Butterfly Conservatory HVAC Design Strategy in Continental Climate

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In this study, it is aimed to expose how the HVAC system has been designed for a Butterfly conservatory in sustainable manner by using climate characteristics and without mechanical cooling. It is also intended to provide guidance for future design attempts considering limited data available in current literature.

Keywords: Butterfly Conservatory HVAC Design, Biomes Design, Butterfly Conservatory, Evaporative Cooling

A butterfly conservatory can be described as environmentally controlled ecosystem for particular species. In this study, it has been aimed to evaluate HVAC design strategy for a tropical butterfly garden located in central Anatolia having continental climate characteristics with sharply contrasting seasons.

In addition to inherent difficulties of butterfly conservatory or biomes design, hot/arid summer and cold winter characteristics of region and tight environmental control parameters make HVAC system design more challenging. HVAC system needs to be flexible to manage different operational control parameters considering significant solar radiation during summer, glass cover, condensation problem etc.

In this study, Konya Tropical Butterfly Garden (KTBG) has been taken as case study to show possible design strategy for a butterfly conservatory in continental climate. KTBG accommodates one of the world's ten largest butterfly aviaries. The project comprises of following sections;

- Butterfly garden, 2 100 m²
- Insect museum, 550 m²
- Multipurpose hall, offices, café and retail units, 800 m²

Design Challenges

The focal point of this project is the Butterfly Garden as it is a habitat for rare species. The main challenges are;

- Creating a microclimate within the Butterfly Garden building to support tropical butterflies
- Glass cover of this area. Butterfly Garden has low-e glass curtain wall carried by circular hollow section steel structure

In the beginning of the design studies we have been given design requirements which demand creating tropical climate within the Butterfly Garden. Local continental climate conditions make the design studies more complicated with the glass façade of Aviary.

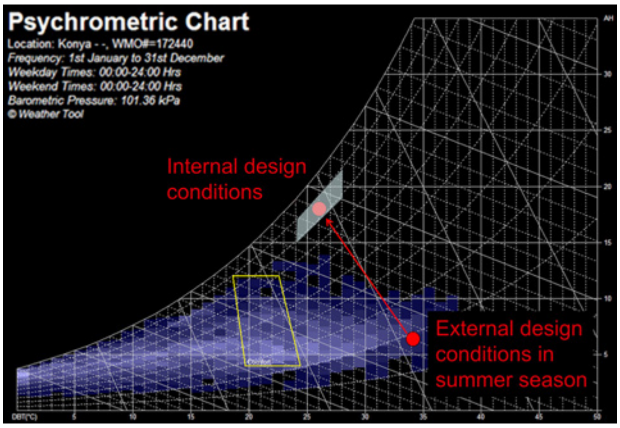
External design conditions; 33,8°C DB (Dry Bulb) and 17,1°C WB (Wet Bulb) in summer (low relative humidity, approximately 19%); –13°C DB in winter.

However, as the butterflies in the KTBG collection would thrive only in a tropical climate, design conditions had to be 26 ± 2°C DB, %85 ± 5 RH throughout the year. By taking the internal design conditions into account, it was necessary to create a high-humidity environment within the butterfly garden where the temperature could be maintained at a consistent level and those requirements are very different from the natural environmental conditions in Konya.

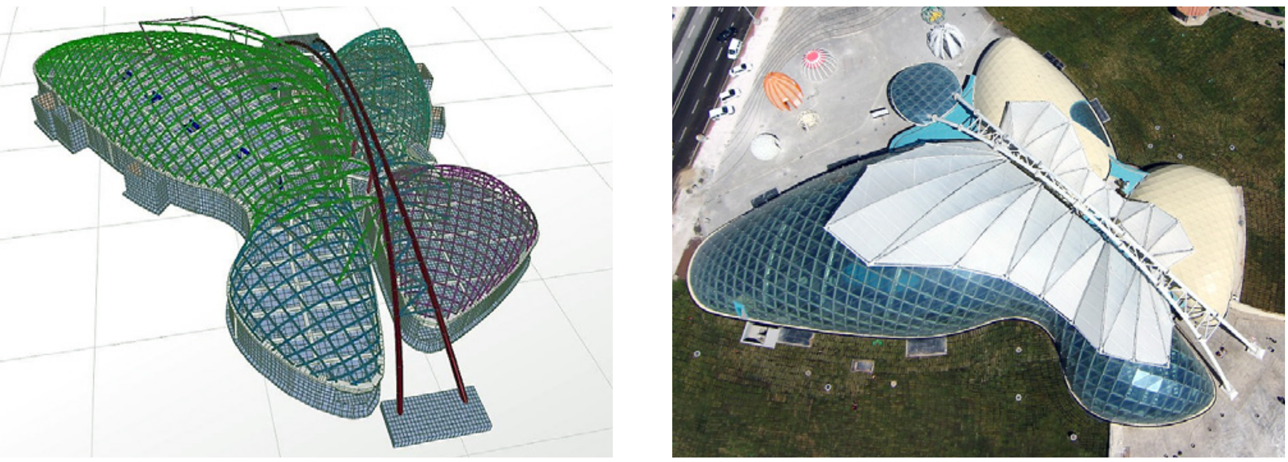
Mechanical Design Solutions

There were two internal design conditions to overcome in energy efficient way;

1. Temperature level
2. Extremely high relative humidity



Psychrometric chart illustrating indoor and summer outdoor conditions against comfort range.


Structural modelling and external view of KTBG.

During design work, some mechanical systems have been reviewed to overcome severe external and internal design conditions which are very different from each other. In addition to achieve the tropical conditions, energy efficiency was the other key issue and finally, it was shown that evaporative humidification/cooling is the most efficient way to create tropical conditions within a continental climate, because it can provide design temperature and humidity levels of 26 ± 2°C DB, %85 ± 5 RH, which means the chillers are free from the cooling loads of the butterfly garden and nursery in summer season. Since the butterfly garden has vast solar loads, due to the abundance of glass, there is a PTFE shading element in the form of butterfly wings, which considerably reduces solar loads located above the building. In winter season, dedicated boiler units provide heating to reach internal design conditions as evaporative humidification process maintains due to the extremely high relative humidity demand.

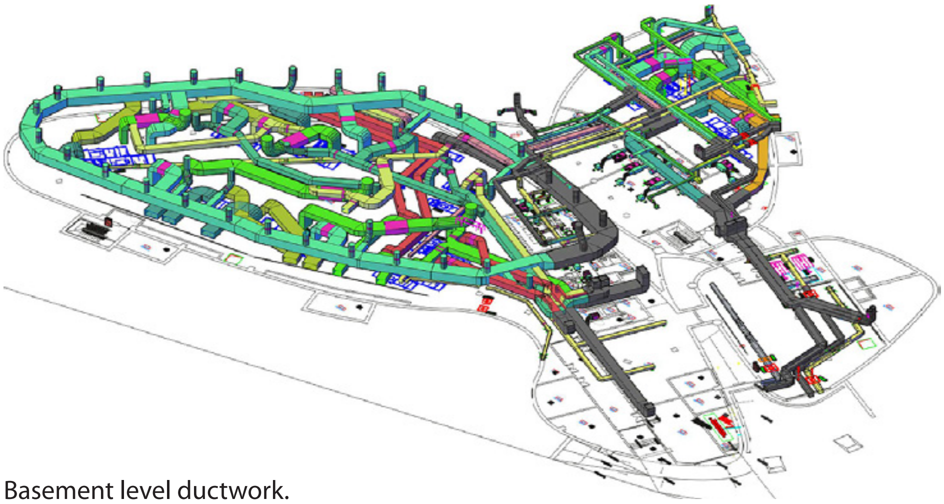
Since the design focuses on the creating a habitat for the tropical butterflies, internal conditions are consistent with these requirements and out of human comfort range.

Ventilation in Butterfly Garden

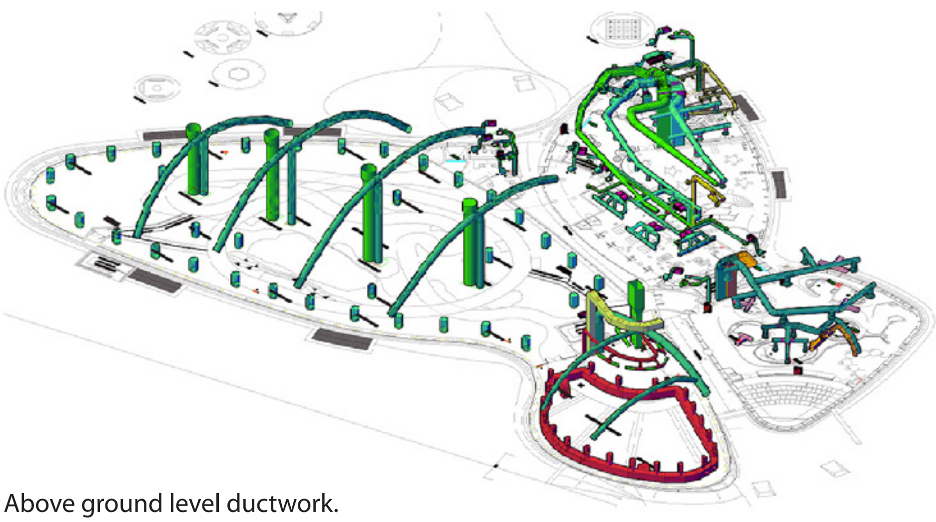
In the beginning of design studies, whole basement level considered and defined as technical areas especially for mechanical systems because of the high-level requirements.

Due to the glass roof, we have tried to find the ways for hiding the ventilation ducts which meet heating and cooling demand in addition to fresh air requirements of indoor area. Conditioned air is provided with displacement air diffusers at the ground level surrounding the butterfly garden and nursery.

In the basement level, a ventilation duct loop has been created. The Butterfly Garden's air handling units, located on the basement floor, are connected to each other with



Basement level ductwork.



Above ground level ductwork.

Façade details of KTBG.

this duct system as a loop in the basement level. Hence the homogeneous air distribution continues even if in the event of air handling unit failure. In this way, high level redundancy and continuity of work have been ensured.

Humidification Process

In order to achieve high level internal relative humidity level by means of evaporative humidifiers, dedicated treatment plant has been accommodated in the basement level. The main plant consists of water treatment units, reverse osmosis system, collection/reserve tank for treated water and all associated equipment.

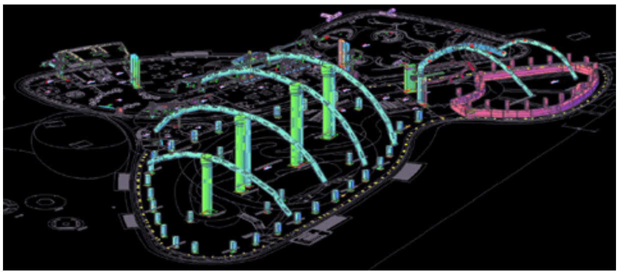
With regard to the humidification process, there are two humidification steps;

- Air handling unit (AHU) integrated evaporative humidifiers
- Indoor evaporative humidifiers

Treated water, coming from the central treatment plant, is supplied to those humidifier sets accommodated in air handling units and indoor area as outlined above. As a first step, mixed air is humidified by AHU integrated humidifier sets before supplying into the butterfly garden. Indoor sensors detect the internal humidity levels to manage the indoor conditions and allow to operate the indoor humidifiers as a second step of humidification process when the additional humidification is necessary.

Façade

Butterfly garden of which footprint is 2 100 m², has glass cover and this results significant heating/cooling transmission loads including solar load.



Ventilation ducts on the inner side of glass façade and displacement diffusers.

Another issue related to the façade is the condensation risk. To overcome this issue, a system which supplies warm air to the inner side of the glass façade was designed to mitigate condensation risk during the cold winter periods.

There is also a net system beneath the glazing which prevents butterflies passing into other spaces or touching the glazing. Exhaust air ducts rise up as columns through the roof, positioned between net and glazing system, so the butterflies are not affected by the exhaust air.

The vitality of UV rays was required for the tropical butterfly species, a UV-permeable lamination film was selected for the laminated glass cover.

Conclusion

In design studies, there were significant constraints to overcome as highlighted above. Although, those conditions made the design more complicated, it was essential to find out inclusive solution in sustainable manner.

Consequences are satisfactory in terms of both perspective; handling the severe climate conditions and sustainable solution. ■