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Research Paper

Analysis of the Relation between Air Flow and Temperature in High-rise Eco-friendly ApartmentDesignconsidering Climate Change Adaptation

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ABSTRACT
Global warming is a term used for the observed century-scale rise in the average temperature of the Earth's climate system and its related effects. Scientists are more than 95% certain that nearly all of global warming is caused by increasing concentrations of greenhouse gases (GHGs) and other human-caused emissions. As the rapid expansion of cities as a result of economic development, many people flowed into the cities, and the structure of the cities became overcrowded, resulting in a higher density of buildings. And the disordered arrangement buildings causes changes in the wind flow and reduces the amount of wind.

This study performed a numerical analysis with the STAR-CCM+ program on the relationship of wind field formation in an apartment complex according to the housing form, number of floors, and direction of layout of high-rise apartments that significantly affect wind path to adapt to climate changes, and the temperature distribution in the apartment complex was analyzed. A numerical results show that the temperature is increased by 2℃ at the back of the group C in the 90° swing arrangement and the 45° swing arrangement except for the parallel arrangement in the 60th floor apartment complex, whereas in apartments on the 15th and 30th floors, the temperature at the building has dropped significantly, except for the tower-type with 45° swing arrangement in the 30th floor apartment complex. This study will carry out a detailed study on fine dust in the apartment complex in the future.

Keywords: *Eco-friendly Apartment design, Climate change, Air flow, Temperature distribution*

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I. INTRODUCTION

Recently, many population flow into the city due to the industrialization and urbanization and as a high-rise and high-density building is being built, it is now feared to be development thoughtless for the environment

Within the earth's atmosphere, accumulating greenhouse gases like water vapor, carbon dioxide, methane, nitrous oxide, and ozone are the gases within the atmosphere that absorb and emit heat radiation. Increasing or decreasing amounts of greenhouse gases within the atmosphere act to either hold in or release more of the heat from the sun.

In reality, it is not very much to conduct wind environment assessment of a building from its planning stage[2)]. Hence, deteriorating wind environment is not only adversely affecting the outdoor environment in the apartment complex, but also significantly impacting the indoor environment[3)].

This study is utilize the STAR-CCM+ program to establish the main building types, floors, the relationship between wind direction and wind field formatting by layout direction of high-rise apartments that have a influence on the wind path when planning the layout of apartment in the apartment complex.

Then, this study presents the best eco friendlyapartment complex layout method for reducing greenhouse gas emission by comprehensively analyzed the flow, ventilation performance, generation of turbulence energy and distribution of temperature in the apartment considering climate change adaptation.

II. THEORETICAL BACKGROUND AND RESEARCH METHODS

2.1 conservation equations[4,5].

1) Conservation of energy

The energy equation in its most general form contains a large number of influences. Since we are primarily interested in the form rather than in the details of the equation, it will be sufficient to consider some restricted cases. For a steady low-velocity flow with negligible viscous dissipation, the energy equation can be written as

$$\nabla(\rho u h) = \nabla(k\,grad\,T) + S_h \quad (1)$$

Where h is the specific enthalpy, k is the thermal conductivity, T is the temperature, and S_h is the volumetric rate of heat generation. The term $\nabla(k\,grad\,T)$ represents the influence of conduction heat transfer within the fluid, according to the Fourier law of conduction.

For ideal gases and for solids and liquids, we can write

$$c\,grad\,T = grad\,h \quad (2)$$

Where c is the constant-pressure specific heat. With this substitution, the energy equation becomes

$$\nabla(\rho u h) = \nabla\left(\frac{k}{c}\,grad\,h\right) + S_h \quad (3)$$

If c is constant, the h~T relation simplifies to $h = cT$, which would lead to

$$\nabla(\rho u T) = \nabla\left(\frac{k}{c}\,grad\,T\right) + \frac{S_h}{c} \quad (4)$$

In this manner, either the enthalpy or the temperature can be chosen as the dependent variable. The steady heat-conduction situation is obtained by setting the velocity u to zero; thus,

$$\nabla(k\,grad\,T) + S_h = 0 \quad (5)$$

2) Conservation of Energy 6).

The differential equation governing the conservation of momentum in a given direction for a Newtonian fluid can be written along similar lines; however, the complication is greater because both shear and normal stresses must be considered and because the Stokes viscosity law is more complicated than Fick's law or Fourier's law. With u denoting the x-direction velocity, we write the corresponding momentum equation as

$$\frac{\partial}{\partial t}(\rho u) + \nabla(\rho u \mu) = \nabla(\mu\,grad\,u) - \frac{\partial p}{\partial x} + B_x + V_x \quad (6)$$

Where μis the viscosity, p is the pressure, Bx is the x-direction body force per unit volume, and Vx stands for the viscous terms that are in addition to those expressed by $\nabla(\mu\,grad\,u)$.

3) Conservation of mass(Continuity equation)

If the dependent variable if denoted by ϕ, the general differential equation is

$$\frac{\partial}{\partial t}(\rho\phi) + \nabla(\rho u\phi) = \nabla(\Gamma\,grad\,\phi) + S \quad (7)$$

Where Γ is the diffusion coefficient, and S is the source term. The quantities Γ and S are specific to a particular meaning of ϕ. Not all diffusion fluxes are governed by the gradient of the relevant variable. The use of $\nabla(\Gamma\,grad\,\phi)$ as the diffusion term does not, however limit the general ϕ equation to gradient-driven diffusion processes. Whatever cannot be fitted into the nominal diffusion term can always be expressed as a part of the source term.

The density appearing in Eq. (7) may be related, via an equation of state, to variables such as mass fraction and temperature. Further, the flow field should satisfy an addition constraint, the mass conservation or the continuity equation, which is

$$\frac{\partial}{\partial t} + \nabla(\rho u) = 0 \quad (8)$$

Another useful representation if the Cartesian-tensor from of these equations.

$$\frac{\partial}{\partial t}(\rho\phi) + \frac{\partial}{\partial x_j}(\rho u_j\phi) = \frac{\partial}{\partial x_j}\left(\Gamma\frac{\partial\phi}{\partial x_j}\right) + S \quad (9)$$

$$\frac{\partial\rho}{\partial t} + \frac{\partial}{\partial x_j}(\rho u_j) = 0 \quad (10)$$

Where the subscript j can take the values 1, 2, 3, denoting the three space coordinated.

2.2. Analysis condition

Most of Cheonan city and Asan city apartment are analyzed for climate change adaptation. Cheonan city and

Asan city area are northwesterly wind with the average speed of 1.6m/s[4].
The height of the apartment is 1,000m and the height is 500m including the apartment complex applied to this study. The shape of the apartment is arranged as flat type and tower type. The height of the apartment is 2.9m and the climatic condition, the numerical analysis was performed. The temperature condition is 298K in the apartment complex, and the temperature of the wind and the temperature of the calculation area is 288K. The layout of the apartments was numerically analyzed as shown in Fig. 1.

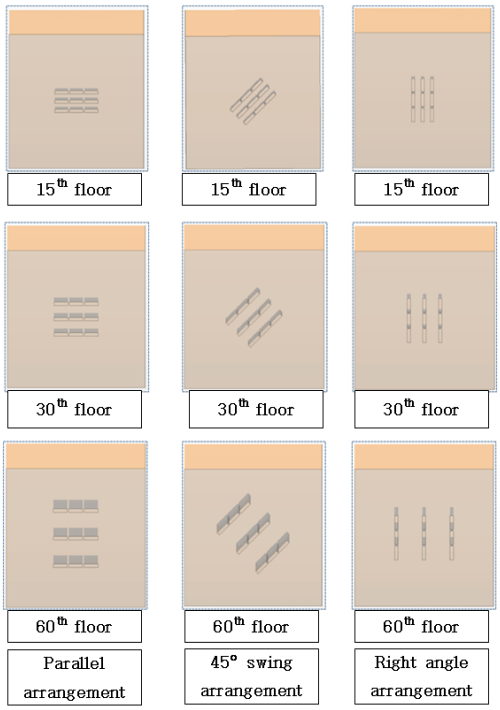

Fig. 1. Apartment complex depend on the arrangement direction

2.3. Numerical analysis method

In this study, numerical analysis is performed with the general code STAR-CCM+ 9.04.009-R8 for the analysis. The grid is used with the polyhedral grid.

The grid generation is shown in Fig. 3. In order to facilitate the numerical analysis in the apartment complex, it was classified into 3 groups (A, B, C group).

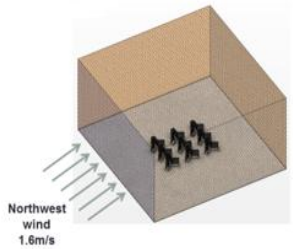

Fig. 2. Calculation domain and grid generation

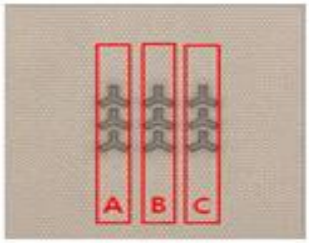

Fig. 3. Separated by apartment group in right angle arrangement

III. NUMERICAL ANALYSIS RESULTS

3.1. Wind direction

In the parallel arrangement, there is not much change in the wind flow, and in the 45° swing arrangement and right angle arrangement, the wind flow changes remarkably according to the number of layers.

In the 15th floor apartment complex, the height of the building does not affect the wind flow. However, in the 30th and 60th apartment complexes, except for the parallel arrangement of the plate type, wind flow stagnant.

The parallel arrangement was more active than 45° swing arrangement and right angle arrangement.

As the number of apartment floors increases, the flow is stronger as the number of apartment floors increases. This means that as the number of floors increases, the effect of frictional force from the ground is less.

As the flow according to the apartment type was examined, it was found that the overhead type flow was stronger than the plate type, and the flow of air from the outside was more active.

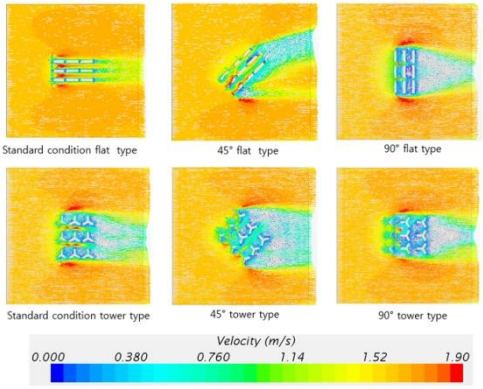

Fig. 4. The wind direction of 15 layers

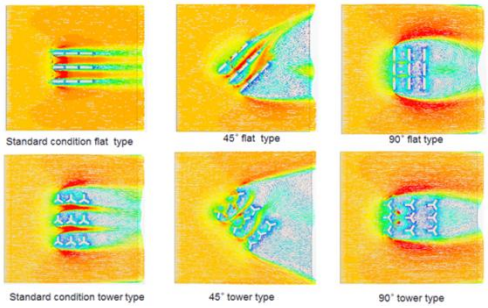

Fig. 5. The wind direction of 30 layers

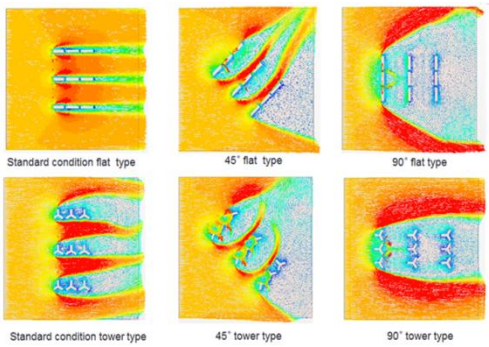

Fig. 6. The wind direction of 60 layers

3.2. Temperature direction

In the 15th floor apartment complex, the temperature of the building is 290K.In the 30th floor45° swing apartment complex, the local temperature rises to around 300K behind the apartment complex, but the temperature between the buildings in the rest of the apartment complex may be lower than the temperature of the building.Apart from the parallel arrangement in the 60th floor apartment complex, the arrangement of the plate-shaped and overhead-shaped arrangement at 45° swing arrangement and right angle arrangement increased

the temperature of the apartment complex to about 2°C behind the apartment complex.

As shown in Fig. 7, the numerical analysis area is divided, and the change in temperature according to the number of stories is analyzed in detail with the results from each area. As shown in Fig. 8, the panel shows a graph of temperature rising sharply from the number of apartment floors above 30th behind the C group.

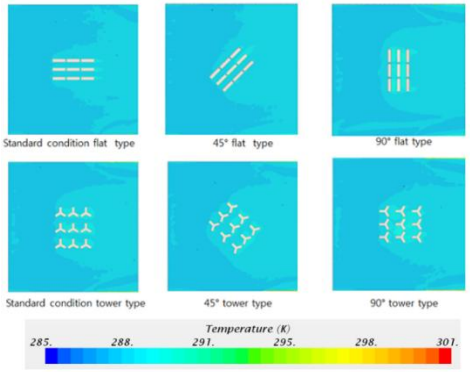

Fig. 7. The temperature direction of 15 layers

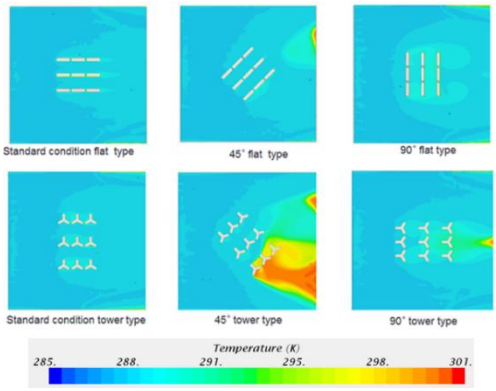

Fig. 8. The temperature direction of 30 layers

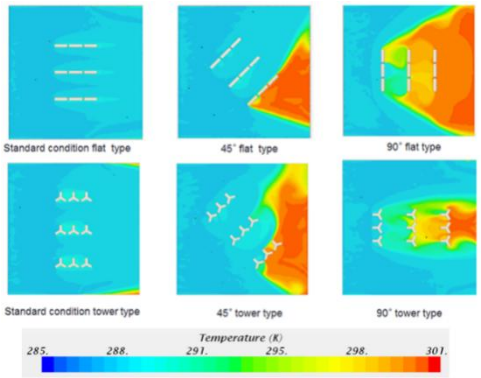

Fig. 9. The temperature direction of 60 layers

The temperature levels described above for irreversible and extinction-level global warming are not hard and rigid boundaries, but boundary ranges that describe the related consequences and their intensities within a certain level of global warming. These temperature boundary levels may be modified by future research. More about how irreversible global warming and extinction-level global warming can come about because of complex interactions will be explained in the tipping point information will set the foundation necessary to understand how we are already creating the conditions that have not only created irreversible global warming, but also extinction-level global warming if we keep going as we are now. Within the climate's many systems and subsystems, there are factors that directly and indirectly affect the overall stability of the global climate and our temperature. One of these factors is that some climate systems and subsystems have apartment eco friendly design considering climate change.

IV. CONCLUSIONS

The results are as followings

1) In case of the 15th floor apartment complex, both the direction of arrangement and housing form show a large drop in temperature, and analysis shows that the flow of wind in a parallel arrangement moves more actively.

2) Design 30th floor apartment complex, it can be judged that the flat-type and the tower-type have little difference in temperature changes in parallel arrangement and right angle arrangement, whereas the flat-type may be better than tower-type if they are in a 45°swing arrangement.

3) Design of the 60th floor apartment complex, in a right-angle arrangement

and 45° swing arrangement, except for a parallel arrangement the temperature is 2℃higher behind the group C and, in particular, the flat-type indicates that the temperature changes have become worse.

4) In case that the temperature changes according to the number of floors by area, considering that the temperature curve rises sharply as the number of floors rises after the fact of no change to the 30th floor, it is judged that it is possible to plan the proper layout of apartment if the floors of apartments are adjusted to be on or below the 30th floor (approximately 87m) when planning the site layout.

Therefore, comparing the correlation of wind flow, pressure distribution, turbulence energy generation and temperature distribution due to the reduction of greenhouse gases, the 30th floor tower-type form was superior in the right angle arrangement.

On the 45°swing arrangement, the 30th floor flat-type is found to be the optimal layout of apartments considering eco friendly.

Based on the numerical analysis results conducted in this study, the research is planned to be carried out on fine dust removal in apartment complex and the development of optimized apartment complex for consideration of climate change adaptation.

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