CLIMATE RESPONSIVE RESIDENTIAL BUILDING DESIGN IN TURKEY - A CASE STUDY

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Abstract
Passive elements could be considered the best when designing a new energy efficient building. Many "Energy Efficient" and ''Climate Responsive" buildings with the use of the right design and green technologies considerable have been developed. The technologies employed in sustainability or green building are constantly evolving and may differ from region to region, but, fundamental principles persist from which the method is derived (U.S. EPA, 2010 ; WBDG, 2009). This paper is based on a researching project which analyzed a residential building and its settlement designed by author as suitable for warm and humid climate region conditions and with fundamental principles of climate responsive buildings. The study tries to determine the potential of thermal comfort improvements by analyzing of the potential of natural ventilation and sun on designed building and settlement in Adana. For this purpose, a residential model were developed and some sustainable design recommendations for residential buildings in warm and humid climate regions were then introduced.

Keywords : Environmental Sustainability, Passive Design, Climate Responsive Design, Residential Building Design, Turkey.

1. Introduction

'Passive architecture' has the great advantage in that it requires no external energy source and therefore has neither a running cost nor does it contribute to environmental pollution. Such features can enhance the visual appearance of a building and will help to preserve its fabric (Szuppinger, 2011, 3). Therefore, passive elements could be considered the best when designing a new energy efficient building. It is a key component of the 21st century's green economic revolution (Bere, 2014). Many ''Energy Efficient" and ''Climate Responsive" buildings with the use of the right design and green technologies considerable have been developed (U.S. EPA, 2010 ; WBDG, 2009).
"...Good design is a key aspect of sustainable development, is indivisible from good planning, and should contribute positively to making places better for people ..." (NPPF*, 2012, 1).*

"Climate-responsive" or passive design strategies (natural ventilation, daylighting, etc.) are hallmarks of sustainable. As temperatures and humidity levels rise, and as wind and precipitation patterns fluctuate, climate-responsive buildings may no longer respond as they were designed to do (buildinggreen.com). Optimizing passive design is the first step towards reducing the energy demand of a building or project. Initial site planning establishes the orientation, massing and location of the components and uses of a project, all of which impact and set the parameters for passive design strategies. The initial site planning of a project has significant impact towards achieving a green or high performance building. Things like the siting, massing and orientation of buildings set up the parameters and potential limitations for the later design process. These early stage design decisions are fundamental to optimizing passive design, determining the degree of site development and providing green or open space. In terms of passive design, these are the first steps in minimizing the building's energy demand, providing natural ventilation, daylight, shade, and thermal comfort. Allowing for natural and mechanical ventilation along with air-conditioning can significantly reduce energy use (BCA, 2010, 24,29).

Briefly, Design strategies should allow for optimal use of natural energy strategies (daylighting, natural ventilation, passive cooling, etc.) as well as integration of renewable energy devices (Haase, 2006, 3). Currently, a number various sustainable building, climate-balanced, including environmental, economic, and social benefits have been made. Nowadays, the number of Passive houses is rapidly growing across Austria, Germany and Switzerland. In January 2004, in Germany alone more than 4000 dwelling units have been built in a passive house standard (Antonova, A., 2010, 38). Similar initiatives are especially necessary for Turkey's cities ongoing rapid urbanization.

1.1. The Goal and Method of the Research

This study's aim is to mitigate the problems of climate balanced design that are necessary for a residential building in Adana. So, this paper analyzes the warm and humid climatic conditions in buildings and its energy conservation strategy. For this aim, a residential building with warm and humid climate design strategies was developed in Adana (Turkey) and the impact of location and climate, size and orientation on the thermal comfort was investigated on a model.

The steps of the design process are as follows ;

- analyzing the environmental issues faced by the people of Adana,
- examining climatic data collected from the "Meteorological Department for Adana",
- examining "Energy Performance Regulations (BEP-TR)" in the buildings,
-developing the sustainable strategies with the concepts of passive designs (which is used for heating, cooling, ventilating, daylighting etc.) for 'warm and humid climate regions',
- developing proposals with these strategies on where buildings are located (on available site in 'Çukurova University Campus'.
- creating sketches and drafts for pre-design, and then, various alternatives with 3D computer program,
- designing a residential building that is environmentally sustainable and creating 'a house model' to be sample for the whole city,
-developing sustainable house models for 1-2 person and 3-4 person families (for academicians),
-achieving creative design a changable modular system in settlement.

2. Study Area

In the study conducted with objectives described above was analyzed (in great depth particularly in relationship to residential buildings) the environmental issues ecological. The Adana, 4. capital city located southern of Turkey, was chosen as the study area. It has a population of 2.149.260 in the year 2013 and is the sixth most populous city in Turkey (adana.gov.tr).

Figure 1. Turkey and Adana City Map (Source: bing.com/images)

The buildings features of old city;
The old Adana is a historic city, located on the old tumulus (1500 yearly), and has some features as follows ;

- Architectural style arising with socio-cultural values and climatic factors is admitted an unique example,
- The orientation of the dwellings (Climate Balanced Design" or "Energy Efficient Design) are valuable samples for today's,
- These buildings show good examples of the use of natural, local building materials and are excellent models that will inspire today.

Figure 2. Views of the Old Adana City (Source; enguzelevler.com)

The current buildings features/issues developing towards the north of the old city ;

- There has been tremendous pressure on the housing environment caused by rapid and erroneous urbanization.

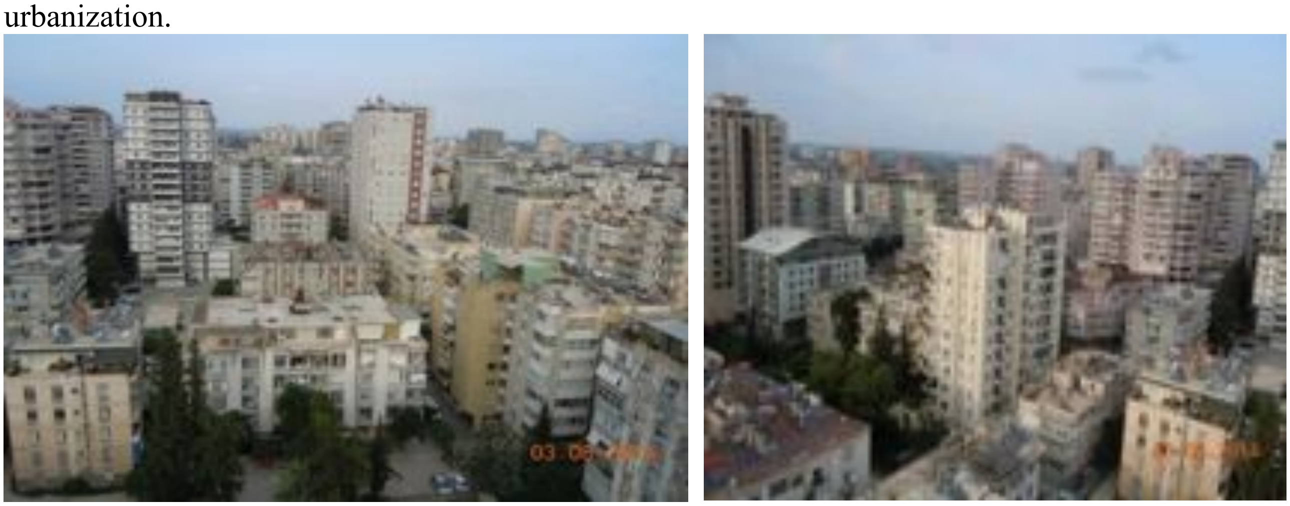


Figure 3. Views of the New Adana city (Photo; Çerçi, 2014)

- With the increasingly rapid growth of buildings, housing, the environment and in terms of other urban facilities has become essentially unsustainable.
- Mostly there are not natural light and air in residential interior and exterior spaces due to conflicting land use,
- Despite the ongoing urbanization in the city, urban development projects ecologically weren’t developed efficiently and were deprived of climate responsive design.

Figure 4. New settlement Areas at the ‘Seyhan’ River Side (Source; bing.com/images)

Figure 3 and **4** show us, new Adana which is the most developed region of the city with rapidly urbanizing as townscapes and villagescapes (density, livability and sustainability).

2.1 Climate Data

Turkey's different climate classifications are made. Widely accepted that Turkey has consisted of 4 main climatic characters. These climate zones are shown in the map (Figure 5).

Terrestrial / Continental Climate
Black Sea Climate
Mediterranean Climate
Marmara Climate

Figure 5. Turkey's Climate Zones (Source; mgm.gov.tr)

Adana has a typical Mediterranean climate. Winters are mild and wet and summers are hot and dry. But, more excessive heat and humidity can be felt due to Adana being located on mostly a large stretch of flat topographically. So, Adana has an unpleasant warm and humidity climate for city dwellers. Therefore, there is a need for ecological design to be considered important the sustainable principles to reduce problems.

Table 2. Climate Data for Adana (Source ; "Meteoroloji" (in Turkish), 2010 ; "Adana Climate, Average Monthly Temperatures, Rainfall, Sunshine Hours, Graphs", 2013)

Climate data for Adana [hide]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	23.0 (73.4)	25.0 (77)	32.0 (89.6)	37.5 (99.5)	40.6 (105.1)	41.3 (106.3)	44.0 (111.2)	43.8 (110.8)	43.2 (109.8)	39.4 (102.9)	33.3 (91.9)	30.8 (87.4)	44 (111.2)
Average high °C (°F)	15.1 (59.2)	16.2 (61.2)	19.6 (67.3)	23.8 (74.8)	28.2 (82.8)	31.7 (89.1)	33.7 (92.7)	34.5 (94.1)	33.1 (91.6)	29.1 (84.4)	22.4 (72.3)	16.7 (62.1)	25.34 (77.63)
Daily mean °C (°F)	9.7 (49.5)	10.8 (51.4)	13.6 (56.5)	17.5 (63.5)	21.5 (70.7)	25.3 (77.5)	27.9 (82.2)	28.0 (82.4)	25.7 (78.3)	21.2 (70.2)	15.6 (60.1)	11.3 (52.3)	19.01 (66.22)
Average low °C (°F)	5.5 (41.9)	6.1 (43)	8.6 (47.5)	12.3 (54.1)	16.1 (61)	20.2 (68.4)	23.6 (74.5)	23.8 (74.8)	20.8 (69.4)	16.3 (61.3)	10.8 (51.4)	7.1 (44.8)	14.27 (57.67)
Record low °C (°F)	−8.1 (17.4)	−6.4 (20.5)	−3.6 (25.5)	−1.3 (29.7)	5.6 (42.1)	12.6 (54.7)	16.8 (62.2)	14.8 (58.6)	10.9 (51.6)	4.8 (40.6)	−1.0 (30.2)	−3.5 (25.7)	−8.1 (17.4)
Precipitation mm (inches)	106.7 (4.20)	88.1 (3.469)	66.9 (2.634)	58.2 (2.291)	46.2 (1.819)	21.5 (0.846)	11.9 (0.469)	10.2 (0.402)	15.6 (0.614)	42.7 (1.681)	81.0 (3.189)	139.1 (5.476)	690.1 (27.17)
Avg. rainy days	10.1	10.4	10.0	8.4	6.6	2.9	1.0	0.7	2.6	5.6	7.2	10.6	77.3
% humidity	60	59	56	59	59	61	60	60	55	49	50	60	57.3
Mean monthly sunshine hours	145.7	145.6	179.8	207	262.1	315	328.6	316.2	264	223.2	171	139.5	2,717.7

Source #1: Devlet Meteoroloji Isleri Genel Mudurlugu[12]

Source #2: Climate and Temperature[13]

As seen in **Table 2**, there are mild temperatures in short winter and warmer climate in long summer months, so, to minimize the solar heat gain primarily in summer are critical design parameters.

To realize the design in line with the hot and humid climates zone where the building is located, design principles, many studies and applications examined were analyzed.

2.2. Energy Performance Directive of Buildings of Turkey

In Turkey, formal measures for the conservation of energy in architectural design are written down in “Section Three”-"Energy Performance of Buildings Directive" (IEP) are located.
Some of the topics in this section including measures to be taken against climatic influences in the building design are as follows:
-Considering zoning and land/parcel status in the architectural design of the building, heating, cooling, ventilation, lighting needs are kept to a minimum,
-Taking into account the effects of sun, humidity and wind, the opportunities of natural heating, cooling, ventilation and lighting is utilized to the maximum extent,
-In the orientation of interiors and buildings, considering meteorological data (solar, wind, humidity, rain, snow, and so) that in climate, architectural solutions should be created and unwanted heat gains and losses should be avoided (BEP, 2008).

2.3. A Model Proposal for Residential Building

Figure 6. Çukurova University's Balcalı Campus in Adana (Source ; www.haritamap.com) and the area where the model residential is applied

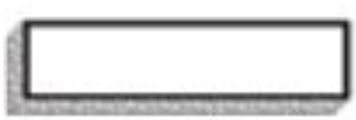
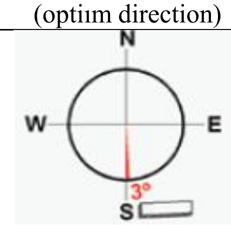
Region that the project will be realized in are located on available site in 'Cukurova University Campus' which is unique part of Adana city.

Topics achieved in study as follows ;
-First, the concepts of passive designs (which is used for heating, cooling, ventilating, daylighting etc.) for 'warm and humid climate regions' were developed (These are orientation of the building, shape of the building, main material of the walls, shading, trees around the house).
-Then, concepts of passive designs were analyzed ; walls, windows, insulation, heating system, ventilation and air conditioning, renewables.
-With this model, some proposals then developed.

As seen from **Table 3,** based on certain norms of climate responsiveness, residential buildings were designed ;
Building orientaion factors, mainly ;

- Sun and wind,
- Topografic features and,
- View

Table 3. Form, orıentation of buıldıng, and available arazi / yerey eğimi in warm and humıd clımate zone (Source; Zeren, 1990)

CLIMATE ZONE	BUILDING FORM	ORIENTATİON OF BUILDING (optiım direction)
WARM AND HUMID CLIMATE	Long rectangular form exposed wind 	

The settlement of residential buildings created from rectangle forms in "clustered building organization" as follows;

- along the east – west axis on the land,

- towards to east 3° from south (S → 3º E)
- towards to mild wind from west-south,

Additionally;

- 5 row building in street organization
- from front to back 1. and 2. row 2 flat ; 2. and 3. row 3 ; 4 and 5. 4 flat (**Figure 7**)

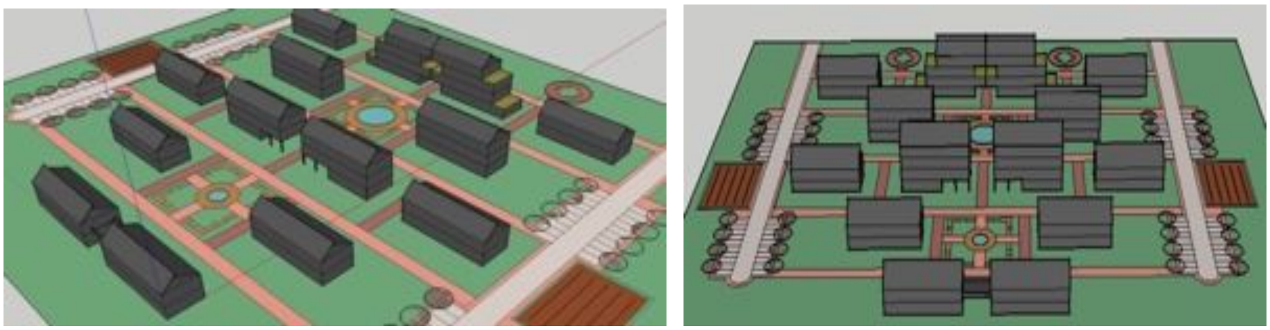


Figure 7. The settlement of residential buildings

There are totally, 42 flats in three different type designed with modular axe. By sliding the modules to create different combinations in settlement, some features have been determined such as garden terraces, unmonotonous building- environment and recreational spaces.

Max benefiting from sun and wind with sliding of the blocs in the street order are as seen from **Figure 8, 9 and 10.**

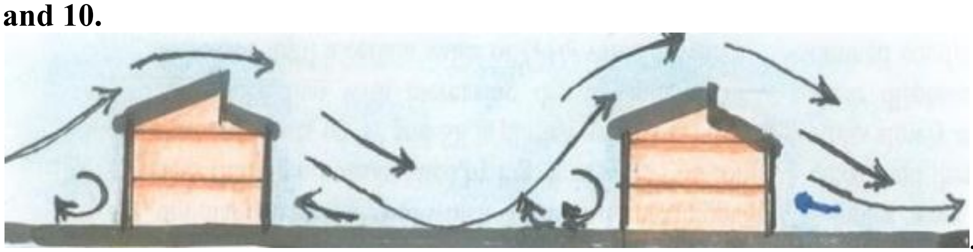
,

Figure 8. For wind flow : min h > 2,5

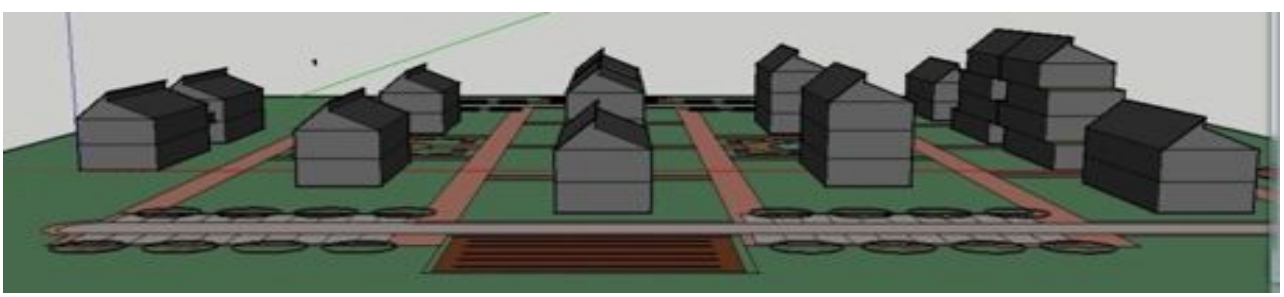


Figure 9. For access the sun ; the settlement of residential buildings

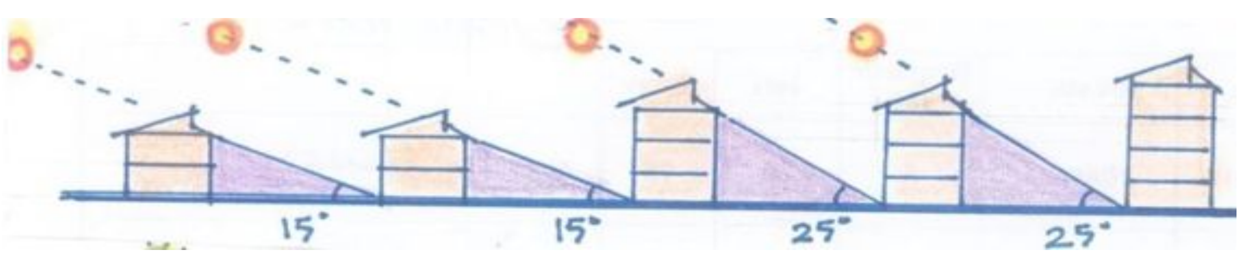


Figure 10. For access the sun ; the distances of the buildings

Forming Housing Blocs;
The approximate basic area per inhabitant is around 30 square meters **(Figure 11)**.
- 2 person families ; one flat and dublex' are 60 m 2 2,
- 3-4 person families ; only one flat is 120 m2.

Figure 11. Residential plan for 4 and 2 person families

Figure 12. The front view of residential

Tüm bloklar
-ikiz düzende yerleştirilmiş,
-tesisat bağlantısı için ıslak
hacimler yanyana ve /veya üstüste getirilmiştir.
All blocks;
-in double order on the land are placed,
-wet areas for installations connection are located adjacent and / or overlapping

Orientation;
-towards the south for solar access to the residents' living areas,
-the south, west and north for views to the river of all residents settlemets,

Windows;
-Maximizing the windows on the south side to take advantage of available solar energy in winter months, while protecting it from temperature extremes in summer months **(Figure 13)**,
-Minimizing the windows on the north side.

Figure 13. Transparent surfaces of living areas placed at an angle of 63^0 due to the sun's rays in south direction do 27^0 angle to the earth.

Daylighting;
More natural light and lessen the need for electric lighting during the day with effective window placement is provided.
Ventilation;
In buildings properly designed with ventilation system (passively/naturally) to provide adequate ventilation of cleaner air from outdoors or recirculated is filtered air without the need for mechanical equipment.
Among the blocs “venturi effect” with mild wind from south to eliminate moisture from indoor and outdoor sources during the summer **(Figure 14)**.

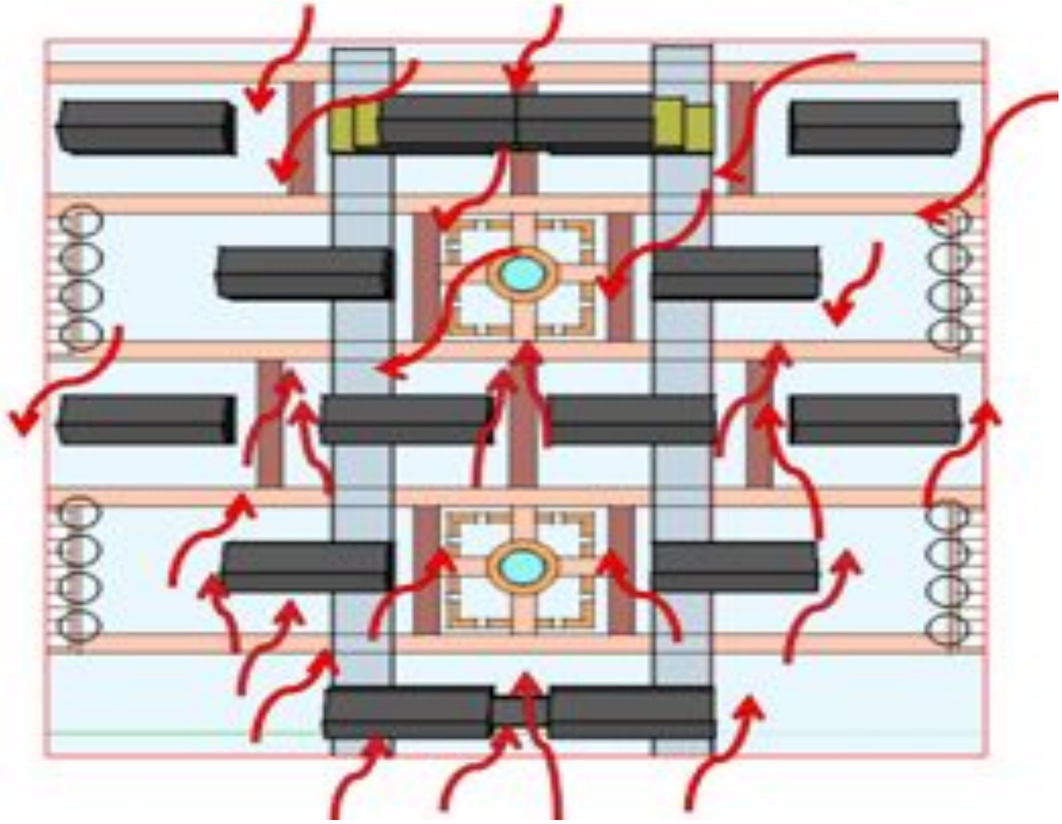


Figure 14. Among the blocs “'venturi' efficiency”

Open spaces;

In two gardens and other public areas located in the middle of residential areas. In the summer, they allow for breeze and shadowing opportunity considering solar and dominant wind direction to reduce uncomfortable humidity and the temperature in air. In the winter, benefiting entirely solar radiation in the south, sheltered from strong winds in the north, a temperate climate in the courtyard was created.

Plant communities and trees;

To reduce heat losses and gains through the landscape of buildings;

-in the south on the front is made afforestation that shed their leaves in the winter,

-in the east and west, blocking the solar radiation by shading the summer **(Figure 15).**

Figure 15. Trees shed their leaves in the winter in the south of building

Landscape Elements;

Building facades and entrances, streets and gardens facing in a northerly direction,
- In the winter, to protect themselves from harsh north-easterly winds blowing afforestation and wind control elements are placed.
- In the summer, into the wind will be out of the environmentally sensitive landscape elements are placed.
Around the building, in particular, pedestrians in areas where they often use; warning and divider panels, boundary markers, wall and so on. landscape elements, protect from the sun, wind blocking are designed.

Car parking area;
Located in the eastern and western sides of the residential parking per apartment is designed for a total of 80 vehicles (**Figure 16).** Against solar reflectance and visual pollution, with older plants were camouflaged with vegetation and trees wrapped pergola. Also, against noise and air pollution, alternative means and use of bicycles has been proposed.

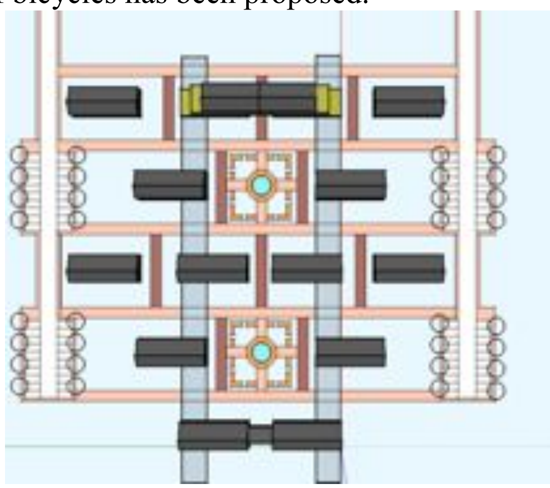


Figure 16. Car parking area

3. *Evaluation the residential model and conclusion*

Adana city chosen as study area are in a special position as climate. The new residential areas in city has been planned without considering the heat gain in the summer months. Interior comfort is provided with mechanical cooling systems more than natural system and caused considerable loss of energy. So, this paper focuses on providing healthy indoor and outdoor environments through the use of orientaion access to natural sunlight and wind.
In the study, the recommended design guidelines for the sustainable residential buildings in Adana were focused on climate responsive design were analyzed on climate responsive design and a local residential model developed, and some sustainable design recommendations were then introduced.

Results of the measures taken in planning phase for model residential are as follows ;
-During the winter months; with some measures taken such as gaining heat from sun, good heat absorbing and storing capacity of the walls, mechanical equipment for heating may not required. "Even, it may be possible overheating of the building needs its own".

-During the summer months; with some measures such as the placemet of the transparent surfaces, measurement, an angle of the sun's rays in south, shading devices, mechanical equipment for cooling may not require.

-In 'summer and winter'; providing indoor comfort of air conditioning, as well as in greatly reducing the load of air conditioning systems. Beside, by creating heat zones ın south and north in planning, the heat losses can be reduced.

As a result; this sustainable building model evaluated with climate-responsive planning principles may refer to other structures in Adana city that is environmentally responsible and resource-efficient.

Figure 17. The re-plannings of forest lands !!! (Yüceer, Çerçi, 2003)

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