The Effect of Spatial Distribution on Heat Transfer in the Inner Spaces of Buildings in Urban Areas

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Abstract

Two experimental models are built to investigate the effect of a geometric arrangement of building distribution over populated lands in urban areas; they are traditional and reciprocal models. The experimental results show that the heat transfer and temperature degrees variation is much more active and effectible for reciprocal (chess) arrangement model than traditional arrangement Model. The study indicates that with an 1) initial temperature of 23.3°C for the inner space of the buildings and for cooling process, traditional and reciprocal modes offer 20.9°C and 20.4°C after 70 minutes respectively. Whereas for heating process, traditional and reciprocal models offer 45.8°C and 48.5°C after 70 minutes respectively.2) initial temperature of 39.4°C for the inner space of the buildings and for cooling process, traditional reciprocal models offer 25°C and 21.5°C after 70 minutes respectively. Whereas, for heating process, traditional and reciprocal models offer 46°C and 49°C after 70 minutes respectively.

Keywords: Traditional Model, Reciprocal Model

المستخلص

تم بناء نموذجين مختبريين لاستكشاف تأثير الترتيب الهندسي لتوزيع الابنية في المناطق المأهولة من الاراضي المدنية هما النموذج التقليدي والمتعاقب. ان النتائج المختبريه بيّنت ان الانتقال الحراري والتغير في درجات الحرارة فعال ومؤثر كثيرا في نموذج الترتيب المتعاقب (الشطرنجي) منه لنموذج الترتيب التقليدي. أفادت الدراسة انه بالنسبة ١) لدرجة حرارة ابتدائية مقدارها ٢٣,٣ درجة مئوية للفضاءات الداخلية للأبنية وفي عملية التبريد انّ النموذجين التقليدي والمتعاقب اعطيا ٢٠,٩ و ٢٠,٤ درجة مئوية بعد ٧٠ دقيقة على التوالي في حين انه في عملية التدفئة انّ النموذجين التقليدي والمتعاقب اعطيا٤٥,٨ و ٤٨,٥ درجة مئوية بعد ٧٠ دقيقة على التوالي. ٢) لدرجة حرارة ابتدائية مقدارها ٣٩,٤ درجة مئوية للفضاءات الداخلية للأبنية وفي عملية التبريد انّ النموذجين التقليدي والمتعاقب اعطيا ٢٥ و ٢١,٥ درجة مئوية بعد ٧٠ دقيقة على التوالي في حين انه في عملية التدفئة انّ النموذجين التقليدي والمتعاقب اعطيا٢٦ و٤٩ درجة مئوية بعد ٧٠ دقيقة على التوالي.

الكلمات المفتاحية: نموذج التقليدية، نموذج المتبادلة

Introduction

Shehada and Lukman (2009) indicated that in the past human been depended on nature characteristics for cooling, heating and lightening. This is clearly shown in the historical architectural configuration in his traditional buildings of ancient civilizations.

More than a third of the energy consumed in industrialized countries is used in creating acceptable conditions of thermal comfort and lighting in buildings, but such demands are harmful to the environment and are of concern to building experts. Internal thermal conditions are determined by the climate, the heating and cooling plant, and people's behavior, together with the characteristics of the building fabric itself .Takasha and Akira (2011) simulate heat balance on building and urban surfaces. Their results of the distribution of convective heat transfer coefficient in an urban canyon model are compared with that of a wind tunnel on the surface temperature distribution and convective heat flux from the building external surfaces are examined using coupled simulation method. Burchiu S. Et al (2000) devote to analysis of the influence of thermal stratification on heat transfer through vertical large openings in multi zone buildings by usind a zonal model to simulate thermo-convective fields with upper and lower zones which are separated by horizontal plane.

Howard et al, (2012) builds a model to estimate building sector energy end-use intensity (kwh/m^2 floor area) for space heating, domestic hot water, electricity for space cooling and electricity for non-space cooling applications in New York City. The model assumes that such end use is primarily dependent on building function, whether residential, educational or office for example, and not on construction type or the age of building. The modeled intensities are calibrated using ZIP code level electricity and fuel use data reported by the New York City Mayor's Office of Long-Term Planning and Sustainability. The results provide the ability to estimate the end-use energy consumption of each tax lot. The resulting spatially explicit energy consumption can be a valuable tool for determining cost-effectiveness and policies for implementing energy efficiency and renewable energy programs.

In this research, the study is focused on the effect of spatial distribution of the buildings over the land extent on the natural temperature of inner spaces of buildings to save the excess energy spent on air-conditioning.

Research Significance

Population eventually who lives in the regions of Mediterranean weather much more suffer heat variety in side building space due to the meteorological category changing, the major parameters in this context are; heat and wind speed. Although the human been spends much labor and energy to enhance air-conditioning of the buildings, he in turn exposes to new environmental challenges such pollution. More knowledge about the effect of these parameters may attribute little to human been education and ease his life.

Objectives

This study is aimed to investigate the effect of building areal distribution and arrangement over land extent. However, the study focuses to investigate the effect of geometrical distribution of buildings in urban areas.

Theoretical Conceptualization

It is Supposed that exchanging of heat between the inside space and outside is severely affected by the distribution of buildings over a specified area and winds obstacles. In this study, two models are tested; they are traditional and reciprocal models.

Traditional model means that the inhabited area is divided into equi-areas and each area represents a building whereas the street separates the buildings unit. Fig.(1) shows the suggested traditional model.

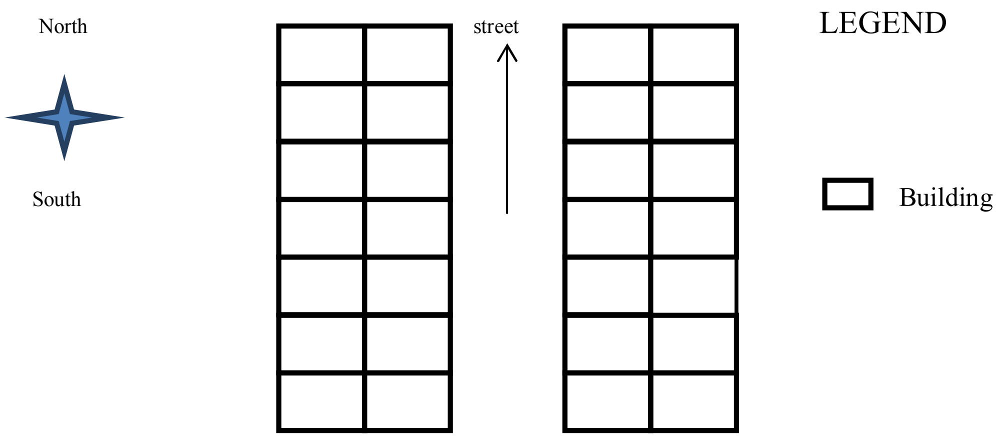

Fig.(1) Suggested Traditional Model

Reciprocal model is supposed to be of the same previous populated units but they are distributed reciprocally a building is followed by an empty area (may be garden) and so on. This shown graphically in Fig.(2)

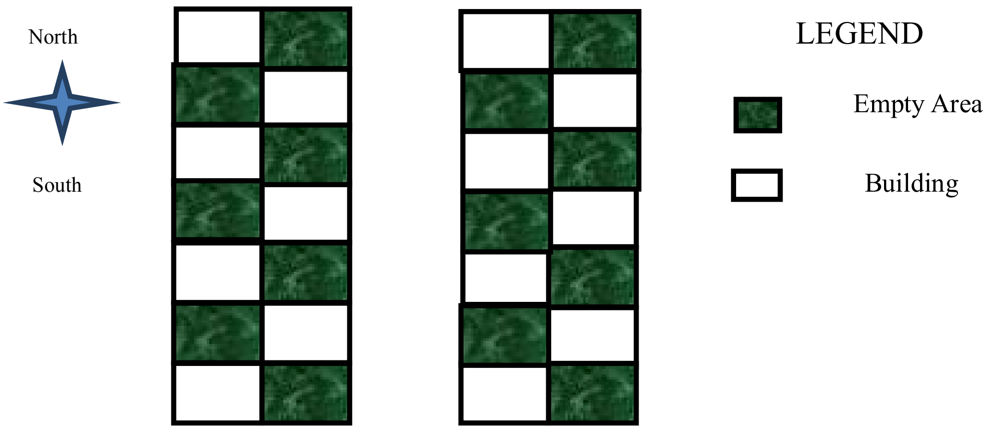

Fig.(2) Suggested Reciprocal Model

Wind Categories

For the previous models arrangements, there are three probable wind categories for each model. Theoretically, they may be illustrated as follows:

1) Traditional Model

a) Southern wind category

b) Southern East wind category

c) Southern West wind category

The a, b, and c categories are shown in Figs. (3, 4 and 5) These wind categories are tested next under heat flux transfer.

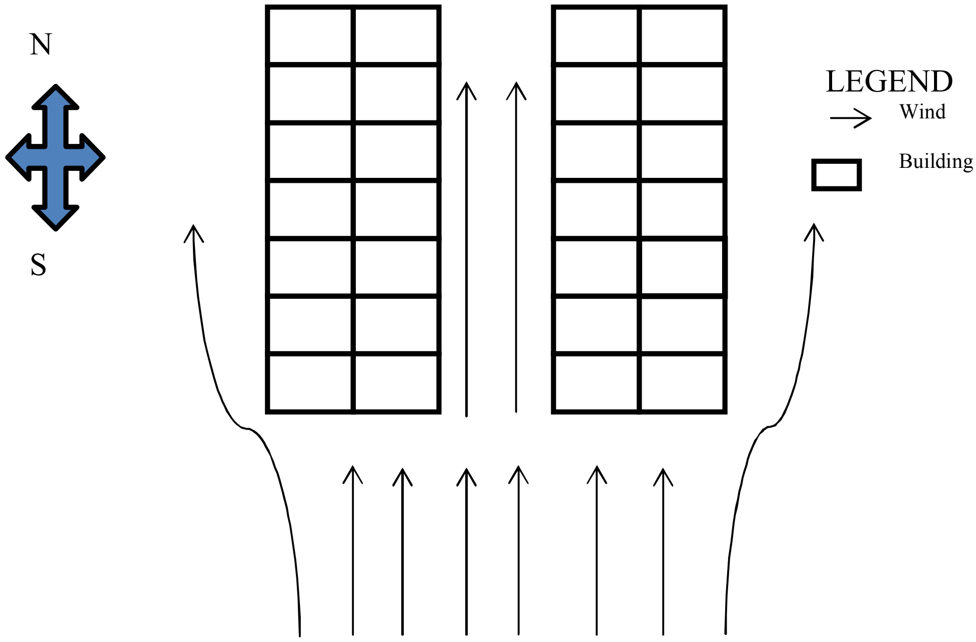

Fig.(3) Southern Wind Category of Traditional Model

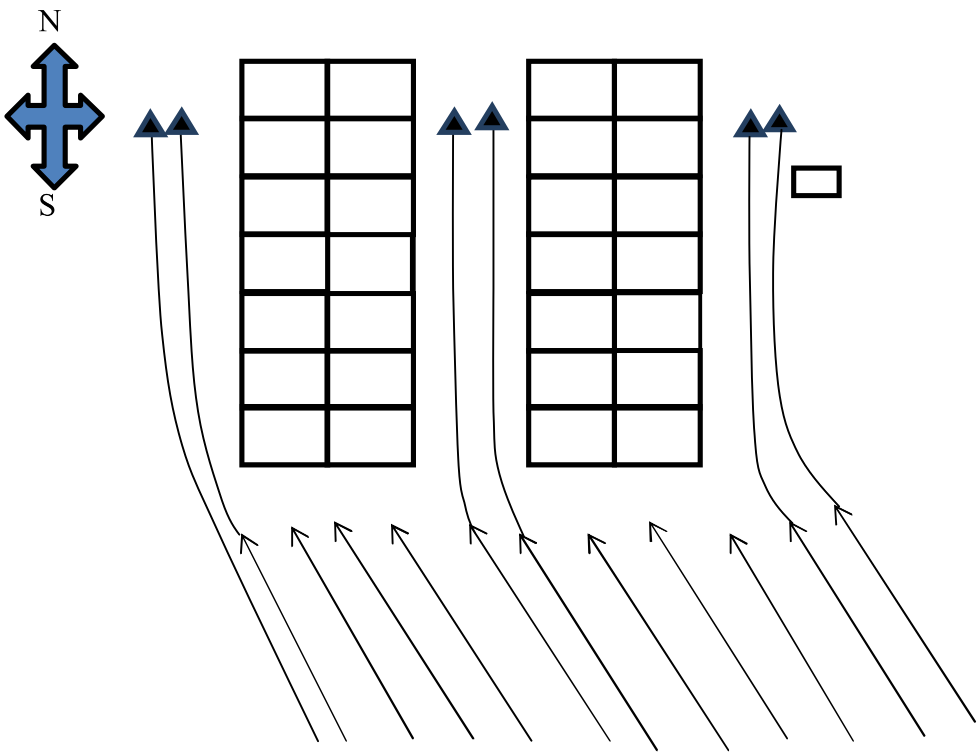

Fig.(4) Southern-East wind Category of Traditional Model

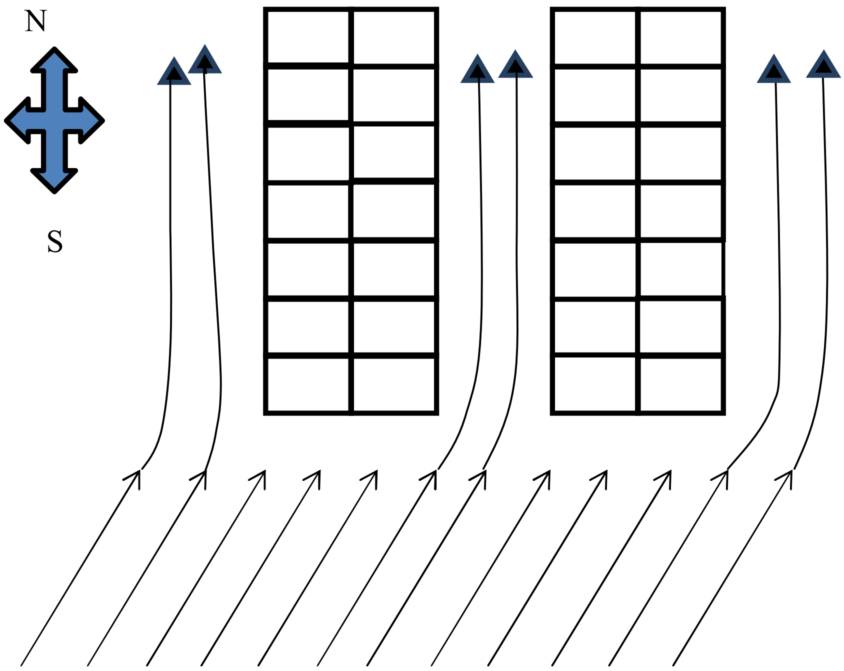

Fig.(5) Southern-West Wind Category of Traditional Model

2) Reciprocal Model
d) Southern wind category
e) Southern East wind category
f) Western Category

The d, e, and f categories are shown in Figs.(6, 7 and 8).These wind categories are also tested for heat flux transfer.

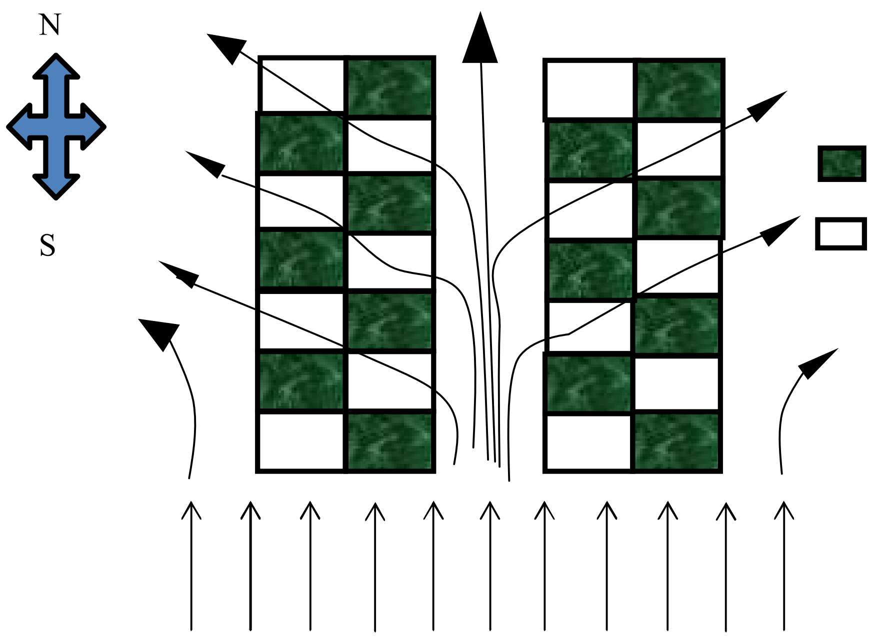

Fig.(6) Southern Wind Category of reciprocal Model

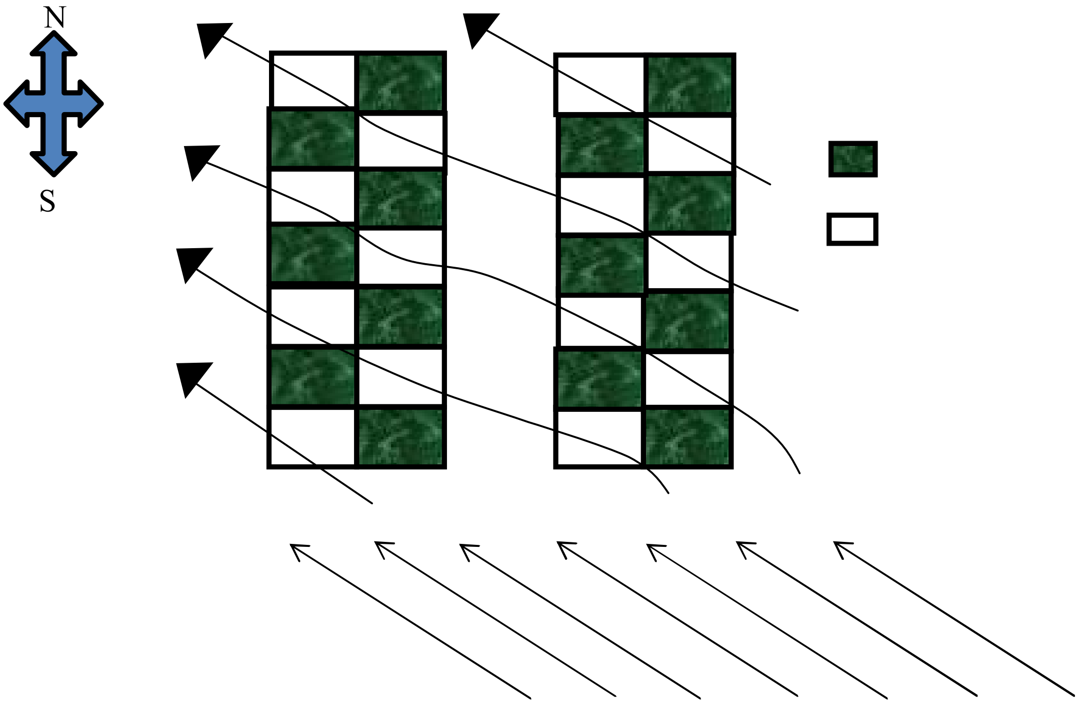

Fig.(7) Southern-East Wind Category of Reciprocal Model

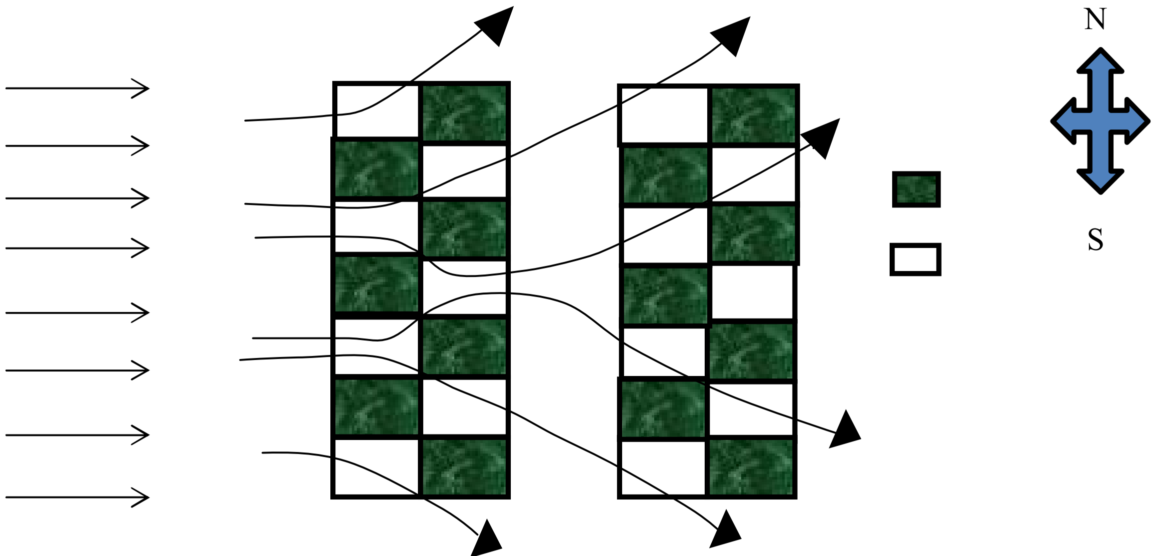

Fig.(8) Western Wind Category of Reciprocal Model

Experimental Testing and Models Operation

The two types of the models (whether traditional and reciprocal models) are built and simulated by a glass cubs (each glass cub is provided with a thermometer) to represent the buildings and then they are setup over a flat and Isolated plate according to the foregoing suggested models categories as shown in the Figures (3 to 8). After the setup process has been accomplished, a wind current is then exerted toward the model with an initial temperature and then the inside temperature variation with time proceeding of the glass cubs are observed.

The testing methodology is based on two scenarios:-

The temperature of the wind source is lower than the room and models temperature and chosen to be 20^{o}C .

The temperature of the wind source is higher than the room and models temperature and chosen to be 50C.

Traditional Model Results

Initial Temperature 23.3C (represent winter)

The initial temperature of the glass units and room temperature has been found to be 23.3C. After the initial wind current temperature of 20C and 50Cfor each cooling and heating process has been carried out respectively. The temperature begins to vary with time proceeding until the model temperature is rebalanced. Temperature variation with time advance is shown in Fig.(9).

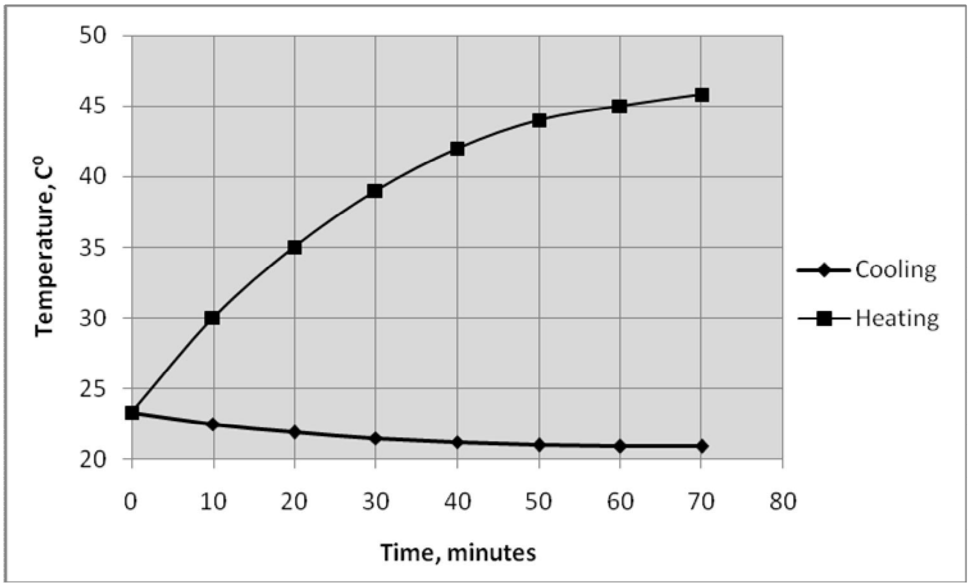

Fig.(9) Temperature variation of Traditional Model for Wind Category in Winter

Initial Temperature 35.5C (represent Summer)

The initial temperature of the glass units and room temperature has been found and focused to be 39.4C in summer. After the initial wind current temperature of 20C and 50 C for each cooling and heating process has been carried out respectively. The temperature begins to vary with time proceeding until the model temperature is rebalanced. Temperature variation with time advance is shown in Fig. (10).

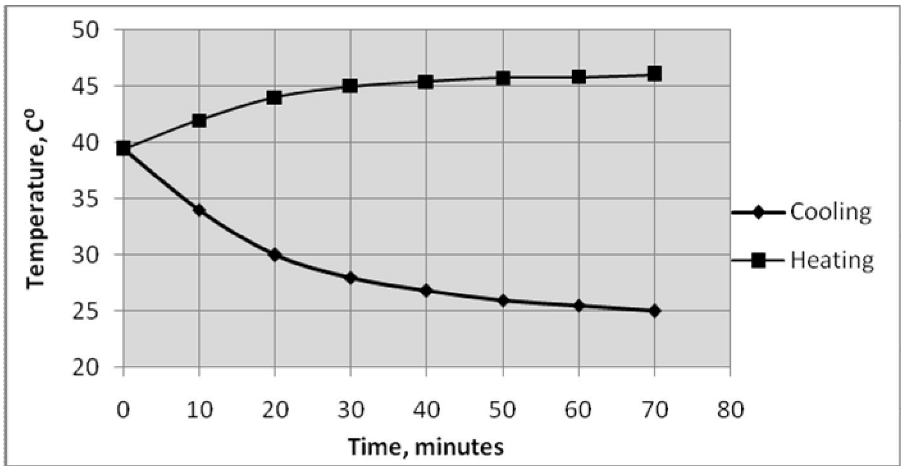

Fig.(10) Temperature variation of Traditional Model for Wind Category in Summer

Reciprocal Model Results

The reciprocal model is rearranged to be as shown in the Figures (6, 7, & 8). After the model has been justified, it is run also for two cases with initial temperature of 23.3 C□ and 39.4C□ to represent winter and summer seasons repectively. The heat source is exerted by the model also with 20 C° and 50 C° for cooling and heating processes respectively. The model is firstly run for winter simulation process and the temperature variation with time is represented in Fig.(11).

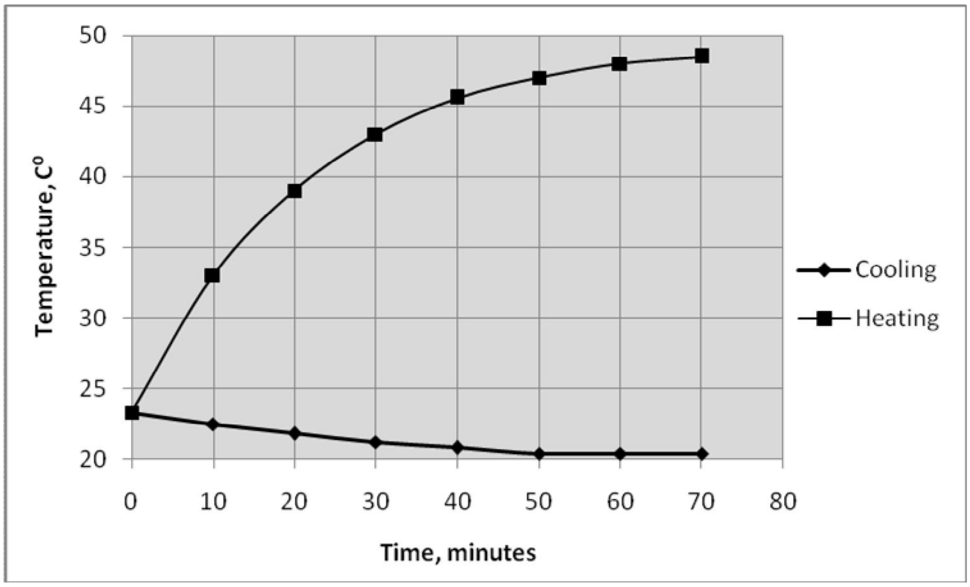

Fig.(11) Temperature variation of Reciprocal Model for Wind Category in Winter

Secondly, the model is run for the simulation of summer season for both cooling and heating process and the results temperature variation are represented graphically in Fig.(12)

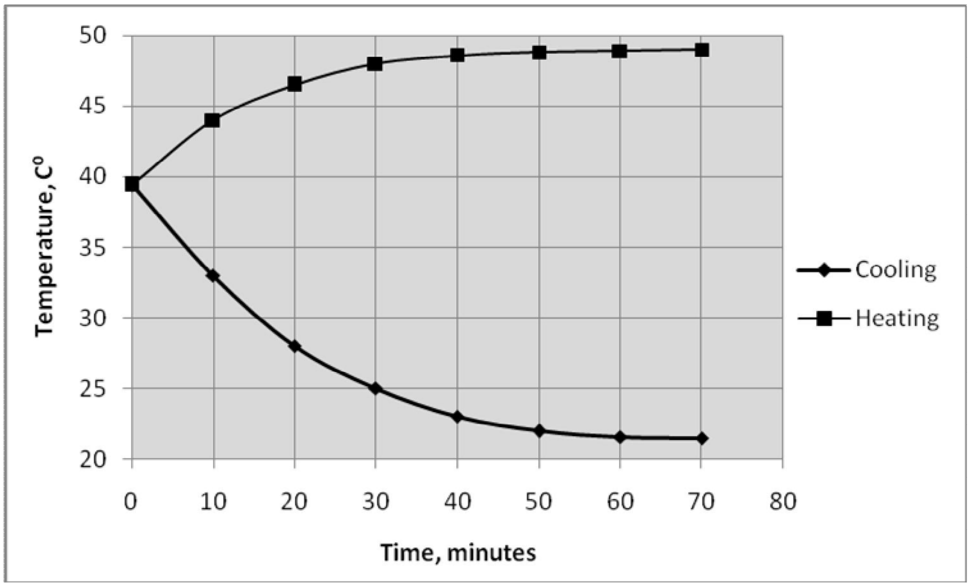

Fig.(12) Temperature variation of Reciprocal Model for Wind Category in Summer

Validity of Reciprocal Model & Comparison

Fig.(13) shows the comparison between the temperature variation of traditional and reciprocal models. Although, a constant source heat of 20C and 50C are used for both cooling and heating processes to run the two models with initial temperature of 39.4C, it is observed that the reciprocal model is characterized with a rapid temperature variation with time advance. In addition, the final temperature degrees of the inner spaces of the building units are different from traditional building units.

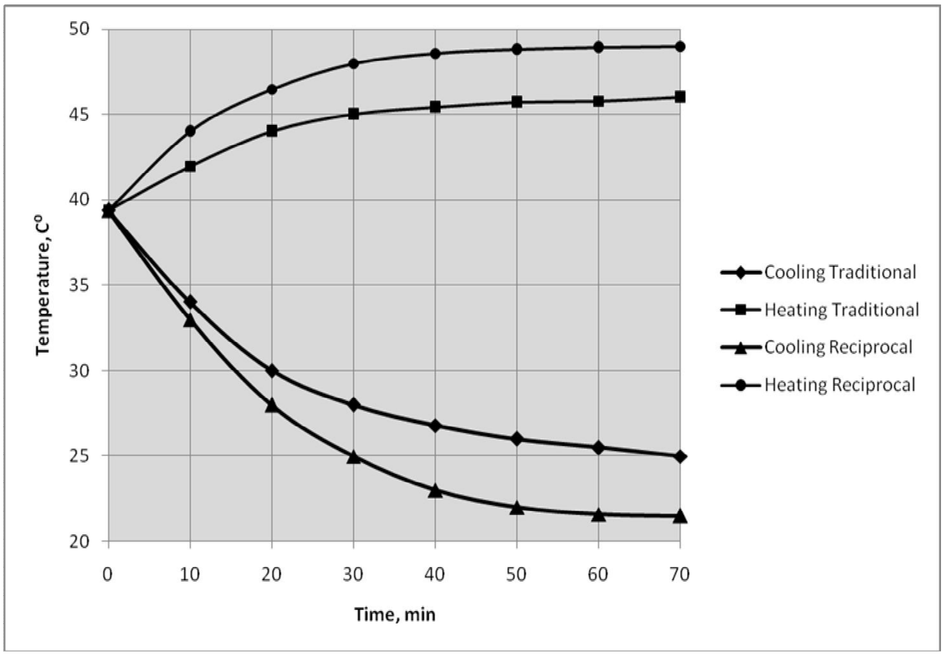

Fig.(13) Comparison between Temperature variation of both traditional and Reciprocal Models

Results Discussion

For traditional model, there are two cases:-

The model is run with initial temperature 23.3°C of inner spaces of glass cubes. The temperature begins to vary with time to reach 20.9c° and 45.8 c° for cooling and heating after 70 min respectively.

The model is run with initial temperature 39.4 c° of inner spaces of glass cubes. The temperature begins to vary with time to reach 25c° and 46 c° for cooling and heating after 70 min respectively.

For Reciprocal model, there are two cases:-

The model is run with initial temperature 23.3c° of inner spaces of glass cubes. The temperature begins to vary with time to reach 20.4c° and 48.5 c° for cooling and heating after 70 min respectively.

The model is run with initial temperature 39.4 c° of inner spaces of glass cubes. The temperature begins to vary with time to reach 21.5c° and 49 c° for cooling and heating after 70 min respectively.

The comparison of Fig (13) indicates that the reciprocal model is proven to be a good tool to accelerate temperature variation.

Comment 1 : The temperature values and the suggested wind categories under study are chosen to be fitted with Iraqi Environment.

Comment 2 : The forgoing results are identically obtained for all suggested wind categories which are remembered in Figs (3 to 8)

Conclusions

The result of the current experimental study leads to the following conclusions:-

The heat exchanging of the inner spaces of the building is much more affectible if the reciprocal arrangement of building is used. This Phenomenon is favorable in the countries where the weather of Mediterranean is dominant.

Reciprocal arrangement of buildings is a gift of nature but it is accompanied with area loss.

With an initial temperature of 23.3c^o:-

For cooling process, traditional and reciprocal models offer 20.9c^o and 20.4c^o after 70 minutes respectively.

For heating process, traditional and reciprocal models offer 45.8c^o and 48.5c^o after 70 minutes respectively.

With an initial temperature of 39.4c^o:-

For cooling process, traditional and reciprocal models offer 25c^o and 21.5c^o after 70 minutes respectively.

For heating process, traditional and reciprocal models offer 46c^o and 49c^o after 70 minutes respectively.

Recommendations

According to the results of this study, we recommend the followings:-

For the regions where and when the weather of Mediterranean is dominant, a reciprocal arrangement of buildings is preferred to guaranty a natural softening of the inner temperature.

For cold and hot regions and where the inner temperature is preferred to maintain constant, traditional arrangement of building is recommended.

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