11.8 AN INTRIGUED ANALYSIS TO QUANTIFY THE CAUSES FOR URBAN HEAT ISLAND BY THE REVISED ARCHITECTURERBAN-SOI-UUBAN SIMULTANEOUS SIMULATION MODEL, ***RIVISED-AUSSSM .***

PART.2 QUANTITATIVE ANALYSIS BASED ON HUGE NUMERICAL EXPERIMENTS.

Jun Tanimoto, Aya Hagishima and Tadahisa Katayama *
Kyushu University, Fukuoka, Japan

1. INTRODUCTION

The Urban Heat Island (UHI) resulting from social factors has become an object of great concern, and has been the subject of various types numerical research models. Incidentally, although concrete provisions from technical or general aspects are required to mitigate UHI, the great majority of previous studies have been concerned with the model itself. Looking at most previous studies, the results of numerical simulations are simply treated as examples. One of the reasons why the previous affluent studies have been relatively negative in regard to their effect on concrete discussion is that the model frame is too heavy to conduct systematic numerical experiments based on simulations involving huge numbers. And then, in the present paper we attempt to clarify the causes of UHI quantitatively. We use the Revised-AUSSSM in order to conduct extremely large numerical experiments. This allows us to identify, in a quantitative format, a group of causes leading to UHI. The causes of UHI are so complicated and so widely ranging that a numerical experiment should be considered in light of a certain strategic scheme In fact, it is very important what sort of factors or levels should be taken account in the experiments. The Revised-AUSSSM is useful in that it has a light computing load while still maintaining a relatively high level of accuracy. This allows us to observe many potential factors that contribute to UHI. In these numerical experiments we aim at to produce quantitative, useful, practical, and precise results upon which to base actual provisions against UHI.

2. Holistic Design for Experiments

The numerical experiments regard what factors are significant to UHI from the viewpoint of building architectural design, building mechanical design, or urban planning. Therefore, the scale involves neither a single particular building nor a whole city but a group of buildings.

Actual procedure for the numerical experiments consists of two stages.

The primary experiment is the so-called Variation Study, which attempts to identify relatively significant Factors affecting several assumed Characteristic Values. Variation Study is a technical term in the field of simulation engineering. For instance, a Variation Study having *M* Factors with *N* Levels for each Factor requires you to [run] 1+M*(N-1) times simulation, which is much less than the Perfect Experiment requiring N^M times.

The significant Factors screened through the Variation Study, an experiment based on the Design of Experiment Theory, is subsequently conducted as the secondary step.

* Jun Tanimoto, Interdisciplinary Graduate School of Engineering Sciences, Kyushu Univ., 6-1 Kasugakoen, Kasuga-shi, Fukuoka, 816-8580, Japan; e-mail: tanimoto@cm.kyushu-u.ac.jp

3. Variation Study

Assumed Factors and Levels are shown in Table 1. A combination picking up every gray meshed Level in Table 1 is the assumption for the Standard Case. In Variation Study, the input condition has to be one of the Levels amid focusing Factor and others; this is identical to the Standard Case assumption. In this numerical experiment, we are required to run 49 times simulations.

All the Factors are determined by a perspective intention focusing on a compass-form building design up to the city planning level, which are regarded as controllable, in a sense, in regard to the imposition of practical provisions against UHI.

On the ground of description space, the result can't be shown on this proceedings. However, briefly summarized discussion, we come to following notes.

If the air affecting the individual is focused on, for instance, the case of an individual walking down a street, the influences of both surface vegetation and building HVAC system cannot be neglected. Whereas, in regard to the temperature of the entire air canopy, another significant factor, building density or roughness inspired by a group of buildings, must be taken into account. And following that, if heat from HVACs exhausted into urban air through cooling towers is regarded as significant, much attention should be paid to building design specifications such as HVAC specs, indoor heat generation, and glazing area on walls that have a direct affect on the thermal load of building spaces.

4. Secondary Numerical Experiment by Design of Experiment Theory

The results of Variation Study determined 8 Factors to be considered as shown Table2. We use $L_{81}(3^{40})$ Orthogonal Table to conduct a 3 Level/8 Factor experiment where 9 Interactions inspired by 2 Factors are taken account. As the consequence, the Table for Main Factorial and Interactive Effects are drawn that are very useful but also neglected on this draft.

5. Conclusive Notes

Because of the room to describe, this time, we can't depict sufficiently here. However, looking at the results of numerical experiments, we come to several significant conclusions in terms of teffective provisions against UHI. Our web site, http://ktlabo.cm.kyushu-u.ac.jp/, has more detail. And also, we have an intention to present the whole content to some journal in another opprtunity.

Table 1 Factors and Levels in the Variation Study

Factor	Level			
Building Volume Proportion (Gross Building Covering Proportion, Width of road)	600% (50%, 13.25m)	700% (42.9%, 16.88m)	1000% (30%, 26.42m)	1300% (23.1%, 34.61m)
Gross Building Volume Proportion (Gross Building Covering Proportion, Width of road)	100% (14.3%, 52.66m)	200% (28.6%, 27.87m)	300% (42.9%, 16.88m)	350% (50%, 13.25m)
Ground Surface Covering	Asphalt 1：Soil 0：Lawn 0	Asphalt 1：Soil 1：Lawn 1	Asphalt 0：Soil 1：Lawn 0	Asphalt 0：Soil 0：Lawn 1
Roof Finishing and its Reflectance of Solar Radiation	Concrete slab/ 0.1	Concrete slab/ 0.3	Concrete slab with high-albedo painting finish/ 0.8	Artificial soil 100mm with Lawn
Glazing Area Proportion on Building Walls	10%	35%	60%	85%
Reflectance of Solar Radiation for Building Walls	0.8	0.6	0.4	0.2
Reflectance of Solar Radiation for Roads	0.6	0.4	0.2	0.1
Insulation of Building Walls	Inner Insulation 20mm	Outer Insulation 20mm	Inner Insulation 70mm	Outer Insulation 70mm
Heat Generation in Building Space	0.5 times Sensible 28W/ floor m^2 Latent 6.5W/ floor m^2	General Present Status Sensible 56W/ floor m^2 Latent 13W/ floor m^2	1.5 times Sensible 84W/ floor m^2 Latent 19.5W/ floor m^2	2.5times Sensible 140W/ floor m^2 Latent 32.5W/ floor m^2
Heat Generation by Urban Transportation	0.5 times Sensible 4.85W/ building-block m^2	Present Status in Tokyo Sensible 9.7W/ building- block m^2	1.5 times Sensible 14.55W/ building-block m^2	2.5 times Sensible 24.25W/ building-block m^2
Precipitation (What a day to pick up for analysis?)	The next day of rainfall	The day of rainfall	Intermittent irrigation to building roof	
Operation of HVAC System	Intermittent operation	All day operation		
Set Room Air Temperature for HVAC Control	24℃	26℃	28℃	
Evaporation from Artificial Surface	Considered	Neglected		
Building Allocation System	Staggered grid	Squarely regular grid		
HVAC System	Air Source Heat Pump (HPair), Turbo Refrigerator (TR), Gas Fueled Absorptive Refrigerator (AR) → Private Heat Source Systems HPair plus Heat Storage Tank (HST+HPair), TR plus Heat Storage Tank (HST+TR) → Private Heat Source with Heat StorageTank Systems HPair for District Heating & Cooling (DHC+HPair), Water Source Heat Pump for District Heating & Cooling (DHC+HPwater), TR for District Heating & Cooling (DHC+TR), AR for District Heating & Cooling (DHC+AR) → District Heating & Cooling Systems DHC+HST+HPair, DHC+HST+TR → District Heating & Cooling with Heat Storage Tank Systems Combined with Several Private Heat Source Systems （HPair 30%＋TR 31%＋AR 39%） → Standard Case			

Table 3 Factors and Levels in the secondary experiment based on Design of Experiment Theory

Factor	Level	L1	L2	L3
A	Building Volume Proportion	700%	1000%	1300%
B	Gross Building Volume Proportion	150%	250%	350%
C	Ground Surface Covering	Asphalt 1：Lawn 0	Asphalt 1：Lawn 1	Asphalt 0：Lawn 1
D	Glazing Area Proportion on Building Walls	35%	60%	85%
E	Reflectance of Solar Radiation for Building Walls	0.8 (high-albedo painting finish)	0.5	0.2
F	Heat Generation in Building Space	General Present Status	1.5 times	2 times
G	Set Room Air Temperature for HVAC Control	24℃	26℃	28℃
H	HVAC System	Private System HPair：30% TR：31% AR：39%	Private System+Heat Storage HST+Hpair：30% HST+TR：31% AR：39%	DHC + Heat Storage DHC+HST+HPair：27% DHC+HST+HPwater：41% DHC+HST+TR：9% DHC+AR：23%

Considered Interaction：A×B, A×C, A×F, A×H, B×F, B×G, B×H, D×E, F×H