6 CONCLUDING REMARKS AND FUTURE WORK

This may be just a simple step towards the philosophy of "adaptive Hypothesis" but it is vital to all the personalities (consultants, architects, engineers, and building physicist) that involve making a built environment to speak the same "language" regarding thermal comfort for better outcome.

In the frame of adaptive model whole new areas have to be explored doing further researches. Specially "adaptive opportunities" within the built environment have to be investigated and tactics to increase the adaptive opportunities have to be developed.

The presented wall-opening orientation with the line of vegetation can be taken as simple guidelines to start with for any factory designer who is keen on passive techniques and especially natural ventilation. In addition, other passive techniques such as solar shadings can be coupled easily with this configuration. The designer has the freedom to choose substance for openings and there is a considerable tolerance to change the sizes of the walls and opening and the line of vegetation keeping the main tactics unaltered. Also the acceptability of this presented model has to be explored by creating real size models, Ideas of the occupants have to be acquired after inhabiting the building for some time

A complete research throughout a year with the capacity to calculate indices such as ET* (Mean monthly (or daily) outdoor effective temperature), TOP (operative temperature) and SET (standard effective temperature) is needed to find out the real thermal comfort of our people.

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Appendix A

Questionnaire (Factory Building & Environment)

For factory authorities

Factory ***Date***

1. Preferences for vegetation

1.1 Preference vegetation height within factory premises

a) 2m-5m

b) 5m and above

c) No vegetation prefer

d) vegetation prefer, but no particular height

Comments.....

1.2 Preference distance to vegetation from factory building

a) Less than 3m
b) 3-10m
c) 10-20m
d) As far as possible

Comments.....

Is there any hindrance to have a thin layer of vegetation (grass) about 1-2m in width, outside the factory walls?

Comments.....

2. How important do you think the aesthetic appearance of a factory building?

a) Not important
b) Less important
c) Important
d) No idea

Comments.....

3. How often do you get complain from factory workers regarding thermal comfort?

a) Regularly
b) Occasionally

c) Never

Comments.....

4. What do you think the main factors that influence the thermal comfort in your factory?

a) Low ventilation
b) High solar heat gain
c) High internal heat gain

Comments.....

5. Do workers have the authority or permission to

a) Operate windows, curtains, Etc...
b) Have a walk around within 15-20 minutes time
c) Switch on fans if available
d) Wear short sleeves if possible
e) Unbutton the shirt

Comments: (specially prefer the comments on why workers are not given the authority for unmarked options above)

6. Do you think thermal comfort influence the productivity of workers? (Pls express your idea)

7. Please comment on the inclination of the authorities towards the improvement of the thermal comfort of the factory

8. Do you think wind velocity (5-10 ms^{-1}) has a negative effect on any factory activity?

Appendix B

1. Sri Lanka wind potential

Since Sri Lanka is situated closer to the equator within an altitude of 60 to 100 N, it experiences a typical tropical climate which is somewhat modified by the seasonal wind reversal of the Asiatic monsoons. Main wind directions are Southwest (May-September), North-East (December-February) When the wind speed is low, especially during Inter monsoons, the sea breeze during the daytime and the land breeze during the nighttimes may be present. Winds towards inland are regular in Colombo when the year as a whole is considered. Approximately daytime see breeze affect up to 20 Km from the shore and it can reduce the daytime ambient temperature as much as 2°C.

Measuring Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec
Pattiyapola (D2)	2.5	3.1	2.6	2.3	2.0	0.2	2.9	4.4	4.2	3.1	2.4	2.7
Ambalantota (D3)	1.9	2.1	1.6	1.9	3.2	4.1	4.6	5.1	4.4	2.3	1.8	1.7
Wave Trap (D4)	4.7	4.9	4.3	3.4	4.9	6.2	6.1	6.0	6.1	4.7	3.9	4.2
Bundala (D5)	5.3	5.2	4.2	3.6	4.7	6.7	6.6	6.1	6.4	4.9	4.0	4.8
Palatupana (D6)	4.2	4.2	3.2	3.3	4.9	8.5	7.3	7.5	7.0	4.0	3.8	4.
Eraminiyaya (D7)	2.8	2.4	2.1	1.9	2.4	3.3	3.4	3.2	3.2	2.3	2.1	3.0
Sevanagala (D8)	3.2	3.2	2.9	2.9	2.7	4.8	6.6	7.1	5.5	4.4	2.8	3.2
Hambantota (Met.)	7.0	6.8	5.3	4.8	5.9	7.9	7.5	7.2	8.2	5.0	5.1	6.0
Thanamalwila (Dt)	2.0	1.6	1.1	0.9	1.3	3.2	4.4	6.3	4.2	1		

Table 1 Available wind data for Sri Lanka Average Wind Speed (m/s) in Measuring Locations at 10m height - Hambantota Region Year 1990

Activity	Metabolic rate (W)
Sleeping	75
Reclining	85
Sitting	105
Standing, relaxed	125
Typing	125-145
Cooking	170-210
Housecleaning	210-350
Walking (level, 3-6 km/h)	210-400
Dancing, gymnastics	250-460
Heavy machine work	370-470
Pick and shovel work	420-500

Table2.Metabolic rate of different activities (Rosenlund, 2000)

Clothing	Clo value (clo)
Nude	0
Shorts	0.1
Walking shorts + short-sleeve shirt	0.4
Knee-length skirt + short-sleeve shirt	0.5
Trousers + shirt	0.6
Sweat pants + sweat shirt	0.7
Trousers + shirt + jacket	1.0
Knee-length skirt + long-sleeve shirt + half slip + long sleeve sweater or jacket	1.0-1.1
Men's heavy three-piece business suit	1.5
Men's heavy suit + woolen overcoat	2.0-2.5

Note: Unit clo is equal to $0.155 m^2K/W$

Table3.Clo values for various clothing (Rosenlund, 2000)

Appendix C

Month	Sunshine (hours per day)	Mean daily temperature (C^0)		Minimum & maximum Relative humidity (%)	
		Max (around 14.00 hours)	Mm (around 6.00 hours)	Mm (around14.00 hours)	Max (around 6.00 hours)
Jan	7.5	30.3	22.2	58	90
Feb	8.2	30.6	22.3	59	92
Mar	8.8	31.0	23.3	64	94
Apr	7.9	31.1	24.3	68	95
May	6.2	30.6	25.3	72	92
Jun	6.6	29.6	25.2	73	93
Jul	6.1	29.3	24.9	70	90
Aug	6.5	29.4	25.0	65	90
Sep	6.4	29.6	24.7	67	91
Oct	6.2	29.4	23.8	70	92
Nov	6.8	29.6	22.9	67	93
Dec	6.9	29.8	22.4	61	91

Table1.Climatic Data for Colombo

These are calculated using the psychometric chart assuming that the moisture content remains the same. Minimum relative humidity corresponds to maximum temperature and maximum relative humidity corresponds to minimum temperature.

Type of industry	Average annual salary Per skilled operative (Rs.)
Fabricated metal products	62367
Structural metal products	50238
Non-ferrous metal basic industry	70152
Plastic products	58926
Tire and tube industries	68328
Drugs and medicines	59387
Fibers and plastic materials	61185
Containers & paperboard	62370
Tanneries and leather	65111
Footwear	71934
Knitting mills	61540
Sugar factories and refinery	55315
Chocolate & confectionary	60478
Canning and processing fish	70863
Chemical fertilizer & mineral	75770
Soap and perfumes	63011
Sporting & athletic goods	69485
Watches & clocks	59091
Railroad equipment	61637

Table 2 Average annual salaries Per skilled operative (Rs)

(Source – annual survey of industry 2002: Department of census and statistics)

Appendix D

Validation of the software DEROB-LTH

Although the validation of the software is an important component of the study, there were several practical problems making a proper validation difficult. They can be listed as the following:

1. One of the important inputs required by the software is the number of sunshine hours. This could not be measured in the thermal surveys as the equipment needed (i.e., the sunshine recorder) was not available.

2. The software takes into account the effect of ventilation by way of the number of air changes, which is not very satisfactory.

However, using the average value for the sunshine hours, an attempt was made to validate the software. For this, the three-storey hostel building was used. The variation of the air temperature simulated by the software is given below in graphical form (Chart 1). For comparison, the variation of the air temperature obtained form the actual measurements are given in Chart 2.

Chart 1. Simulated results of three-storey hostel building in Moratuwa (August)

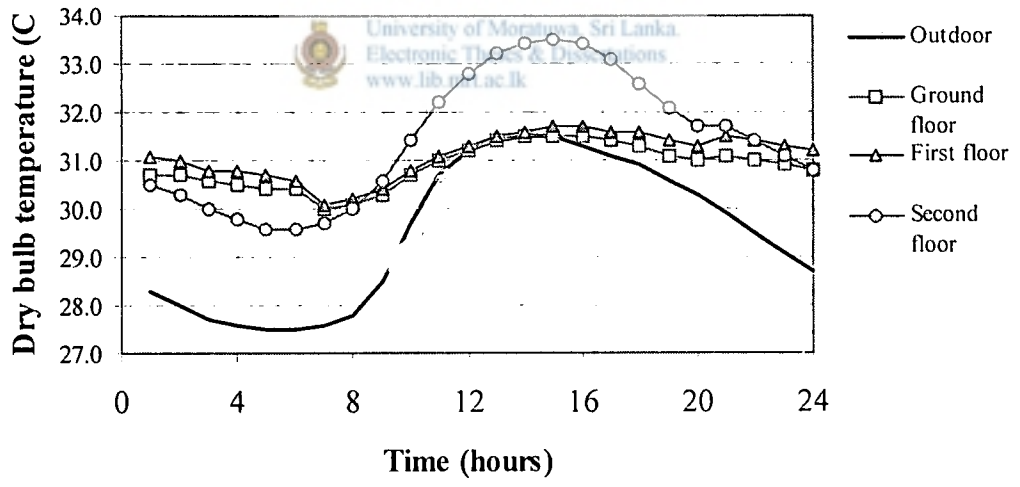
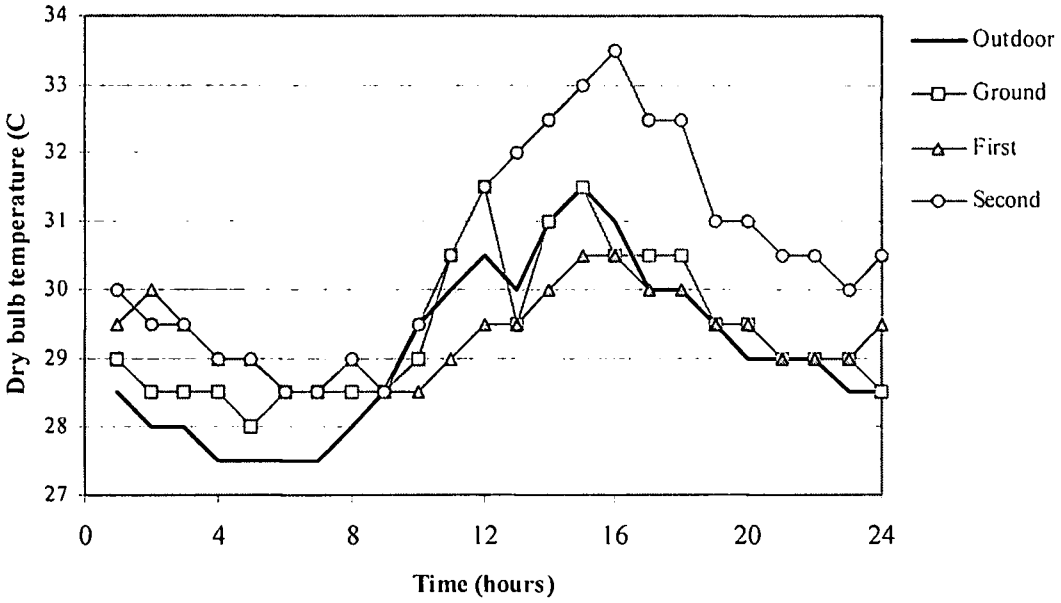


Chart 2. Results of the thermal survey at three-storey hostel building in Moratuwa (August)



Comparison of Charts 1 and 2 shows the following:

1. The software has simulated to a reasonable level the variation of the indoor temperature of the ground floor level and second floor level, highlighting the thermally undesirable effect of the roof.

2. However, it has not satisfactorily shown the difference between performance of the ground floor level and the first floor level.

Since the software is capable of simulating the thermally undesirable effect of the roof to a reasonable level, its use could be justified to a certain extent. However, the fact that the interest of this study is the prediction of the trends and not the prediction of exact conditions further reinforces the justification.