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Review article

The study of the role of two-shelled facades in residential buildings in Guilan

S. Ghanbari*
Master of Architectural, Department of Architecture, University of Applied Science and Technology of Talesh, Talesh, Iran.

*Corresponding author; Master of Architectural, Department of Architecture, University of Applied Science and Technology of Talesh, Talesh, Iran.

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ABSTRACT

In a time when most of the Earth's fossil energy resources are decreasing and the population continue to increase, human needs to control his residential space weather in comfort range without any waste or excessive consumption of energy. Nowadays various technologies are used to create comfort, security, and saving in costs particularly in energy consumption. Two-shelled facade is also one of the measures that with the advancement of knowledge and development of science in recent decades, has made it possible for construction industry to be compatible with the environment so that it can help to adjust heat, cold, light, wind, as well as outside noise and provide residents' welfare without wasting energy. The application of this technology is necessary in modern buildings of Guilan according to the extent of the area in the country that can reduce a large part of fossil energy consumption by creating natural ventilation and draft that it's important factor of comfort is the reduction of excessive moisture in the area that is hard to bear for man. Therefore, the aim of this article is to study of the two-shelled facades and the amount of influence of this technology on reduction of fossil energy consumption and man's comfort in the building. The descriptive-analytic research method has been used in this research based on data collection by library method. The results of this study indicate

that in addition to possibility of natural ventilation while controlling noise, wind, and rain, two-shelled facades case to human comfort in building with reduction of costs and creating a desired landscape.

1. Introduction

Modern science and technology has created a new policy in the past hundred years which considers the natural resources and energy as an unlimited source, architecture and related sciences to buildings usually have followed this superficial view. Cheap fuel, new technologies for heating, cooling, and lighting and increasing residents expectations have shown their consequences in buildings that minimal attention have been paid to their surrounding location in their designing and using (Medy & Fazli, 2013, 2). Excessive dependence of the man to mechanical systems and excessive consumption of energy is caused to hurriedly and accumulative destruction of the environment and energy crisis. Whereas people in the past had to build a building in a way that not only be more compatible with the climatic conditions but also use the useful climatic factors and elements to provide comfort in the building (Spenani, 2004, 84). Local architecture of Guilan is one of the valuable architectures of the past that has had a certain glory and beauty in the country. This architecture that is the consequence of the interactions between man and its surrounding nature, relying on clean energy sources, had been converted the outside inconsistent conditions to an interior balanced and desired space with minimum energy consumption, but it is not observed in the region any more due to the development of so-called modern architecture (Ghanbari& Sharif, 2012). Therefore, regarding that facade is one of the most significant technologies for saving in energy consumption in a building, using two-shelled facades as one of the sustainable architectural elements is a requirement. Particularly in Guilan province where high air humidity is its distinctive climatic feature and the most amount of energy are used to create draft and air conditioning in its buildings. Two-shelled facades that are made today in imitation of traditional architecture are chambers with glass sidewalls that have been revived in architecture and will be effective on energy saving in buildings. Thus, this article has concerned to study two-shelled facade that is one of the new approaches in architecture and can be used as a practical solution to improve the environmental quality and desirability of life.

2. Background of two-shelled facades appearance

Crespo believes that the first instance of double facades in Germany in 1903 and has evolved

In that time, the goal has been to maximize the use of daylight, considering the cold weather and harsh winds in the area. Solution has been a three-storey building where the ground floor was used as warehouse and two others were used for the workplace. The building was successful in achieving its goals and similar phases in the development were built in 1904 and 1908 (Poriazis, 2004). Initial studies were performed in Scandinavia in the 1950s, on windows that have air flow which aims to promote energy efficiency and thermal comfort of the windows in residential homes. Until late '70s and early '80s, little progress has occurred in the construction of two-shelled glass but this facade achieved superiority during the 80s. Many of these facades were designed in response to environmental concerns and others seeking aesthetic multiple layers of glass. In the 90s, the increasing environmental concerns in architectural design from a technical standpoint and also from a political point of view strongly influenced on this process and caused to the development and increasing use of two-shelled glass facades (Saelens, 2002).

3. Two-shelled facades

There are different definitions to describe the two-shelled facade system clearly, parts of which include:

Clysnes and De Herd define two-shelled facade as follow: Secondary facade is an extra shell that is installed on the existing facade and often is crystal. The empty space between primary and secondary shell is a buffer space that isolates the building. This space can be heated by the sun, regarding to the direction of the facade. In structures facing the south, the air heated by the sun is used for heating purposes in the cold season and of curse in other seasons and times this hot air is ventilated (Poirazis, 2004).

Uuttu defines two-shelled facade as a pair of glass shells separated by an air corridor which is also called the hole or intervening space, ranging in width from 20 cm to several meters. Glass shells may be drawn on the whole structure or a part of it. The main layer of glass is usually nonconductor, and as a part of a common structural wall or a curtain wall. While the added layers that are usually single-walled glasses. These layers, makes an air space between them, which primarily acts as a nonconductor against maximum temperature and sound (Uuttu, 2001). And according to the definition of Belgium's Building Research institution, the active facade is the shell that is made of glass in one or more floor or several shells. The shell can be nonconductor against the air or not. In this kind of facades the air chamber is between the shells and can be ventilate naturally or by mechanical tools. Air chamber ventilation strategy may change over time. The devices and systems typically act in an integrated manner and in active or inactive ways to improve indoor air. In many cases, these systems are managed through control systems (BBRI, 2002).

4. Two-shelled facades components

1- Glass frames:In this type of system the inner shell of the facade is made of thermal insulating glass frame in two or three layer that is used in any kind of hardened glasses which the space between glasses is filled with air, Argon or krypton. The outer shell of the facade is usually a single-layer glass frame of timber or laminate.

2- Air chamber: The air chamber is a chamber in which the air flows and the flow rate and the type of it in the two-shelled system depends on the dimensions of the chamber (in both mechanical and natural ventilations), the type of external and internal openings and air exchange between the environment and the space of the chamber also depends on the Conditions of wind pressure on the building shell, Chimney effect, and the Conductivity coefficient of openings.

3- Awnings:The place of awnings in two-shelled facades to protect the building from wind, rain, and the important role that it plays in distribution of heat that is obtained in the inner space, is factors that should be considered. If the awning be in front of the inner facade, especially when not ventilate properly, the air outside the window can be very hot. That is an undesirable phenomenon which in any case, open or closed windows, can cause to heat transfer. Therefore, the ideal place of the awning is at 3/1 of width of the chamber and it should not be closed to the outer layer to reduce the excessive heat and thermal load of this layer.

4- Control system: This system makes it possible to provide desirable thermal comfort situations during a year. When that two-shelled facade has not been designed properly in relation to mechanical ventilation system, there is the possibility of overheating of the inner space during the heat period. This system allows to external situations that affect on internal situations (Basiri et al, 2012, 397).

5. The types of two-shelled facades

Two-shelled Facades term refers to a large group of systems that are similar in appearance and vary in practice. In order to classify this type of systems, we must pay attention to three major differences between them:

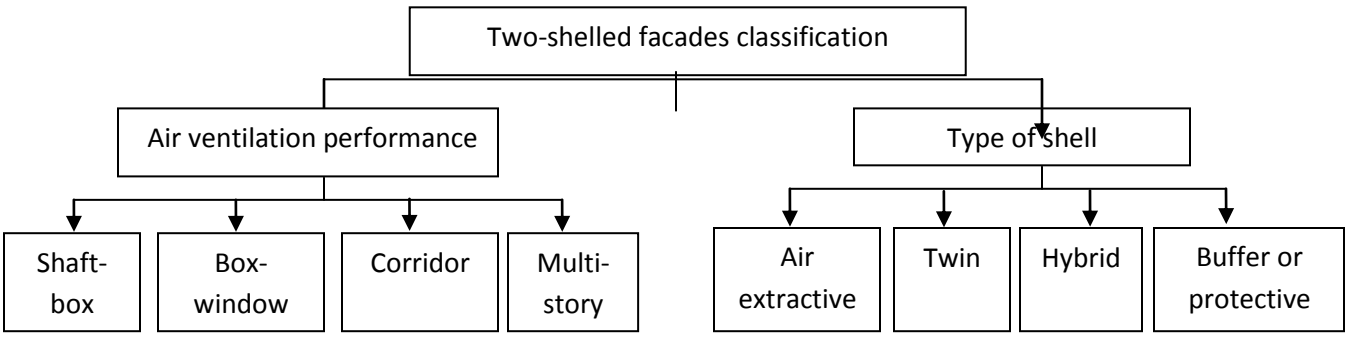
1 - Systems which the internal space or cavity is completely closed in them. This cavity acts as a shield against heat and sound.

2 - Systems which there is an interior mechanical ventilation system in their empty space. The second shell in this type of systems is sound proof and the performance of thermal insulation is dynamic and controllable depending on weather conditions.

3 - Systems that air space is open in them and act as a natural ventilation system. The interior space and second shell act as thermal and sound insulation (an effect, similar to wind tower in old buildings).

Two-shelled Facades can be classified according to the type of Construction, origin, destination and the type of air flow in the cavity. This type of system is divided to 4 categories based on ventilation performance, and the type of the shell that include:

Table 1
Two-shelled facades classification.



(Based on the investigation and processing of the author)

6. Two-shelled facades classification based on performance of the air conditioning

1 - Multi-story facade: In this type of facades the internal space is integrated and the top and bottom of the space is open. The advantage of second facade openness in addition to natural ventilation is its maintenance as well as cleaning.

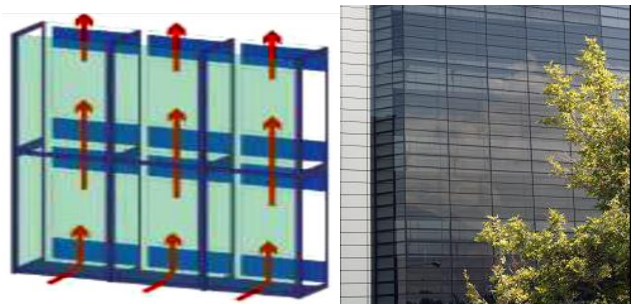


Fig. 1. Multi-story façade.

2 - Corridor facade: In these facades the intervening space is horizontally closed. The advantage of this type of classification is the better ventilation but there is a possibility to sound transmission among internal spaces (rooms).

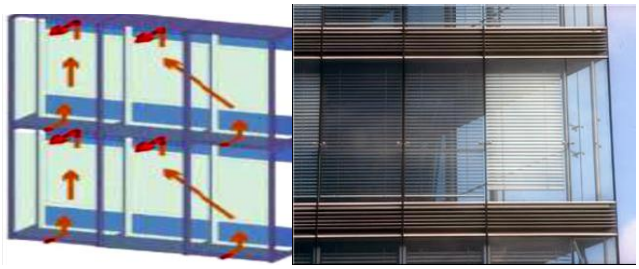


Fig. 2. Corridor façade.

3-Box-window facade: In these facades the internal space around windows is horizontal and vertically closed. The main advantage of this method is to avoid sound and odor transmission in internal spaces (rooms) but natural ventilation is not good.

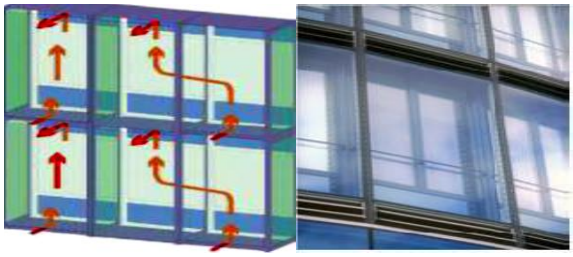


Fig. 3. Shaft-box window.

4-Shaft-box window: In this type the internal space is divided vertically. This method of classification improves thermal and acoustic insulation performance and less number of exterior openings are require.

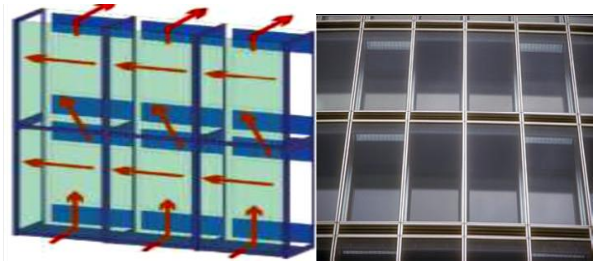


Fig. 4. Shaft-box window.

7. Classification of two-shelled facades based on shell type

1- protective or buffer facade: Protective or buffer facade is composed of two layer of glass and the two layers of glass locate approximately from 250 to 750 mm from each other. The space between two layers is sealed with an air space (Shahriari & Karimzade, 2011). The protective facade is made before the insulation of glass. This insulation is done to increase acoustic and thermal insulation without reducing the amount of light entering the building.

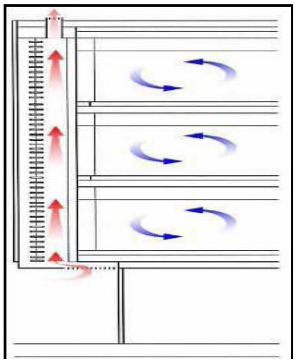


Fig. 5. protective or buffer façade.

2- Air extractive facade: Air extractor facade is made of two glass insulation shell and a secondary single glaze shell that is located in its inside. The warm air which used between layers is ventilated through upper cavity by a fan; through this the internal layer of the glass cools while the outer layer of insulating glass minimizes the heat loss. This system is used where natural ventilation is not possible. Awning devices are mounted inside the cavity (Babolhvayejy&Mirzade, 2011).

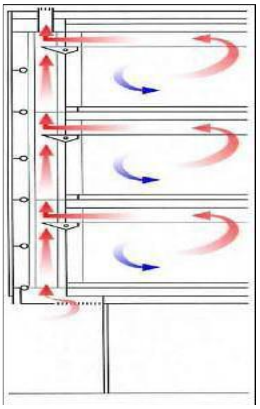


Fig. 6. Air extractive façade.

3-Twin facade: Twin facade is made of a conventional sidewall or a firm wall system with an external shell. The external single glaze shell is used mainly to protect the contents of air cavity (awning devices) against weather (Shahriari & Karimzade, 2011). With this system, the internal shell creates insulation properties to minimize heat loss. It is different from air extractive facade for the presence of pores that make the natural ventilation possible. The valves of internal facade can be opened, while ventilation pores in external shell moderate the minimum and maximum temperature inside the facade (Rashidi & Sharifi, 2009).

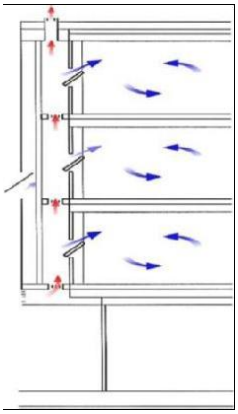


Fig. 7. Twin façade.

4-Hybrid facade (combined): The hybridsystem facade has been combined with one or more characters of above mentioned types to create a new linked system (Babolhvayejy&Mirzade, 2011).

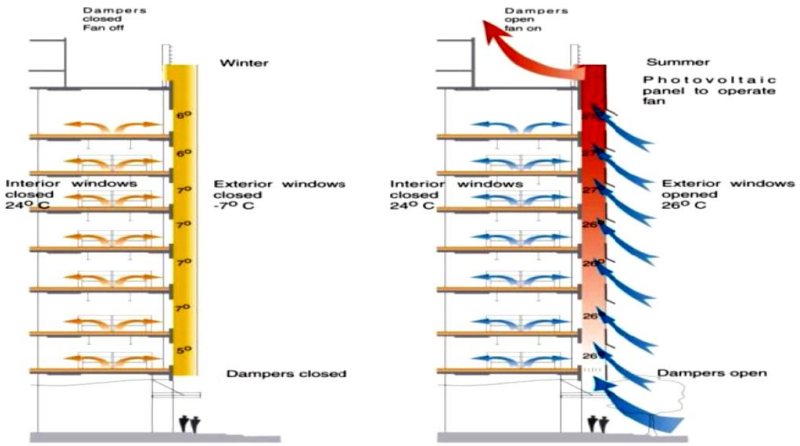


Fig. 8. Wintersummer.

8. The effects of using two-shelled facade in humid temperate regions

Iranian traditional architecture has unique and certain characteristics that mixed Climate, Religion and Culture and … together and it has characteristics such as appropriate design, exact calculations, proper covering forms, regarding scientific issues, long balconies, and various decorations and yet with simplicity it is based on principles such as introspection and veil (Mansuri,2010, 39). In Guilan'sgeographic area, specific climatic characteristics of the region caused that Guilan's local buildings have following features:

Table 2
elements that observe in localarchitecturehumid temperate region.

Type of climate	Type of materials	Type of plan	body	Type of roof	Placement direction	building	Level and number of window	amount of natural ventilation	Collection tissue	Type of external color
Temperate and humid	The use ofmaterialswithlowthermal capacity	Wide and open	Longand narrowgeometric shape	Steep	17/5 degree to South East	Houses on wooden base and three steps above the ground	High	High	Distributed	Light

Adjusting the thermal conditions of temperate and humid areas to life-climatic structural table we find that the main problem in these areas is high humidity of the air in all seasons and a house not only should not onlysatisfythe humanneedfor shelter but also it should be accompanied by relatively climatic comfort (Khakpour, 2007, 64).Therefore, creating comfort conditions in the habitat of this region, this is the reduction of excessive moisture that is hard to bear for man, causes that natural ventilation is an important part of building designing, but today due to thedensity ofthebuildingstogether optimal use ofwind energy that is done by creating natural flow of air in the building and it is one of the best and the cheapest methods of ventilation has been neglected significantly.

In a time where most of the Earth's fossil energy resources are decreasing and the population continue to increase, the world is encountered energy shortage crisis more than before. In our country the excessive consumption of fossil energy in residential spaces to provide hot water, heating and cooling also is one of the most important factors of environmental pollution (Kasmai, 2003, 12). Therefore, the buildings should be designed especially in these areas so that can be provide the possibility of natural ventilation usage for all spaces and thereby it reduces the consumption of nonrenewable energies.In thisregardmanyefforts have been donetoreplacefossil fuelswithnatural and renewableenergiessuch aswind energy and two-shelled facade as a form of the shell of the building is one of the methods that provide the possibility of natural ventilation in addition to controlling other external factors for the buildings.

9. The effect of two-shelled facade on modern building in Guilan

9.1. Creating relaxation in human

Today,due tourbanpopulation growthandvertical growthof buildings, mostpeopleaffected byenvironmentaland personal unpleasant factors have lost their mental balance and relaxation and they have encountered issues such as stress, anxiety, violence and aggression, depression and failure and … Any of thementioned cases are symbols andsigns ofmental illness.Noiseand airpollutionisone of the effective factorsthatthreatenthe mental healthdue to theurban life.Noisepollution stimulatesthe

senseofviolence andaggression in human and althoughair pollutionhas morephysicaleffect but in psychological aspect it causes to weakness ofthe nervous systemand negative effecton it.In addition, although changes inthe industrial ageand consequentlymechanized lifestyle in this modern world have solved some of the problems in human life, withthe increasing useof fossil energies that human believe life is impossible without them; have caused to increase economic costs that have a negative effect on human psychological and mental comfort. Therefore, the most important effects of two-shelled facades are as follow:

1- Visual beauty:Manis a complexcollectionofsoul,mind and body.Just asthe humanbodyneedsfood, his mind and soulalso needs elementsthatgivehimpeace. In city community, which tall buildings, streets and mechanized lifestyle has surrounded everywhere, the internal space of house can be like some nutrition for the man's tired soul that escaping from busy streets and mechanized age are in search of a safe place full of peace. In the past,in Guilan's local architecture, there were trans parentand porous spaces that create visual and close relationship between inside and outside, although these spaces were built to meet climatic needs, they have been in perfect harmony withreligious requirements andcultural beliefsof the peopleof this area, which its beauty manifestations that was the best refuge for the man's tired and pacifist soul have been vanished over time and development of tall buildings (Khakpour, 2007, 29). Therefore, this matter will increase using glass in Guilan's modern buildings, especially tall buildings, because using two-shelled facades, in addition to achieve principles of energy management in Guilan's buildings and reducing pollution can provide beauty to pacify man's psych due to the achievement to proper view and internal and external relationship which is a part of its people culture.

2- Economical: In Guilan province which temperature moderation, high humidity of the air and long time rainfalls are its distinctive features a building must somehow reduce the humidity around the man's body, and provide the possibility for perspiration and evaporation of the skin surface and consequently reduces the body temperature. The way to achieve this is creating draft in the building and the moist air ventilation by the wind that this also causes to reduce the consumption of nonrenewable energies (Khakpour, 2007, 18). The two-shelled facades allow natural ventilation through their openings and extend the time of natural ventilation. Air production by costly mechanical device will be unnecessary that this causes to reduce power consumption. Reducing the power consumption will lead to large savings in the costs of a building (Torkjazy, 2012). It is clear that the costs of construction and maintenance of two-shelled facades due to the additional second shell, intermediate space between them, adjunct fans, and etc is more than single shelled facades, but comparing the investment and interest rates, indicates that using a composition of two layers of facades in the same time and secondary ventilation system is better and more economical than using only one layer of glass facade with an equipped air conditioning (Oesterle et al, 2002).

3- Noise pollution: Discomfort from the noise of the streets is a major problem in urban areas. Vehicle traffic and their activities in the city is one of the main factors of noise pollution that this kind of pollution is one of the most important problems in the urban life. Noise pollution has harmful effects such as Sleep disorders, concentration disorders, and etc on human. Two-shelled facade reduces the noise load of the building i.e. it helps significantly to reduce sound pressure level from the outside to the inside of the building and it is effective on the amount of the effect of this factor on citizens' life.Noise pollution includes noisepollutioncaused bygroundfloorplan and also noise pollution from internal spaces. Two-shelled facade acts as noise insulation against ground floor noises and reduces the amount of noise pass that this is possible when the windows are closed. When these windows are open for natural ventilation, the prosperity of the facade will reduced to a large extent. If the ground floor noise was too high, a sound insulation should be used in the facade.Soundexchangeininterior spacesbetweenneighborspacesoccurs becauseof theintegrated internal spaces of two-shelled facades as well ascorridorsforventilation. This sound exchange intensifies when the windows of internal shell can be open and closed. Installing bad awning devices or high level of ventilation in intervening spaces can also make problem in this situation. To enhance efficiency of the facade, sound insulations and separating devices can be used in internal spaces (Oesterle et al, 2002).

4- Natural ventilation: Today, the use ofnatural ventilationin buildingsto providewelfare anduser's comfort is one of thepointsthat should be consideredin the designof the building.Utilization ofnatural

ventilation, especially in thesummer,reduces excessiveuseof air conditionersinbuildings, so that provide residents' comfort without wasting energy.

In thisregard, two-shelled facades as a form of the building shell provide natural ventilation for building especially in Guilan because of high moisture, while controlling other external factors. Two-shelled facades protect buildings against different weather conditions and they make it possible for users to use opening valves in their life spaces without encountering the problems that exist in single shelled facades. In two-shelled facade the external layer is for protecting the building against weather and usually has some openings to ventilate intervening spaces and internal rooms. Air flow is activated through intervening space of a two-shelled facade by convective current and suction. To achieve more adaptation to environmental situations there is the possibility to close the openings of the external layer completely.To date, theouter skinof this type of facades is made of a layer of tempered glass or laminated glass.In themiddle layeradjustablesun breakersare installed. The internal facade consists of aframewithdoubleglass which preventsheatlossinwinter. In most cases the internal layer can be opened for natural ventilation (Babolhvayejy&Mirzade, 2011).

10. The effect of two-shelled facade on environment

With the advancement of architecture science, buildings are not only a shelter against climatic factors and in any states and various climatic factors, will be developed synchronous and compatible with the environment and will have the least damage to environment. Therefore, the main effects that two-shelled facade will have on environment will be as follow:

1- Reduction of energy consumption: The limitation of fossil energy resources and excessive increasing of its consumption in addition to environment pollution and wasting national assets, has put the future life of human in danger (Kalantari, 2009, 1). Wind and solar energy are the world's greatest energy sources that these energies are clean, cheap, endless, safe, and secure andareavailablein mostareas. These renewable energies won't have the limitation of fossil resources andconsequencesof environmentalandglobal climatechanges. Therefore, getting the solar and wind energies in building is often an effective and desired willing.For this purpose, two-shelled facade can be a solution to provide heat, cold, light, wind and comfort and welfare to residents without wasting energy. In fact, two-shelled facades In addition to providingthe necessarytransparency save the solar radiationabsorbed by theexternal glass facade in the winter and provide the possibility of natural ventilation in the summer through their openings and make the natural ventilation time longer that the intensityoftheheat andhumidityoftheatmosphereis reducedusing proper ventilation and through this the thermal comfort and internal air quality of the building will improve in addition to reduce cooling and heating loads of the building and costly devices will be unnecessary. Therefore, theneed to usefossil energieswill be reduced (Hashemi&Fayaz&Sarshar, 2010).

2- Reducing air pollution: Considering theimportance of the useof fossil energyandproduction of greenhouse gasesandenvironmentendangerment the importanceof usingclean energiesand architecture presenceinthis fieldisextremelyimportant and noticeable.Accordingly,sinceone of the maincauses ofenvironmental pollutionin the worldand especiallyin our country, is fossil energyconsumptionintheresidentialspace, therefore, using two-shelled facade will cause to reduce air pollution in the building due tothe use ofrenewable energies (the wind and solar energy).

11. Conclusion

With the development of modern architecture and the increasing use of fossil energies that are causing economical and environmental problems, using smart materials especially materials such as two-shelled facades in the buildings that have the ability to adapt to environmental conditions is a suitable solution. The technique of using two-shelled facade in modern buildings especially in guilan can be an effective step to reduce cooling and heating costs and has a very important role in saving in fuel consumption. The findings of this article have been presented in a table based on an (swot) analysis that is as follow:

Table 3
Swot.

Threats (T)	Opportunities (O)	Weaknesses (W)	Strengths (S)
Using visual barriers (curtain and awning and …) due to incompatibility with local and cultural issues	Reducing running costs for energy	----------	Using frameless windows in order to conduct a more natural energy such as sunlight deep into the building
----------	Reducing the cooling load of the ventilation devices	----------	No need for air conditioning systems
----------	Light control Considering the amount of light needed and the ability to use and control temperature in different seasons	High initial cost and returning the costs in a long time	Adjustable amount of light, light and heat sensitivity and passing the glass manually or automatically
----------	Using stored energy in the windows at different hours of the day and preventing the loss of energy	Having high costs compared to conventional windows	Providing thermal comfort situation in the building using less energy and no need to electric energy and preventing solar heat to warm the building at the warm times of the year
Installation of bad awning devices or excessive ventilation ofintervening space can cause to increase noise pollution	----------	Having high costs because of installing sound insulations andseparating devices to prevent sound transmission while the window is open for natural ventilation	Noise load adjustment in reducing the level of sound pressure from outside to inside of the building can help significantly and is effective on its efficiency

References

Babolhvayejy, N., Mirzade, B., 2011. The effect of two-shelled facade on energy saving in buildings, Second National Conference on Stable Architecture. Sama Educat. Cultur. Center, Hamadan.

Basiri, H., Noori, N., 2012. two-shelled facade in glass facade as a new approach in architecture shells. First Nat. Confer. New Ideas Technolog. Arch., Tabriz,pp.397.

Belgian Building Research Institute (BBRI)., 2002. Source book for a better understanding of conceptual and operational aspects of active facades. Department of Building Physics, Indoor Climate and Building Services. Belg. Build. Res. Inst., Version No 1.

Ghanbari, S., Sharif KhajePasha, S., 2012. Modeling from local architecture in designing of residential buildings in Gillan. First Nat. Confer. New Ideas Technolog. Arch., Tabriz.

Hashemi, N., Fayaz, R., Sarshar, M., 2010. Thermal behavior of a ventilated double skin facade in hot arid climate. Ener. Build., 42, pp. 1823–1832.

Kalantar, V., 2009. Saving in energy consumption for heating and cooling buildings by replacing of renewable energies. Sev. Nat. Ener. Confer., pp.1

Kasmaei, M., 2010. Climate and Architecture, Isfahan. nashrekhak publicat., sixth print,pp,12.

Khakpour, M., 2007. Architecture of houses in Guilan, Rasht, Iliya Encyclopedia, Encycloped. Culture Civilizat., pp.18-64.

Medy, H., Fazli, M., 2013. Evaluating strategies to reduce energy consumption and its impacts on the environment in the building", First National Conference on Architecture, Urban. Stable Env. , Hamadan.

Oesterle, L., Lutz, H., 2002. Double Skin Facades, integrated planning. British library document supply centre.

Poirazis., 2004. Double Skin Façades for Office Buildings. Divis. Ener. Build. Des..

Poriazis, H., 2004. Double skin Facades for office Buildings. literat. rev., Volume4, Issue3 of Report EBDR.

Rashidi, A., Sharifi, M., 2009. Study of the role of two-shelled facades on reducing energy consumption. First Confer. Stable Arch., Sama Techn. Profess. Colleg., Hamadan.

Saelens, D., 2002. Energy Performance Assessments of single Storey Multiple-skin Facades.PhDthesis,Laboratory for Building Physis. Depa Civ. Eng. Cathol. Univ. Leuven., Belgium.

Shahriyari, S., Karimzade, A., 2011. facades two-shelled facades, a new approach towards efficient use of energy. Second Nat. Confer. Stable Arch. Sama Educat. Cultur. Center, Hamadan.

Spenani, A., 2004. Climatologic Capabilities of Local Architecture, Peyk-E-Nour, Second year., number two,No. 84.

Torkjazy, M., 2012. two-shelled facades, a new technology in architecture and building industry. First Nat. Confer. New Ideas Technolog. Arch., Tabriz.

Uuttu, S., 2001. Study of Current Structures in Double-Skin Facades. MSc thesis in Structural Engineering and Building Physics. Dep. Civ. Env. Eng., Hels. Univ. Technol., (HUT),Finland.