AN ENERGY CONSCIOUS HOUSE FOR MALTA

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ABSTRACT

Winner of First Prize in the 2nd Commonwealth Inter-school Design Competition organised by the Commonwealth Association of Architects (CAA), 1991. The winning design was a pair of houses with wind towers. It was praised by the jury as 'an innovative and original solution to the brief recognising local conditions, elegantly and thoughtfully presented. The planning of the dwelling pleasantly reflected the local lifestyle with an interesting internal environment'. The chosen entry was published in the CAA news, and other architectural journals.

A direct gain system was adopted, each space having a thermal mass for the storage of solar heat while preventing the internal air temperature from rising too much when the sun is allowed to penetrate through the windows. This required choosing the optimum shape, location and orientation of the building as well as the location of both indoor spaces and the openings in these spaces to protect the building from summer heat and from cold and rain in winter. Good ventilation for summer and heating for winter were two of the major considerations in the design.

KEYWORDS

Energy-conscious, house, wind-towers, direct-gain, competition, Malta

INTRODUCTION

Throughout the years, through trial and error, man developed a vernacular and traditional architecture, which modified the external macroclimate sufficiently so as to create a comfortable internal environment. Man designed his cities and dwellings to respond to the local climate so that they could be cooler in summer and warmer in winter. The traditional narrow serpentine streets of the typical Maltese village provided shade from the harsh sun, drawing in the cool breezes but keeping the dust out in summer. In winter, the close-knit streets provided shelter from the wind and cold. The individual houses had massive walls with small openings to mitigate the effects of the outdoor climate. High ceilings and high level windows in larger rooms allowed daylight to penetrate deep inside. The buildings were mostly introverted, depending on beautiful internal courtyards, loggias and private gardens for light and fresh air.

However, new building forms have been imported from other countries with different climatic conditions. The use of new materials and new construction techniques allow structures to be built with a fabric thickness much less than those used traditionally. These resulted in an inadequate thermal performance. We have thus unfortunately come to depend more and more on available fossil fuels as sources of energy to improve the internal microclimate. Since fossil fuel is a finite resource also associated with noxious emissions we are now being compelled to reduce our dependence on conventional fuels and once again resort to the use of solar and other renewable energy sources.

The domestic sector is the largest consumer of energy in Malta and responsible for over 50% of the national energy bill. Energy conservation in this sector can yield appreciable savings. 90% of the delivered energy utilised in buildings for heating, cooling, lighting and appliances is electrical Cachia (1989). The pattern of electricity consumption in Malta is temperature related. This gives rise to peak demand periods above the base power station load in summer and in winter indicating dependence on electricity to provide thermal comfort. Air-conditioning is increasing in popularity for both space cooling and heating especially with higher standards of living. By constructing energy conscious houses, we would be lowering the energy bill without compromising on a comfortable internal environment.

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Inception

The inception of the two prototype housing units proposed has mainly emerged from consideration of Malta's Sub-tropical Mediterranean marine climate. From the outset it was seen that the building was to be designed to provide protection from summer heat and from cold and rain in winter. Good ventilation is also imperative in summer while some heating is necessary in winter.

Direct Gain System

A direct gain system is adopted requiring a skilful and total integration of all the architectural elements within each space - windows, walls, floor, roof and interior surface finishes Mazria (1978). Such a building can usually be built for almost the same cost as a conventional masonry building. Moreover, the payback period for insulation costs is relatively short when compared to the life span of the building. In fact, this payback period, when one does not include extra labour cost for placement of insulation, is of five heating seasons.

Building Shape, Location and Orientation

The building is placed in the northern portion of the sunny area on the site thereby ensuring that the outdoor areas and gardens placed to the south will have adequate winter sun besides being protected from the prevailing winter winds Coleman (1988). This can be clearly seen in Figures 1 and 2. The architectural form is elongated along the east-west axis to expose more surface area to the south during winter for the collection of solar radiation. This is also the most efficient shape for MINIMISING heating requirements in the winter and cooling in the summer.

Location of Indoor Spaces

Spaces requiring least sunlight, such as the garage, the entrance hall and the guest sitting room, are placed on the north side of the building, so as to serve as a buffer between the heated spaces and the colder north face. The bedrooms facing north are designed with a projecting corner facing east to allow the sun's wakeful rays to filter into the rooms early in the morning. The main living areas are placed to the south, also close to outdoor terraced garden, thus capturing the sun's energy during different times of the day. A sitting room separate to the living area is provided on the north side following the local tradition of having a special room to welcome guests.

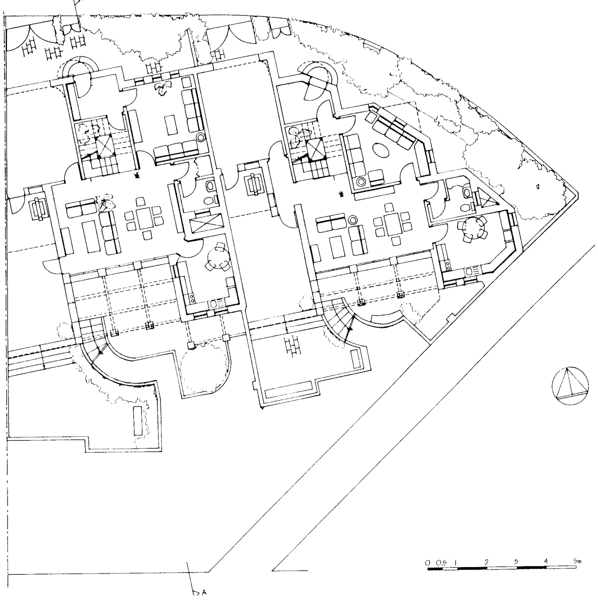


Figure 1: Plan Level 1

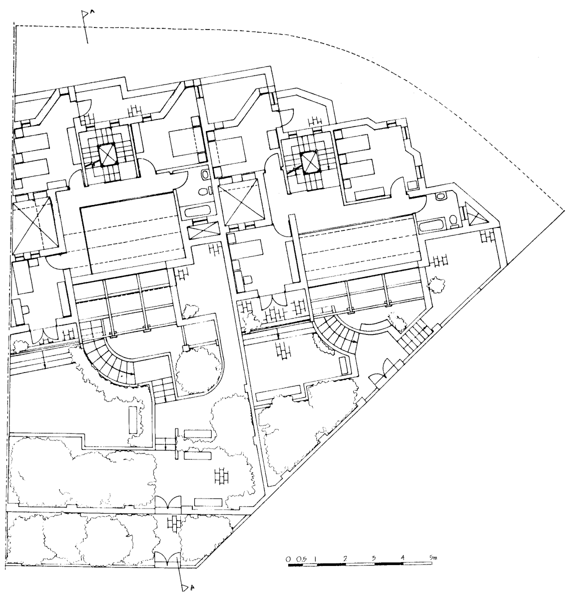


Figure 2: Plan Level 2

Protected Entrance

The main entrance to the building is a foyer that provides an air lock between the building and the exterior. This will prevent a large quantity of warmed air from leaving the building each time a door is opened, since only the air within the enclosed space can escape. Trees provide windbreaks to reduce the wind's velocity against the entrance. The entry space could be used for storage of unheated items and as a place to remove winter clothing.

Location of Openings

Major window openings are located to the south to warm the houses in winter and ventilate in summer as depicted in Figure 3. On the other sides of the building, window areas are kept small to protect against the cold predominant northeast and northwest winds as indicated in Figure 4. In winter, the stairwell is partitioned off by glazing so as to reduce draughts. A metal gate at the entrance provides security when the front door is left open to allow cool welcome draughts to enter the building during the hot summer months. All the rooms have been designed for cross-ventilation in summer so that when the apertures in the building are opened prevalent breezes ventilate the entire space. This is necessary since the local average relative humidity is 75.67%. The building structure is cooled down during the night and serves as a heat sink, which absorbs the heat of the following day.

The Wind Catcher

The wind catcher is based on the principle of catching unobstructed higher-level breezes from the north, northeast and northwest to aid ventilation in the living room during summer De Oliveira Fernandes et al (1988). Figure 5 shows a section through the building, and thus through the wind catcher which is centrally located. The air moves through a duct that passes through a well. A horizontal screen at the top keeps out insects and birds. During winter, aluminium ventilation louvers are automatically closed. In summer, the twin skins of the duct are cooled during the night by natural through ventilation. Moreover, the duct, strategically located in the stairwell, does not receive any direct solar radiation and so its surfaces remain at a lower temperature than the rest of the interior throughout the day. The incoming air is thus cooled by conduction when it comes into contact with the cold inner surfaces of the duct enclosure especially when passing through cool well water. The refreshed air emerges to cool the living room.

The wind catcher duct is constructed of 20mm thick gypsum board skins riveted to steel angles at each corner. When passing through the well the gypsum board skins give way to galvanised steel sheeting welded to angles at the corners and tanked around the base of the duct structure.

Figure 3: South Elevation

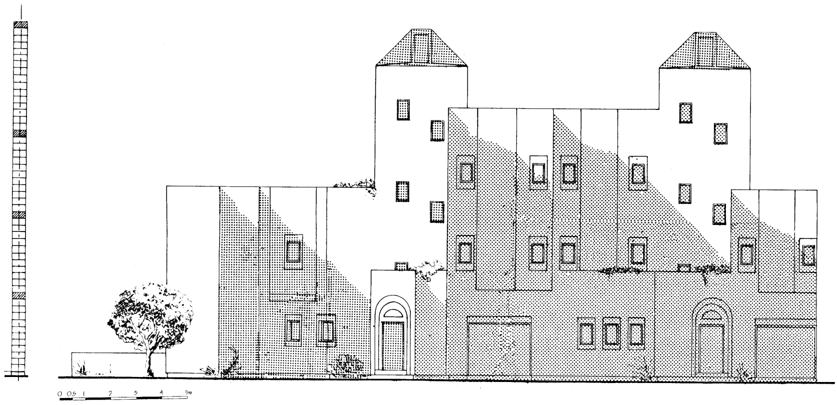


Figure 4: North Elevation

The Well

A cistern for the collection of rainwater has been incorporated in the housing design. Besides aiding the cooling system of the house, the well water is used for garden irrigation and for all washing needs. A pumping system draws water from the cistern up to the roof storage tank. Thus, sparing use is made of the water utility which would only be required for drinking purposes.

The Living Area

The living space is characterised by stepped horizontal shelves that roof the area as shown in Figure 6. These shelves exclude the high summer sun's rays but allow the low winter sun's rays to penetrate the interior. The canopies also serve as light shelves reflecting natural daylight to the interior. This system of canopies also acts as a thermal chimney, whereby heat build-up in the room causes warm air to rise and escape from open windows at the top thus making space for the cool air coming from the wind catcher.

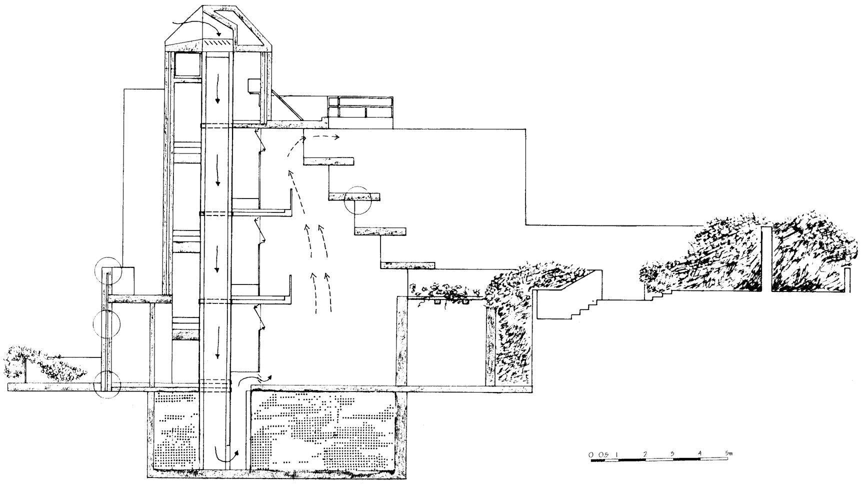


Figure 5: Section AA Protected Entrance

The lower part of the living area has large south facing openings to allow through ventilation. A vine-covered trellised overhang shades these openings whilst providing a cool, relaxing outdoor dining area in summer. During winter the vine is bare exposing the living area to the greenhouse effect - the warm air is trapped inside at night by drawing thick curtains across south facing windows.

The Two Courtyard House

Each of the two houses has a small, shaded courtyard and a large area exposed to the sun with a moderate roofed-over area in between these two spaces Olgyay (1963). Air in the larger courtyard heats up and rises making space for the cooler air from the shaded courtyard. A cool current of air thus ensues in the roofed-over area allowing the family to make use of this space during the hottest hours of summer days.

Solar Collector Plates

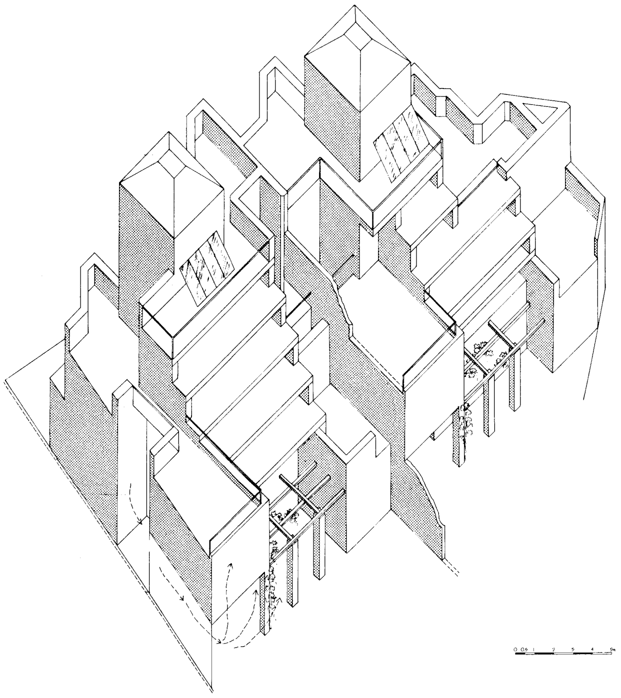
Solar collector plates for water heating are economically feasible in Malta where the sun shines all year round, the minimum hours of bright sunshine being 5.19 in December. For those few days of the year when there's insufficient solar energy an immersion heater in the water storage cylinder maintains the water temperature.

Additional Ventilation Aids

Extractor fans are to be used in the bathroom and in the kitchen to aid ventilation especially in winter when opening windows reduces the inside air temperature considerably.

Construction Materials

Since a direct gain system has been adopted, this implies a heavy building Van Straaten (1967) with interior walls and floors constructed of masonry materials, which is in keeping with the Maltese tradition of building. Terrazzo tiles are laid over a screed as floor finish to a concrete slab, walls are constructed of local limestone blocks and reinforced concrete is the main roofing material while pre-stressed concrete slabs form the stepped roofing of the living room area. All exposed surfaces are painted a light reflective colour. Polystyrene rigid slab insulation is used in a thickness of 76mm in external floor to wall junctions and party walls and in the 100mm air cavity space between the two 150mm skins of the external walls, in the latter reducing original U value of $1.44Wm^{-2}K^{-1}$ to $0.36Wm^{-2}K^{-1}$. Insulation is used in a thickness of 121mm for all the roofing and overhangs. The insulation reduces original U value of $3.42Wm^{-2}K^{-1}$ to $0.28Wm^{-2}K^{-1}$ for the reinforced concrete roof slab 150mm thick.



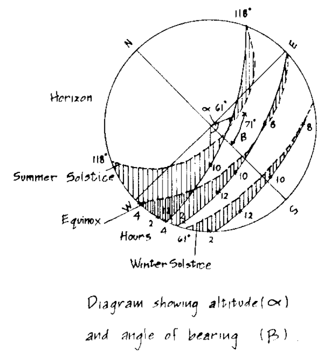


Figure 6: Axonometric

CONCLUSION

For sustainable architecture to be successful, there is a need for an alternative mode of thinking to the present local construction of buildings on both the part of the architect and the client. The recent past has seen housing development that resulted in buildings requiring heating and cooling by mechanical means as well as a lowering in the intrinsic quality and hence beauty of dwellings built without much consideration to nature and climate. In contrast energy conscious houses bring us closer to nature since they develop in response to the climate and to physical site conditions exploiting orientation, daylighting and private external spaces among others. Climatic comfort can be achieved by skilfully manipulating architectural design parameters and natural resources which can result in an aesthetically even more pleasant architecture and interior environment in harmony with traditional cultural values.

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