COMPARATIVE STUDY OF HEATING SYSTEMS IN RESIDENTIAL UNITS WITH EMPHASIS ON FLOOR HEATING SYSTEMS, CORDED RADIATORS AND PANELS

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Abstract. Nowadays, choosing a suitable heating system is important due to the increasing energy consumption in residential buildings. In choosing the optimal heating system, various factors such as installation and maintenance costs, uniform heat distribution, internal air quality and thermal comfort index are considered. In this paper, research on the above factors for floor heating systems, corrosion radiators and panel radiator has been investigated and the results have been analyzed. According to the analysis, the radiator panel system is not suitable for heating goals, and the floor heating system is the most suitable system for this purpose.

Keywords: Floor heating; Corded radiator; Panel radiator; Heat distribution; Thermal comfort.

Introduction. Energy consumption has increased in the last few decades. This increase, on the one hand, is indicative of economic growth and, on the other hand, may be due to low energy prices in countries that own fossil fuels. So, the owners of the industries and private consumers in such countries have not sought to save and use it properly (Sophestay, 1394). According to the International Energy Agency (IEA), the annual energy consumption of residential buildings in the world increased about 2.4 percent between 1995 and 2005.According to statistics, about 86 percent of the world's energy consumption comes from fossil fuel sources such as natural gas, coal and gasoline (Tverberg, 2013).However, fossil fuels can provide our energy for one or two centuries.The results of the latest research shows that the constructions sector in Iran gets more than a third of the country's energy consumption. Energy consumption in various sectors of the economy of Iran has been increased in recent years.The main reasons for the increase in energy consumption in the household and commercial sector are the following: designing of buildings, type of building, consumable materials, types of heating and cooling systems, construction methods and interior architecture(Chapter 19 of the National Building Regulations, 2002).

Types of heating systems

In general, air conditioning systems can be divided into two groups of radiation systems and displacement systems.The basis of the operation of the displacement systems is the exchange of heat through the natural or forced displacement and the air conditioning of the room for the inhabitants.Air conditioning systems, coolers, fan coils and radiators are a subset of displacement systems.However, in radiation systems, the contribution of the radiation mechanism to the exchange of heat between the system and the environment is greater than other mechanisms.In these systems, the air does not directly heat, but the heat exchangers first heat the surfaces, and then the heat from the surfaces is transmitted by the moving mechanism to the adjacent air. Radiation systems are divided into two groups according to their surface temperature:1. high-temperature radiant systems such as gaseous radiators and electric heaters, and 2. low temperature radiant systems such as insoles and ceiling cooling systems (R. D. Watson K. S. Chapman, 2001). The low-temperature radiant systems have advantages such as low noise pollution due to the lack of mechanical ventilation of the air blower, the closeness of the water supply temperature to the design temperature inside, the uniform distribution of heat throughout the room space, and the absence of adverse air gradients (R. McDowall, 2007).However, low temperature radiant systems such as insole heating systems have more thermal insulation than displacement systems.Air conditioning designers and engineers are looking for hybrid systems (radiation-shifting) that, in addition to having the desirable characteristics of low-temperature radiant systems, have a relatively low thermal instability.One of these hybrid systems is the baseboard radiator system. In this research, heating systems used in residential buildings are considered under different conditions:

1. The initial cost of running heating systems
2. Heat distribution in the interior of the building
3. Indoor air quality
4. Thermal comfort

Execution and maintenance costs for floor heating systems, panel radiators and baseboard radiators

Each thermal system has two fixed and current costs.Fixed costs include the initial purchase price and installation of heating equipment. According to, the cost of equipment and the implementation of under-floor heating systems and radiator panel is almost the same and the cost of the baseboard radiator is 20% higher than the other two.Current costs include costs due to the use of the thermal system, which includes maintenance costs and fuel consumption costs.In the floor-heating system and baseboard radiator, due to lower temperatures, the life of the engine room or the package is much longer.On the other hand, the efficiency of these thermal sources is higher at lower water temperatures, while for panel radiators, due to the high temperature, the life of the equipment decreases.The under-floor heating system does not require annual maintenance and ventilation, and the life of the five-layer pipes, which forms the main part of the system, is over 100 years old.This is while the radiator systems are repaired on average every 5 years.If the effect of reducing maintenance costs and increasing the efficiency of the thermal system is neglected, the important part of reducing costs is the reduction of fuel consumption in the floor-heating system.In a winter period for a 110 square meter unit, the floor heating system and baseboard radiator have 600 metric cubic meters less consumption of natural gas than the panel radiator system(KhorasaniZadeh et al. 2011).

Table 1 Numerical comparison of the losses of heating systems in the same working conditions (KhorasaniZadeh et al. 2011)

Room or space	Total heat loss in the heating system with a 10% confidence rating(W)	Total heat losses in the baseboard radiator system with a 10% confidence rating(W)	Total heat loss in panel radiator system, including 10% confidence rating (W)
The hallway, rooms and toilets	462	482	550
Dining room	3922	4225	5037
kitchen	1317	1505	1753
Bedroom 1	645	620	766
Bedroom 2	705	680	837
Bathroom	533	500	652
The whole unit	7584	8012	9595

Heat distribution in the interior of the building in different heating systems

Heat transfer from heat exchanger surfaces to heating space is an important factor in determining the degree of thermal comfort for residents (MostafaRahimi, MehrzadEtemadi, 2014).Since the 1970s, and especially in the last decade, extensive research has been carried out on the study of air circulation and distribution of temperature in various spaces, including residential, office, industrial spaces, and so on.In 1989, King Yan Chen carried out research on energy analysis and indoor conditions in homes equipped with radiator panels.In this study, a three-dimensional study of the distribution of air flow velocity, room temperature distribution and turbulence energy was used.He conducted this review for two different heating systems.The first system was the radiator heating system and the second system was the heater heating system.He showed that the use of the heater heating system provides a better environment for comfort (Qingyan Chen, 1989). John Mayren et al., (2008) studied the pattern of flow and thermal fittings. (Jonn Are Myhren, 2007). They studied two heating systems in this study.They had two rooms, one equipped with a radiator heating system and the other with a floor heating system.They used numerical simulations of these two different heating systems. Finally, according to Fig. 1, the use of floor heating is more appropriate.

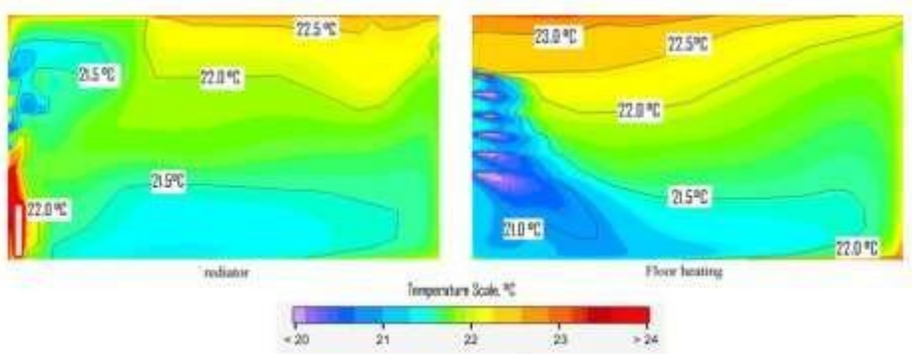

Figure 1Distribution of temperature in floor heating and radiator systems (Jonn Are Myhren, 2007)

Abdulzadehet al., (2016) conducted an energy assessment for floor heating and baseboard radiator. In this paper, the conditions for checking heating systems for identical physical and thermal conditions in the rooms with and without windows have been made. Figure 2 indicates the heating system of the floor and the baseboard radiator in the room (Abdolzadeh, 2016).

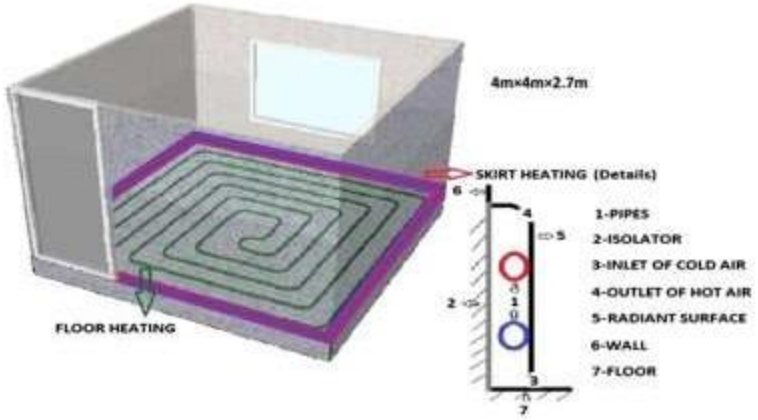

Figure 2 Schematic image of the floor heating system and cabinet radiator in the room (M. Abdolzadeh, 2016)

For this purpose, simulation was performed using the ANSYS software, and the condition of Figure 3 is intended to be introduced to the software.

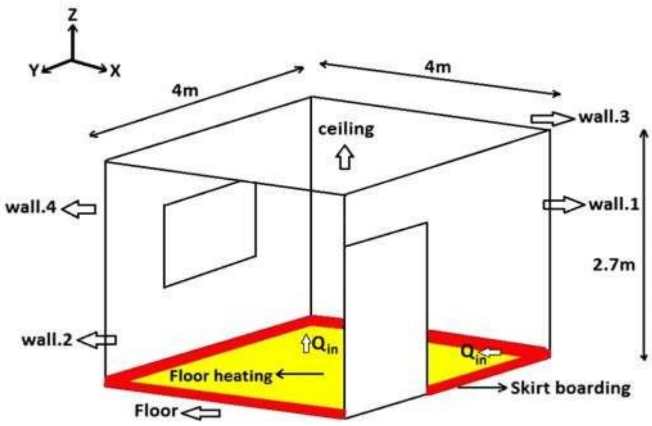

Figure 3 Model Designed in Simulation Software (M. Abdolzadeh, 2016)

Figure 4 indicates the temperature distribution in the vicinity of the floor for insulating and the baseboard radiator system. As shown in Figure 4 (a), when there is no door and window for the room, the maximum temperature in the midpoint of the floor surface is 28 ° C; and in accordance with Figure 4 (b), in the case of a room with a door and window, the maximum room temperature is 25.2 ° C and in the right corner of the room. The temperature distribution for the first and second states for the heating system of the baseboard radiator is shown in Figure 5 (c, d). It can be seen that for a room without a window and window, the maximum temperature is near the walls and at 25.5 ° C. This value is not the highest temperature, because the highest temperature occurs at the top of the baseboard radiator in 15 cm above the floor at 33 ° C.For room mode with the presence of the door and window, the temperature distribution is shown in Figure 5 (d). It is observed that the uniform distribution of temperature at a distance away from the wall does not occur in this case.

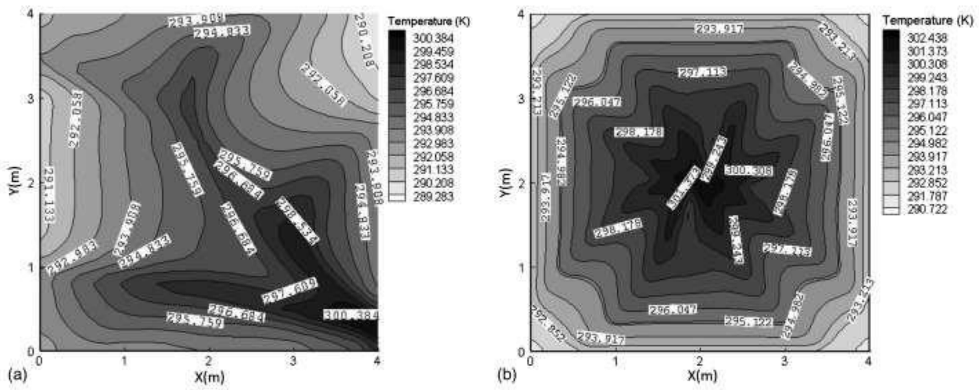

Figure 4 Distribution of temperature in the vicinity of the floor in the heating system of the floor in scenarios, (a) without a window and (b) with a window (M. Abdolzadeh, 2016)

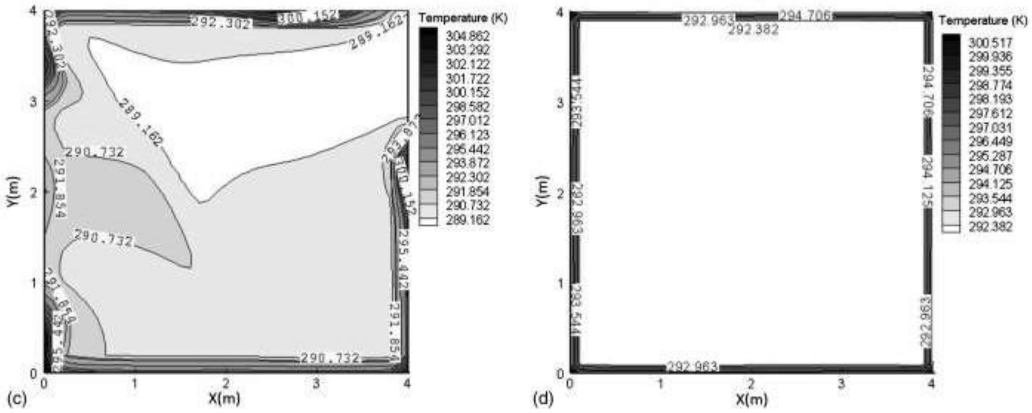

Figure 5 Distribution of temperature in the vicinity of the floor in the heating system of the floor in scenarios,(a) without a window and (b) with a window (M. Abdolzadeh, 2016)

Figure 6 indicates the distribution of temperature in two floor heating systems and baseboard radiator. As can be seen from the Figure 6, the under-floor heating system has a more uniform temperature variation compared to the baseboard radiator system in the direction of the height of the floor.

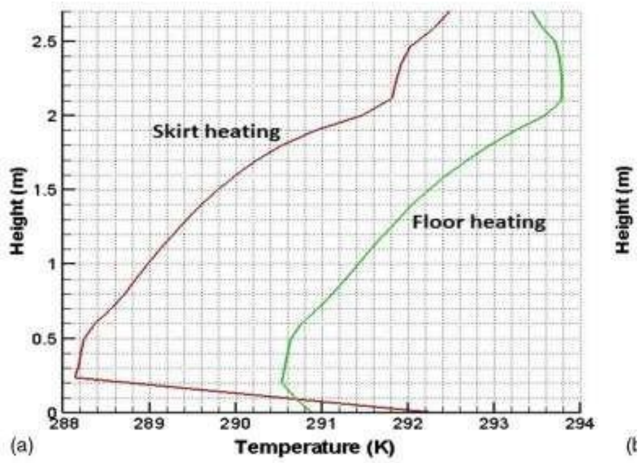

Figure 6 Distribution of temperature in two systems of floor heating and baseboard radiator (M. Abdolzadeh, 2016)

To check panel radiators, BazmAraet al., have simulated the distribution of temperature with the following conditions.In this study, a room with 20 square meters is considered.The south wall is a wall of the outer wall, and a window is installed on this wall.The western wall is also considered as algorithm external wall and there is no window in it.The northern and eastern walls of the inner wall have no role in load calculations. The ceiling is also connected to the outside and the floor is assumed to be insulated.Figure 7 indicates the temperature contours in the radiator system. Despite the fact that the temperature distribution is uniform in this case, Figure 8, which shows the room temperature variation at two cross sections in front of the radiator and the center of the room from floor to ceiling, indicates the range of temperature changes in this case.

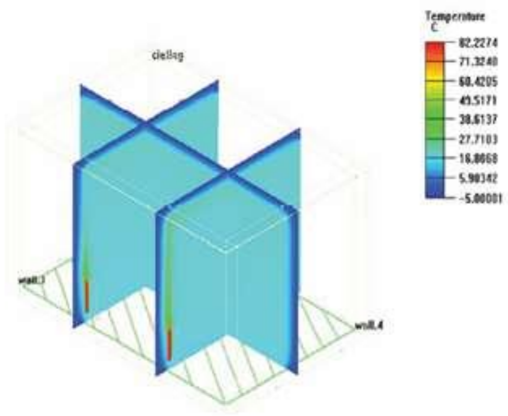

Figure 7 distribution of temperature in the radiator system in the isometric view

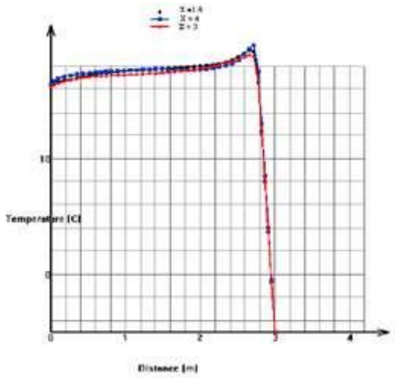

Figure 8 the temperature in the center of the three cross sections in the radiator system from floor to ceiling

Comparison of indoor air quality in buildings with corrugated radiator system and floor heating

The issue of indoor air quality in buildings with conventional heating systems is one of the issues that has recently been addressed by air conditioning engineers.The lack of use of masonry equipment in buildings with radiant heating systems causes the quality of air inside them to drop out of buildings with other heating systems.S. Weichenthal, (2007) compared the indoor air quality of the home with an electrically heated heating system and compared it with wood burner, oil, and gas.V. Golkarfard et al., (2014) compared the air quality in a room with a heating system. The initial amount of carbon dioxide in the room air was 1000 ppm and the concentration of the input pollutant from the filtered valve and window seam is 400 ppm and 1000 ppm, respectively.The thermal flux of the inlet for the floor heating and ventilation system has been adjusted so that the average thermal comfort index of the persons in the breathing area is the same for both systems and within the permissible thermal comfort standard. The surface temperature of the skirting is about 45 ° C and the temperature of the floor is approximately 25 ° C.Figure 9 indicates the distribution of speed in meters per second in the breathing area in the floor heating system and baseboard of skirting. The speed in the breathing area in the floor heating system is lower than that of the skirting system which indicates lower thermal floating power in the floor heating system than the skirting system. Therefore, it is expected that with increasing thermal floating power the average concentration of pollutants in the respiratory zone increase.

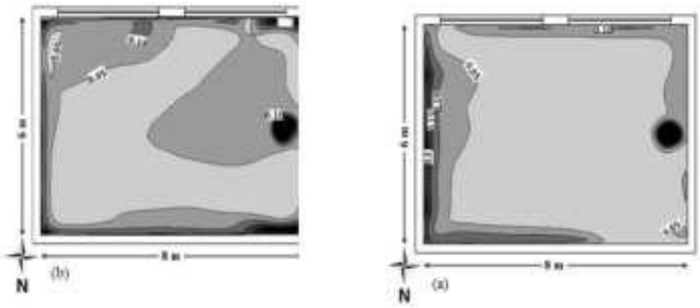

Figure 9: (a) air velocity in the floor heating system in meters per second, (b)air velocity in the radiator grill system in meters per second

Figure 10 indicates the average concentration of respiratory pollutants for these two systems. By comparing the average concentration of pollutants in the respiration region, it is noted that this amount in the heating system of the floor is about 20 pp of the frigate heating system.

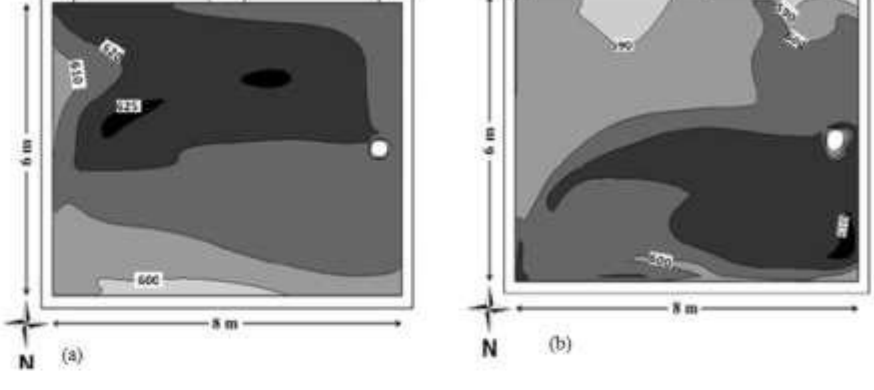

Figure 10: (a) Concentration distribution in ppm in the floor heating system, (b) Concentration distribution in ppm in baseboard radiator

The study of air velocity distribution and thermal comfort index in heating systems

Air conditioning systems have become an integral part of buildings.The accurate design of the air conditioner systems requires a proper estimation of the thermal comfort conditions.In fact, the main purpose of all air conditioning systems is to create the ideal conditions for the people's thermal comfort.Although there is no definite definition for thermal comfort, it usually refers to the definition given in the ASHRAE HandbookFundamentals facility standard to express its meaning.

Figure 11 (a) indicates thefloor heating systems for floor heating. The velocity contours of the floor heating system,as it is seen, air velocity, other than a limited area close to the roof, is about 0.2 meters per second in the whole room.Low airflow speed is also effective in thermal comfort, and the high velocity of airflow, in addition to its effect on reducing comfort factors, causes irregular circulation of dust and leads to issues such as the blackening of curtains and walls in systems such as radiators. The low flow rate of air in the floor heating system is an advantage. Figure 11 (b) indicates the speed contour for radiator systems. As seen in these figures, the air velocity in the above of the radiator is much higher than in other areas, and this leads to the problems that have been expressed.

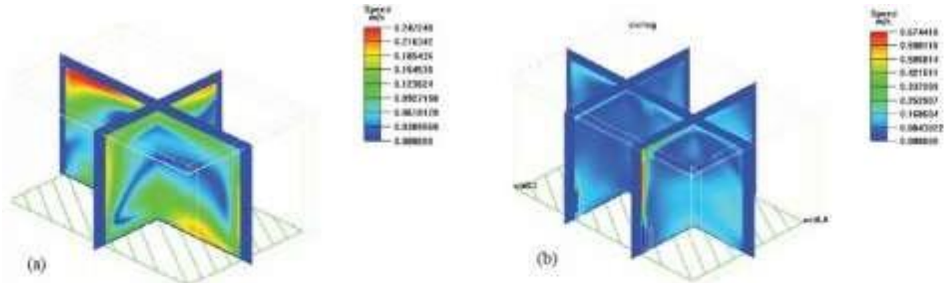

Figure 11: (a) speed distribution in the floor heating system, (b) distribution of speed in the radiator system

Conclusion. In order to compare the heating systems in residential buildings, the cost of installation and maintenance, the distribution of heat in the interior, the air quality inside and the thermal comfort index caused by the heating systems were examined.The results showed that, compare to the other two systems, the radiator heating system was cost effective in installing, but it has a high maintenance cost, and, given the need for higher temperatures for heating, over time, the user will be charged more.In comparing to the floor heating and the skirting radiator,and due to the lower initial cost and lower operating temperature and lower maintenance cost of the floor heating system, these systems are more cost-effective and more efficient than baseboard radiator.One of the important indicators in heating systems is the uniform distribution of heat in the environment. According to the findings, the radiator panel system does not have a uniform heat distribution and the temperature difference is up to 8 ° C. Therefore, this thermal distribution system is not suitable, and in the baseboard radiator system, the heat distribution was even more uniform, and in line with the height difference of temperature it is about 3 ° C. For the floor heating system, the heat distribution is also uniform, just like the baseboard radiators. Altogether, baseboard radiators and floor heating systems are suitable for the uniformity of heat in the environment.In the heating system of the floor other than the restricted areas near the ceiling, the speed is almost uniform and low.For a baseboard radiator system, although the speed is high near the bottom of the floor, but in a significant part of the room space, the speed of the air is within the permissible range.In general, the floor heating is more suitable for thermal comfort than the other two systems.Finally, Table 2 indicates algorithm summary of the checked items.

Table 2 Examining different heating systems

Indicator / heating system	Initial cost and maintenance fee	Heat distribution in the indoors	Indoor air quality	Thermal Comfort Index
Floor heating	Medium initial cost Low maintenance fee Low energy consumption (starting temperature 20-25 ° C)	Uniform heat distribution (temperature difference in altitude of 3° C	Medium Quality Air (Flow rate of about 0.1 m / s)	High thermal comfort
Skirting	High initial cost Average maintenance cost Low energy consumption (starting temperature 45 ° C)	The heat distribution is approximately uniform (temperature difference in altitude 3 ° C)	High air quality (Air velocity ca. 0.2 m / s)	Medium thermal comfort
Panel Radiators	Low initial cost	Non-uniform heat	Low air quality (Air	Low thermal

	Average maintenance cost High energy consumption (starting temperature 70 ° C)	distribution (temperature difference at 8° C)	velocity ca. 0.4 m / s)	comfort

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PROVIDING A MODEL TO ANALYZE THE IMPACT OF TOURISM DEVELOPMENT ON SUSTAINABLE ECONOMIC GROWTH: COMPARISON OF EUROPEAN DEVELOPED AND ASIAN DEVELOPING COUNTRIES

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Abstract. Studies and research have shown that many theorists and international organizations have already started to discuss the development of tourism due to the importance of tourism and its impact on economic growth and socio-cultural development. In some developed countries tourism development not only does not lead to economic growth, but even as a result of significant costs and a reduction in the level of social welfare in their society.However, recently a new approach has criticized both aspects of this relationship, which suggests that this is not a self-help relationship. In this regard, the purpose of this study is to determine whether economic growth in some countries has led to an increase in economic development due to the expansion of tourism activity over the past two decades or not. Therefore, algorithm sample of 24 countries including Iran has been used, indicating that this relationship exists in more developed countries and it makes sense of tourism as a driving force for economic development for less developed countries and even in developing countries.

Keywords: Tourism, Economic Development; Economic Sustainability; Structural Balance Model

Introduction. In recent decades, most international organizations have argued that tourism can be recognized as a tool for economic development in many parts of the world. In addition, many economic presses have recognized tourism's ability to do so. Nevertheless, in recent years, research has been done on the relationship between these two dimensions,which shows that in some countries tourism development not only does not lead to economic growth, but also as a consequence of significant costs and a reduction in the level of social welfare in their society (Ding Du1, Alan A. Lew, and Pin 2014). Therefore, there are two opposing theories regarding the concept of tourism as a tool for social economic progress. Tourism is not a magical and automatic solution for all countries to increase the level of prosperity, but it is not true that tourism has the ability to become a tool for progress. In fact, tourism has become an effective