Review on Mitigation Technologies for Controlling Urban Heat Island Effect in Housing and Settlement Areas in Housing and Settlement Areas in Hyderabad.

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ABSTRACT:

The effects of climate changes on urban areas, which are home to over half of the worlds population, are already being felt. One of the problems urban areas are facing is the integrated effect of climate change and the Urban Heat Island (UHI) effect. Among the negative outcomes of rapid city growth is the expansion of the problems posed by urban heat islands (UHIs), defined as areas in a city that are much warmer than different destinations, especially in comparison with rural areas. Urban heat island (UHI) effect is a kind of heat built up happening within urban area due to urban construction and human activities. It is identified as the most perceptible characteristic of urban climate. The increase of land surface temperature caused by UHI effect will definitely impact material flow and energy flow in urban ecological systems. The geographical, socio-economic and urban form data of the study area and its resulting vulnerability to UHI were initially estimated. In view of these features, a local spatial planning approach is proposed, and the study proceeds to a detailed amendment of the land use plan, within part of the vulnerable zone.

This paper discusses few mitigation technologies for UHI phenomenon that have been developed by Experts. Some mitigation technologies such as double skin facade, shading strategies, and many more are discussed in this study; include the strengths and the weaknesses of each strategy. The focus of the study is mainly on the capability of building skin designing in which thermal conductivity, infrared emissivity, and specific heat factors.

Modification of urban environment is due to various environmental activities. Greater Hyderabad is one of the fastest growing urban centres of India. Rapid urbanization of Greater Hyderabad is leading to increase in urban sprawl, densification of core city. The urban landscapes of Hyderabad are dominated by built-up area with impregnable surface. Fast pace of urbanization and associated alteration of energy and radiation balance influenced the thermal regime, along with micro-variation in climatic conditions within urban area. Among the urban micro-climatic variables temperature has played a key role leading to extreme events like heat waves, formation of micro-heat islands etc.

KEY WORDS: Climate change, Urban Heat Island mitigation strategies, urban planning and house and settlement areas.

Introduction:

Urban structure of a city which includes, land use planning, building morphology, surface characters along with the anthropogenic heat which is delivered from vehicles and equipment such as air conditioners are the most essential factors causing increase in air temperature or urban heat island. These in turn increase air pollution and also energy utilization of buildings in providing thermal comfort inside the buildings by use of refrigeration. This eventually leads to an increase of greenhouse gas emissions and negative effects on health of citizens of developing cities. The climate that prevails in the large urban areas like metropolitan and mega cites is significantly different from those in non-urban settings characterized by soil and vegetative cover. Greater Hyderabad is one of the fastest growing urban centres of India. Rapid urbanization of Greater Hyderabad is leading to increase in urban sprawl, densification of core city.

This study is inspired to look the mitigation technologies for Urban Heat Island, particularly on Building Skin designing. This paper is a primer report which is planned to increase urban environment because of Urban Heat Island and to discover a new alternative solution for UHI mitigation. Urban Heat Island can be detected by surface or air temperature. Figure 1.showed that commercial and residential areas are the third most areas which have the hottest temperature. It implies the Urban Heat Island intensity in this area is high, and that is the reason we need to mitigate UHI in housing and settlement. Figure: 1

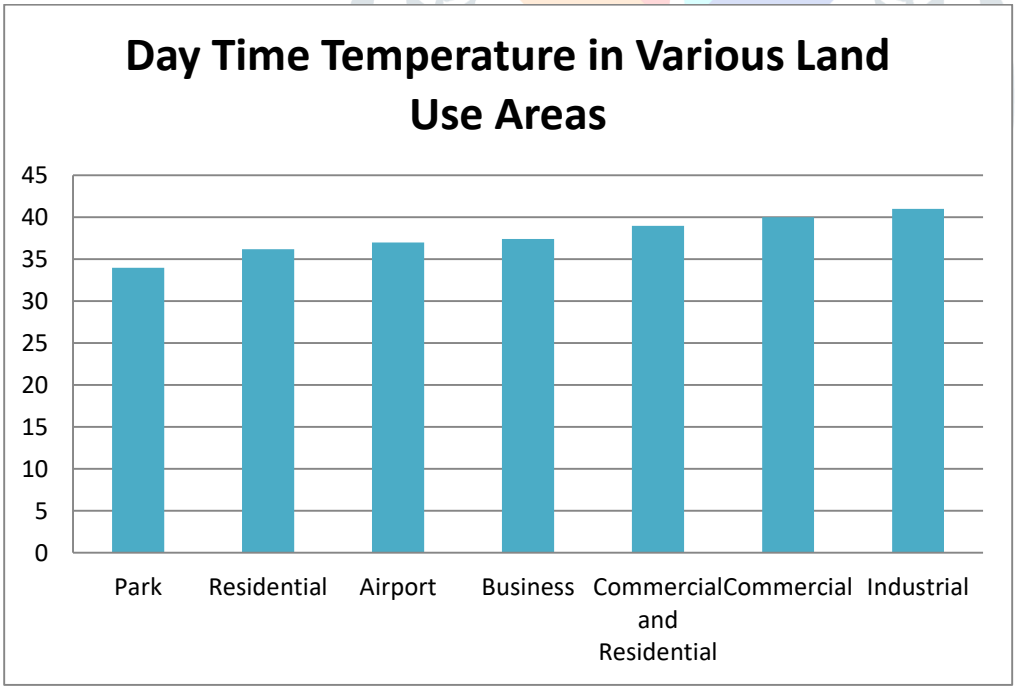
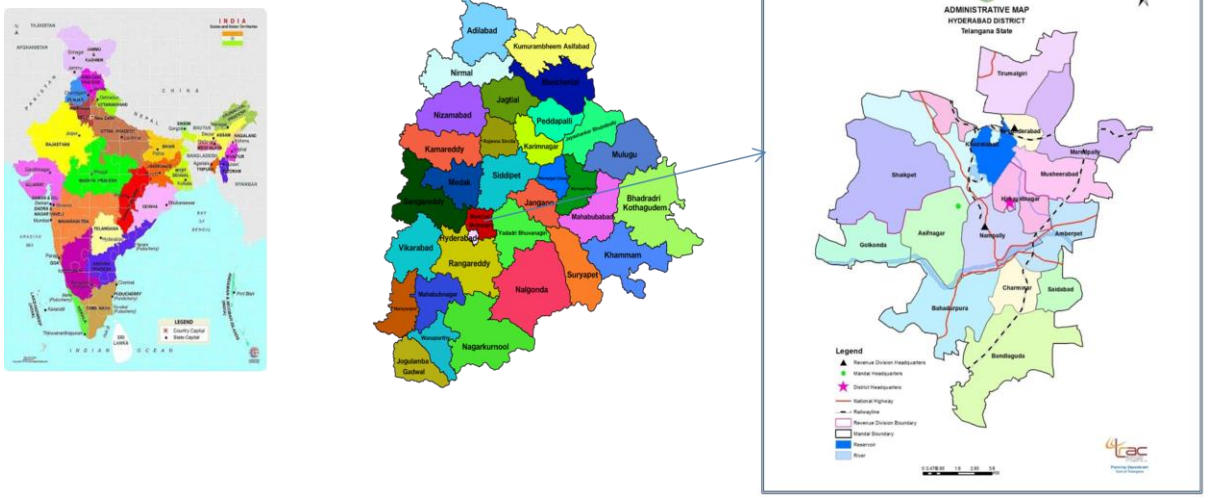


Figure 1. Daytime temperature in various land use areas

Study Area:



Hyderabad is one of the mega cities of India and is the capital of newly formed Telangana state. Telanagana lies at 17°.36' N latitude and 78°.47' E longitude. Hyderabad is located on Deccan plateau with an average altitude of 536 m above mean sea level. Municipal Corporation of Hyderabad became Greater Hyderabad with the process of 12 surrounding municipalities covering an area 650 sq.km. Hyderabad City is divided in to five zones (North, South, Central, East, and West) and 18 circles Hyderabad city expanded form 175 sq Km to 650 sq Km with formation of Greater Hyderabad. Population is over 60 lakhs. L.B Nagar,Malkajgiri, Quthbullapur, Patancheru, Gaddiannaram, Kapra, Kukatpally , Ramachandrapuram , Uppal kalan , Alwal ,Serilingampally , Rajendranagar municipalities from Ranga Reddy and Medak districts merged into Greater Hyderabad Municipal Corporation . Greater Hyderabad observed rapid urban development and land modification due to demographic, spatial and economic growth. Today, with fast phase of urbanization and industrialization. Hyderabad has appear as an important Information Technology (IT) , business educational and cultural destination, Inadvertently , this situation is culminated into terrify growth in built up area, loss of agriculture land, water bodies , vegetative cover along with increasing levels of air pollution, suspended particulate matter and emission of greenhouse gases. All these factors contributed to climate change and microclimatic variations within the city. Hyderabad city population was recorded to be 6,809,970 (6.8 million) at latest Census of 2011. Currently, Greater Hyderabad is the fourth most populous city of India. In 2007, GHMC (Greater Hyderabad Municipal Corporation) was created and more area was occupied to cater to ever increasing population of the city.

The causes of UHI are identified:

1. **Greenhouse gas emissions**: To reduce the UHI effect the roof top can be painted with lighter or white colour. The roof tops act as high reflective surface, controlling solar radiation gain.

2. Thermal properties of materials: Impermeable surfaces and building materials influence the microclimate and thermal comfort conditions, since they absorb considerable heat during the day, which they release back into the climate around at night, thus contributing to the urban heat island impact.

3. **Urban morphology and city size:** Urban morphology, which relates to the three-dimensional form, orientation and spacing of buildings in a city, also

plays a role in the forming of Urban Heat Island. Large buildings and narrow streets can hamper good ventilation of urban centres because they create canyons where the heat generated by solar radiation and human activities accumulates and remains trapped. Landscaping, specially increasing open spaces and green spaces in the urban design to increase free air flow and also to increase evapotranspiration, thereby reducing the temperature.

- 4. Building design should make provision for breeze way cross ventilation to promote free air flow.
- 5. Adequate spacing between buildings will allow accumulated heat to escape.
- 6. To increase vegetation cover/green spaces in form of urban forestry and gardens around buildings in order to reduce temperature.
- 7. **Anthropogenic heat:** The production of anthropogenic heat such as heat emitted by vehicles, air conditioners and industrial activity is another factor that contributes to the development of heat islands, particularly in dense urban areas where activities are concentrated. The best way to mitigate Urban Heat Island initially is to know about the reasons of the phenomenon explained above. After we know the causes, we could explore how to mitigate the phenomenon itself.

Important Points:

- High settlement density, inadequate vegetation, and having no open space in neighbourhood were fundamentally connected with higher temperature.
- In the light of the UHI related issues discussed by the authors of the special issue, we accumulate the research questions from these studies, focusing on future research directions as fallow.
- Automate the whole urban modelling process various types of special or external urban features should be considered.
- A more holistic study of relationship between the reduction of temperature in the urban environment and its consequents for the reduction of emissions should be considered.

Selection of research studies:

This paper reviews recent research about some various strategies to mitigate UHI impact in the urban environment. The main objective of such systems is to map mitigation technologies for Urban Heat Island, and to find new innovative solution for UHI mitigation to improve urban life. The article must be profound investigation of the heat island effect to be included in this review, its characteristics, influential factors, consequences, mitigation strategies, etc. The result of this study will reveal the possible effective strategies to mitigate UHI effect. However, it should be underlined, because of the correlation and interrelation, some of these strategies might be overlap to each other, and it is also because some of these researches tend to imply few of the methodologies at the same time.

UHI mitigation strategies:

For decades, the specialists has been developed some mitigation strategies to confront the Urban Heat Island phenomenon. . A portion of the techniques truly has a major effect on environment. The systems implied are focusing on the air temperature decrease or surface temperature decrease. The common mitigation strategies are explained below.

Green spaces:

Based on research, the combination effects of tree shading and evapo transpiration cause a big decrease in temperature, and even produce what are referred to as cool islands within the city. Varied studies have analyzed the temperature in parks and beneath trees. The overall conclusion was that green areas were cooler than areas with none greenery in another research. At varied locations, the air temperature, relative humidity, and different meteorological factors were measured. The results obtained indicated that vegetation considerably changed the city climate. The analysis analyzed over that parks and green areas might help to mitigate urban heat island effects and reduce cooling energy consumption in summer. What is more, it had been found that such green areas additionally reduced the temperature changes made by building materials, stabilizing the temperature fluctuation caused by building materials. However, it had been not satisfactory explicitly however park affected the formation of the heat island. The cooling result looked as though it would depend on the elements of the recreation center and accordingly the occasional radiation conditions; however there was no linear relation between the dimensions of the park and therefore the intensity of the cool island. This intensity was primarily determined by the realm occupied by the trees and greenery within the park in addition as by the form of the park.

Vegetation: Lighter colours of paving, and cooler roofs can reduce the air temperature as much as 3° C. The study above consolidated all three aspects to reduce the air temperature. Another studies analyzed the use of vegetations and planting only can reduce air temperature between 1.3 – 1.6° C.

Green roofs: Green roof fraction has to be close to 90% and the cool roof (albedo = 0.7) fraction has to be close to 95% in order to reduce the near-surface UHI by 0.5 °C.

Albedo: The albedo of a surface is a shell of sunlight reflected by the surface. The increase in albedo and vegetation, it has impact to the reduction in the surface temperature and near-surface air temperature. This study demonstrated that the use of materials with high albedo properties decreased the radiation absorbed by building and urban structures. By keeping these surfaces cooler, the intensity of long wave radiation was reduced. From this study, it can be concluded that by modifying albedo of the surface (0.25 to 0, 40), air temperatures can be decreased as much as 4°C.

Pavements: Thermal balance in pavement depends of the amount of solar radiation absorbed by the pavement, the emitted infrared radiation, the heat transferred by convection to the atmospheric air, the heat put away into the mass of the material and the heat conducted to the ground.

Building skin designing to reduce air temperature: The reduction of the air temperature varies between 1-3° C. In order to mitigate the heat island more detail, the mitigation strategies could be developed in micro scale of urban space, or the building scale, which is more related to architecture scope. Building skin or envelope absorbed the heat from solar radiation, and emitted the heat to the environment. The potential of building skin designing in which thermal conductivity, specific heat, and infrared emissivity factors could lead to the maximum reduction of air temperature and UHI intensity. Building skin designing for UHI mitigation strategies which have been explored by experts are explained below specifically their effects to reduce air temperature.

Double skin facade: It has been found that the heat gains from the building envelope can be reduced by applying the Double skin facade, the reduction of heat gains causes an enhanced energy performance and lower cooling loads. Additionally, the application of double skin facade can help achieve lower pavement temperature, which increases the outdoor conditions for pedestrians. In terms of Urban Heat Island intensity, the application of double skin facade have resulted in a reduction of about 1.4°C which is a significant enhancement to the urban environment.

Tree shading strategies: The tree canopies are able to maintain the surface cooler than the air above. Temperature is cooled by 1 ◦C at the pedestrian level (1.5 m) in the morning and by 1.5 ◦C in the afternoon.

Vertical greeneries: Green facade and living walls Vertical greeneries consist of two types: living walls and green facades. Green facade is a kind of green walls in which a simple structure (such as metal frames, square panels and cable systems for retaining structure) for scaffolding attached to the wall of building, and acts such as anchor for creeping and climbing plants: vine, ivy and etc. Green facades can rely on fences and columns or be built as an independent structure. Green facade scaffolding structure can be different materials such as wood, steel (galvanized, stainless, coated), plastic or aluminium, etc., each of this materials will follow the usage , aesthetic aspects and different functions.

Reflective coatings: A cool coating applied on a rood could reduce the temperature (1.2-3.7°C). Look at figure 2 below for the comparison of building designing method for reducing air temperature.

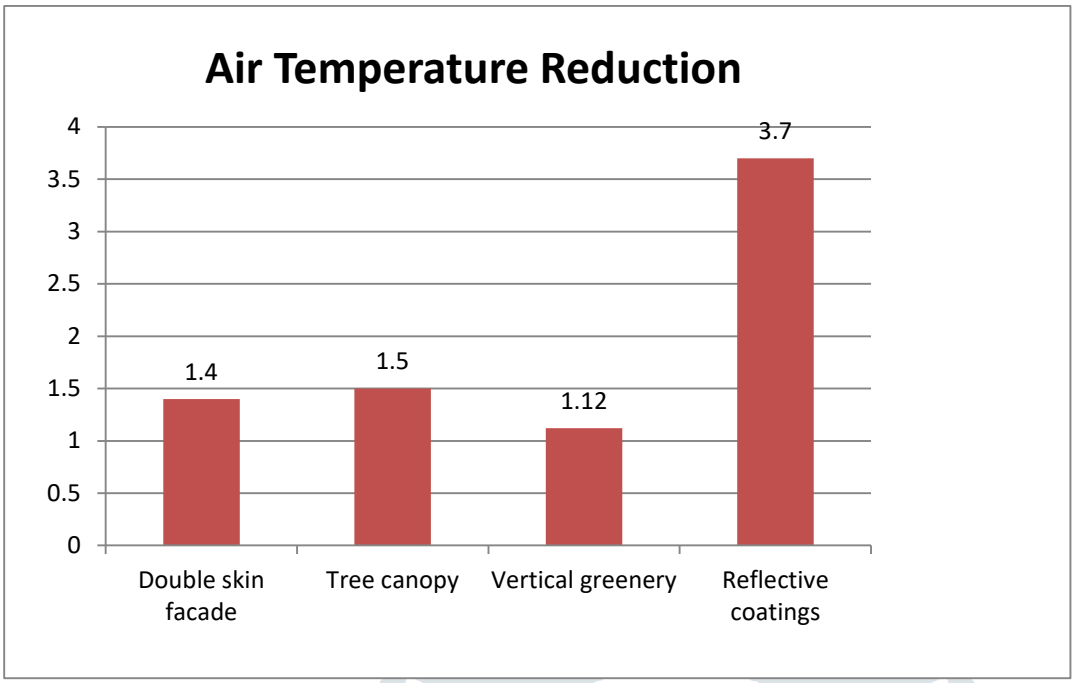


Figure 2: **Air temperature reduction with several building skin designing method**.

Building skin designing to reduce surface temperature: To measure Urban Heat Island, experts usually use air temperature or surface temperature. Correlated with building envelope, it is hard to use air temperature as a factor to be examined, so it would be easier to use surface temperature as a factor to be examined.

Vertical greenery system: The use of vertical greenery system, the reduction of wall surface temperature could be maximized to 11.58 °C.

Tree canopy system: The use of tree canopy system, the reduce of wall surface temperature could be maximized to 9 °C.

Reflective coatings: The use of reflective coatings, the reduction of wall surface temperature could be maximized to 19.9° C.

Double skin facade: The use of DSF, the reduction of wall surface temperature could be maximized to 7° C.

Thermal insulation: With the use of thermal insulation, west wall surface temperature could be reduced up to 26°C (from 49°C to 23°C). This result means thermal insulation is one of great solution to reduce surface temperature. Look at figure 3 for comparison building skin method for reducing surface temperature. From figure 3 below, we can conclude that thermal insulation is a great solution to reduce surface temperature. Surface temperature reduction is up to 26°C.

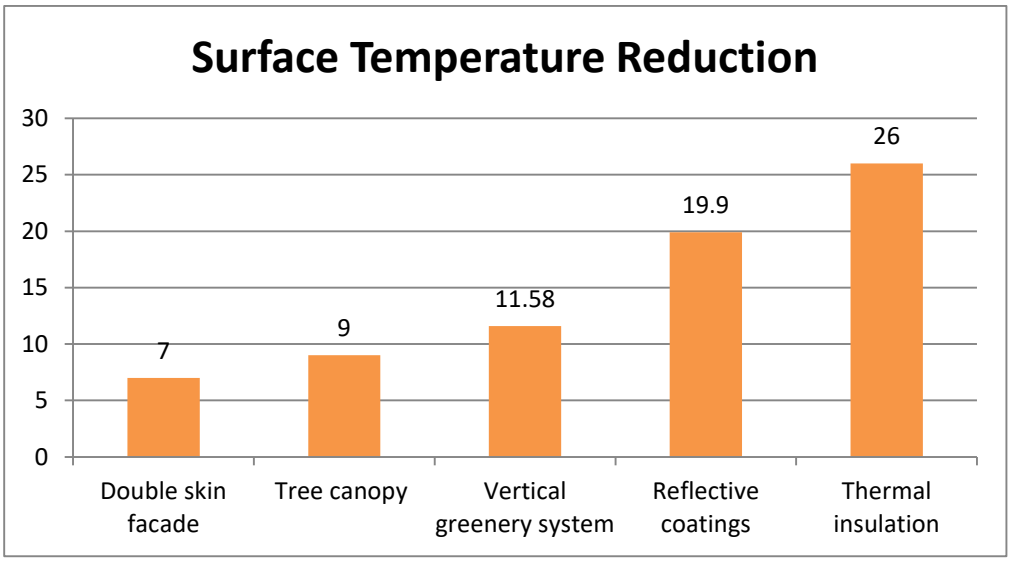


Figure 3: Surface temperature reduction with several building skin designing method. Source: Analyzed by literature reviews.

Thermal insulation as Good UHI Mitigation Technology Opportunities:

We could see that we still have some room for the improvements of building skin designing for UHI mitigation. Thermal insulation could be explored as good UHI mitigation technology opportunities. How thermal insulation could be one of potential strategy for UHI mitigation is explained below. Physical developments in Hyderabad generally use heavy material in building envelope such as brick and concrete. This heavy material component has a high heat capacity that stores a lot of solar heat (see figure 1). This has a detrimental effect on the thermal environment, where the heat stored in the morning and afternoon is released back in the afternoon and evening in the form of heat re-emissions resulting in a hot city environment becoming hotter (see figure 2). This extreme rise in urban temperatures resulted in the emergence of the Urban Heat Island phenomenon where Hyderabad city temperatures differ significantly compared to rural temperatures. This heat island phenomenon significantly affects the activity, productivity, and quality of life of urban residents so that mitigation is needed to prevent further damage.

Conclusions:

The present study finds that thermal insulation could be the potential strategy to mitigate Urban Heat Island effects in Hyderabad, by large amount of surface temperature reduction (26°C) with the use of thermal insulation. With large reduction of surface temperature, the heat will not absorbed much into heavy weight materials and it will not reradiate heat much into environment as well. So, it is why thermal insulation could be potential to mitigate Urban Heat Island, by increasing the thermal resistance of the building envelope. Thermal insulation is one of the easy and effective ways of energy conservation and heat reduction available today. It offers a number of applications in residential sectors, and also commercial and industrial sectors. To find the best thermal insulation to mitigate Urban Heat Island effects, we need to understand about two most important factors of thermal insulation: heat resistance and heat re-emission, and their sub factors such as thermal conductivity, thermal diffusivity, density, thickness, specific heat capacity, albedo, and emissivity. We need to explore the most combination of the factors with most advantages to reduce maximum surface temperature and air temperature. One of the most

developed thermal insulation is bio-massed insulation or natural fiber, because it is cheap and it is everywhere, it is easy to dispose as waste, so it will reduce negative impact to environment, and it has a very low thermal conductivity. So, we can begin the exploration of thermal insulation to mitigate UHI effects from pure bio-massed insulation, or mixed bio-massed insulation lightweight concrete insulation – agriculture waste based thermal insulation.

SUGGESTIONS:

The present study of urban heat island mitigation strategies indicates that a range of options is available for heat reduction and cooling in urban areas. Also our review clearly shows the benefit of applying several mitigation measures at the same time. In fact, when these measures are used concurrently, an additive effect is observed in terms of cooling both buildings and cities, which helps protect the population from the negative health impacts of urban heat islands.

• Give priority to the application of urban heat island mitigation strategies in the areas where populations vulnerable to heat live.

• Choose measures adapted to the Hyderabad climate, i.e. that consider the area's seasonal climatic variations.

• Reduce the production of anthropogenic heat by encouraging the use, utilization of practical methods of transportation renewable energy and energy-efficient appliances and equipment.

• Promote the natural water cycle in urban areas through installations that allow water infiltration at the source. Improving the availability of water in the soil will provide cooling of urban areas through the process of evaporation.

• Adopt the principles of bioclimatic architecture, which provides guidance for adapting buildings to the summer climatic conditions in Hyderabad, including the use of shading devices.

• Encourage small- and large-scale greening activities as well as the protection of wooded areas. Identify opportunities for urban greening, conduct an inventory of the urban forest heritage, and ensure that proper practices are followed when planting vegetation in order to optimize plant growth and extend plant life.

• Promote ventilation in buildings and cities in the summer months, which will help maintain a comfortable thermal environment for building occupants and city dwellers.

• Reduce dependence on air conditioning. Use passive methods to cool buildings by minimizing internal cooling losses, reducing the amount of heat that enters a building, controlling heat generation in buildings and ensuring successful ventilation.

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