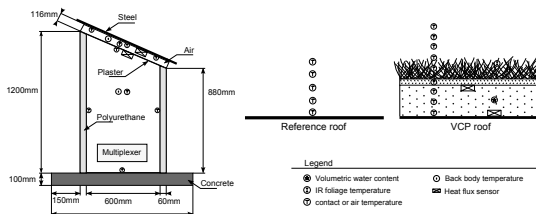


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# III – EXPERIMENTATION

## Situation

- Reunion Island (Indian Ocean)
- March to August

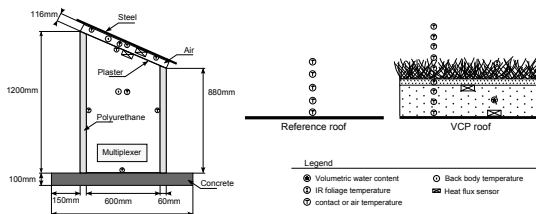


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# III – EXPERIMENTATION

## Situation

- Reunion Island (Indian Ocean)
- March to August

## Conditions

- $T_{\text{air}}$  : 26.7°C to 21.2°C
- RH : 75%
- $I_r$  : 1000 W.m<sup>-2</sup> to 600 W.m<sup>-2</sup>
- $W_s$  : 1.75 m.s<sup>-1</sup> to 2.4 m.s<sup>-1</sup> (2m)

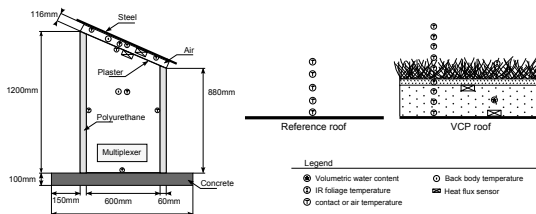


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# IV – RESULTS

## Raw data : Evolution

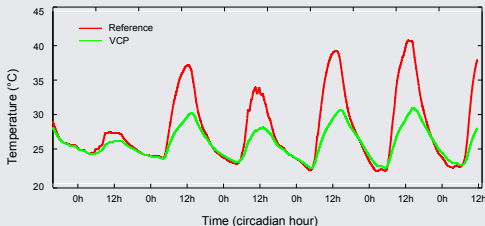


Fig. 2 : Evolution of the reference and VCP Isotests air temperature from the 23<sup>rd</sup> to the 28<sup>th</sup> of March 2014.

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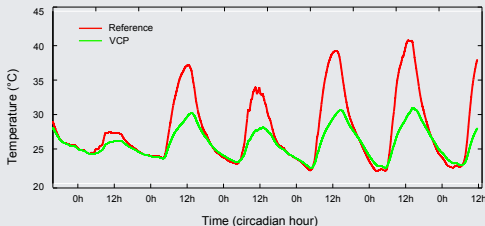


Fig. 2 : Evolution of the reference and VCP Isotests air temperature from the 23<sup>rd</sup> to the 28<sup>th</sup> of March 2014.

## Raw data : Average values

- Heat flux → Gain : 94.61%    Loss : 88.62%
- $\Delta T_{noon}^{max}$  → Steel : 41.4°C    Plaster : 18.9°C

# IV – RESULTS

## Numerical treatment

- Approximation : quasi-static state (around noon)
- $R_{VCP}^*$  : FOURIER's equation
- $R_{layer}^*$  : Additive property

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$R^*$  : equivalent resistance.



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## Characterization

- $R_{VCP}^* = 0.302 \pm 0.016 \text{ m}^2 \cdot \text{K} \cdot \text{W}^{-1}$
- $\lambda_{sub}^* = 0.319 \pm 0.017 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$
- $\lambda_{veg}^* = 0.775 \pm 0.046 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$

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$\lambda^*$  : Equivalent thermal conductivity

# V – DISCUSSION

## Energy saving

- Averaged reduction :  $8.19 \pm 0.41 \text{ W.m}^{-2}$
- Consumption economy :  $30.0 \pm 1.5 \text{ kWh.e.m}^{-2}$

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Results averaged over the 5 months

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## Origins of impacts

- Radiative protection
- Inertia : delay and lower the intensity
- Evapotranspiration (low)

# VI – COMPARISON : HONG KONG / REUNION ISLAND

## Jim and Tsang's experimental design

- Sky woodland over 150 m<sup>2</sup>,
- Soil : 100 cm,
- Trees : height of 5-10 m,
- Humid tropical climate.

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## Remark 1

*"The transpiration rate varies widely depending on seasonal and weather conditions"*

→ **Verified for evapotranspiration.**



## VI – COMPARISON : HONG KONG / REUNION ISLAND

### Remark 2

*"The tree canopy layer could reduce solar radiation reaching the soil surface"*

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### Remark 3

*"The soil substrate layer of the intensive green roof can be considered as a large heat sink on the rooftop to reduce temperature fluctuation"*

→ **Substrate do act as heat sink.**

## VI – COMPARISON : HONG KONG / REUNION ISLAND

### Remark 4

*"In winter, the subtropical intensive green roof triggers notable upward heat flow from the substrate to the ambient air"*

- Not observed,
- Origin : VCP design and the meteorological conditions,
- Water content : heat loss amplifier
- Process : Evaporation (if adequate RH and  $W_s$ ).



## VII – CONCLUSION

### Experimentation

- Original extensive VCP (sloped steel roof)
- Conductivities :  $\lambda_{sub}^* = 0.319$ ,  $\lambda_{veg}^* = 0.775 \text{ W.m}^{-1}.\text{K}^{-1}$
- Saving :  $8.19 \text{ W.m}^{-2} \rightarrow 30.0 \text{ kWh.e.m}^{-2} / 5 \text{ month}$

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Reunion Island – tropical humid climate

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Reunion Island – tropical humid climate

### Comparison Hong Kong / Reunion Island

- Similar behavior (except winter heat loss),
- Loss : governed by meteorological conditions and VCP water content,
- Evaporation : heat loss amplifier.





THANK YOU FOR YOUR ATTENTION



# Annexes

