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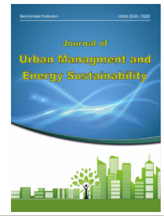

CASE STUDY RESEARCH PAPER

Evaluation of energy consumption of tropical houses in approach to sustainability (Case Study: Tehran City)

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ABSTRACT

Most materials used in cities undergo different changes in albedo over time. For example, the albedo of concrete and colored stones decreases over time, while asphalt becomes brighter and increases its albedo. In today's world, sustainable architecture, especially in conjunction with green architecture, plays a crucial role in the use of new polymer materials produced with smart technology and nanotechnology, with an emphasis on using renewable resources instead of the earth's non-renewable resources. Sustainable architecture incorporating green and recyclable materials offers a logical response to the challenges and problems of the industrial age. Building materials play an important role in sustainability. As a metropolis with energy consumption from fossil fuels, high energy costs, and air pollution, the city of Tehran needs appropriate solutions to reduce energy consumption. The purpose of this research is to investigate the amount of energy consumption reduction in residential buildings in Tehran by using three types of ASHRAE standard concrete, engineering system standard, and smart concrete in the external walls of residential buildings, and the result shows that the amount of energy consumption is close in using ASHRAE standard and It shows the engineering system in cladding walls and a significant reduction in energy consumption if smart concrete is used in external cladding walls.

Running Title: Energy consumption of tropical houses in approach to sustainability

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INTRODUCTION

According to statistics from various institutions, the rate of urbanization and its continuous growth is projected to increase energy consumption to 80% of total consumption by 2050 (Bose, 2010). The program for the conversion of energy sources is based on five axes, according to which buildings account for the largest part of urban energy consumption (Morris & Pehnt, 2015). Increased urbanization has led to a change in land cover, with impermeable materials such as asphalt and building materials replacing natural soil. These impervious surfaces play a critical role in influencing thermal comfort and the overall environment. Urban materials are selected by architects, designers, and urban planners based on several factors, including safety, durability, cost, and environmental considerations (Giguere, 2009). The majority of urban-use materials experience varying albedo variations over time. Concrete and colorful stones, for instance, lose albedo over time, but asphalt gets brighter, and its albedo increases (Scicluna, 2016). Studies conducted in Athens indicate that the widespread use of high-albedo materials can reduce air temperatures by up to 20 degrees (Nuruzzaman, 2015). The use of urban high albedo materials can have both positive and negative environmental impacts while mitigating the effects of heat islands. When high albedo materials are used solely to lower ambient temperatures, vegetation cover can decrease, leading to thermal stress, lower humidity, and other related problems when adequate vegetation is not present (Schrijvers et al., 2016). The use of new polymer materials created with smart technology and nanotechnology is significant in the modern day, and sustainable design, particularly when integrated with green architecture, plays a crucial role. Instead of using non-renewable Earth resources, the emphasis is on utilizing renewable ones. The challenges and issues of the industrial age can be rationally addressed by sustainable building, which uses eco-friendly and recyclable materials. Construction materials are essential to sustainability.

Architects of the future will have the capability to design buildings whose geometry adapts to the weight of the occupants, enabling them to create structures that interact optimally with the environment and conserve energy. Understanding the properties and applications of smart materials is essential. Smart materials represent a new category of substances and products with the capacity to sense and process environmental stimuli, responding accordingly. In other words, in reaction to the physical or chemical influences of the environment, these materials can change and are capable of reversibly changing their shape, form, color, and internal energy. In dividing materials into three groups — non-intelligent, semi-intelligent, and intelligent materials — the first group, non-intelligent materials, lacks the specific properties mentioned above. Semi-intelligent materials can change their shape and form in response to environmental influences, but these changes are temporary and limited in time. In contrast, intelligent materials exhibit changes that are repeatable and reversible. Due to their exceptional capacity to adapt to changing environmental conditions, intelligent materials are often referred to as "flexible" and "adaptable" materials (Addington & Schodek, 2015). Considering the importance of making building materials smart for optimizing energy consumption, this research emphasizes the use of building materials, such as smart concrete. It specifically investigates their application in a case study of cold and mountainous climates, taking into account the development of a model as an innovative aspect of the research. The results obtained from the behavior of smart concrete, as per its specific type in the Murray sample's climate, along with the analytical variable simulations, can also be considered an innovative approach. Therefore, the current research focuses on self-regulating concrete, and the results will be interpreted and generalized upon extraction. The primary objective of this research is to explore and assess the application of smart materials in the cold and mountainous climate of Tehran city, aiming to establish a specific framework of findings.

Research Background

Based on both internal and external studies concerning energy consumption in buildings, with a specific emphasis on building materials and the approach of enhancing consumption through smart materials, the following points can be highlighted:

- Pachanari and Davoudi (2021) present the results of their research titled " Studying and Investigating the Role of Smart Green Materials in Sustainable Green Architecture " as follows: The origin of green building is a process for building environmentally friendly buildings and conserving energy. Green building practices reduce the environmental impact of buildings, by utilizing environmentally friendly, biodegradable, renewable, and recyclable materials. The purpose of introducing green materials that can be used in green buildings based on Iran's environmental conditions is to harmonize these types of materials with sustainable architecture to properly exploit resources and energy, prevent air pollution, and match them with the environment. The introduction of these building materials plays a vital role in promoting sustainability. Nanotechnology is the process of creating materials atom by atom, which allows for the production of novel materials with desired qualities. One of this technology's notable achievements is its efficient application in the generation, consumption, and storage of energy, which has resulted in a considerable shift in this industry. Notably, this technology has given rise to innovative materials like the 'smart brick,' which was examined in this article. According to the study, the smart brick has a heat flux transfer value that is roughly 34.2% lower than that of a regular brick, resulting in less thermal energy loss.

- Shafizadeh et al. (2017), in collaborative research titled "Study Of Suitable Construction Materials With Sustainability Goals, " emphasized in the article's abstract that due to the increasing growth of the construction industry and the limited availability of non-renewable resources, appears to be no alternative but to incorporate sustainable building materials into the construction of human structures to fulfill the demand for construction materials. This imperative arises in the context of a volatile global economic situation and the extensive societal challenges that have entangled this industry. Therefore, in this research, by examining a number of previous studies conducted on sustainable building materials, we have reached the conclusion that it is indeed possible to develop materials that align with sustainability considerations. Although contradictory results have been found in this regard, sustainability must be considered throughout the entire production process of primary raw materials, from their inception to their lifecycle termination, including recycling.

- Parisa Razmara et al. (2016), in research titled "Self-Compacting Concrete: Green Concrete Technology With an Environmental Perspective," conducted a comprehensive examination of 15 mix designs, each involving different percentages of slag from the forging furnace and recycled materials as substitutes for cement and natural materials. Their findings conclude that the concurrent combination of two types of slag materials, each with a 15% replacement, and recycled concrete with a 25% replacement, offers viable substitutes for cement and natural materials, respectively. This approach not only reduces the consumption of cement and natural coarse aggregate in self-compacting concrete but also effectively recycles waste materials, thereby reducing environmental pollution. Moreover, the sustainable preservation of natural resources and the implementation of proper processing techniques can lead to the production of environmentally friendly green materials characterized by optimal durability and resistance

- Amir Vaisi (2015) cites the following findings in his paper "Smart Materials: A Transformation in Sustainable Architecture,": Because construction consumes a large portion of the world's energy, and the usage of energy management systems causes the program to reduce the appropriate consumption of energy and so saving and optimizing energy consumption and expenses will be considerably lowered if the consumption of energy is decreased while also considering the correct interaction with the environment. Creating a sustainable architecture compatible with the climate is one of the goals of designers and builders of smart buildings and their construction with materials such as smart materials.

- Vafamehr (2001) introduces smart materials in the following manner: Smart materials are those whose chemical, mechanical, electrical, magnetic, or thermal characteristics can change in response to alterations in the environment without the need for external control such as voltage. Among these smart materials, there exists a subset with immense potential for application in the field of architecture. This specific group of materials can transform their properties in response to variations in their surrounding environmental conditions, either by harnessing existing energy or through controlled inputs. It is anticipated that this class of smart materials will find diverse and extensive applications within the realm of architecture.

- Segbansa and Balu (2016) conducted a study in Turkey in which they modeled the thermal and mechanical properties of a material. This material was created by combining fly ash waste materials with natural components, including modified corn oil, pellet, and clay, for use in sustainable building walls. The researchers reached a significant conclusion of their investigation, suggesting that this compound has the potential to serve as a novel renewable material. Moreover, it exhibits commendable thermal and mechanical characteristics.

- Kelm and Wiggins (2016) did research on the use of natural stone as a building material for sustainable development in England. They arrived at a key conclusion after evaluating several examples involving historic stone buildings. Natural stones provide beneficial features such as strong resistivity and malleability. When these stones are mixed with traditional mortars, such as lime mortars, which have lesser resistance, and when the right principles are employed to ensure the desired strength, they can be very useful for constructing. The longevity and reusability of such buildings are critical aspects of their potential for sustainable development.

- Delmastro and colleagues published their findings in 2018 under the title "Karst's Selective Method of Energy Policies for Buildings." Their research looked into energy efficiency policies in the urban landscape, specifically the role of buildings. The major goal was to clarify the concept of low-carbon cities as a model and to develop policymaking measures that prioritize the integration of sustainable building components.

- Meg Brooker (2018) studied the "Effects of Building Materials on Micro-urban Climate." She explored the influential characteristics of architectural design, including building materials, in depth in her work, and aimed to understand how these impacts emerge in its elements. Prioritizing each parameter, isolating essential elements, and assessing the right strategy for each one was all part of the research. In another study titled "Indices of building elements for the analysis of energy consumption" conducted by Morganti et al. (2018), which parallels the approach of the current research, a more in-depth analysis was performed using a macro-scale analysis method. Another noteworthy research project is the one conducted by Russo et al. (2017), titled "Analysis and Innovation of Early Yielding Building Materials with a Focus on Energy Performance and Optimization in Residential Contexts." This research began with a micro-scale exploration and delved into the variables that influence the performance of these materials. In the context of the micro-urban climate and the diverse characteristics of building materials, the researcher ultimately derives their results from the distinctive attributes of these materials. This includes factors like the surface reflectivity level and the specific effects on urban walls.

As a result of a review of domestic and foreign studies, it was determined that the majority of these studies, particularly domestic ones, have focused on the conceptual structure and course of energy consumption developmentally, whereas, in foreign studies, the consumption process in building dimensions is still discussed. Finally, utilizing the combined technique and assessing it in the sample, this study attempts to explain the function of smart materials in the change of energy consumption in a practical way.

MATERIALS AND METHODS

The current research is of descriptive-analytical type, considered an applied goal, and considering the extraction of the optimization model, it can also be given a developmental role. The research tool is library and documentary, and the use of basic sources is given priority, in order to carry out the analysis stage in the form of field sampling. Also, the use of simulation and analysis software in the sample materials is recognized.

In the first stage, a specific research framework can be developed based on the collection of opinions by reviewing the theoretical literature and the background of the research to achieve the initial conceptual framework and also to explain the proposed model to present the role of building materials in the issue of building energy consumption. The second step is to choose a case sample based on the proposed model. According to the basic information based on geographical, climatic, and other factors, its current state is based on the kind of materials in seven positions, including the external wall, roof, and floor the ground, the external entrance, the separating wall, the light barrier, are all simulated and preliminary analyzed. Following that, the same study is performed, and the results are examined and interpreted, after using the characteristics and impact of smart materials in replacing the current materials.

This research is based on a series of simulations made by the simulation software Energy Plus version 9.5, Open Studio version 1.5, and Radiance version 5.2 to calculate the amount of energy consumption and lighting of buildings. The geometry of the building is modeled by Open Studio version 1.5 software and connected to simulator engines. It should be noted that the energy codes used in the residential part of the urban bed are taken from the ASHRAE 90.2 standard of 2018. The purpose of these analyses is to find the most important architectural elements affecting the energy performance of buildings and their development in contemporary architecture.

Standard-7730 Ergonomics of the thermal environment - Analytical assessment and interpretation of thermal comfort is accomplished by computing the average vote estimate index and the average percentage of unhappy persons, as well as local thermal comfort standards, which deal with thermal comfort indicators in a computational manner. This standard is based on heat balancing principles and experimental data collected from a room under constant weather conditions. These investigations were founded on the concept that residents interact with their surroundings in a dynamic manner. Among the human variables used to calculate thermal comfort, we can refer to the rate of clothing and activity of people. Clothing is an effective factor in the heat exchange of the human body with the surrounding environment. Clothing as a non-conductive structure covers a part of the body and reduces the contact of the body surface with the surrounding environment. On the other hand, the person changes the body's metabolic rhythm with the activity he performs. As a result of the thermal efficiency of the body, we notice heat production. ASHRAE standard 55 residential sections, the clothing rate for simulating energy in the winter season is equal to 1 and in the summer season is considered equal to 0.5 kilos, also the activity rate is assumed to be equal to 70 watts per square or 1.2 meters. Table 1 shows the different values of clothing and activity rates.

Table 1: Clothing and activity rates

Activity rate clothing rate		Activity rate clothing rate		
Activity rate	Activity rate	Activity rate	Activity rate	Activity rate
(Met.) Metabolic Rate (W/sqm) Type	(Met.) Metabolic Rate (W/sqm) Type	(Met.) Metabolic Rate (W/sqm) Type	(Met.) Metabolic Rate (W/sqm) Type	(Met.) Metabolic Rate (W/sqm) Type
Failure value activity	Failure value activity	Failure value activity	Failure value activity	Failure value activity
(Clio.) Type	(Clio.) Type	(Clio.) Type	(Clio.) Type	(Clio.) Type
Cover	Cover	Cover	Cover	Cover
0.6 41 sleeping 0 without clothes	0.6 41 sleeping 0 without clothes	0.6 41 sleeping 0 without clothes	0.6 41 sleeping 0 without clothes	0.6 41 sleeping 0 without clothes

0.7 47 rest 0.1 underwear	0.7 47 rest 0.1 underwear	0.7 47 rest 0.1 underwear	0.7 47 rest 0.1 underwear	0.7 47 rest 0.1 underwear
1 58 sitting 0.5 men's style summer clothes	1 58 sitting 0.5 men's style summer clothes	1 58 sitting 0.5 men's style summer clothes	1 58 sitting 0.5 men's style summer clothes	1 58 sitting 0.5 men's style summer clothes

The defined use in the simulated residential cases is of short duration, and to compare the building with contemporary buildings, the presence of people and their type of activity are defined similarly to contemporary structures. In this program, the presence of people in the building is defined from 6 pm to 6 am (8 am to 5 pm is assumed to be working hours). Figure 1 shows the attendance times of people during a year. The per capita value of the attendance of all people is assumed to be 0.025 people/square meter. This figure means that for an area of 100 square meters, 4 people are present in this space.

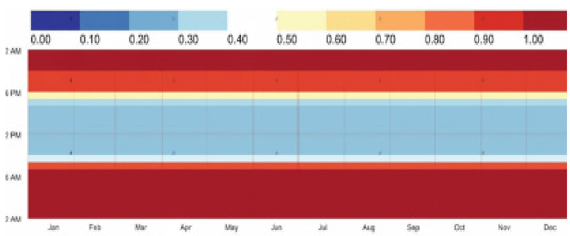

Fig 1: People's attendance schedule

Air temperature, average radiant temperature, relative humidity, and wind speed can be mentioned among the factors that influence the determination of the thermal comfort zone. These indicators were studied in the climate analysis. In general, due to the effect of these factors on each other, as well as the effectiveness of clothing and activity rates on thermal comfort, it is not possible to determine specific numbers for each of these factors. ASHRAE Standard 55 establishes the limits of each of these factors based on statistical data for providing thermal comfort. According to this standard, a temperature of 23 to 25 degrees Celsius provides thermal comfort for almost all people. To ensure thermal comfort, the temperature difference between the head and feet should not exceed 3 degrees Celsius. As the relative humidity decreases, the rate of evaporation increases. The pleasant level of relative humidity is in the range of 30% to 70%, and the relative humidity of 50% is the most ideal possible value. Another factor that is important in thermal comfort is the intensity of the airflow, in general, if the airflow has a speed greater than 0.2 m/s, it can be uncomfortable for the residents. It should be noted that there are differences in the ASHRAE 55 standard between places where residents are able to open and close their windows and places equipped with air conditioning systems. Therefore, in the aforementioned standard, different criteria are considered for buildings with natural ventilation and buildings equipped with an air conditioning system.

If thermal comfort conditions are not provided, these conditions can be provided by using active systems. In general, it is necessary to determine the temperature of cooling and heating around the consumption of active systems. According to the standards, the starting temperature for heating equipment is equal to 21.7 °C and for cooling equipment is equal to 24.4 °C. It should be noted that the maximum temperature provided by the system is assumed to be 30 and the minimum temperature is 18 degrees Celsius. Also, the appropriate range for relative humidity is assumed to be between 20 and 80 percent. Due to the fact that the systems are the same in different simulation options, the performance rate of the systems has been assumed to be equal to 1 (there is no energy loss), so heat recovery systems have also been considered economical. In general, the assumed facility systems have ideal air conditions. Considering the importance of environmental issues and the amount of carbon dioxide equivalent due to the operation of the building, the amount of 0.231 kg of carbon equivalent per kilowatt hour for heating purposes and 0.612 kg of carbon equivalent per kilowatt hour for cooling and electricity purposes should be considered.

As previously mentioned, Table 2 provides a summary of the space utilization assumptions.

These specifications are defined in accordance with ASHRAE 90.2, which is relevant to low-consumption residential buildings.

Table 2: Defaults for space utilization

Per capita usage, attendance of average people, activity rate, clothing rate	Per capita usage, attendance of average people, activity rate, clothing rate	Per capita usage, attendance of average people, activity rate, clothing rate	Per capita usage, attendance of average people, activity rate, clothing rate
Residential - independent 0.025 people/square meter 1.2 Winter 1 - Summer 0.5	Residential - independent 0.025 people/square meter 1.2 Winter 1 - Summer 0.5	Residential - independent 0.025 people/square meter 1.2 Winter 1 - Summer 0.5	Residential - independent 0.025 people/ square meter 1.2 Winter 1 - Summer 0.5
Lighting consumption rate	Lighting consumption rate	Lighting consumption rate	Lighting consumption rate
(When present) equipment consumption rate	(When present) equipment consumption rate	(When present) equipment consumption rate	(When present) equipment consumption rate
(Gas) equipment consumption rate	(Gas) equipment consumption rate	(Gas) equipment consumption rate	(Gas) equipment consumption rate
(When present) equipment consumption rate	(When present) equipment consumption rate	(When present) equipment consumption rate	(When present) equipment consumption rate
(Absence)	(Absence)	(Absence)	(Absence)
Watt/square meter 11.5 - watt/square meter 6.65 2.00 watt/square meter	Watt/square meter 11.5 - watt/square meter 6.65 2.00 watt/square meter	Watt/square meter 11.5 - watt/square meter 6.65 2.00 watt/square meter	Watt/square meter 11.5 - watt/square meter 6.65 2.00 watt/ square meter

Climate

The maximum and minimum dry temperature recorded in Tehran is -5 and 42 degrees Celsius. The extreme cold of this city has reduced the relative humidity and dryness of the air in the city. In general, 41.16% of the year in Tehran is in a condition without heat stress, while 52.48% of the year in this city is in a state of cold heat stress. Based on this weather information, Tehran has 2575 cold-degree days and 403 hot-degree days annually. As it is clear in the graphs, the cold currents in this city start in December and continue until the end of March. According to the annual wind of this city, the prevailing wind of this city is from the west side and the highest recorded wind speed for this city is 26.8 meters per second. Also, due to the low wind speed in this city, there is a need to protect the building against the wind in only 49 hours of the year. The maximum elevation angle of the sun in the long summer days in this city is about 74.2 degrees, which is a great angle for the sun to shine. As a result, at this time of the year, the use of a small horizontal canopy can provide the required shade for the southern windows. Due to the high elevation angle of the sun, the sun's rays shine almost vertically on the horizontal surfaces of the building in summer noons; Therefore, horizontal surfaces, such as the roof, receive a large amount of radiant energy in these conditions, and this amount of absorption reaches its maximum value around noon; Therefore, the vertical surfaces, especially the surfaces located on the south face of the building, receive the most amount of useful radiant energy, and therefore, these surfaces have the potential to be used for passive heating of the building. Also, Figure 4 shows the simulated state of Tehran's sky dome. It should be mentioned that the highest level of radiation in this city is equal to 2018 kilowatt hours per square meter per year.

Figure 2 shows the psychometric diagram of Tehran city. According to the psychrometric diagram of this city, both heating and cooling are needed to achieve the thermal comfort conditions required by humans in residential buildings. In this city, about 11.8% of the time of the year, the conditions are within the range of thermal comfort. Table No. 1 shows the annual percentage of time and the number of hours that each of the passive and active methods are capable of providing thermal comfort in this climate. The need for heating and cooling energy in a building, regardless of the climate of the location of this building, depends on its architecture and also on its thermal shell materials. The duration mentioned for each of these methods was determined only according to the climate, and the characteristics of the building, including its architecture and materials, did not play a role in determining these amounts.

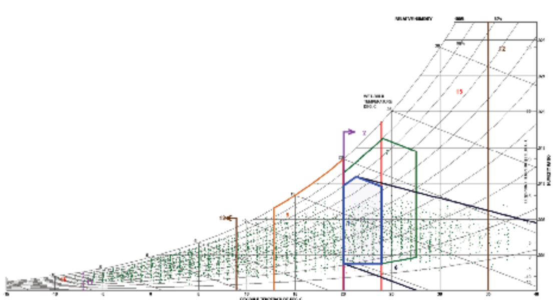

Fig 2: psychometric diagram of Tehran city (analysis software: Climate Consultant version 6)

3. **DISCOSION AND FINDING**

Case study

For the geometrical definition of the walls of the building, the outermost surface of the walls of the building has been selected for thermal zoning in the simulation software (according to the change in the thickness of the walls, the average thickness has been applied in the software), then the effective volume for cooling and heating the space has been seen for the significant area of the walls of the building. Also, the physical properties of the materials have been determined in the software according to the edition of 2019, topic 19 of the National Building Regulations. For example, in order to define the walls of the house, brick walls with a heat transfer coefficient of 0.88 W/m-K are considered, or around the definition of the openings of the building, they are defined as single-pane glass with a wooden frame, and its heat transfer coefficient is assumed to be 5.70 W/m-K. It should be noted that except for the communication spaces, the rest of the building spaces are ventilated. Despite the constant use of spaces with the direction of the different presence of people in the space, thermal zones are defined in multiple ways. Also, in order to investigate the effect of the physical variables of the architecture, the seasonal shading of plants in the outer yard has been omitted, but the shadow size on the building has been calculated by the software in the geometry part of the building by defining it as a substrate. The simulation results stated in this part show the amount of energy required to establish thermal comfort conditions along with the assumption of constant equipment consumption loads in all spaces of the building. In these analyses, the investigation of passive solutions based on the user (people present in the building) which has been traditionally used, such as regional heats or moving into the living space during the day, has been omitted.

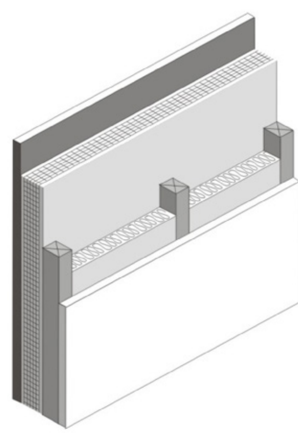

Fig 3: Simulated exterior wall layers

In the study of contemporary residential types, sample apartment units have been selected based on statistical results. The specifications of all the walls are considered similar to the suggestions of topic 19 of the national regulations of the building with insulation. The chosen structure is metal. In the simulation results of the residential apartment, we see the annual need of 55 kWh/sqm in the cooling sector, which is mainly due to the high thermal capacity of the building shell and sunlight. On the other hand, in the heating sector, the annual requirement of 147 kWh/sqm is predicted, this requirement is mainly related to heat loss in the form of convection flow from the building walls and unwanted air infiltration into the building. According to the opening surface of the building, artificial lighting consumption for this building is estimated to be equal to 9.5 kWh/sqm annually. Also, home equipment consumption is estimated at 38 kWh/sqm, and hot water consumption of 45 kWh/sqm. In total, the energy consumption of this apartment is estimated to be 295 kWh/sqm in case of operation under contemporary structures. The amount of equivalent carbon consumed in case of default operation is predicted to be 107 kg/sqm annually.

The plan of the desired unit has been modeled in the Open Studio software space and the thermal volume, materials, heating and cooling facilities, and other items have been observed based on the standards in the topic of 19 buildings. The type and amount of activity, the conditions of coverage, and other details are also considered according to what has been stated and if not mentioned, as a default standard or as a fixed variable.

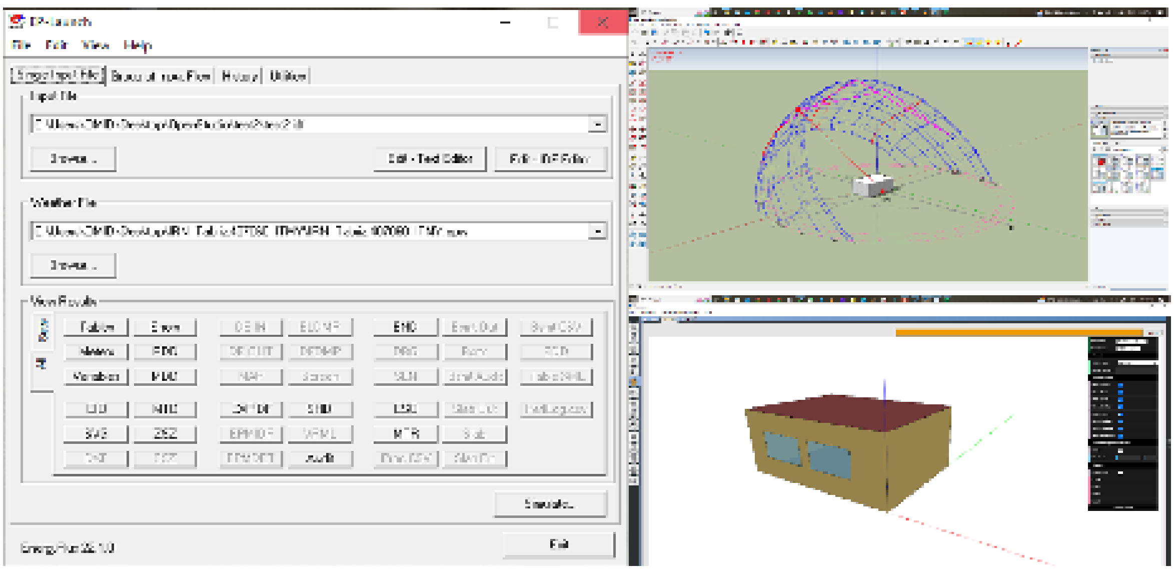

Fig 4: Modeling of the apartment unit in Open Studio 1.5 software space

After modeling, the amount of annual energy consumption for the desired unit is in two modes; It is done by using normal concrete and using thermochromic concrete, which is insulated against heat transfer. The amount of annual energy consumption in both modes was investigated in five fields of lighting, cart and electrical equipment, cooling and heating, and graphs 5 and 6 show the amount of change in energy consumption per building unit in the case of using two types of concrete.

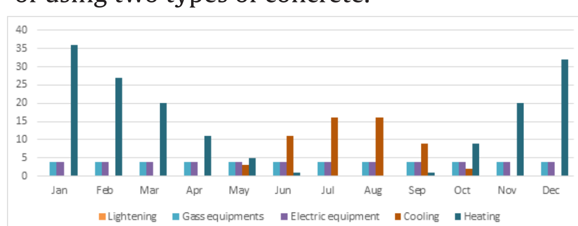

Fig 3: Monthly graph of energy consumption of an apartment unit – Tehran city with ordinary concrete

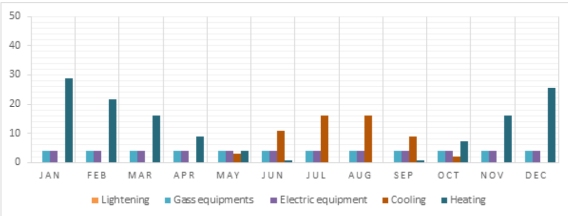

Fig 3: Monthly graph of energy consumption of an apartment unit - Tehran city with thermochromic concrete

For a better and more tangible comparison of these two situations, we can see the amount and how the energy consumption in the building differs in the comparison chart below. It is clear that according to the studied climate and the main energy in question, which is gas energy for heating, the difference was also in this case. By examining these changes, we get to know the effect of using smart materials on the amount of energy consumption in the building.

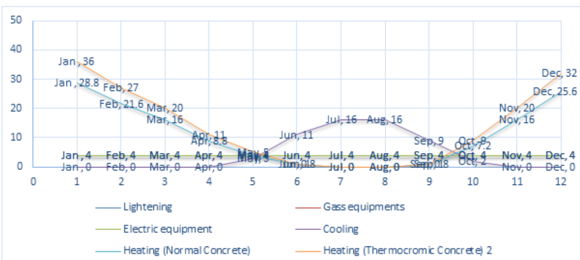

Fig 3: The amount of difference in energy consumption per building unit in the two modes of using thermochromic and normal concrete

RESULT AND CONCLUSION

In general, the main issue in cold climates is providing thermal comfort in the indoor space in winter, and for this purpose, various equipment and insulation works are used in buildings. The use of these items is forced to some extent according to the laws. However, regarding the materials used in the main structure of the building, especially in the external walls, old and traditional materials are still used. Regarding the physical system of buildings, the use of thermal mass is unattainable due to the importance of building weight and structural performance, and the use of thermal insulation in buildings is more important to designers. The simulation results of the energy requirement also confirm the more effective use of smart materials. In the national standards of Iran, the minimum thermal resistance considered for building shells is equal to 0.5 m2. K/W; Achieving this amount of resistance for the external wall by using only thermal mass leads to the thickness and weight of unusual walls. Due to the potential of heating and air conditioning equipment to provide thermal comfort conditions, the residents of contemporary houses have a bio-balanced model in their buildings. Today, smart concretes have shown a very high efficiency in various cases and fields. As mentioned, normal buildings use normal and not smart materials. The main reasons are price and cost. In this research, an attempt was made to evaluate the impact of the use of smart concrete on the amount of energy consumption required for heating in order to achieve standard thermal comfort inside the building. The results show that in the general state of gas energy consumption, which is the dominant energy for providing internal heating of the building, if smart concrete of thermochromic type is used in the outer walls of the building, approximately 19-22% of the energy consumption required for It has reduced the generation of heating. Therefore, this amount of energy saving in a building can create significant efficiency in the urban context and on larger scales. According to existing studies, in developing countries, 40% of the energy consumption in the city is in the building, and taking into account this amount of difference in consumption with the use of smart materials, it is clear that a significant amount of energy consumption will be saved in the building sector. Became. In addition to the saved cost, this item will also reduce the amount of pollution caused by energy production and its consumption in the building. Therefore, the need to use smart materials in new constructions, especially thermochromic concretes, is clear to prevent unnecessary heat exchange. In future research, the type and composition of these materials can be investigated in the surrounding walls, as well as the use of other smart materials in buildings and their impact on energy consumption.

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