

# **20<sup>th</sup> Earoph World Congress & Mayor's Caucus**

*Research Paper*

**“Building & infrastructure design  
To improve thermal comfort”**

*by*

*Mazlin Ghazali, Architect M.Ghazali*

*&*

*Mohd Peter Davis, Universiti Putra Malaysia*

# Case Study: Malaysia

## 1. Practical solution to Indoor heat stress

*Combine Cool Roof, wall shading plus thermal mass night time ventilation*

## 2. Proposed HONEYCOMB solution to

**Urban Heat Island**

*reintroduce trees*

*less roads more parks*

*large savings for Developers*

## 3. MEASURING CONSUMER ACCEPTANCE

Figure 3 Outdoor versus indoor daily temperature during Malaysian heatwave

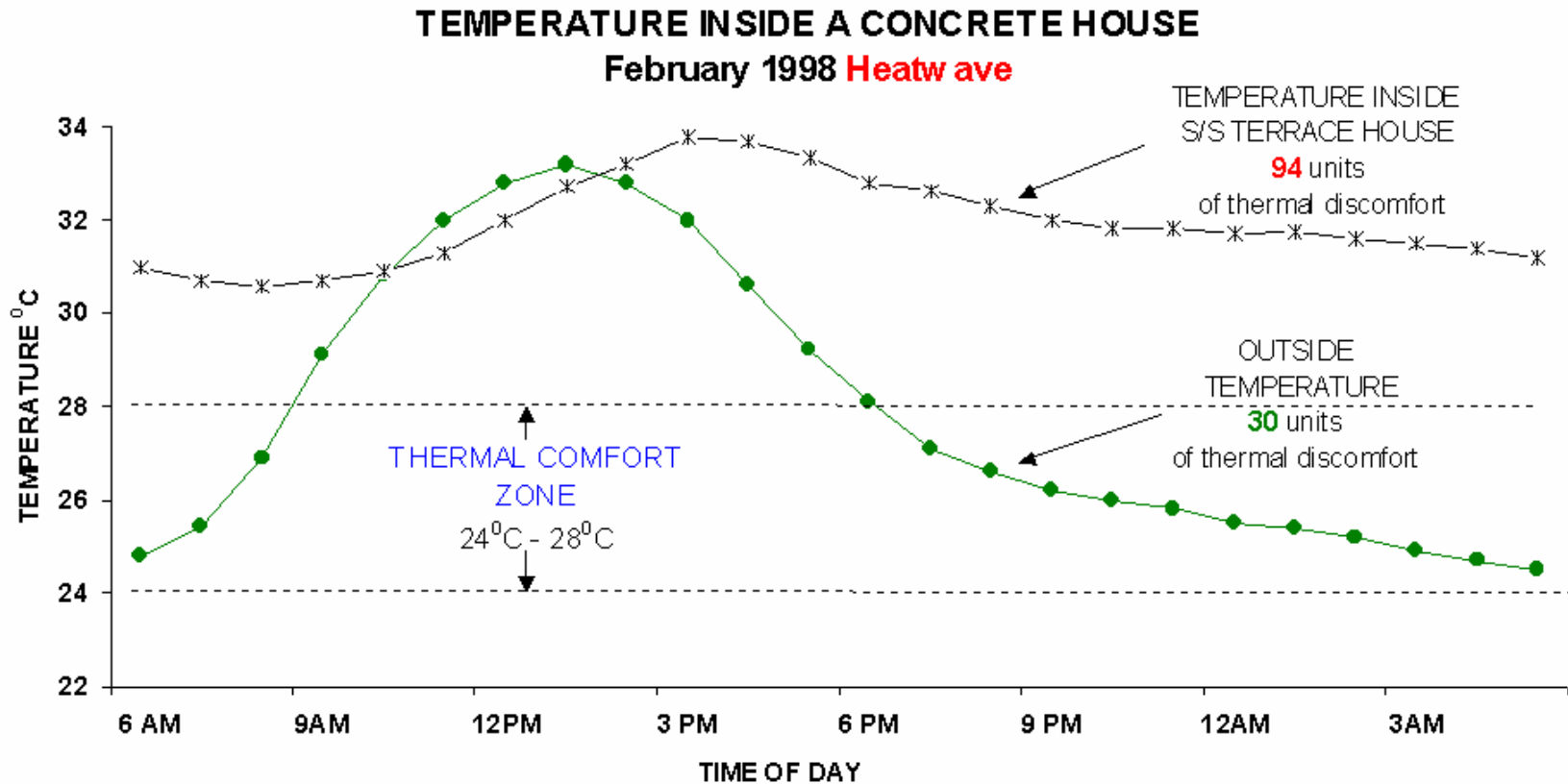
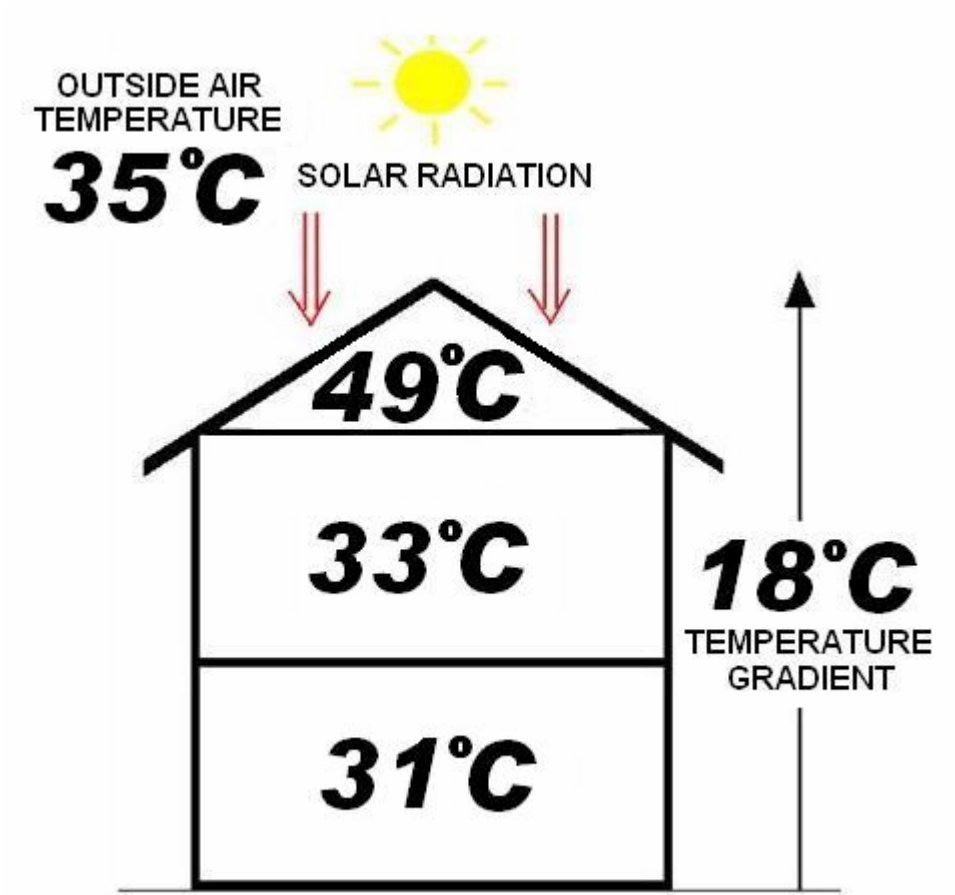


Figure 4 Temperature gradient in a terrace house at 3pm on a very hot day





**Figure 5 Roof space temperature in terrace house compared to renovation with Cool Roof**

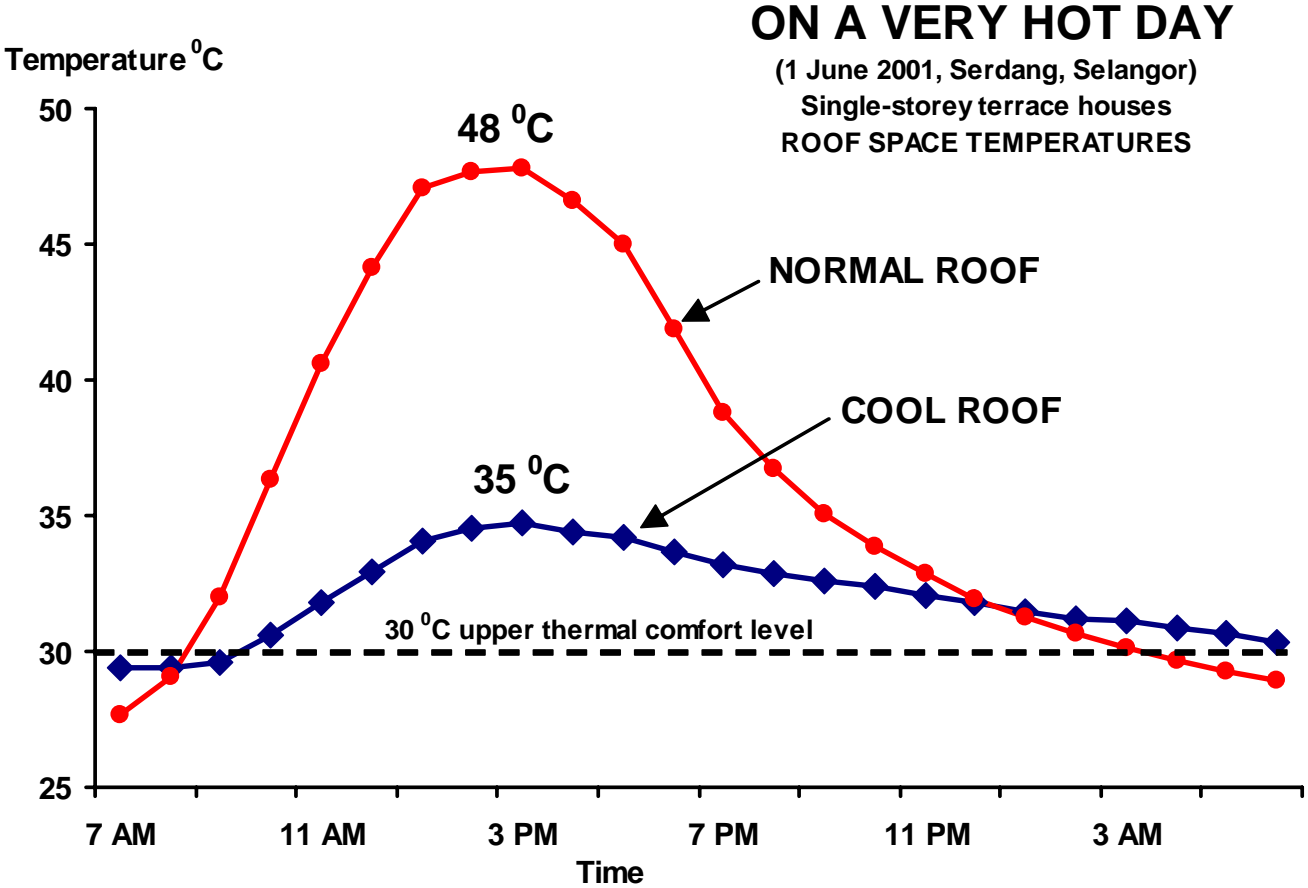
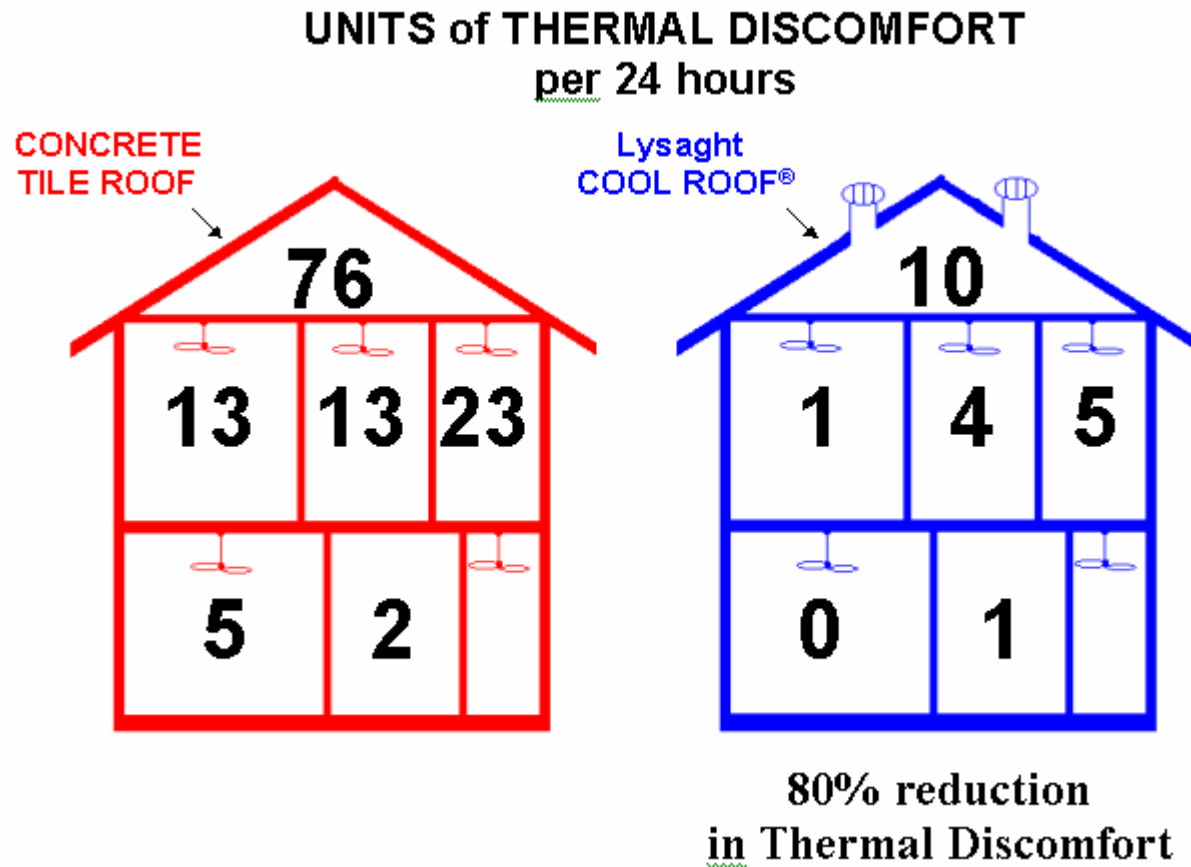


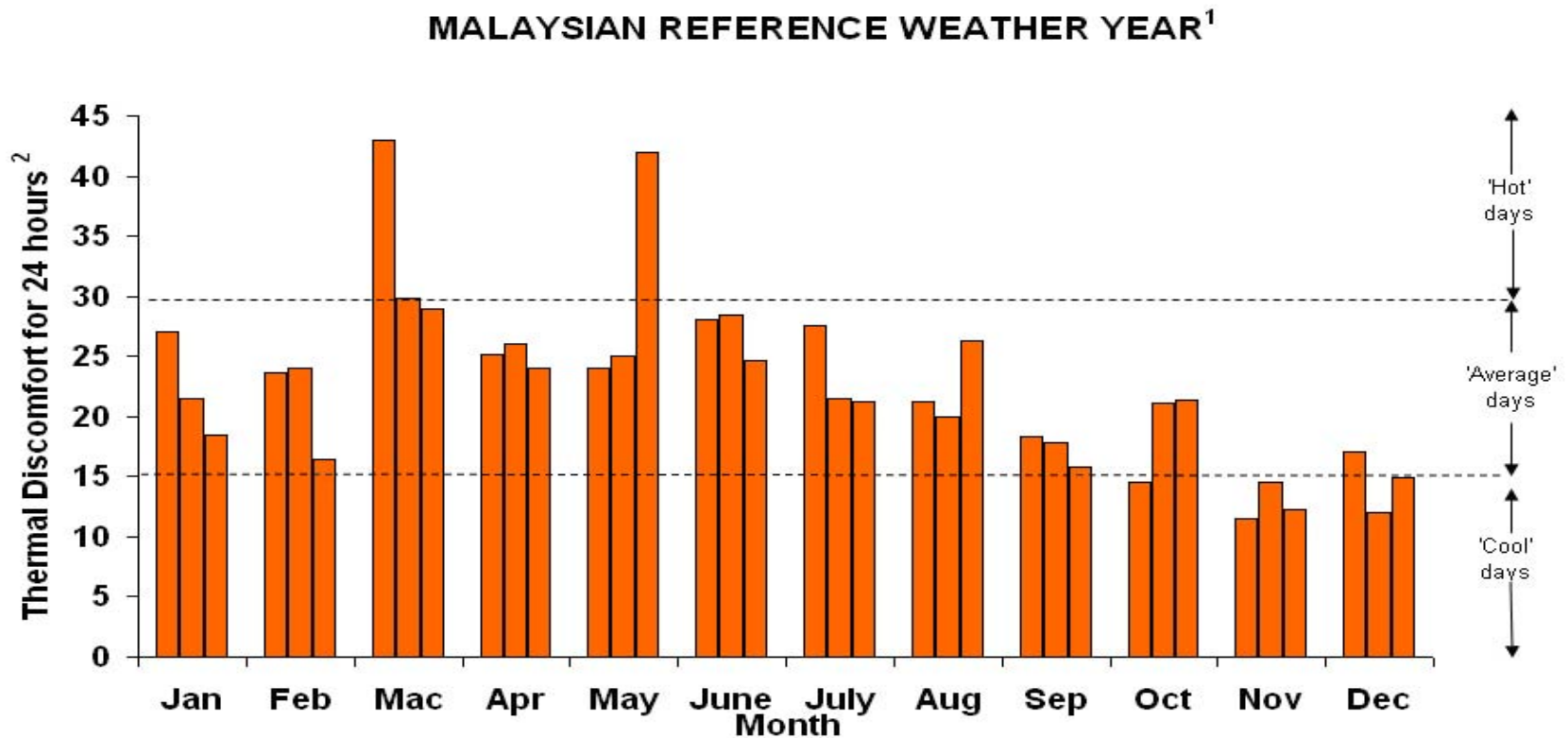
Figure 6 Thermal discomfort in terrace house versus renovation with cool roof







**Figure 2 The Malaysian weather year expressed in human thermal discomfort**



<sup>1</sup>Reference G Reimann, M.P.Davis, A.Zain Ahmed (2000). Workshop Environment Friendly Township for Developing Countries, Universiti Putra Malaysia, Serdang, Selangor, 31 January.

<sup>2</sup>Assuming 28°C Upper Thermal Comfort Level Reference: Mohd Peter Davis, S. Shanmugavelu, Nurizan Yahaya & Nor Azian Nordin (2000). Construction Industry R&D Achievement Seminar. The Mines, Sri Kembangan, 12 September

# MASTER BEDROOM **Hottest day** (8 March)

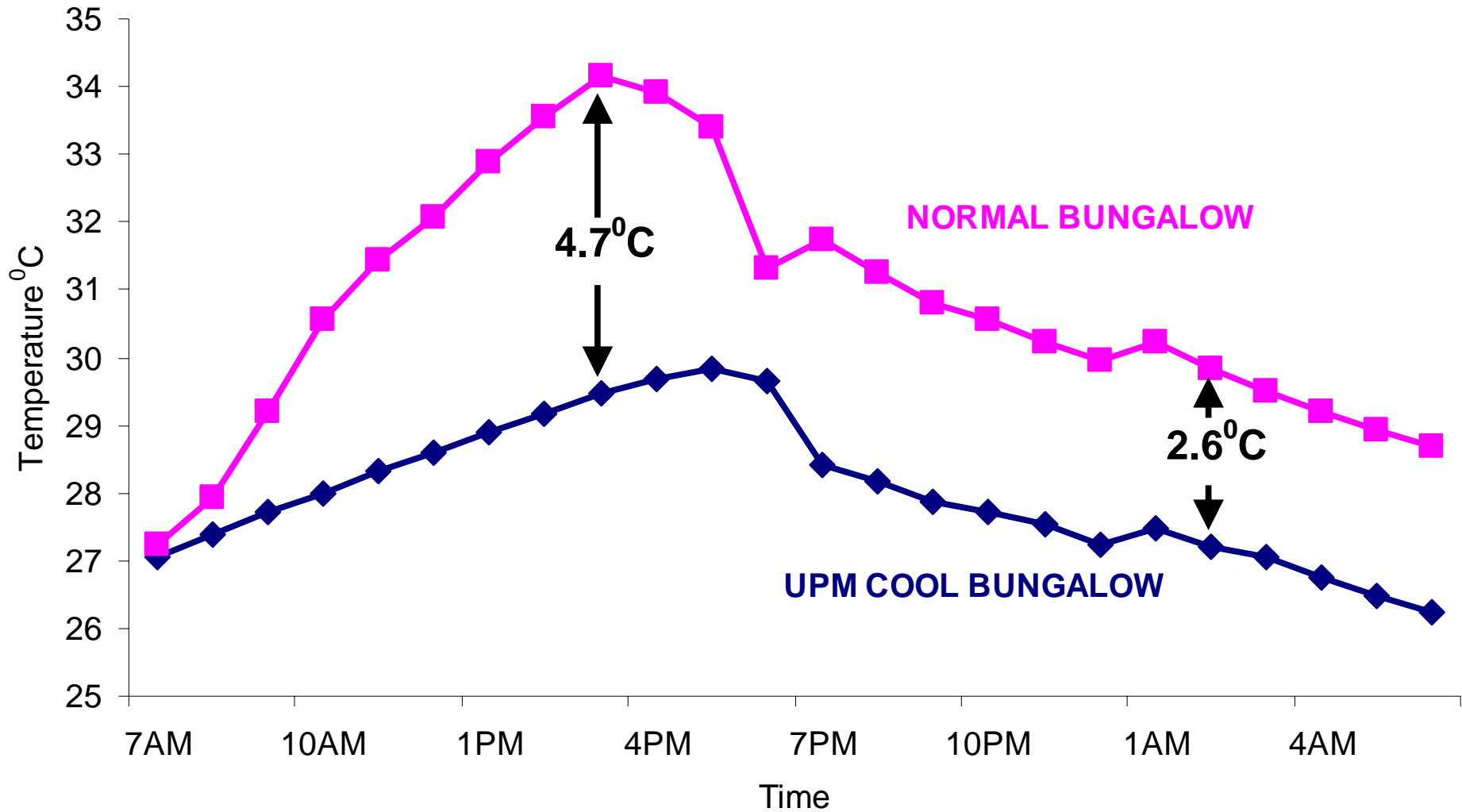


Figure 7 Computer simulated maximum temperatures on hottest day of year

**HOTTEST DAY OF YEAR (8 March)  
MAXIMUM TEMPERATURE**

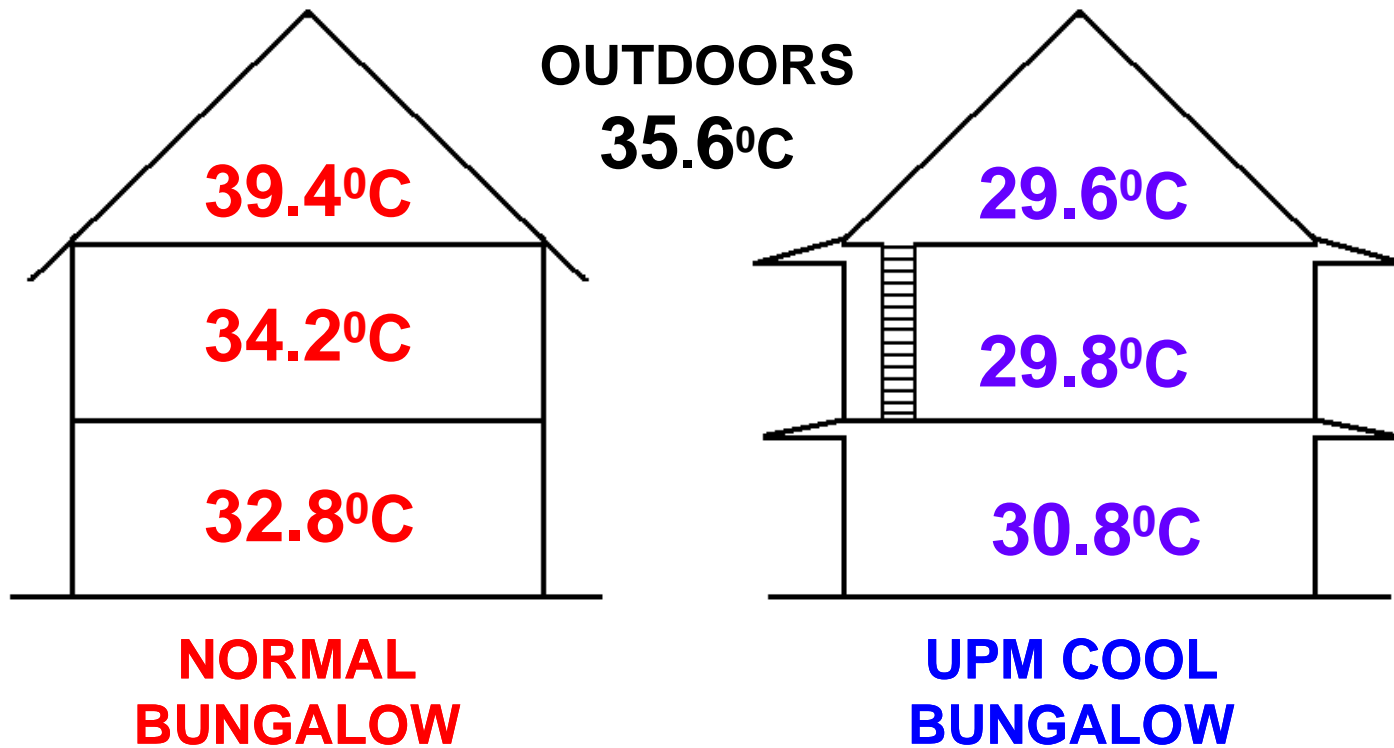
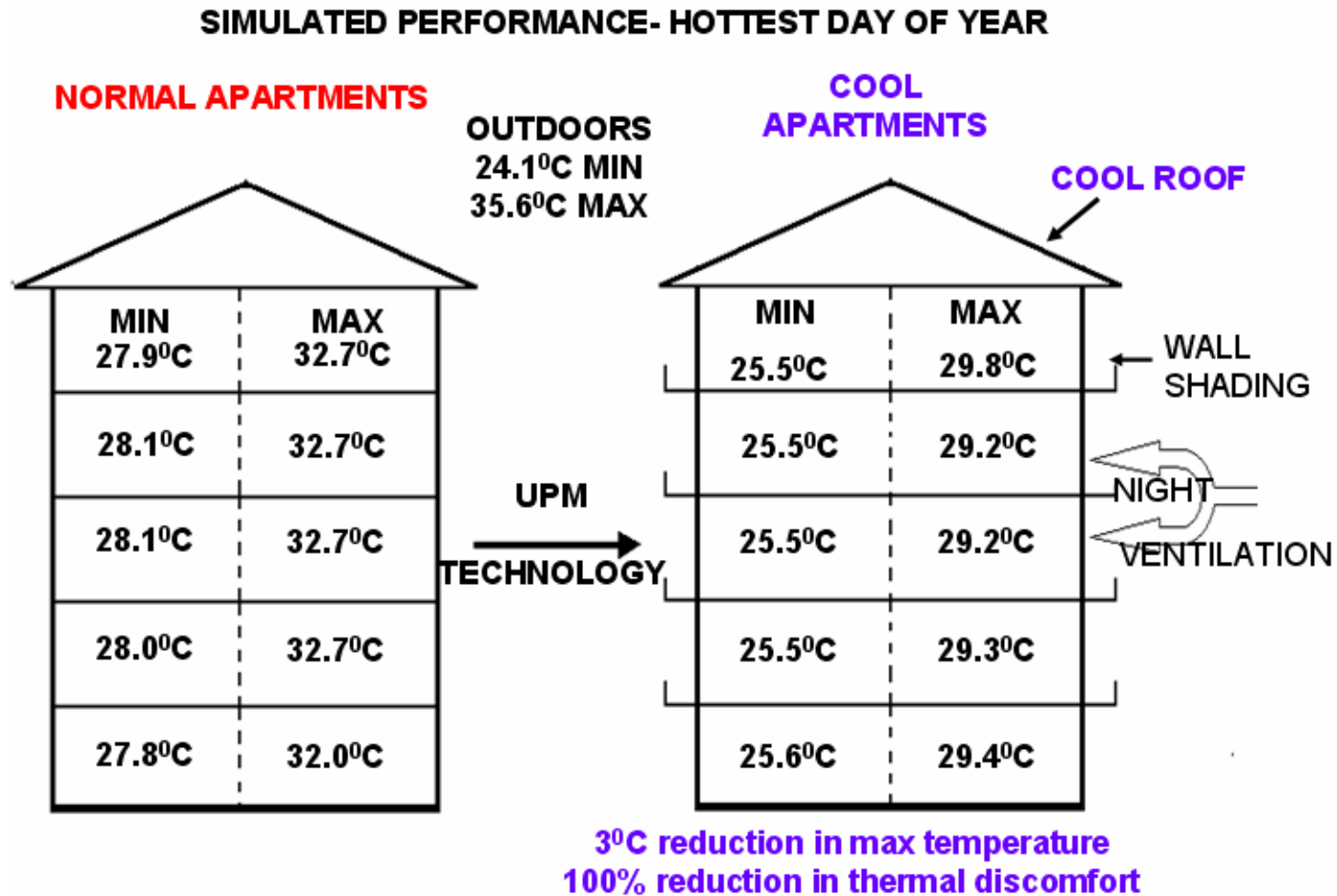


Figure 8 Computer simulated min/max temperatures of 5 storey apartments



# Summary of Cool House Technology

**Solves hot house problem**

- **without air-conditioning**
- **at no extra building cost**
- commercial designs from

Arkitek M. Ghazali

- *Ready for adoption by Developers*

**If Malaysia adopts  
this Cool House technology  
will save the country  
**RM 200 BILLION**  
in electricity  
over 30 years**

## Sketch of an Urban Heat-Island Profile

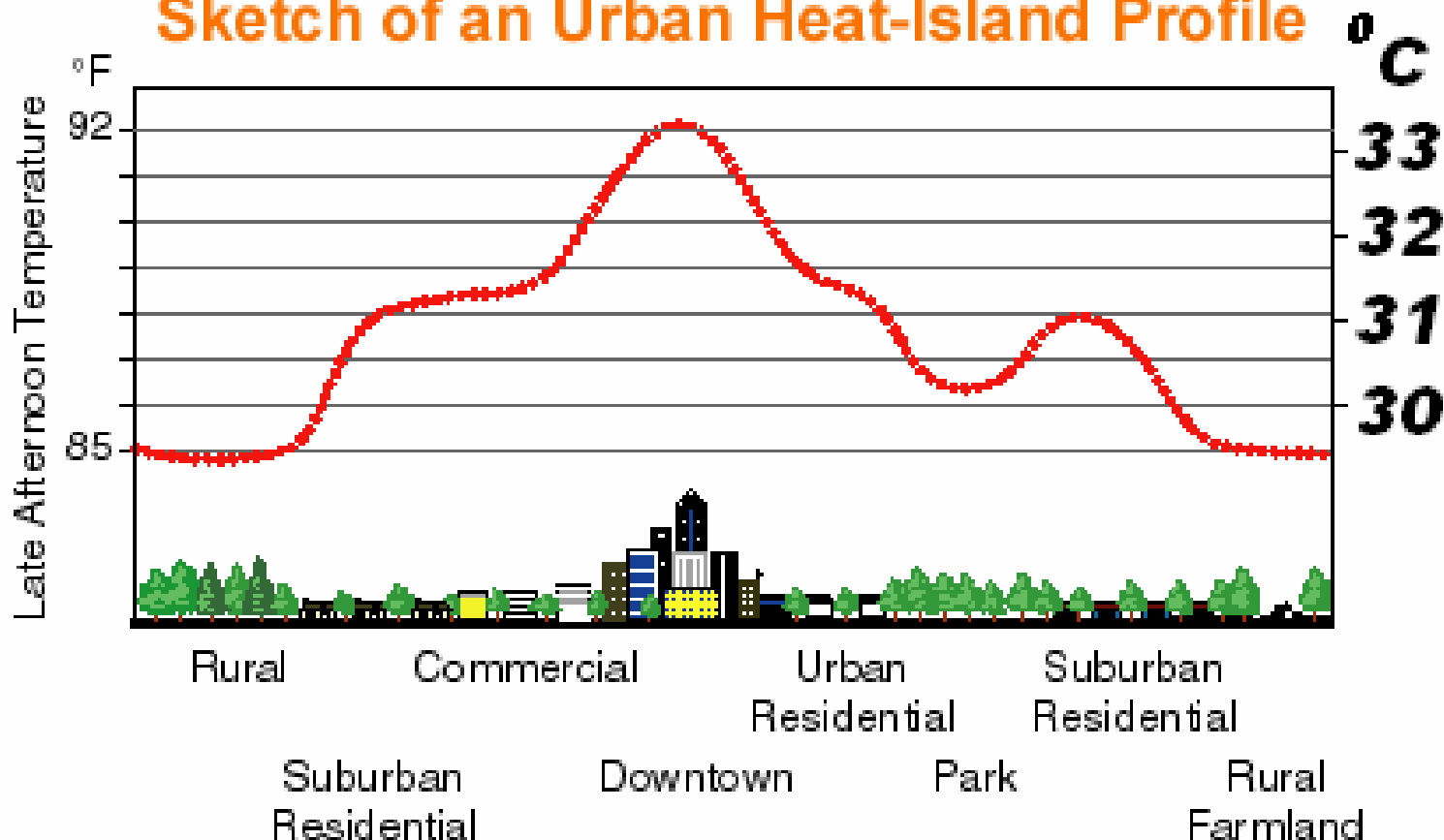
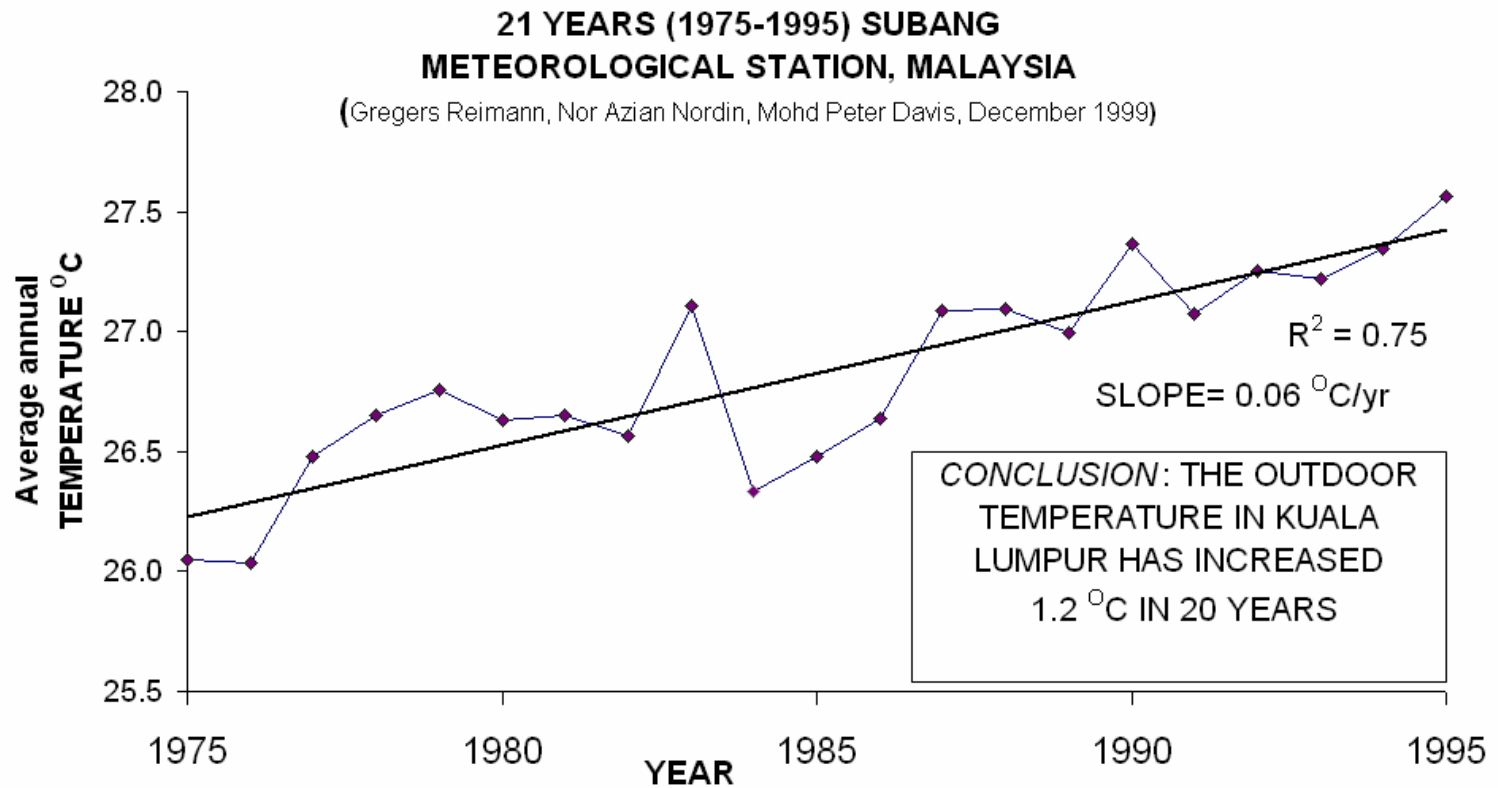


Figure 1 Average yearly temperature in Kuala Lumpur, 1975 to 1995





# Problem: 'Heat Island Effect'

## Many cities are getting hotter by 0.1°C to 0.6°C per decade

- Baltimore USA 0.1°C per decade
- Shanghai China 0.1
- Oakland USA 0.2
- Tokyo Japan 0.3
- Los Angeles USA 0.4
- Kuala Lumpur 0.6

**Conclusion: KL holds the world record !**

**Table 1 Thermal discomfort- outdoor versus indoors in a range of houses**

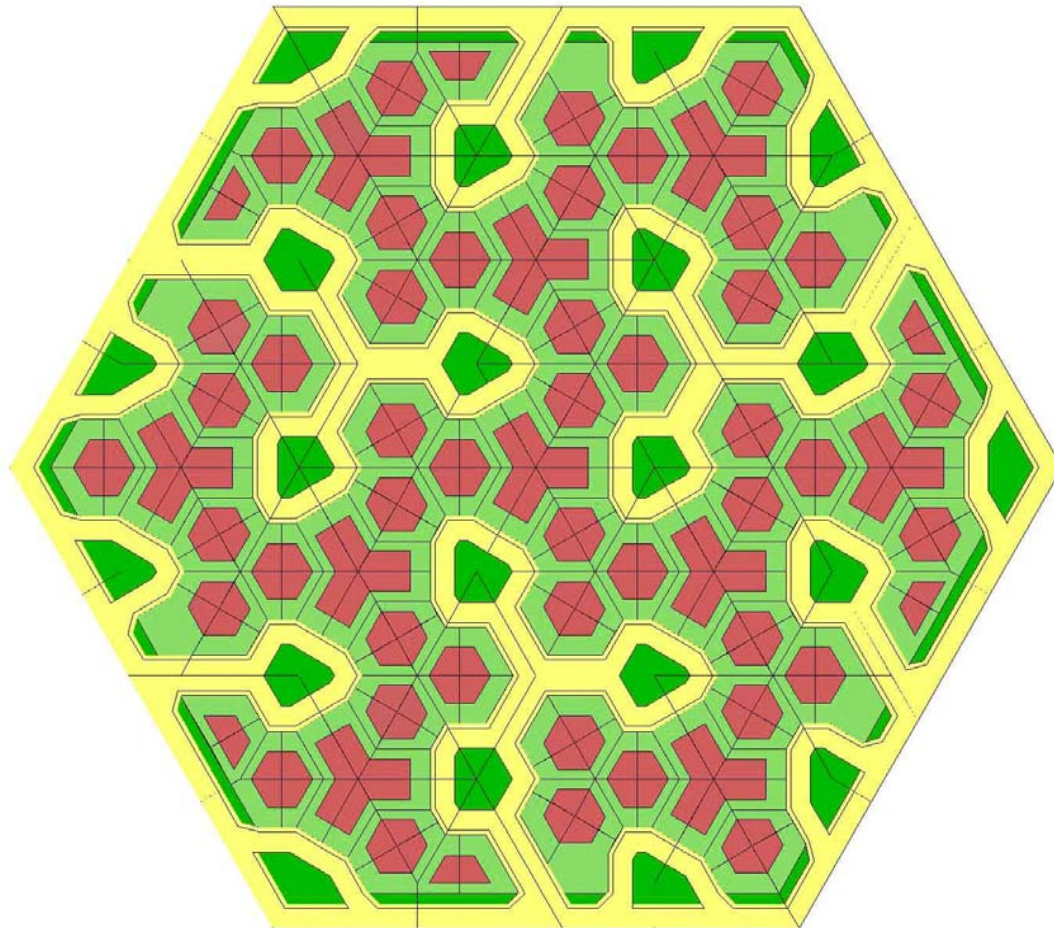
# Thermal Discomfort

during Feb 1998 heat-wave

	<i>Discomfort units <u>per 24 hours</u></i>
<b>Outdoors (under a tree)</b>	<b>30</b>
Single Storey link- Serdang	94
Long house- Balakong	72
Double Storey link- Balakong	70
5 Storey Flats (Top Floor)- Serdang	70
d/s bungalow- Bangi	47

# Honeycomb<sup>®</sup> Housing

Inventor: Malaysian Architect Mazlin Ghazali



# THERMAL COMFORT HONEYCOMB HOUSING

*THE AFFORDABLE ALTERNATIVE TO TERRACE HOUSING*

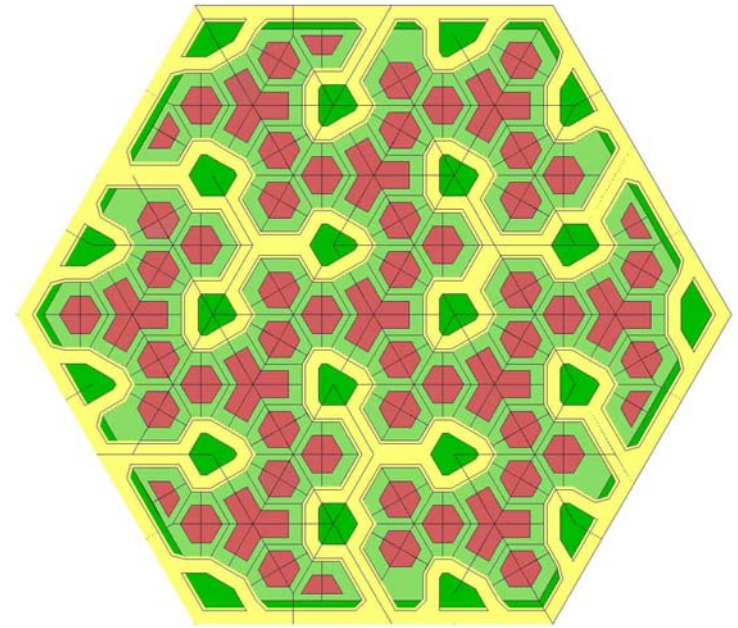


UNIVERSITI PUTRA MALAYSIA

**MOHD PETER DAVIS  
MAZLIN GHAZALI  
NOR AZIAN NORDIN**



288 units low medium cost terrace houses on 20.7 acres



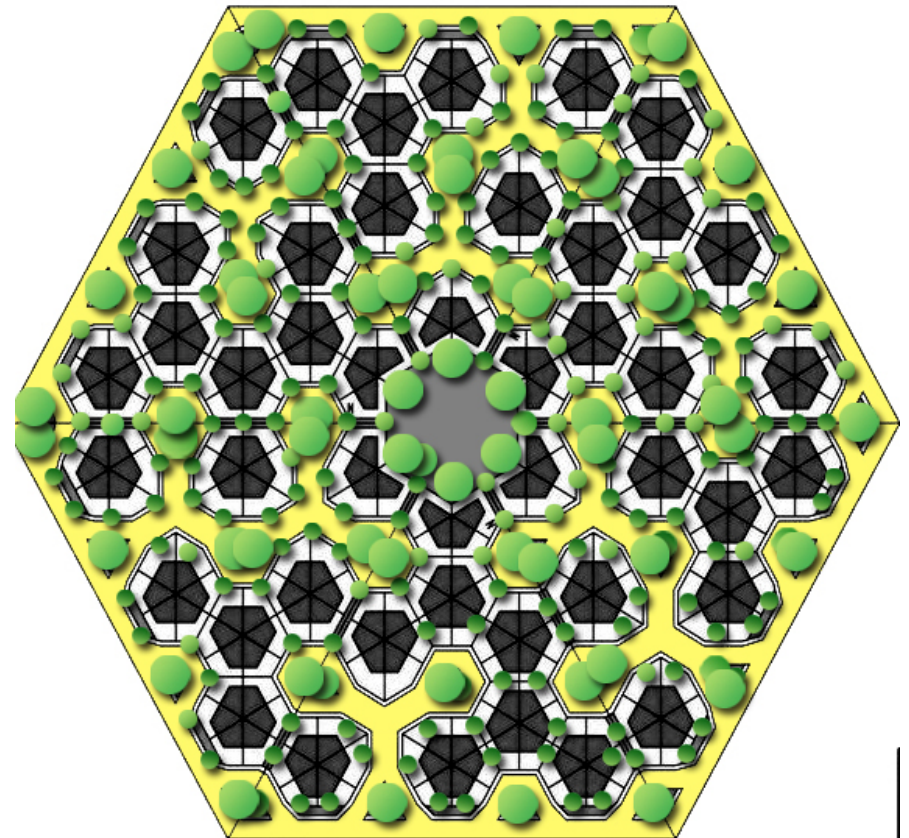
246 units low medium cost honeycomb houses on 16.4 acres

	Terrace	Honeycomb
Road	46%	33.5%
Saleable land	43%	55%
Green area	11.1%	11.1%
Number of units per acre	14.4 units	15 units
Average lot size	1300sf	1609sf
Potential Tree Shade	15%	46%

Figure 11 Comparison between theoretically efficient terrace house layout versus honeycomb layout

# FROM HEAT-ISLANDS TO COOL OASIS

- The road shoulder with its cables and pipes are not suitable for trees: but **big shady species can thrive in the small communal gardens** of Honeycomb Housing
- The clearing of trees to create concrete jungles are the main contribution to the heat-island effect
- Roofing the house with thick insulation and **shading the external hard landscape and roads** maximizing the tree canopy area is a strategy, pioneered by UPM, used in Honeycomb Housing
- **Evaporation from leaves will further cool the external environment**



**TERRACE Housing  
versus  
HONEYCOMB Housing**

***Infrastructure  
Cost Analysis***



**DOUBLE STOREY TERRACE - TYPE 1**  
 20'(6.1m) X 70'(21.3m)=1400 sf

**DOUBLE STOREY TERRACE - TYPE 2**  
 20'(6.1m) X 75'(22.86m)=1500 sf

**BUNGALOW - TYPE 5**  
 65'(19.81m) X 100'(30.48m)=6500 sf

**SEMI DETACHED BUNGALOW - TYPE 3**  
 45'(13.7m) X 80'(24.38m)=3600 sf

**SEMI DETACHED BUNGALOW - TYPE 4**  
 50'(15.24m) X 100'(30.48m)=5000 sf



**QUADRUPLEX HOUSE - TYPE 1**  
 STANDARD LOT : 1387 SF  
 FOOTPRINT : 650 SF

**TRIPLEX HOUSE - TYPE 2**  
 STANDARD LOT : 3870 SF  
 FOOTPRINT : 1896 SF

**DUPLEX HOUSE - TYPE 3**  
 STANDARD LOT : 3974 SF  
 FOOTPRINT : 2200 SF

**TRIPLEX HOUSE - TYPE 4**  
 STANDARD LOT : 4766 SF  
 FOOTPRINT : 2493 SF

**BUNGALOW - TYPE 5**  
 STANDARD LOT : 6500 SF  
 FOOTPRINT : 2698 SF

TERRACE HOUSES

HONEYCOMB HOUSES

**Proposed Housing Development At Mukim Semenyih,  
 Ulu Langat District,  
 Selangor Darul Ehsan, Malaysia**

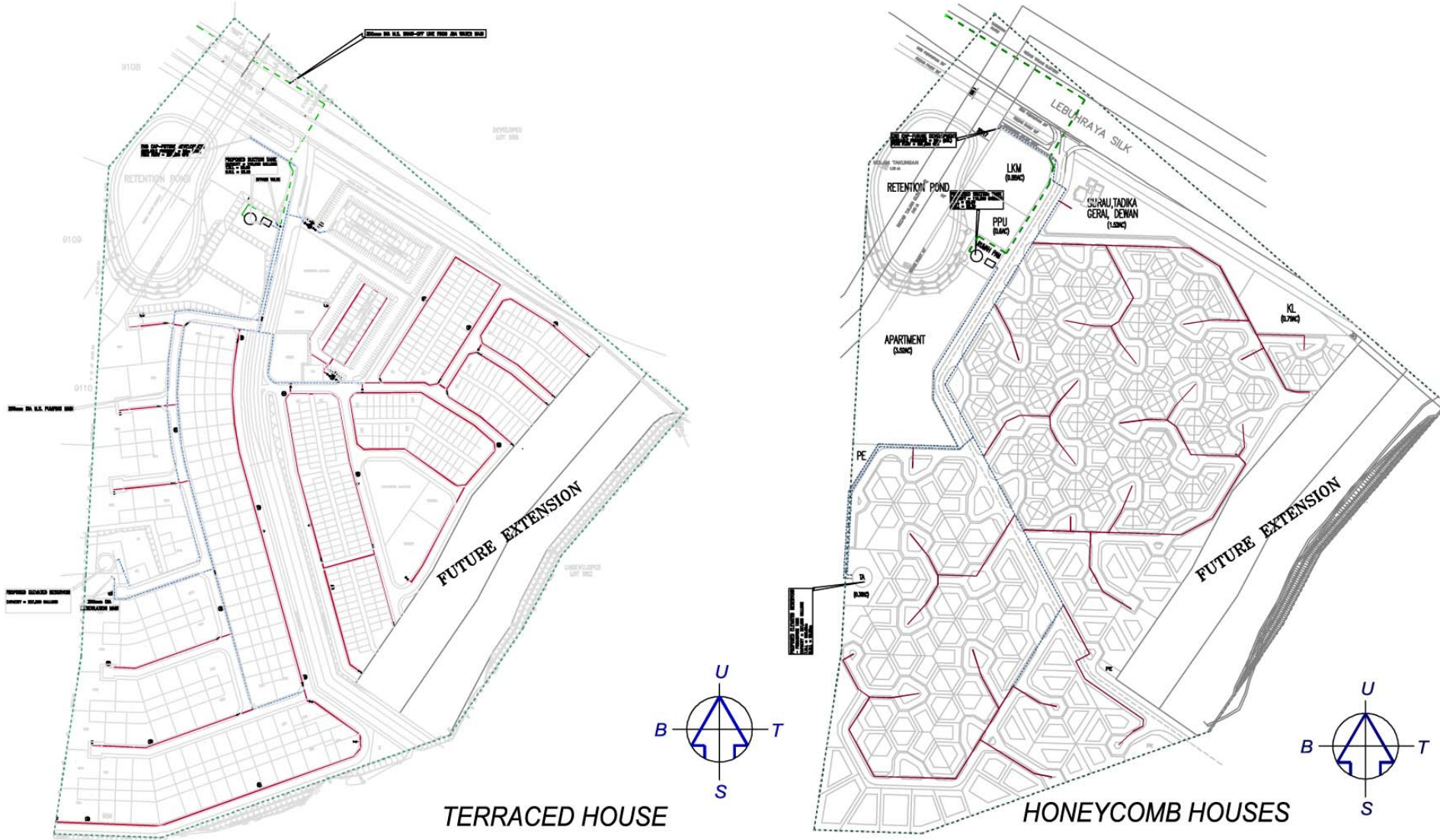
Figure 20



	Saleable Land (acres)	Road Reserve (acres)	Green (acres)	Amenities (acres)	Units
<b>Original Built Option</b>	23.21	14.42	7.46	8.01	304
<b>Honeycomb</b>	23.92	13.56	7.76	8.01	328
<b>Increase/(decrease)</b>	0.71	(0.86)	0.3	0	24
<b>% Increase/(decrease)</b>	3.1%	(6%)	4%	0%	7.9%

**Figure 22 Comparison of Acreage, Units and Density  
Proposed Housing Development At Mukim Semenyih,  
Ulu Langat District,  
Selangor Darul Ehsan, Malaysia**

# Comparison of the Quantity of Water Reticulation System



Proposed Housing Development At Mukim Semenyih,  
Ulu Langat District,  
Selangor Darul Ehsan, Malaysia

Figure 23

# Comparison of the Quantity of Sewerage System

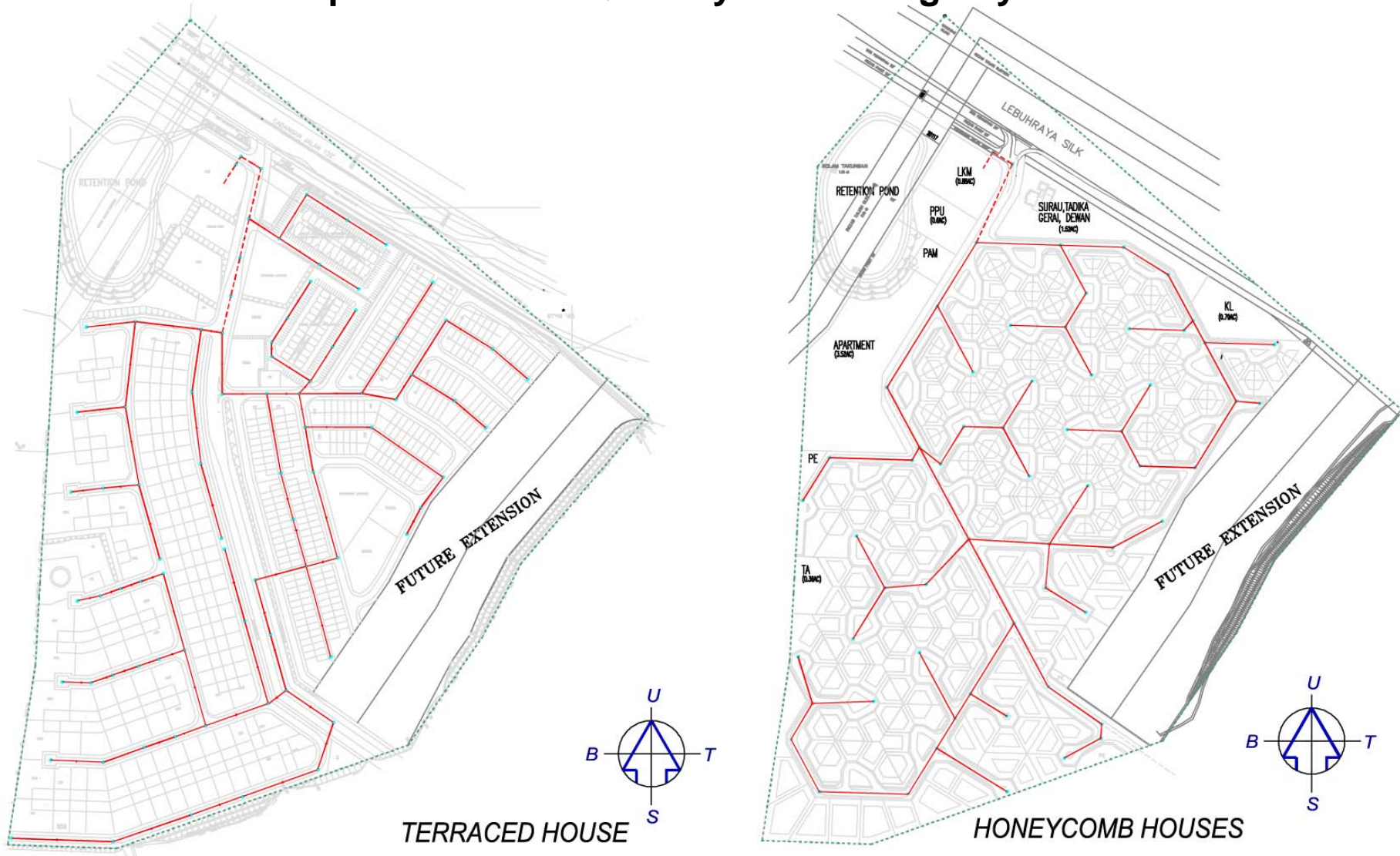


Figure 25

Proposed Housing Development At Mukim Semenyih,  
Ulu Langat District,  
Selangor Darul Ehsan, Malaysia

# Comparison of the Quantity of Road and Drainage System

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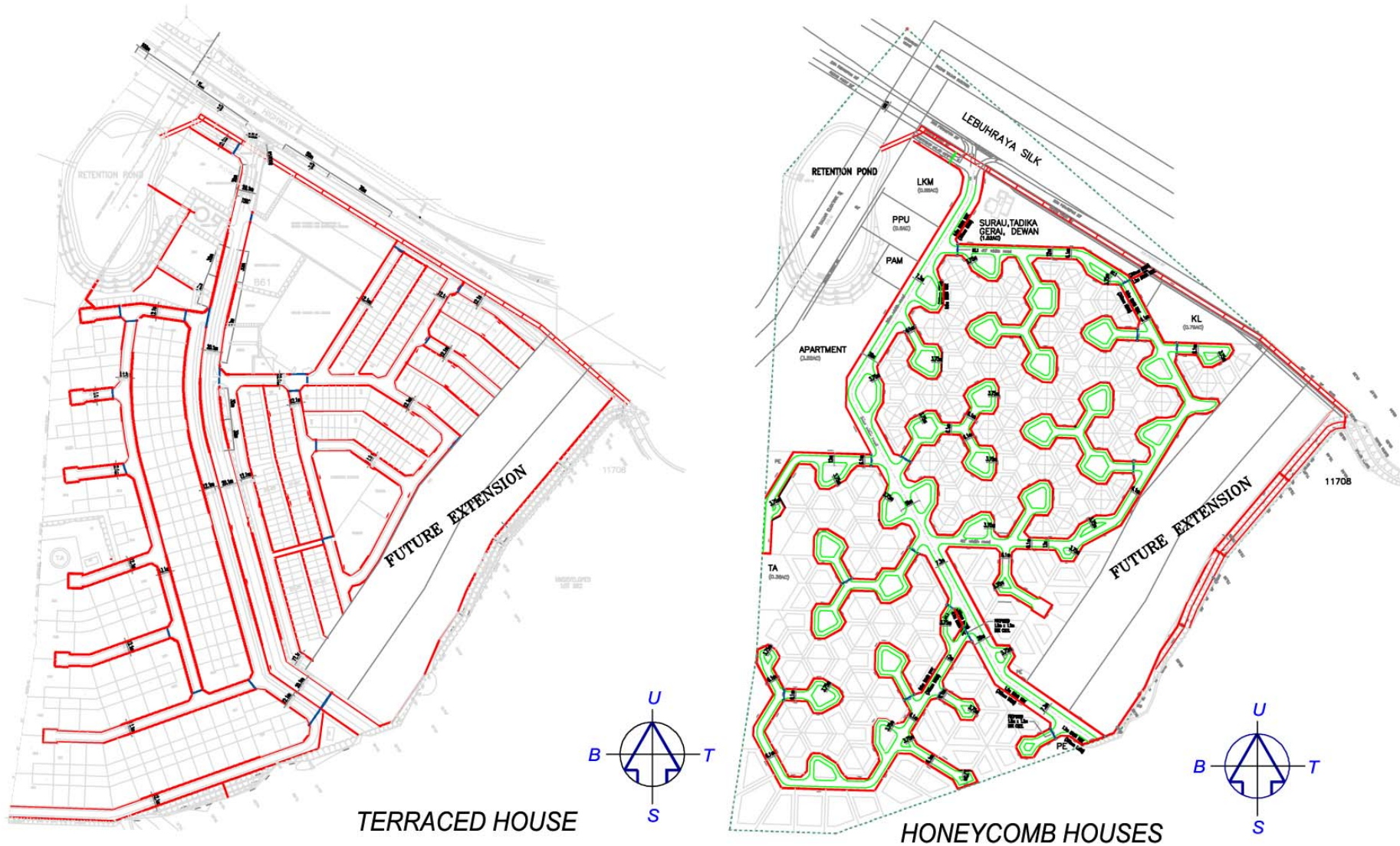


Figure 27

Proposed Housing Development At Mukim Semenyih,  
Ulu Langat District,  
Selangor Darul Ehsan, Malaysia

TABLE 29

## COMPARISON OF COST SAVING FOR INFRASTRUCTURAL WORKS

ITEM	DESCRIPTION	(A) ORIGINAL PROPOSAL ( TERRACE HOUSE SYSTEM )		RATE (RM)	TOTAL RM	(B) AMG PROPOSAL ( HONEYCOMB SYSTEM )		RATE (RM)	TOTAL RM	SAVING OF SYSTEM		RATE (RM)	TOTAL RM
			<b><u>SEWERAGE SYSTEM</u></b>										
1	225mmø VCP PIPE	3628.50	m	112	406,392	3084.10	m	112	345,419	544.40	m	112	60,973
2	300mmø VCP PIPE	207.00	m	243	50,301	131.00	m	243	31,833	76.00	m	243	18,468
3	NOS. OF MANHOLE	83.00	Nos.	2,500	207,500	64.00	Nos.	2,500	160,000	19.00	Nos.	2,500	47,500
			Sub Total		664,193			Sub Total	537,252			Sub Total	126,941
	<b><u>ROAD &amp; DRAINAGE</u></b>												
1	0.6m DRAIN WIDE	7414.00	m	150	1,112,100	6690.00	m	150	1,003,500	724.00	m	150	108,600
2	0.9m DRAIN WIDE	186.00	m	200	37,200	292.00	m	200	58,400	-106.00	m	200	(21,200)
3	1.2m DRAIN WIDE	389.00	m	250	97,250	165.00	m	250	41,250	224.00	m	250	56,000
4	1.2 X 0.6m BOX CULV.	176.00	m	600	105,600	132.00	m	600	79,200	44.00	m	600	26,400
5	1.2 X 0.9m BOX CULV. (BC1)	41.00	m	700	28,700	40.00	m	700	28,000	1.00	m	700	700
6	1.8 X 1.2m BOX CULV.	35.00	m	1,000	35,000	24.00	m	1,000	24,000	11.00	m	1,000	11,000
7	PREMIX ACCESS ROAD	28798.94	m2	48	1,382,349	26667.67	m2	48	1,280,048	2131.27	m	48	102,301
			Sub Total		2,798,199			Sub Total	2,514,398			Sub Total	283,801
	<b><u>WATER RETICULATION</u></b>												
1	150mmø UPVC PIPE	3291.43	m	35	115,200	2489.58	m	35	87,135	801.85	m	35	28,065
2	200mmø UPVC PIPE	1181.02	m	62	73,223	1097.19	m	62	68,026	83.83	m	62	5,197
3	150mmø MS PIPE	292.40	m	105	30,702	473.70	m	105	49,739	-181.30	m	105	(19,037)
4	200mmø MS PIPE	59.17	m	120	7,101	156.82	m	120	18,818	-97.65	m	120	(11,718)
			Sub Total		226,226			Sub Total	223,718			Sub Total	2,508
			<b>GRAND TOTAL</b>		<b>3,688,618</b>			<b>GRAND TOTAL</b>	<b>3,275,368</b>			<b>GRAND TOTAL</b>	<b>413,250</b>
	No of Units				304				328				
	Cost per Unit				12,134				9,986				2,148

# Saving infrastructure cost with Honeycomb

	<b>TOTAL</b>	<b>NO OF</b>	<b>COST</b>
	<b><u>Cost Units</u></b>	<b><u>Units</u></b>	<b><u>per unit</u></b>
TERRACE as built	RM3,689m	304	RM12,133
HONEYCOMB Option	RM3,275	328	RM 9,986

***BOTTOM LINE FOR DEVELOPER***

***18% SAVINGS***

***PER DWELLING***

# **HONEYCOMB THERMAL COMFORT HOUSING**

**IS FEASIBLE**

**Economically  
and Technically**

**BUT**

***Is it acceptable***

***to***

***House buyers ??***

# Survey Strategy

Preference survey in predominantly Chinese area (Taman Johor Jaya)

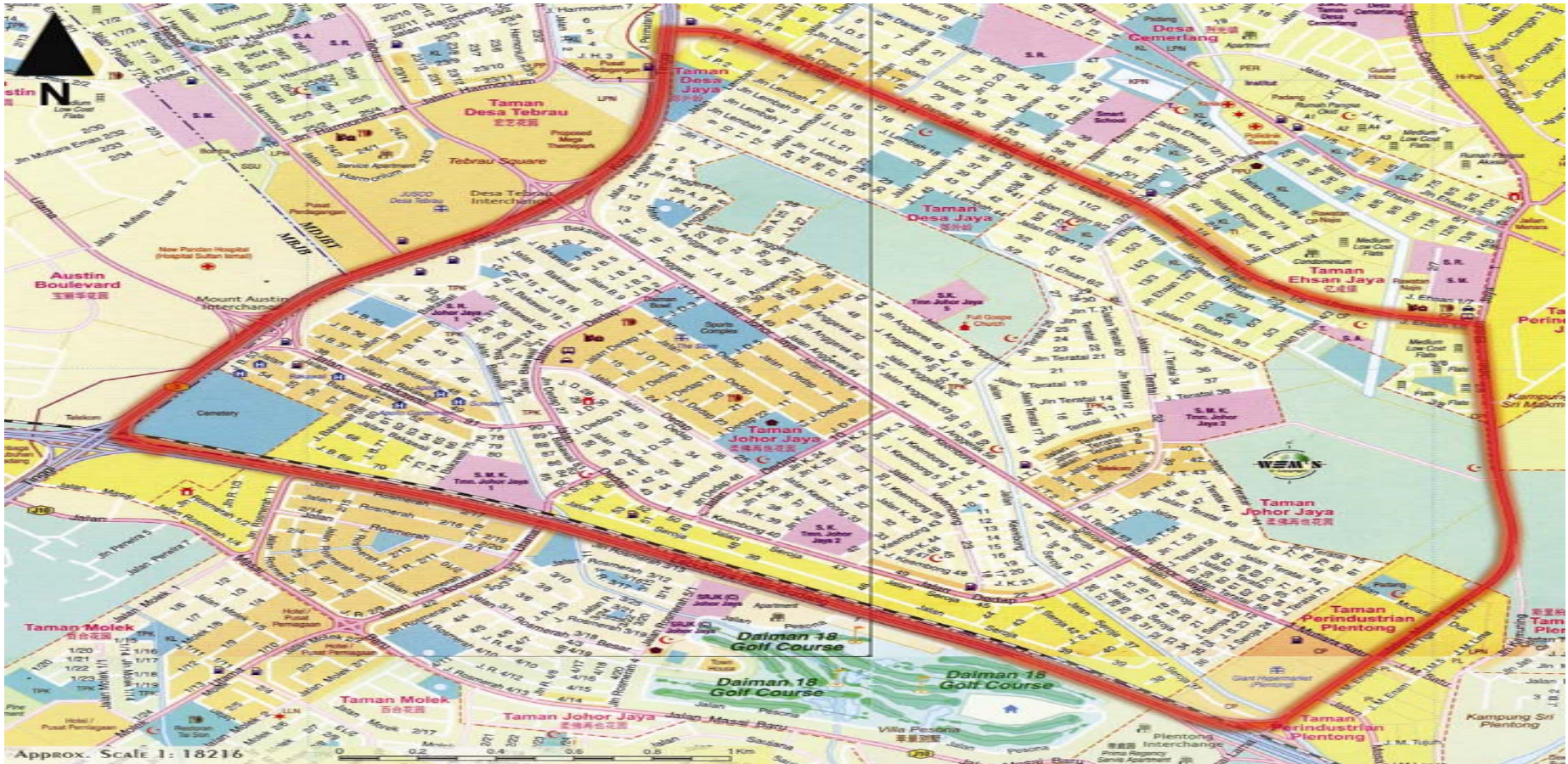
**150 randomly selected Households**

**Short questionnaire**

Choose between:-

1. RM220,000 commercial Terrace house
2. RM220,000 concept Honeycomb house





*Johor Jaya Township (8830 Residential Houses)  
150 Households were randomly selected for the housing survey.*

# Random Sampling Technique

## ‘Stratified sampling’

1. Map of Johor Jaya divided into 8 areas
2. 3 Areas randomly selected
3. 10 roads in each area randomly selected
4. 5 Houses per road randomly selected

**150 houses letterboxed**

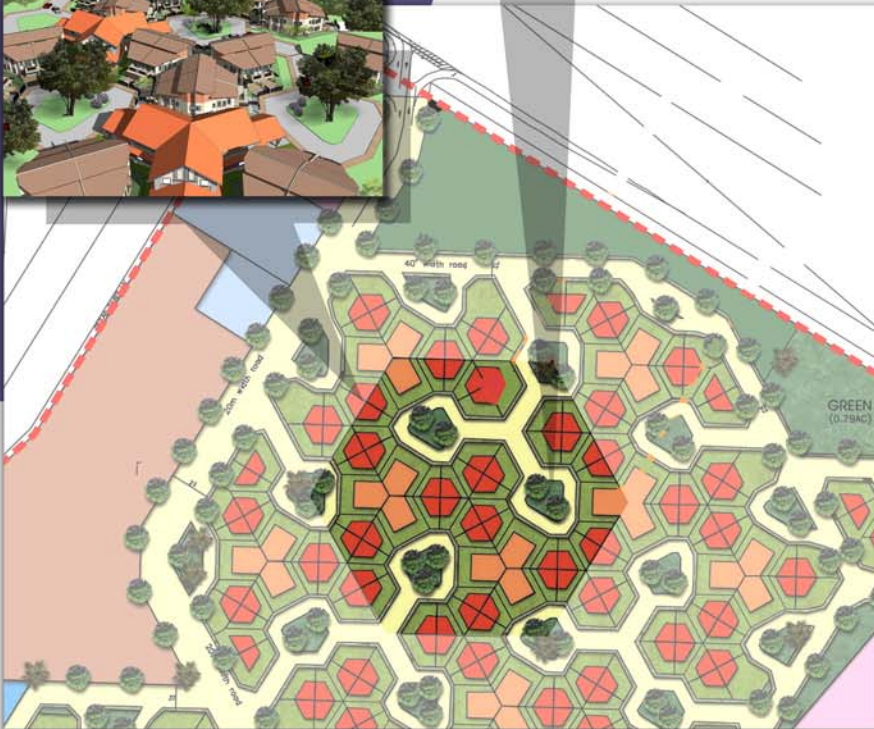
**UPM Letter + colour brochures**

# HONEYCOMB HOUSE

## HONEYCOMB LAYOUT



COURTYARD  
PERSPECTIVE



# TERRACE HOUSE

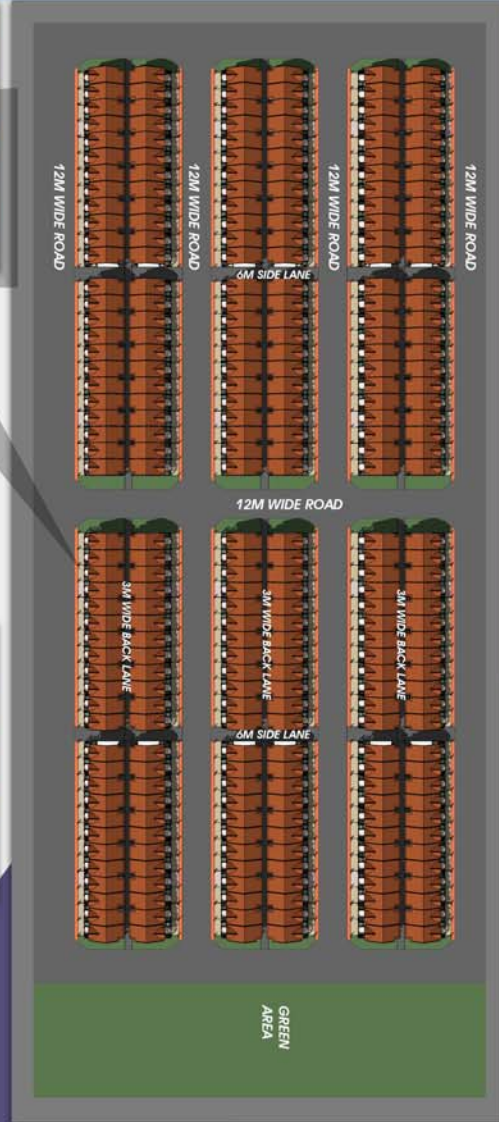
## TERRACE HOUSE LAYOUT



FRONT VIEW OF TERRACE HOUSE



BIRD EYE VIEW



# HONEYCOMB HOUSE

PRICE : RM 220,000



**GROUND FLOOR PLAN**

	HONEYCOMB HOUSE	TERRACE HOUSE
LAND AREA	1,778 sq.ft.	1,430 sq.ft.
BUILT UP AREA	2,026 sq.ft.	2,277 sq.ft.
<b>GROUND FLOOR</b>		
	SQ.FT.	SQ.FT.
LIVING/DINING	411.2	400
BEDROOM 4	128.2	80
DRY/WET KITCHEN	185.1	242.5
BATH 3	56.0	18.73
CAR PORCH	133.5	145
YARD		25.3
<b>UPPER FLOOR</b>		
	SQ.FT.	SQ.FT.
MASTER BED	231.4	280
BEDROOM 2	166.8	194.3
BEDROOM 3	130.2	110.3
FAMILY	127.0	115.4
BATH 1	45.2	45.7
BATH 2	56.0	51.7
STAIRCASE	59.7	50.0
BALCONY	122.7	129.2



**UPPER FLOOR PLAN**



**GROUND FLOOR PLAN**

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**UPPER FLOOR PLAN**

# HONEYCOMB HOUSE



# TERRACE HOUSE



# HONEYCOMB HOUSE

PRICE : RM 220,000

# TERRACE HOUSE

PRICE : RM 220,000



**Ground Floor**



**Ground Floor**

# HONEYCOMB HOUSE

PRICE : RM 220,000

# TERRACE HOUSE

PRICE : RM 220,000



FIRST FLOOR PLAN

FIRST FLOOR PLAN

# Consumer Preference Test

## Terrace versus Honeycomb House

Both houses:- RM220,000, 4 bedrooms  
3 bathrooms 2 car porches

	<b>TERRACE</b>	<b>HONEYCOMB</b>
--	----------------	------------------

Built-up area	<b>2277sf</b>	<b>2026sf</b>
---------------	---------------	---------------

Land area	<b>1430sf</b>	<b>1778sf</b>
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**Honeycomb house** 11% less built-up area  
24% more land





# Consumer Preference Test

	TERRACE	HONEYCOMB
• All Races	34%	66%
• Chinese	44%	56%
• Malays	16%	84%
• Indians	42%	58%

56% of Chinese respondents  
& two thirds overall  
preferred HONEYCOMB house

# Calculation of Potential HONEYCOMB Customers amongst Johor Jaya's 8830 households

	% of Population	number of Households	% Honeycomb Customers	<b>Number of Customers</b>
<i>CHINESE</i>	58%	5121	6.9%	<b>352</b>
<i>MALAYS</i>	33%	2914	12.5%	<b>364</b>
<i>INDIANS</i>	8%	706	41.7%	<b>294</b>
<b><i>TOTAL</i></b>	<b>99%</b>	<b>8741</b>	<b>11.4%</b>	<b>1010</b>

# UPM Summary

## Johor Jaya Random Household Survey

Survey Period 24-26 March 2006

1. Feng Sui beliefs will not prevent most Chinese buying the RM220,00 Honeycomb house
2. Preference Test: 66% Honeycomb house  
34% Terrace house
3. Johor Jaya (8830 households)  
**1010** HONEYCOMB Potential buyers  
**299** TERRACE Potential buyers

# Latest Survey 24-28 July 2006

## KUANTAN



Survey of 513 Kuantan Respondents  
(73% Government Servants)

**24 TIMES MORE  
POTENTIAL BUYERS  
for Honeycomb houses (308)  
compared with  
equivalent terrace houses (13)**

**CONCLUSION**

**Overwhelming preference for  
Honeycomb Housing**