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ANALYSIS OF ANNUAL ENERGY REQUIREMENTS OF NONRESIDENTIAL BUILDINGS

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ABSTRACT
In the presented paper, the interactions between different building and design parameters and building energy requirements in a non-residential building through energy simulation programs has been analyzed.
The building studied is an office building, located on Istanbul-Turkey with five floors. Occupancy, electrical consumption and chilled water consumption show marked weekday / weekend difference. Hourly heating and cooling loads throughout the typical year were calculated by EnergyPlus simulation program. Hourly meteorological data required in the analysis were obtained from Government Meteorology Office. Four pipe Fan-Coil, HVAC system are designed. Using the energy simulation model, several different opportunities for energy conservation were investigated. .The effect of the parameters like insulation and thermal mass, shading, window systems including window area and glazing system, night ventilation on annual building energy requirements is examined and the results are presented..
Keywords: Annual energy requirement, office building, Turkey,

1. INTRODUCTION

A great amount of world energy demand is connected to the built environment. The connection between the increased CO_2- discharge to the atmosphere and the use of energy is also a motive to render a more efficient energy usage, and lowering the total energy demand.
Buildings are responsible for an increasing share of the total energy use in Turkey, up to about a half at present. For commercial buildings, space cooling and heating is needed throughout the year, and electricity use in the commercial buildings, accounts for about one-third of the total energy consumption in Turkey [1] and fully air-conditioned office buildings are important commercial electricity end-users since the mid-1990s. Therefore, reducing energy use for space cooling and heating in buildings is a key measure to energy conservation and environmental protection in Turkey.
Study of the factors affecting the energy performance of office buildings and the energy characteristics of the building systems is essential for a better understanding of the energy conserving design principles, and operational strategies. With the help of computer programs for detailed building energy simulation, it is now possible to examine these factors extensively and systematically through the use of a computer modeling technique [2].
Among various aspects of energy conscious design, energy performance of the building deserves great attention, especially for office buildings [3-7]. Most of the previous studies [3-6], are valid for cooling load in the hot and humid climates; studies which were related with mild climates are very rare. With rapid economic growth, there have been marked increases in office building development projects, and there is a growing concern about energy consumption in buildings (especially commercial developments such as office buildings) and its likely adverse impacts on the environment.

The aim with this paper is to, by energy simulation, investigate how the energy demands in an office building are changing with changing conditions and control strategies. An energy simulation program, Energy Plus [8] was used for this purpose. The analysis of the interactions between different conditions, control strategies and heating/cooling loads in office buildings in Turkey through building energy simulation program has been evaluated. The effect of the parameters like the climatic conditions ,insulation and thermal mass, aspect ratio, color of external surfaces, shading, window systems including window area and glazing system, ventilation rates and different outdoor air control strategies on annual building energy requirements is examined and the results are presented.
It is hoped that the work and its findings would give architects, building managers and HVAC engineers a better understanding of the dynamic interactions and energy use implications.

2. OFFICE BUILDING

Building analyzed in this paper is a five floor office building in İstanbul with 8943 m^2 area. Total wall area is 4651 m^2 and glazing area is 860 m^2.

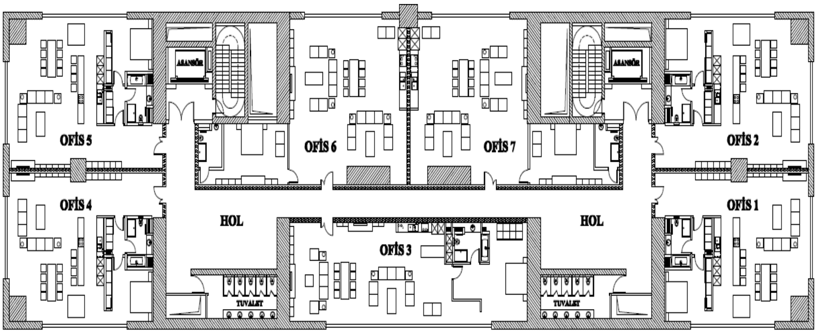

Figure 1. Building Floor Plan .

Construction of the building is determined according to ASHRAE and TS825 (Thermal Insulation in Buildings) standards. Overall heat transfer coefficient for outside wall is 0.44 W/m^2K, for floor 0.19 W/m^2K, for roof 0.40 W/m^2K and for window 2.40 W/m^2K. For thermal calculations required lighting power density, human occupancy, heat gain from devices, filtration and infiltration rates, set point temperatures for heating and cooling for each zone are determined according to ASHRAE standards [9-12] and given in Table 1. Heating and cooling set point temperatures are 22°C and 25 °C respectfully during the 8 a.m. and 7 p.m. and 14°C/ 28°C during 7p.m. and 8 a.m. and weekends

Table 1. Design criteria for given building

	Lighting (W/m^2)	Occupation (m^2/person	Devices (W)
Office Rooms	11.8	25.5	493
Entrance hall	14	25,5	6300
Rest rooms	8	-	-
Conference Rooms	14	4.6	3360
Parking Lot	3.2	-	-
Stair Halls	8	-	-

Weather related factors included all the weather data based on measurements made at the respective measuring stations in the İstanbul were obtained from National Meteorological Institution [13] Hourly heating and cooling loads were calculated by EnergyPlus, which is a building energy simulation software developed by the US Department of Energy.

3. RESULTS AND DISCUSSION

In this paper, the effects of the various low-energy design strategies on the cooling and heating loads of office buildings in İstanbul through building energy simulation program are evaluated. Using the verified building energy simulation model, several different opportunities for energy conservation were investigated. Six passive thermal design strategies were identified, namely, insulation and thermal mass, glazing systems, window size and shading devices. Using the parameters described above, the performance of base case office building was simulated using the weather data file from the local meteorological observatory as the climatic input.

3.1 Insulation and thermal mass

In analyzing the thermal behavior of walls, different level of thermal resistance is achieved by adding extruded polystyrene (EPS) thermal insulation to the external walls of the office building. It is possible to decrease total heating load of the building by introducing the of 80 mm thick insulation on the inside of the wall produces the maximum saving of 19.67% annual required cooling energy and 34.4% annual required heating energy when compared to the base case in mild climate (İstanbul)

3.2 Window systems

Window design affects the energy use of the building with heat transfer, heat gain from the sun, infiltration and daylight. The net effect of the window system on the total energy requirement of the office building including the heating, cooling, and illumination energies, depends on the window design characteristics and weather conditions and solar radiation.

Table 2. Effect of Glazing Ratio and Type of glazing on Energy Requirements

Glazing	Glass Type	Heating Req. (kWh/year)	Cooling Req. (kWh/year)	Boiler Capacity (kW)	Chiller Capacity (kW)
20%	T 1	175702.8	94441.7	274.4	430.1
	T 2	192872.2	76555.6	274.4	397.3
	T3	170811.1	76055.6	264.5	381.3
30% (ref)	T 1	167047.2	131444.4	286.5	507.4
	T 2	189511.1	99163.9	286.5	457.5
	T3	157644.4	99919.4	266.3	433.2
40%	T 1	159838.9	171975.0	299.3	592.9
	T 2	187372.2	126491.7	299.3	523.3
	T 3	145727.8	129738.9	270.5	490.9
50%	T 1	155658.3	201738.9	309.5	662.3
	T 2	186244.4	148672.2	309.5	576.6
	T3	137069.4	154.091,7	274.6	538.2
70%	T 1	151647.2	254.019.4	328.3	786.3
	T 2	185644.4	186741.7	328.3	672.5
	T 3	125305.6	193566.7	282.1	623.4
90%	T 1	150638.9	361994.4	366.0	1044.0
	T 2	189986.1	267025.0	366.0	874.5
	T 3	108341.7	277727.8	297.4	805.1

In this analysis, different designs of window system are taken into consideration in order to observe the interaction of the heat gains and/or loss and the depending energy requirements. The effect of increasing the glazed area in the base case building to two times its original size and decreasing it to the half of its original size was evaluated. While doing this, effect of glazing type was also tested. Three different type of glazing are compared: Type 1(T1) is double glazing with U= 2.46 W/m^2K and solar heat gain coefficient(SHGC) is 0.85. Type 2 (T2) is a glazing with low SHGC (0,63) and it has the same U value. Third type (T3) is a low emissivity film coating double glazing with U= 1.35 W/m^2K and SHGC= 0.58. Results of the simulation are given in Table 2. It is observed from the simulation results that the cooling energy decreases with the low emissivity glass because of the higher overall reflectance of solar energy.

3.3. Effect of Shading

Several shading devices can be used internally and/or externally in office buildings. In this study, the effects of internal shading devices have been studied since it is more common application in office buildings. The simulation results indicate that as the shading fabric is getting closed, the reduction in both annual required energy and cooling energy become greater. Amount of saving with an inside shading is about 10 % for cooling load.

3.4. Night Ventilation

Especially during the cooling season, night ventilation is avery useful tool to decrease the building cooling load requirements. Results of the analysis is given in Table 3

Table 3. Effect of night ventilation on cooling load

	Cooling Energy Requirement (kWh/year)	**Fan Energy Consumption** (kWh/year)
Night Ventilation (Forced)	115400.0	31075.0
Night Ventilation (Natural)	115130.6	29675.0
Without Night Ventilation	131444.4	36227.8

4. CONCLUSION

It is believed that the work and its findings would give architects, building managers, HVAC engineers and energy researchers a good idea about the likely impacts and a better understanding of the dynamic interactions on the thermal performance of office buildings

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