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A MODEL TOOL FOR PREDICTING OF OUTDOOR AIR TEMPERATURES ON CONSTRUCTION MATERIALS MANUFACTURE PERFORMANCE IN BAGHDAD

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ABSTRACT

Heat has become a common problem in construction industry production and timing in Baghdad region which consider as arid zone. However, construction industry management engineers have no assessments tool to evaluate their planning impacts on the productivity, especially the impact of productivity due to the chance of heat. This paper discusses the development of an empirical assessment for heat prediction to evaluate the impact of construction product. Empirical model of minimum, maximum and mean ambient temperature for Baghdad have been developed and validated, based on the long term field measurements between the period of January 2001 and March 2012. The independent variables that were used in the models are daily minimum, maximum and mean temperature at the reference point, average daily total solar radiation, building area percentage over radius 50m, 100m and 150m surface from the building center, average building height to area ratio, total wall area to green area ratio, sky view factor, and albedo. Sensitivity analyses were carried out to observe the dependence of air temperature due to the variations of each variable. An ideal type construction manufacture was used to simplify the variation of manufactory body, world field green field distribution. The sensitivity analyses were carried out by varying some of the following important parameters; green land cover density), manufacture building height, wall area, work field area which effect the incoming solar radiation (sky view). The screening tool for work place was developed with the motivation to bridge between research finding, especially the air temperature prediction models and the construction management engineers.

Keywords: model, air temperature, Baghdad, climate factors, construction productivity.

INTRODUCTION

In recent years, construction materials demands have become increasingly in Iraq. The development of construction industry is imperative for economic growth of the nation.

However, many industries production and timing in Iraq and Middle East is affected by weather factors, especially, heat, dust storms and humidity. Thus, when the manufacture is affected by the out door thermal radiant environment, In addition, in the case that a manufacture building is affected by the outdoor environment, indoor factors such as the position of thermal storage mass and windows can be elaborated in design of direct gain systems. This relationship between the outdoor environment and the design of thermal storage mass on the floor is an influential factor for ambient temperature fluctuations.

The climate change problem of urbanization is not an exception to Iraq. Iraq attracts a large pool of foreign investment companies' particular construction firms and trade from all over the world. Furthermore, the federal government has a plan to increase the infrastructure rebuilt especially, residential suburbs. New urban development can be exceeding to accommodate the social and economic needs of people.

Adverse impacts on urban climate condition may emerge, such as thermal discomfort and pollution in the construction manufactures employee.

Previous studies reported that urban heat phenomenon has become a common imperative problem in the major cities worldwide, (Oke, 1971; Padmanabhamurty, 1990 and 1991; Sani, 1990 and 1991; Swaide and Hoffman, 1990; Eliasson, 1996; Giridharan, *et al*., 2007 ;) as well as in Iraq (Hasson and Alaskary, 2013).

Asawa proposed a coupled simulation of outdoor thermal balance and building heat load. This method can calculate heat load by considering the outdoor thermal radiation environment while Ozaki calculate the environment heat by considering the material characteristic of the internal environment.

This study discusses the development of an empirical model for ambient air temperature prediction to evaluate the impact weather factors on construction manufactures in Baghdad region.

METHODOLOGY

The field measurements data for the models development were between January 2001 and March 2012. Meanwhile, field measurements data between March and August, 2012 was used for the model validation. The quantities were monitored: daily minimum, maximum, average air temperature was monitored by means of shielded copper-constantan thermocouples. Total solar radiation. Incident and reflected solar hemispherical radiation (0.3 -3 micros) for the reference point. The instrument was used with Eppley pyrometer model 4-48, mounted horizontally with its sensing surface 1.5 m above the ground surface. The ratio of daily total reflected and incoming shortwave radiation were calculated for surface albedo. Percentage of surface land area over radius 50 m and 100 m, 150 m, average height of the building are ratio, manufacture wall surface area, green land cover area ratio, actual sunshine hours ratio n/N, wind speed WS, relative humidity, and rainfall. Hourly first- differences terms for current and prior weather variable were also included. Note that the information contained in the first differences variables is implicit in the current and prior data, but providing this information explicitly was found to improve model performance.

Table-1. Relationships of radius influences.

Air Temp.	**Temperature, minimum, C**			**Temperature, average, C**			**Temperature, maximum, C**		
Radius (m)	R^2	**F**	**Sign. p<0.05**	R^2	**F**	**Sign. p<0.05**	R^2	**F**	**Sign. p<0.05**
50	0.35	28.17	yes	31.05	28.21	yes	0.10	4.01	yes
100	0.31	31.11	yes	35.12	26.21	yes	0.19	6.00	yes
150	0.28	29.34	yes	34.28	23.46	yes	0.06	5.37	yes

Altitude variable, Kestrel 4200 packet weather tracker was used to measure the altitude of each measurements point. The altitude measurements indicated that there are differences across Baghdad are only about 34 m above the sea level which consider relatively flat. The altitude level in Baghdad is influence the air temperature condition of around 0.31K, base ed on atmosphere lapse rate of - C/m (ISO, 1975). For this reason, altitude is excluded from the model development. Relative humidity was measured with a thermistor. Wind speed was measured by a sensitive anemometer installed at the height of 2 m above the ground. The analogue signals for the Hewlett-Packard Automatic data Acquisition/Control system model. The output data was continuously on hourly basis using a Hewlett Packard model 9845 B computers connected on line with the data acquisition system. Minolta digital camera and fish eye lens was used for sky view measurements. The images were proceed into black - white images in which sky is white and the manufacture and trees are black, sky view was calculated according to (Matzarakis, 2000). Radius of 600 m was determined as influence of area and significantly impact to the air temperature (Kruger 2007). The analyses were done for the major parameters of land green cover, G_{cover} the building height to land area ration H/B which may affects the sky view, wall area values.

Table-2. Input on climate predictors based on data at Baghdad weather station in 10 June 2013.

Climate factors	**Data**
Reference minimum air temperature,	26.6 C
Reference average air temperature	38.6 C
Reference maximum air temperature	50.5 C
Reference incoming total solar radiation	33.4 MJ/m^2/d
Reference outgoing solar radiation	6.6 MJ/m$_2$/d
Reference maximum solar radiation	3.24 MJ/m^2/d
Reference incident solar latitude	80 degrees
Reference sunshine	14.3 hours
Reference wind speed	6.5 m/s
Reference mean hourly Albedo	0.14

The sensitivity analyses were carried out to analyze the dependence of the air temperature due to the variations of each variable. A typical type of Baghdad urban suburb was used simplify the variation of building, open work field and trees distributions. Table-2 shows the input on climate predictors based on data at Baghdad Weather Station in were used in this sensitivity analyses based on the conditions on 10 June 2013.

The data used for the prediction of air temperature including, reference of minimum, average, maximum air temperatures, total incoming, outgoing solar radiation, wind speed, rainfall and sunshine duration obtained from the Baghdad Weather Station, and research center in Baghdad. The other parameters used in the calculation, H/B, $A_{covered}$, A_{opened}, $G_{covered}$, W_{area} are straightforward to be obtained. Albedo, LE and n/N are calculated.

RESULTS AND DISCUSSIONS

The results discussed here are for the experiments with air temperature prediction models. The microclimate factors data collection compared the accuracy of year around and seasonal modes, each of was instantiated by 17 distinct initial networks differing only in initial random weights. The trend analysis of was done to identify the behavior the variables through the regression coefficient values and their correlations with dependent variable (Pearson Correlation). Some independent variables are significant; however, it is important to analyze how these variables work in determining the air temperature. Table-3 gives the regression results for minimum, average and maximum air temperatures models. The correlation coefficients for air temperatures minimum and average, are 0.90, and 0.68 respectively, while it is fair at 0.46 for minimum air temperature model. Figure-1 shows that the calculated minimum air temperature can fit with the measured one. About 40% of the differences between the measured and calculated air temperature is within acceptance range, 0.5 - 1 C (Table-4). The validation of average air temperature model is similar to the minimum air temperature model, (Figure-2) the calculated values of the average air temperature model is between 0.25 - 0.65 C, (Table-4).

The validation for the maximum air temperature regression model (Figure-5) with R^2 0.46 value is fair (Table-3), From the Figure-3 it can be note that some points. The differences of measured and calculated results is relatively large more than 2 C (Table-4), due to the existence of anthropogenic heat which not cover the model has influence on the prediction model. The difference is large if they compared with the minimum and average air temperature.

Figure-4 gives the values of between the minimum, average and maximum air temperatures comparisons. It can observe the view sky reduction due to LAI of trees varies the behavior of the calculated minimum, average and maximum air temperatures. The increase in greenery density can reduce the minimum air temperature (Table-5). The green ration covered $G_{covered}$ and view sky, and LAI influence the average temperature. Greenery due to high LAI Low sky view) provides shading to the environment thus reduces the air temperature. While the reduction in average air temperature due to increase in $G_{covered}$ between 0.03 -0.20 and LAI more than 4.5 m^2/m^2. The increase in greenery density affects the openness to the sky, which reduces the maximum air temperature through its shading effect.

The change in building height seems to have relatively influences on minimum, average and maximum air temperature (Table-5). The reduction in heat through its relation with sky view factor due to the increasing in LAI.

Table-3. Relationships between air temperatures and reference climatic factors at Baghdad.

	Inter a	Slope b	A covered %	Q_t	G_{cover}	H/B_{ratio}	W area	N	α	R^2	F	SE
T min	2.04	0.886	0.007		0.210	0.032	2.0E-5			0.90	1805	0.53
T avg	5.76	0.746	0.006	2.0E-02	0.03	-0.025	1.0E-02	0.33		0.68	334.5	0.37
T max	17.17	0.431	0.009	0.13		0.18	5.3E-03	1.333	.98	0.46		

Table-3 shows the variables modified in different temperature models for the sensitivity analyses. This stage is to develop the air temperature prediction models that use only the significant variables (<5%). The variables that have opposite sigh between regression coefficient and Pearson correlation have also been removed.

Figure-6 and Table-5 show the Leaf Area Index and solar radiation weighting function, f(LAI) to an LAI of ~ 4.0 at which the time the wheat canopy is intercepting about 97% of the solar radiation. The extinction coefficient of that, 0.79 obtained from Turner, 1960. The leaf area index of wheat crop increased from 2.68 and 5.21 m^2/m^2 during the period JD, 130 to JD, 150, then decreased to 1.48 in JD.

Solar radiation interception also contributed to the radiation balance of the canopy. Figure-6 shows the estimation of the solar radiation interception by the canopy. The solar radiation interception was computed on a unit of leaf area index as follows:

$$RsI = Rs \, (1 - \exp(-0.79 \, LAI))$$

Solar radiation inteception was lower on JD, 198, but still represented a significant energy source for the canopy. After rainfall, on JD, 198, a much cooler soil surface reduced the thermal radiation on canopy. Figure-6 suggests that the thermal radiation from the soil and also influence the pattern as well as the magnitude of LEc, took place when the soil surface was dry. These conditions may need to consider that the mid plot soil surface temperature measurements and the opaque view factor model may have caused an overestimating of RsI near mid day.

Similar climate of that westren desert of Iraq is also including rising desertificationlevels, low winter rainfall, and high evaporation with a high sun-shine duration. Several rainfalls occured during the the experimental period and no rainfall during the JD, 198 and 220.

To derive the estimated LAI influence value, mature trees with high values of LAI more than 4.5 m^2/m^2 predominantly influence the green ratio of these measurements points consequences affected solar interception. Based on the regression result, the following equation it can be estimated that the LAI values increase about 1.3 for every green ratio increase of 1.

$$LAI = 1.321 - 0.97 \, G$$
$R^2 = 0.741$ and $F = 36.4$

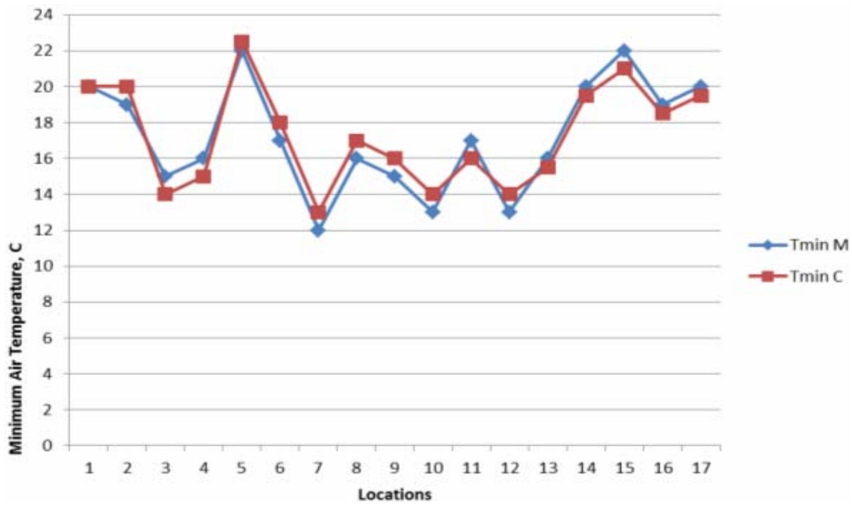

Figure-1. Relationship between measured and calculated minimum air temperature at different locations.

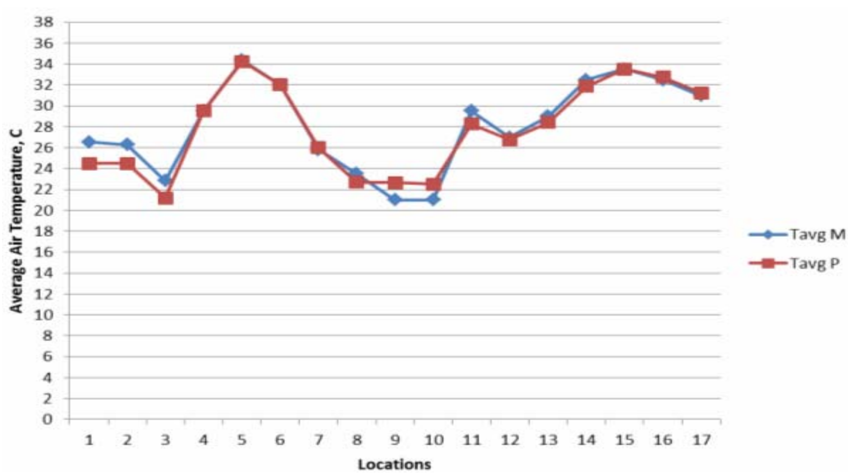

Figure-2. Relationship between measured and calculated average air temperature at different locations.

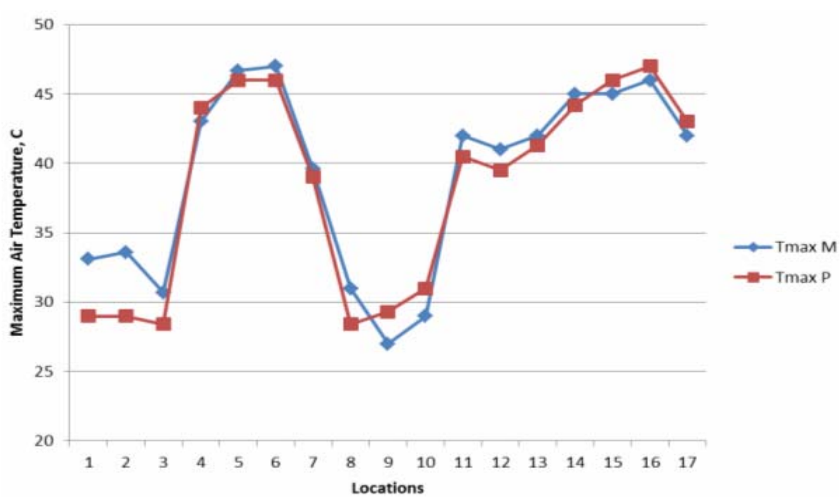

Figure-3. Relationship between measured and calculated maximum air temperature at different locations.

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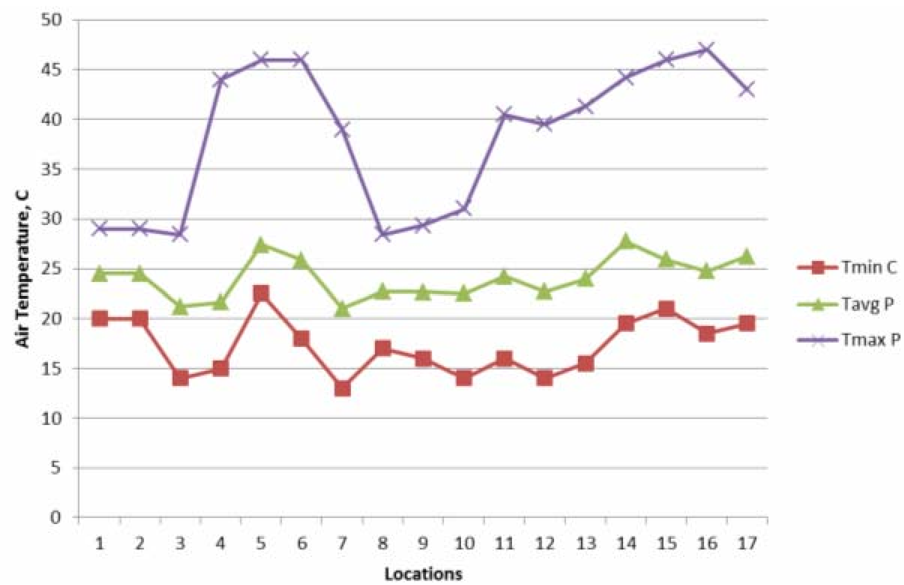

Figure-4. Relationship between calculated, minimum, average and maximum air temperature at different locations.

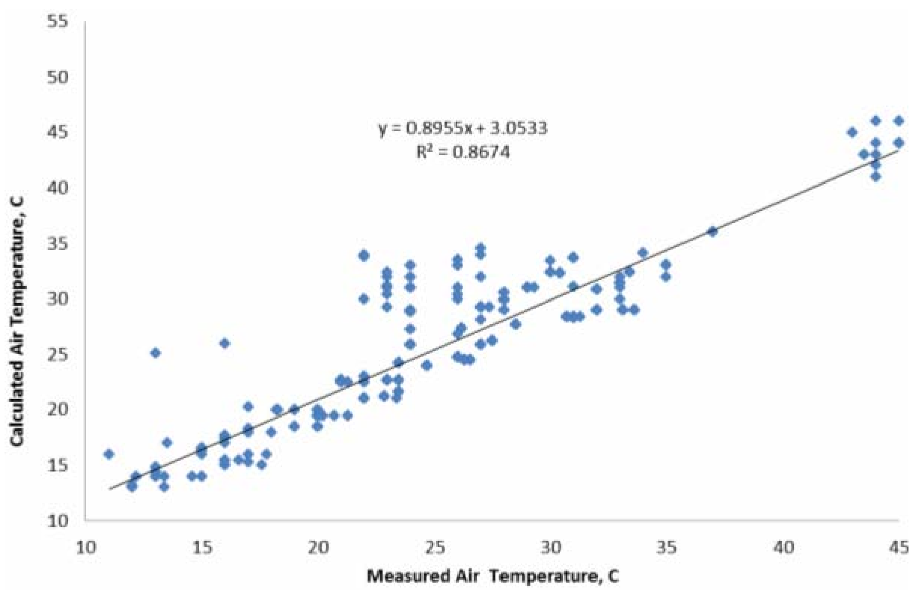

Figure-5. Relationship between measured and calculated air temperature.

Evaluation of calculated air temperatures

Closeness of the calculated to the measured values was checked by comparing, (i) the differences between the calculated and measured air temperatures and (ii) standard deviation of the average differences, (Table-4). The average differences (D) and standard deviation of the average differences (SD) is defined as:

$$D = 1/n\ \Sigma\ (T_{calculated} - T_{measured})$$

$$SD = \sqrt{[\Sigma(T\ calculated - T\ measured) - nD]\ /\ n - 1}$$

Table-4 gives the values of differences (D) and standard deviation of differences (SD) between measured and calculated air temperatures. The average standard deviation differences was the greater in the maximum air temperature (3.25 C) and tend to decrease (0.01 C) in the average air temperature.

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Table 4. Average differences (D) and standard deviation of differences (SD) between measured and calculated air temperatures.

Temperature, minimum		Temperature, average		Temperature, maximum	
D	SD	D	SD	D	SD
0	0	-0.05	1.45	-2.1	2.90
1	0.71	-0.8	1.27	-2.6	3.25
-1	0.71	-0.65	1.17	-2.3	1.63
-1	0.71	0	0.01	1	0.71
0.5	0.35	-0.1	0.07	-0.7	0.49
1	0.71	0	0.01	-1	0.71
1	0.71	0.2	0.14	-0.6	0.42
1	0.71	-0.8	0.57	-2.6	1.84
1	0.71	0.65	1.17	2.3	1.63
1	0.71	1.5	1.06	2	1.41
-1	0.71	-0.25	0.88	-1.5	1.06
1	0.71	-0.25	0.18	-1.5	1.06
-0.5	0.35	-0.6	0.42	-0.7	0.49
-0.5	0.35	-0.65	0.46	-0.8	0.57
-1	0.71	0	0.00	1	0.71
-0.5	0.35	0.25	0.18	1	0.71
-0.5	0.35	0.25	0.18	1	0.71

Table-5. Relationship between average LAI and calculated air temperature.

LAI, $m^{2/}m^2$	Temperature, min, C	Temperature, avg., C	Temperature, max, C
4.1	20	24.5	29
4.2	20	24.5	29
5.3	14	21.2	28.4
4.5	15	21.65	44
3.6	22.5	27.4	46
5.5	18	25.85	46
5.6	13	21.0	39
4.3	17	22.7	28.4
4.5	16	22.65	29.3
5.7	14	22.5	31
4.0	16	24.2	40.5
5.0	14	22.7	39.5
4.5	15.5	23.95	41.3
4.0	19.5	27.75	44.2
3.8	21	25.9	46
4.0	18.5	24.75	47
4.1	19.5	26.25	43

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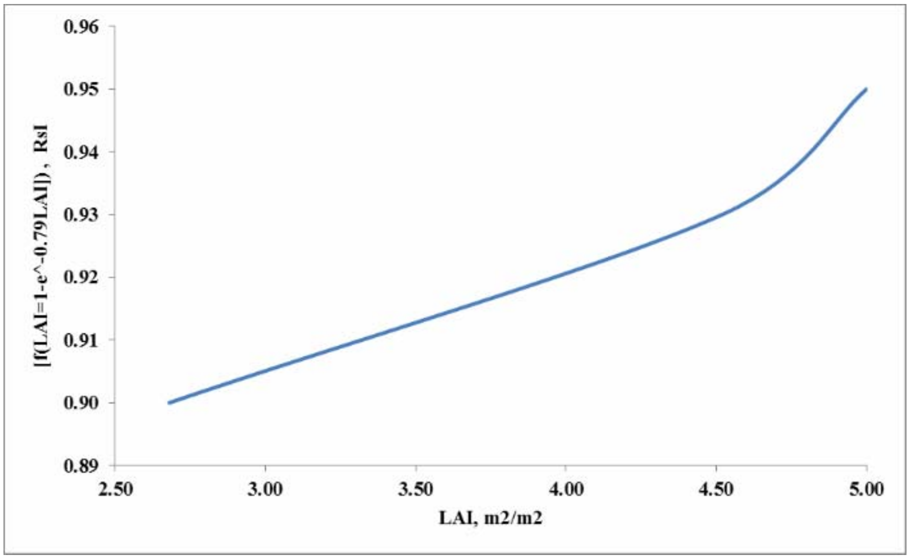

Figure-6. Solar radiation weighting function, f (LAI) to an LAI.

CONCLUSIONS

The sensitivity analyses have also successfully shown the performance of the air temperature calculations models in relation to their variables. There are close relationships between the building characteristics and greenery environment. Construction management's engineers play an important role to minimize the negative impact of heat on the work environment as result of their designs, anywhere in Baghdad and surrounding suburbs. It is important that increasing covered work are and greenery area of the industry environment. Sometimes, it needs to increase the work open area which is in turn increase the incoming solar radiation. In this situation, we should increase the greenery density to reduce the air temperatures, no though its evaporative cooling but also its shading. Therefore, construction engineers should find the optimum design by adjusting the variables that meet the design objectives including the economic objectives.

The model development focused on fairly on wind speed between 3 - 7 m/s and dust atmosphere (visibility between 10 - 500 m) weather conditions. The author believes that engineers and planners do not able to change the master plan design inside the industry unless change the future designs for the construction manufactures.

Notations

$T_{min,}$	Minimum air temperature, C
$Tma_{x,}$	Maximum air temperature, C
Tav.	Average air temperature, C
$Q_{t,}$	Total solar radiation, J/m^2
$Q_{in,}$	Incoming solar radiation, J/m^2
$Q_{out,}$	Outgoing solar radiation, J/m^2
N	Sunshine duration
α	Albedo
H/B	Building height to area ratio
$A_{covered}$	Work busy area / total area covered, m^2
A_{open}	Open work area
W_{area}	Total wall surface area, m^2
$G_{covered}$	Green land ratio, m^2
WS	Wind speed, m/s
R	Rainfall, mm
LAI	Leaf area index, m^2/m^2
LE	Latent heat, J/m^2
JD	Julian date.

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