

# Ecological Building Design Criteria: A Case Study in Ankara

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## ABSTRACT

Buildings cause environmental impacts through their life cycles. Ecological building design criteria, which appeared to decrease these impacts, aim to make designs sensitive to environmental problems, to protect the ecological balance, and to fulfill the required comfort and health conditions. In the context of this paper, ecological building design criteria were determined in global scale as energy conservation, water conservation, material conservation, and livable design, and applications of these criteria were described. Later on, Ankara City located in the middle Anatolian region of Turkey was selected as working area, and the applicability of the ecological building design criteria in the selected area have been identified. An ecological building was designed in Gazi University Campus in Ankara, and the design was examined according to the presented ecological building design criteria.

**Keywords:** *Ecology, Ecological Building, Ecological Building Design, Solar House*

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## 1. INTRODUCTION

Population growth, urbanization and pollution threatening natural resources because of the developing industry have become the most important problems of the humanity. The starting point of the studies aimed at protecting environment and solving environmental problems is to know and recognize the problems [1]. The building sector, including housing, comprises 30 to 40% of the world's total energy demand and approximately 44% of total material use [2]. Similarly, green house gases causing global warming result mostly from the building sector [3]. Therefore, ecological building design has gain importance recently.

## 2. ECOLOGICAL BUILDING DESIGN CRITERIA

Ecology is a science which analyzes the relationships of organisms with their environment and each other and which consists of sub-branches [4]. Ecological building design includes building designs containing building materials which respect environment, reduce energy consumption to minimum, use local and renewable resources instead of natural resources, create healthy indoors, use solar energy, natural ventilation and natural lighting, and which are reusable, recyclable and maintenance-free [5-6]. Buildings have adverse effects on environment during their lifetimes, since construction till demolition [7]. In order to reduce these effects, ecological building design criteria should be adopted in designing the buildings.

The aims of ecological building design are to reduce energy, maintenance and repair costs, illnesses related to buildings, to reduce waste and contamination and to increase the efficiency of building materials, building

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comfort and the resistance and flexibility of the building and its components [8].

Within this concept, designers should adopt as a principle to create designs containing building materials which respect environment, reduce energy consumption to minimum, use local and renewable resources instead of natural resources, create healthy indoors, use solar energy, natural ventilation and natural lighting, which

are suitable for physical environment conditions, which increase the level of energy conservation on the building skin and which are reusable, recyclable and maintenance-free [9]. Ecological building design criteria should be categorized as energy conservation, water conservation, material conservation and livable design. These criteria are presented in Figure 1.

ECOLOGICAL BUILDING DESIGN CRITERIA	<b>ENERGY CONSERVATION</b>
	Use of renewable energy resources Consideration of physical environmental data Energy-conscious building shape design Energy-conscious building envelope selection Energy-conscious landscape design
	<b>WATER CONSERVATION</b>
	Reduce of water consumption Reuse of water Use of water without contaminating Protecting water levels
	<b>MATERIAL CONSERVATION</b>
	Material conserving design Appropriate building material selection
	<b>LIVABLE DESIGN</b>
	Preservation of natural conditions Urban design Design for human comfort Becoming environmentally conscious

Figure 1. Ecological building design criteria

## 2.1. Energy Conservation

The use of energy resources starts during the mining and producing these sources and continues during the construction and utilization phase of the building. The energy consumed for heating, ventilation, lighting and fitting during the utilization phase of the buildings does harm to the ecosystem [10]. It is impossible to regenerate the consumed energy. Thus, methods which provide energy conservation should be used. Energy conservation might be provided by some methods such as use of renewable energy resources, consideration of physical environmental data, energy-conscious building shape design, energy-conscious building envelope selection, and energy-conscious landscape design.

Utilization of renewable energy resources: Providing energy from local resources by using renewable energy sources helps solving the environmental problems. Nowadays, geothermal energy, water, solar energy and wind power, which are environment-friendly, easily acquired, renewable energy resources, have been used in buildings in different ways [11]. While utilizing renewable energy resources, two systems –passive and active– are used [4]. Passive systems are design

measures taken in order to utilize the solar energy. Thanks to these measures, heating and cooling costs can be considerably reduced and energy conservation can be provided. Active systems work through mechanic equipments integrated into the building for acquiring electrical and thermal energy from renewable energy resources such as solar and wind.

Consideration of physical environmental data: Physical environmental data are selection of location and direction, topography, biodiversity (flora and fauna), wind and climate [11]. The main principle in selecting location and direction of the building should be to utilize solar radiation in winters and to be protected from excessive sun lights in summers [3]. Such criteria as determining the positions of the buildings according to each other, constructing roads in deference to the prevailing wind, arranging green fields as a balancing element for climatic factors, taking general settlement decisions according to the directions are very important in terms of creating natural micro-climate at the desired level and energy conservation [12-13].

Energy-conscious building shape design: Building shape could be defined via constructional geometric variables

like shape, building height, roof type and pitch, pitch of the face. In parallel with the form and organization of these variables, through natural heating and cooling, heat loss of the building can be reduced. The size of the building lot which affects the building shape is directly related to heat losses [4]. Small-scale buildings which have simple geometric shape and use indoors efficiently have lesser problems with the environment. These buildings need less resource in the construction phase and less energy in the utilization phase and thus reduce heat losses. As these buildings produce less waste in the demolition phase, negative environmental effects decrease [7].

**Energy-conscious building envelope selection:** The structure composed by the building materials which break off indoor and outdoor in buildings is defined as "building skin" [14]. The building skin is one of the important elements increasing the level of thermal comfort. In ecological designs, it is recommended to limit the gaps in the building skin to 40%. Thermal comfort could be provided in winters by preventing the air heated inside the building to pop out and in summers by preventing the hot air outside to move in. At the same time, it is required to implement heat insulation on the exterior surface and windows of the building [15]. As heat insulated walls increase the level of thermal conservation of the building, it leads heat losses to reduce [16]. For the heat insulation materials to meet the desired performance, their porosity should be high, density should be low, water absorption rate should be low and they should have both insulation feature and some features like humectancy, incombustibility, lightness, practicability and resistance to corrosion [17].

The main source of heat losses is sun light and windows, the building elements which provide visual communication. In climates in which heating is important, windows should have such features as low heat loss and condensation, air tightness and acquiring hot surface [4]. In order to maintain thermal comfort inside the building, according to the direction of the building, high-performance windows preventing heat losses should be used [7].

**Energy-conscious landscape design:** In heating and cooling the buildings, energy consumption could be reduced by using several herbs. Using trees and bushes in the west and northwest facade of the buildings prevents the undesired setting sun to enter into the building [7]. By placing deciduous trees in the south facade and evergreen plants in the north facade of the building, we can utilize the winter sun and be protected from the cold winter winds [4].

In designing roofage, green roof consisted of soil, plants and edible landscape [18] should be preferred. Green roofs reduce the temperature in the settlements, disburden waste water systems by retaining rain water, decrease air pollution, store the carbon gas, protect the materials under top roofage from the negative effects of the sun and therefore help these materials be more long lasting and enduring. Green roofs creating natural living space for birds and other creatures have more aesthetic

outlook than conventional roofs. In green roof designs, the area of the building is regained [4].

## 2.2. Water Conservation

Maintaining water conservation is one of the most important features of the ecological buildings [4]. Reduction in water consumption provides a fall in wastes, too [7]. Water conservation might be provided by some methods such as reduce of water consumption, reuse of water, use of water without contaminating, and protecting water levels.

**Reduce of water consumption:** To reduce water consumption and thus the amount of waste water, waterworks and tools which use water efficiently should be preferred. Showerheads, taps, anhydrite, vacuumed and compost closets help to reduce water consumption. Compost closets suitable both for houses and commercial use reduce the burden of the sewerage system in the land [7]. In landscaping, using the herbs that need little water or peculiar to that region is an effective method reducing water consumption. Nature compatible plant design and maintenance can provide water conservation up to an amount of 50% [17]. Especially in the regions whose annual rainfall amount is low, using regional xerotolerant plants needing little water and installing an irrigation system will reduce water consumption [7].

**Reuse of water:** Reuse of waste water in the buildings for such purposes as irrigation, cooling, toilet cleaning and fire extinction besides as drinking water has become an ecological approach providing water conservation. However, the quality of the transformed water should be searched and it should continuously be controlled if it has any harmful effects [4]. The buildings produce two types of waste water: grey and black water. Grey water generally includes the ones coming from washing machines, showers, baths and kitchen taps. There are hair, soap, slough, detergent, oil, food particles, cosmetics and other house chemicals in it. Black water comes from the toilet. This water need to be biologically processed in the sewage or septic tank through ecological solutions [19]. To be able to be used in irrigation, grey waters should be separated from black waters. In the buildings to newly build, separate plumbings can be installed for both type of waste water; but it is hard to install a system which will separate these waters in the existing buildings. Retaining rain waters and reusing them in convenient places benefit to water conservation. The quality of rain water could differ according to its closeness to high level pollution sources. However, its quality is generally high and helpful for water installation. The mildness of rain water increases the power of cleaning. Besides, as the acidity of rain water is helpful for the soil with high PH value, it could be seen as the best water source for plants. The system to retain rain water should be designed in compliance with the amount of the annual rainfall of that region and usage purpose of the water to be retained [7].

**Use of water without contaminating:** Ecological buildings could provide water conservation by selecting the plants accommodated themselves to the conditions

of that region. As this type of plants is resistant to harmful insects, they remove the need of using pesticides which causes water pollution. Such methods as infiltrating and retaining rain waters in water pools, constituting wetted areas and implementing permeable pavements increase the water quality. In houses, researching alternative cleaning agents which do not cause water pollution and preferring to use them will very effective [7].

Protection of water levels: Using sewerage system in moving rain waters out of the settlements is a widely used method. But the approaches which provide these waters to transfer into the permeable bed bearing ground waters instead of the sewerage are more ecological solutions. Thereby, groundwater levels will be protected and it will still be possible to reuse them and by disburdening sewerage system floods will be prevented. In order to protect the groundwater levels, waters can be permitted to merge into ground waters again through an effective design of rain water permeability. Therefore, it is important to avoid using impermeable materials in paving of cart ways and pedways, to use less thick, permeable materials and to protect open fields [4].

### 2.3. Material Conservation

Material conservation might be provided by some methods such as material conserving design and appropriate building material selection.

Material conserving design: Because of the size and the various materials of the building which is the architectural product, the possibility of reusing waste building materials as recyclable is so limited. At this framework, the construction and the materials should be made with healthy materials suitable for human nature, not industrial building materials which include poisonous substances. Natural materials whose synthetic admixture is none or at the minimum level such as field stone, wood, wood fiber, clay, straw, rush mat, flax, hemp, reed are totally recyclable and reusable materials. Such materials as construction panels manufactured from hay bales or thermic insulation panels keep energy consumption at an economical level and they are completely healthy as there is no byproduct or poisonous product in them [12].

Appropriate building material selection: Material selection in ecological designs is the most important feature of the design in terms of its compliance with ecological criteria. At the first stage, the selection of natural building materials which don't do harm to the nature might come to mind. However, ecological design includes the selection of natural and nature conscious materials. It is possible that scarce natural resources could get harm in selecting these materials. At this point, the selection of nature conscious artificial materials has gained priority. The respect of artificial materials for nature depends on a series of criteria. These are enduring materials whose maintenance cost is low, materials including substances which will do little harm to the nature in the production phase, nature conscious materials in the construction, utilization and demolition phases of the building and materials that can be used as

recyclable especially after the demolition of the building.

### 2.4. Livable Design

The main objective of the building sector is to produce artificial environments in order to provide the security, health, physiological comfort, psychological needs and productivity of the users. In these artificial environments, human beings, other living and non-living beings have to live together. Therefore, in designing habitable places, it is important to find solutions providing the buildings to subsist with the environment and users [20].

Preservation of natural conditions: In ecological building design, solutions should be oriented to conserve the topographic structure of the land, ground and aboveground water levels, existing vegetation cover and aquatic/terrestrial creatures. Designs involving solutions inconsistent with the topographic structure of the land are not economical and could do harm to the micro-air conditioning of the land as they affect the flow of the water and the wind [21]. Excavating under the local water level, positioning the building in a way hindering the water level and interfering in the water level during the construction phase might harm the natural process and also the water above the soil might cause pollution [22].

Urban design: Ecological design in urban design should be handled at the urban scale which is a larger scale than buildings. In designing cities, methods to be implemented should aim not to interfere in the features of the local environment, to conserve energy and water, to create mixed-functional designs, to reduce the use of private cars and instead to popularize public transportation [23].

Design for human comfort: People spend 70% of their lifetimes indoors [24]. Thus, in ecological building design, methods aiming to preserve human health indoors, to increase the indoor air quality and to improve comfort conditions should be implemented.

Becoming environmentally conscious: The most prominent factor in conveying ecological building design criteria and theoretical data into practice is that the public is aware of them and they understand and embrace the importance, benefit and necessity of them. In this type of designs which focus on making building-environment and building-user live in harmony, the main role of the designer should be creating building areas that increase the security, health, psychological comfort and welfare and productivity of the users and should be taking environmental values into consideration. Feeling the advantages of an ecological building by living inside of that building is one of the most impressive ways of raising environmental awareness in the public. As a result of spreading this awareness in the public, the desires of the users will change in this direction and designers will start to give priority to ecological building design criteria in their design decisions.

While designers support increasing environmental awareness with sample buildings, educational institutions can increase the enlightenment on this issue through lectures, courses, seminars, conferences. Besides, the attitudes and efforts of government officials on this matter are very important. When we analyze the countries where the ecological consciousness has developed, the contributions, incentives, laws and regulations of the environment-conscious government are observed [7].

### 3. AN ECOLOGICAL BUILDING DESIGN

The numbers of ecological designs in the world has been rapidly increasing. In parallel of this increase, in Turkey, especially universities start several applications on this matter. In Turkey, since 1980 till now, ecological buildings which have different usage areas, different numbers of floors and different functions have been designed. The examples of these ecological buildings in Turkey can be listed as METU Solar House (ODTÜ Güneş Evi), Ege University Institute of Solar Energy (Ege Üniversitesi Güneş Enerjisi Enstitüsü), TÜBİTAK National Observatory (TÜBİTAK Ulusal Gözlemevi), Energy Efficiency Training Association (Enerji Verimliliği Eğitim Tesisi), Pamukkale University Clean Energy House (Pamukkale Üniversitesi Temiz Enerji Evi), Diyarbakır Solar House (Diyarbakır Güneş Evi). With the purpose of contributing to add a new one to these designs and increasing the number of ecological building samples in Turkey, in this article, a sample ecological building has been designed in Ankara located in the Central Anatolian Region.

Ankara is a city which has intense environmental problems caused by industrialization and housing. The most prominent adverse consequence of the growing population due to industrialization in Ankara is the growing need for accommodation. This need mostly causes unplanned housing which consists of unfit and of poor quality dwellings in the area. The principal reason of environmental pollution in Ankara is dense, unfit and non-standard housing. In most of the buildings, even minimum comfort requirements are not able to be met and only the buildings which can meet only the need of accommodation are constructed [1]. Therefore, it is gaining importance to adopt the criteria of ecological building design providing solutions to decrease the environmental problems caused by buildings in Ankara and to implement them by paying attention to the physical environment conditions of Ankara.

The climate of Ankara is hot and dry in summers and cold and rainy/snowy in winters. In summer months, the region receives hardly ever rain and the relative humidity is low. Some parts of the large territory of the city of Ankara differ from each other in terms of climate. In the south, steppe climate which is the characteristic of the Central Anatolian Region and in the north, the features of mildness and rainfall of the Black Sea Climate could be observed. The hottest months are July and August and the coldest month is January. According to the annual averages, Ankara receives sunlight for averagely 7,4 hours in a day. In the months of March and April, the city gets high winds. The

direction of the prevailing wind which differs depending upon the topographic structure of Ankara in its separate counties, is northeast in Yenimahalle and its average speed is 3,2 m/sec [1].

In this article, Gazi University Campus, which is located within the boundaries of Yenimahalle district in Ankara Province in the Central Anatolia Region, was selected as the design area. The campus is located in an area surrounded by the roads those have heavy traffic as demonstrated in Figure 1.



○ The status of the design area in Ankara

Figure 1. The satellite image of Gazi University Campus in Ankara [25]

In Gazi University, there is no sample building which will enable qualitative and quantitative measurements and surveillances related to the ecological performance of the buildings be made practically on-site and will stand as data for using simulation programs. The designed sample building will contribute to the solution of this problem, too. There is an inactive, functionless and empty land with no green fields located behind the ateliers and laboratories of the Construction Education Department, Technical Education Faculty, Gazi University. This land has been selected as the appropriate design area for the sample building design. Design decisions have been taken considering the physical environment conditions of this area selected in the designing process of the building. Figure 2 is the satellite image of Technical Education Faculty in Gazi University Campus and demonstrates the selected design area.



■ The projected sample ecological building [25]

Figure 2. The satellite image of Technical Education Faculty in Gazi University Campus

### 3.1. Designing Process and Design Decisions Related to the Ecological Building Design Criteria

The designing process of the building is the process when building decisions are taken thoroughly, within the framework of the taken decisions building design and practice are realized and the building is put into service. The designing process which affects the formation of

physical and social environment consists of planning, programming, designing, practice and utilization.

When this process is handled as a system, the decisions taken at each stage of the system constitute data for the next stage. In each stage, there are some criteria to be considered. One of these criteria is ecological building design criteria. Ecological building design includes building designs containing building materials which respect environment, reduce energy consumption to minimum, use local and renewable resources instead of natural resources, create healthy indoors, use solar energy, natural ventilation and natural lighting, and which are reusable, recyclable and maintenance-free [26]. In order to realize ecological building design criteria defined in Section 2, we need to take correct decisions at the beginning of the design. Within this concept, in order to realize ecological building design, firstly design decisions related to the ecological building design criteria, the building function, and then the selection of material and structure were taken.

Ecological building design criteria can be listed as energy conservation, water conservation, material conservation and livable design as declared in Section 2. The design decisions for the sample ecological building related to the ecological building design criteria are presented in Table 1.

Table 1. Matrix of design decisions related to the ecological building design criteria

ECOLOGICAL BUILDING DESIGN CRITERIA		DESIGN DECISIONS
ENERGY CONSERVATION	Use of renewable energy resources	Use of photovoltaic
		Use of geothermal energy for heating and cooling
		Use of passive solar systems
		Prevention of heat loss
		Use of wind energy for ventilation and cooling
		Use of daylight for lighting
		Use of solar collectors for heating
		Selection of energy-conscious lighting equipment
	Consideration of physical environmental data	Proper directing of the building
		Selection of the proper area for settlement
	Making arrangements that reduce car addiction	Constructing roads that provide pedestrian and cycling transportation and circulation in the building lot
		Integrate design with public transportation
	Energy-conscious building shape design	Use of simple geometrical forms
		Efficient use of interior spaces
		Making the building lie in the east-west direction
Increasing solar savings fraction by enlarging the southern facade		
Energy-conscious building envelope selection	Decrease of building envelope surface	
	Selection of efficient isolation materials	
	Use of high performance joinery and glass	
Energy-conscious landscape design	Use of plants for heating and cooling	
	Use of green roof applications with edible landscape	
ER CONS ERVA Reduce of water consumption	Implementing landscape that needs little maintenance and uses the water efficiently	
	Using xerotolerant plants with little water need	

		Using plumbing which runs water efficiently
	Reuse of water	Using plumbing which enables rain water to be retained and reused
		Recycling of grey water
MATERIAL CONSERVATION	Material conserving design	Decrease of building envelope surface
		Use of simple geometrical forms
		Efficient use of interior spaces
		Reuse of existing buildings and infrastructure
	Appropriate building material selection	Use of building materials and components with long life and low maintenance
		Use of recycled building materials and components
		Use of building materials and components made from renewable sources
		Use of recycled materials for packaging of the building materials
		Use of local and regional building materials
LIVABLE DESIGN	Preservation of natural conditions	Preservation of existing flora and fauna
		Respect of topographical contours
		Protection of habitat
		Preservation of water table
		Repairing and reusing existing structures/infrastructures within the framework of ecological criteria
		Avoiding building materials during whose production the substances upsetting the balances are used
	Urban Design	Reducing pollution
		Promote mixed use development
		Reducing use of private cars via pedestrian and cycling transportation and circulation in the building lot
	Design for human comfort	Using water-based natural materials instead of synthetic based dye
		Using indoors wooden materials which were dried naturally and do not contain preservatives
		For the walls of the building not to moistened, building basements as high as needed and protecting it with eaves
		Forming proper comfort conditions indoors
		Maintaining sufficient air stream indoors
	Becoming environmentally conscious	Experiencing the harmony of the building with the environment via sample buildings
		Preparing promotional and seminar presentations that describe users the relationship between the building and the environment after the construction
		Making arrangements which enable experimental studies inside of the sample building in order to draw attention to the issue

After taking the design decisions related to the ecological building design criteria, design decisions related to the building function, and the selection of material and structure were taken.

### 3.2. Design Decisions related to the Building Function

It is decided to give the function of an “environmental research and training laboratory” to the designed

building. The main function of the building is “ecological building demonstration office” as it is a model one. The building consists of a research laboratory to make researches about the ecological performances of buildings and to use simulation programs; a training laboratory to exhibit and introduce the ecological building materials; a meeting hall to organize training and introduction seminars; two offices to use as workrooms; a system room and a WC. The design decisions related to the building function are presented in Table 2.

Table 2. Matrix of Design Decisions related to the Building Function

BUILDING FUNCTION	DESIGN DECISIONS
Ecological Building Demonstration Office	Implementing ecological building design criteria as much as possible in the design
Research Laboratory	Designing a laboratory where researches related to the ecological performance of the buildings can be conducted and simulation programs can be used
Training Laboratory	Designing a laboratory where ecological building materials could be demonstrated and promoted
Office	Planning independent places to be used as an office when needed
Meeting Hall	Creating places suitable for seminars and scientific meetings

The design decisions taken related to the building function will enable us to experience the harmony of the building with the environment and to measure / assess the ecological performance of the ecological buildings through sample building, RD (Research and Development) studies on environmental issues, related undergraduate and master lectures, promotion of ecological materials, training seminars and courses. At the same time, it will be seen as a guide for the ecological building design process and constitute a source of information for new ecological building designs in Ankara.

### 3.3. Design Decisions related to Material and Structure Selection

It is decided to design the building with concrete masonry system and ecological building materials. It is deemed suitable to use gas concrete in the walls as it is thought that it will be more ecologically advantageous. Gas concrete is an inflammable material providing energy conservation in the production phase and heat insulation. It protects other materials during the fire and reduces the cost of the damage that the fire do. Using waste material in the production of gas concrete contributes to the protection of the ecological balance.

As 80% of its volume consists of holes, it provides more production with fewer raw materials. Waste materials outcropped especially during its shearing in the production process are totally recyclable. Gas-emissions in its production are lower than other building materials with similar production purposes [9].

Gas concrete has the feature of heat insulation and provides qualified insulation due to its porous structure. However, with the purpose of better insulation and energy conservation, it is decided to implement an additional insulation on the building. Extrude polystyrene foam and ecological insulation plaster has been used on the exterior facade.

In order to utilize the solar power passively, a solar room in which low-e coated windows are used has been designed in the southern facade of the building. The material of the heat storing wall in the solar room is the same with the material of the other walls and its exterior has been painted black for more radiation gain. It is aimed to transfer the heated air inside of the room into indoors through air ducts and to transfer the cool air indoors into the solar room again through the ducts

in the lower part. Furthermore, it is thought that the vacuum impact of the solar room will provide natural ventilation.

In windows, window systems with low U-value and heat gain coefficient and with high glass visibility have been decided to be used. In this way, it is planned to reduce energy consumption by decreasing the problem of heating and lighting.

Natural timber has been preferred as the flooring material and it is decided to colorize the timber with non-poisonous dyes. Also, it is projected to conduct insulation under the flooring with extrude polystyrene foam. It is preferred to use ecological materials like ceramics glazed tiles and made from such natural materials as clay and sand in wet floors.

It is settled to use green roof as the roofage. Through green roofs conserving energy and reducing heat gain and loss in the building, roofs which are not used apart from its cover purpose could be utilized effectively. Green roofs enable natural habitat to grow and prolong the lifetimes of the roof systems by protecting them from high temperatures. When the temperature reaches to 35°C in summer in hot climates, the temperature of the roof surface reaches to 65°C. These high temperatures directly affect the interior and exterior vicinity of the building. When the roof is protected by a layer of soil and shadowed by the plants, surface temperature usually does not come up above the air temperature in the vicinity. Besides, plants and soil make the water evaporate and create a cooling effect, moisten the air, make people breathe more easily and cool the building in a natural manner. In winter, the layer of soil provides an additional insulation [27].

### 3.4. Configuration of the building and the building elements

In this section, the configuration of the building elements, and the building, which is decided to be designed as “environmental research and training laboratory”, has been determined. On condition that we don't make concession of the naturalness and structural unity in parallel with the needs, it is decided to design a small-scale building which has simple geometric shapes and uses indoors efficiently. Thus, the building will have rectangular building form and an area of totally 140 m<sup>2</sup> - 98 m<sup>2</sup> for the ground floor and 42 m<sup>2</sup>



for the mezzanine. Ground floor plan and mezzanine plan of the ecological building are presented in Figure 2 and in Figure 3.

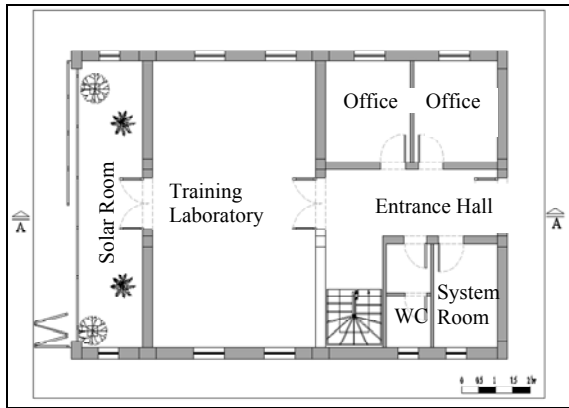


Figure 2. Ground floor plan

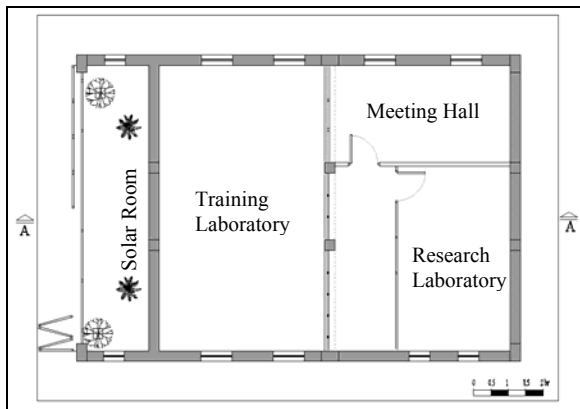


Figure 3. Mezzanine plan

The direction in which sun lights are the most active in Ankara is the directions inside the angle set by the south, its 30° east and 30° west. So, it is suitable to position the capacities of the buildings mostly used in daily life into the south and the directions inside the mentioned angle. It is decided to position the solar room of the building into the south.

It is agreed to use “geothermal heat pump” in the building for conserving energy. Because the heat is stable under the ground after a certain depth for a whole year, using vertical heat pumps is thought to be more feasible and water is selected as the geothermal fluid. It is planned to transfer the fluid into the building through pipes located 3m under the ground and then through the same pipes into the underground. Pipes will be connected to the system room and the fluid will circulate inside the building via the pipes crossed under the floor. By this way, the burden of cooling in summers and heating in winters will be lighted.

It is planned to use “solar collectors” in order to acquire hot water and to use “photovoltaics” to generate electricity. It is planned to store the hot water acquired from the solar collectors situated on the roof in insulated tanks and to provide water at the needed

temperature via the heat exchanger control unit inside the tank. Moreover, the taps and flushes in wet floors will be selected from the types that use water efficiently.

It is settled to cover indoors with light colors for the purpose of reducing the need for artificial lighting, preventing the light to be absorbed and creating more luminous places. Besides, it is considered that energy could be conserved by using automat systems. To lessen the burden of lighting, we have utilized from windows, placed windows especially on the east and west facades and designed a dormer window.

It is agreed to use “green roof” with 23% slope whose advantages have been described in the Section 3.1.3 as the roofage. Thus, it is projected to retain rain waters and to regain the area of the building. It is thought that rain waters could be retained in the water tank located near the building and the retained water could be used in the flushes and garden irrigation. As green roof provides shade and contributes to evaporation, it will help to reduce the temperature in the settlement. Roof plan, sections and facades of the ecological building are presented in Figure 4 and in Figure 5.

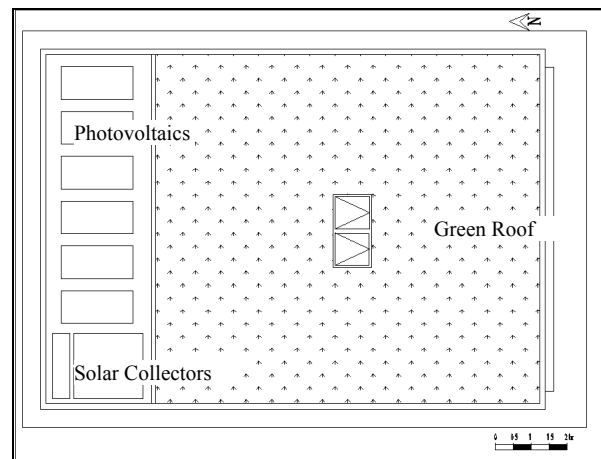


Figure 4. Roof plan

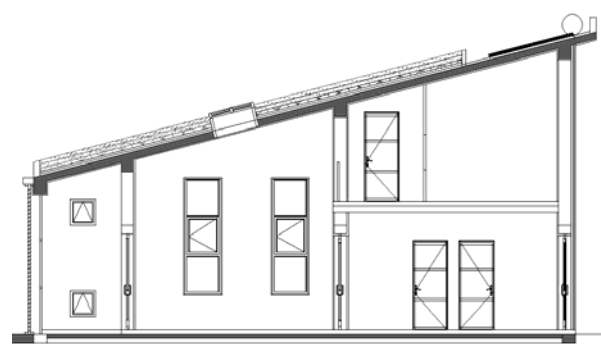


Figure 5. Section A-A

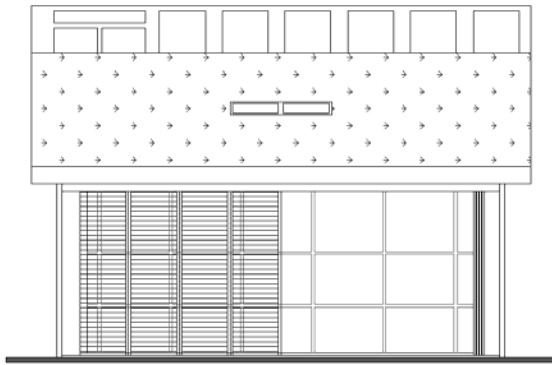


Figure 6. South facade

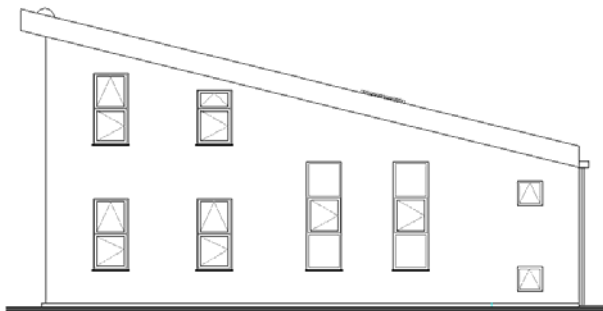


Figure 7. West facade

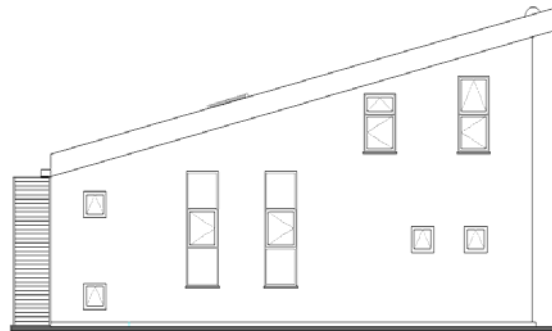


Figure 8. East facade

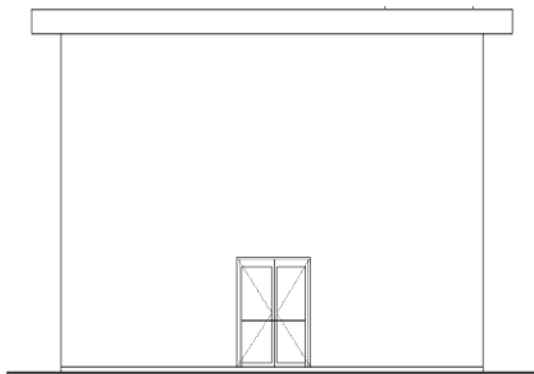


Figure 9. North facade

Passive heating will be provided by adding a “solar room” into the south facade of the building. The colors and the equipment structure of the walls are important for collecting solar energy at the highest level. So, gas concrete has been selected as the collecting element and it has been decided to paint this element black. In order to transfer the heat into indoors more rapidly, little “culverts” have been designed on the wall separating the solar room and indoors at the bottom and the top.

“Natural ventilation” has been projected by taking air from the holes in the lower elevations, providing natural air circulation among the places and verticals and venting the heated air from the holes in the upper elevations. An indoor corridor has been designed in the north-south direction and doors and windows in the section opening to the corridor have been positioned facing one another. Therefore it is considered that natural air circulation will be realized when the doors and windows are opened.

A specially designed “wooden louver” which can move vertically and horizontally will be used in order to prevent heat losses of the windows in the solar room and to avoid from the sun when intended (See Figure 6 and 8).

We have paid attention to arranging small roads produced by permeable materials for ped walks which do not prevent rain waters to leak into the subsurface for the conservation of groundwater levels and avoiding ornament plants that need water. It is decided to make landscaping which could contribute to the building to realize its function in the building lot and it is planned to grow new types of trees with different features as there are no trees in the vicinity of the building. It is decided to grow deciduous trees in the south facade and ever-green trees in the north facade.

In this way, the trees in the south facade will both provide shade with its leaves in summer and enable utilizing sun lights as they defoliate. The trees in the north will lessen the burden of heating in winter by reducing the impact of the wind with their leaves and branches. It is deemed suitable to plant pine trees that can be naturally grown in Ankara in the north and such trees as juniper and oak in the south.

#### 4. CONCLUSION

Within the framework of this study, a sample building which will enable qualitative and quantitative measurements and surveillances related to the ecological performance of the buildings be made practically on-site, and will stand as data for using simulation programs has been designed in Gazi University Campus.

The most important feature of the building designed with the function of environmental research and training laboratory is being a sample ecological building design which uses ecological building design criteria all together as much as possible. Thanks to these features, it has gained the function of being “ecological building promotion office” at the same time.

The design decisions taken related to the building function will enable us to experience the harmony of the building

with the environment and to measure / assess the ecological performance of the ecological buildings through sample building, RD studies on environmental issues, related undergraduate and master lectures, promotion of ecological materials, training seminars and courses. At the same time, it will be seen as a guide for the ecological building design process and constitute a source of information for new ecological building designs in Ankara.

Data acquired from this type of building designed at a small-scale will be a guide for new bigger-scaled buildings with general usage. To popularize the ecological building design criteria at the local and global scale, the relations fictionalized in this study should be taken into consideration and adopted as an architectural design approach by the designers. At the same time, this approach should be supported with scientific researches, training programs, laws and regulations. While designers support increasing environmental awareness with sample buildings, educational institutions should increase the enlightenment on this issue through lectures, courses, seminars, conferences.

While there are several ecological building applications in Turkey, they are not sufficient in quality and quantity. The number of this type of applications launched by universities should be increased, different scientific studies should be conducted on this issue and public and private sector should give financial support to these projects.

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