A Passively Climatized Building, 2500 m. Above Sea Level

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Abstract

After many years of research, Bakirlitepe-Saklikent near Antalya was selected as the site for National Observatory of Turkey. Bakirlitepe, which can be classified within the best locations whole over the world for observation purposes, has an altitude of 2547 m. Close to the observatory buildings a main building for the observers to rest and sleep during daytime had to be designed and constructed. There were many environmental and functional restrictions for the design. The clear sky, which increases the opportunity for observation and results in high solar radiation values, reminded the designers of the potential of solar utilization. The restrictions that shaped the building, the passively climatized architectural features and the thermal analysis are described in the paper.

1 INTRODUCTION

Today's scientific research on stars is simply based on the angular differentiation of the looking eye. Therefore by using a large dimensional mirrored telescope, angular differentiation can be increased thousands times. For example a 150 cm. diameter mirrored telescope can increase the collection of light 560,000 times more relative to normal human eye, coming from billions of years away. Until recently, there were no such possibilities in Turkey for scientific research on universe save for a few just for academic purposes at some universities.

In 1979, a group of academician by the support of the Scientific and Technical Research Council of Turkey (TUBITAK) started to search for a proper location for the construction of a national observatory. It is called "a proper location" because achieving a better quality of angular differentiation of light is based on not only the size and quality of the telescope but also the restrictions of the physical environment. The efficiency of a telescope is highly effected from the global atmosphere. Therefore the site to be selected should be free from air pollution such as dust and smoke; and from light pollution such as city lights. Also the weather conditions must be stable and appropriate for human body. Number of days with clear sky should be as high as possible which in turn effects the efficiency of observation period.

The polluted air zone in Turkey can be accepted to be between 1500-2000 m. altitude. Therefore, the observatory buildings should be constructed above 2000 m. altitude and economical, biological and technical inputs limit the altitude to be below 3000 m.

Site selection study was completed in 1986, and Antalya-Saklikent-Bakirlitepe peak was selected as the location. The peak is 50 km away from Antalya, located at 36.85°N latitude and 30.33°E longitude, with a 2547 m altitude. The collected data indicates that the astronomical view, clearness and quality of sky is very well and the site can be classified within the best locations whole over the world.

2 DESIGN STAGE

GUNARDA Energy and Building-Research and Consultancy Inc. is selected as a design team in 1994. The design stage has started in June 1994 and completed within 17 months. Totally 1800 m² buildable area is designed for three different buildings. T40 and T150 are the observatory buildings for 40 cm and 150 cm diameter telescopes, respectively. The third one is the building for accommodation and study rooms for researchers where laboratory and workshops are thought within (Fig. 1). In late 1994 a team from Middle East Technical University (METU) Department of Architecture and Department of Physics joined for the thermal analysis and the evaluation of this building. The article will brief the subjects related with this building which can be called as the “main building”.

2.1 Building Schedule

The main building is composed of two levels (Fig. 2). First floor has two different sections which are physically joint to each other. The first section has a large workshop with crane where mirror treatments and all mechanical end electrical repairs and small productions can be held in. In this section there is one dark room for light laboratory, control room, garage, water storage tank and pumps. Second section has computer center, study rooms, tea and TV room, kitchen and dining room, reception hall and security room, WC, laundry and ironing room and electrical control panel’s room.

Second floor has 7 bedrooms including bathrooms. Bedrooms are designed for day time resting and sleeping of the research astronomers since they work through night time.

2.2 Design Criteria

Unfortunately no design criteria for such special observatory buildings could be found in the literature survey, so visits are paid to La Palma and Tenerife Islands in Canary Islands, and Arhiz in Russia which is close to the southern border to Georgia. These visits helped to enlarge the vista and to find out the possible problems of the buildings to occur. Through the design phase, a set of discussion and coordination meetings have been organized and some physical restrictions have been set.

Since the observations require a completely clear, dark, stable and clean environment, the other auxiliary buildings such as main building should be specially designed not to produce any heat, smoke, dust, and light. The demand to protect the location from dust and smoke gave way to the use of electricity for heating the building. But the climatic conditions would cause the operating cost to be high. Also in winter conditions when the buildings is not in use the electronic devices could be in trouble because of low temperature. Therefore even in unexpected weather conditions the building temperature must be above freezing point.

The ambient air temperature dropping well below freezing point forces not to have movable parts on the exterior of the building. The difficulty in driving large trucks on the steep roads, that were under construction, gave way to use lightweight materials and to utilize local materials. Due to the short construction season, it is not practical to have cast-in-place reinforced concrete for the structural system. The high amount of snow by closing the access roads blocks out the site from the rest of the world which in turn directs the designers to minimize the manual control of the system. Maintenance of the building such as painting and repairing of exterior surfaces should also be as minimum as possible, and the materials should be durable.

Creation of any unexpected air movement will be a disadvantage for the observations, so during the night time heated building must not radiate out. Hence, the building must be highly insulated. The initially collected meteorological data indicated that the potential of solar utilization in that region for heating the building is very high. So it is decided that all these factors should be considered in the design phase.

2.3 Thermal Evaluation

The climatic data of the site was not available from the meteorological bulletins since it is a remote area. Although during the site selection studies the necessary data for astronomical observation purposes were collected, climatic data of only a 4 months summer period is available (Aslan et al, 1986) for thermal analysis of the building. Hence, a climatic data is prepared to be used for a thermal evaluation study and the building is thermally improved within the framework of restrictions. The details of this study can be found elsewhere (Demirbilek et al).

3 APPLICATION STAGE

The restrictions caused by the observation requirements, harsh climatic conditions, and remote site mentioned as the design criteria had a fundamental effect on the choice of materials and the design of the building.

3.1 Material Choice

In the construction of the main building instead of concrete modular prefabricated “gas-beton” of 20 cm thick is used both for load-bearing and non load-bearing walls and floor panels. Gas-beton is a special expanded concrete with lightweight aggregate and has a conductivity of 0.24 W/m°C, density of 600 kg/m3, and specific heat of 0.84 kJ/kg°C.

Closed celled high density extrude polystyrene heat insulation material of 5 cm thick is applied to the external walls, ceiling, and ground floor with conductivity values of 0.0348 W/m°C, 0.0267 W/m°C, and 0.0267 W/m°C, respectively. On top of that insulation, rock wall construction of local material is applied on three sides of the building to protect it from heavy snow and frost. The rock wall has rough cut surface to obtain larger heat loss area for back radiation. The roof is covered with a single sheet trapezoidal aluminum above the insulation material leaving a gap in between.

3.2 Design of the Building

The two observatory buildings are located to the northern part of the site whereas the main building facing to south is almost hidden behind a small hill in order not to reflect any light at night time. Openings, such as windows, are planned to be small. In this way minimum amount of light will be let to outside at night time for not affecting observation process; and to bedrooms at day time where the researchers will sleep. To keep the room at desired temperature (in worse case over 0^{o}C) and to decrease the nighttime outgoing radiation the envelope of the building is highly insulated.

In this climatic and physical environment due to construction and most of all maintenance problems it would be very difficult to use active solar panels for heating. Instead passive solar heating system is selected. The building has openings only towards south. The designed system seems to be similar to Trombe wall system but having only convective heat transfer to the interior space. Front facade is designed to utilize solar radiation for heating the building up. A sloped window is constructed in front of the south wall to form a greenhouse. The glazed wall is of tempered glass to resist the environmental impacts and double glazed to decrease the heat losses. It extends to the second floor with the same tilt angle, to increase the amount of solar radiation received, placed in front of the sloped wall with an air gap in between. Instead of collecting and storing heat on the black painted wall and let it flow to inside in night time, it is planned to take the heated air into the room by the help of vents immediately. The air heated within the greenhouse naturally rises up and gets into the interior space. In this way the risk of outgoing thermal radiation towards the glass wall during observation hours is decreased.

There are two sets of vents per floor. One in lower level for cold air inlet to the greenhouse, second in higher level for heated air let into the room and also one added to the roof to control the air flow. The gap between the trapezoidal aluminum sheet cover of the roof and the insulation material is designed to let the heated air to pass through for melting the snow on the roof so that the obtained water can be collected in water storage tanks and be filtered and used as tap water. The air can be directed either towards the gap between aluminum roof panel and the roof structure for melting the snow in winter time or to the sky for ventilating in summer time. To protect the building from over heating in summer time, stack effect ventilation is helpful. Side vents placed at the lower parts of the greenhouse let the chilly and clean ambient air flow into the greenhouse and then the air is exhausted via roof vents.

4 CONCLUSION

The high number of requirements to be fulfilled in the design of the National Observatory Building of Turkey resulted in a special design. Most of the requirements were directly or indirectly related with ESD principles. Observational ones forced the site to be free from not only dust and smoke, but also thermal radiation an light which in turn affected the building to conserve energy and be environmentally friendly.

Site being a remote one, required the building to be self-sufficient as much as possible since during the turn-off period the building will not be occupied. Any failure in the heating system can damage the equipment and the building, so the building is an energy efficient one utilizing solar energy. Rock as a local building material is used in the construction which will not need maintenance and painting.

The building is a very special one which will be the center of a worldwide and national attraction of attention. Observatory is classified among the best of its kind whole over the world and will be serving to many other countries as well. Inauguration by the president of Turkey in September 1997 attracted attention of the public. It is hoped that these points will have a positive effect on the application of passive climatization of buildings.

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6 REFERENCES

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Figure 1
Main Building, National Observatory T40 being at the background.

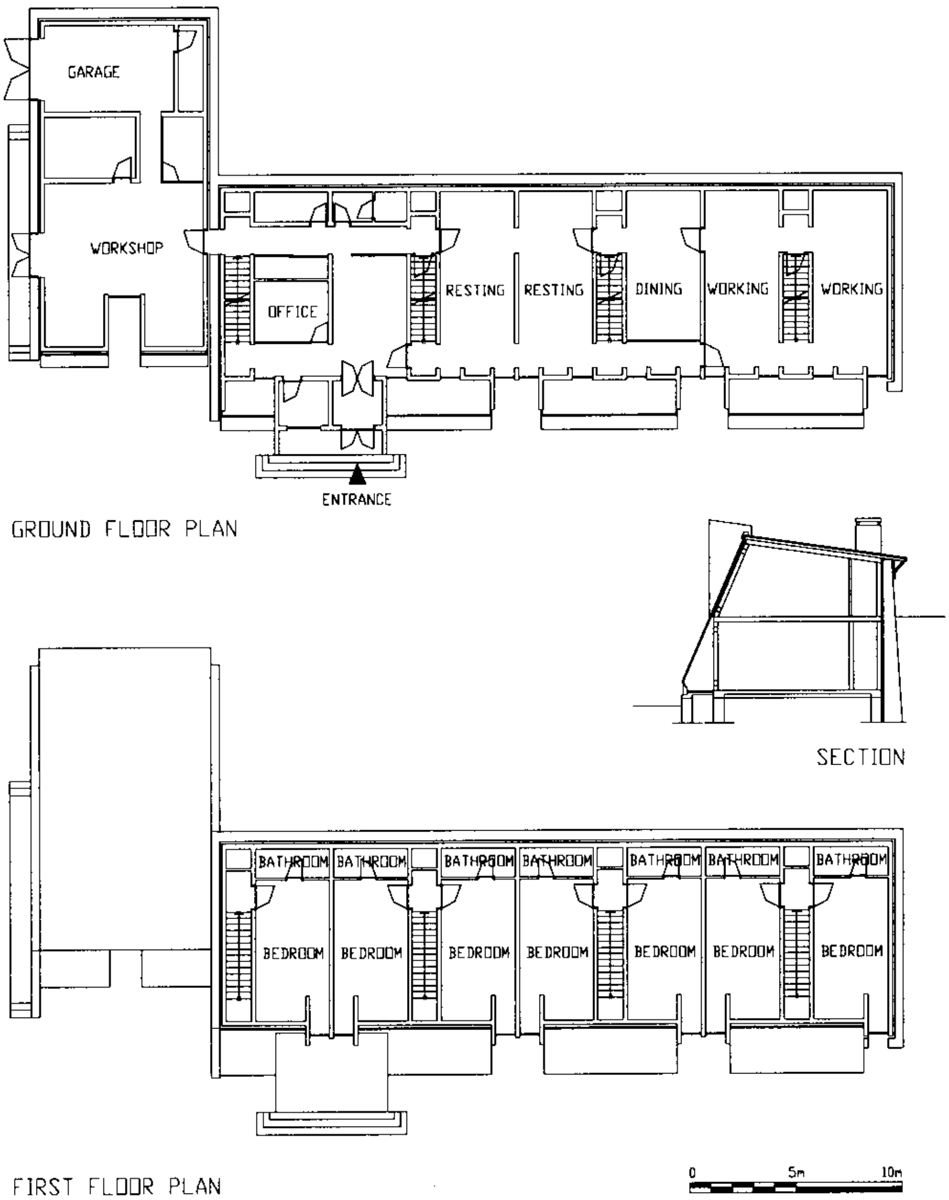

Figure 2 Plans and section of the building.