Shading device were determined as a fixed light shelf based on climate conditions of school location. Since the sun is higher in the sky during the rest of overheated period, any light shelf that extends to the line shown will fully shade the window for the whole over heated period. This full shade line was defined by angle 57.46^{o} (August 30-at the end of overheated period). The aim of using shading device on school building is to prevent the overheating and visual glare in summer period. Light shelf permits sunlight to enter classroom in underheated periods. Overheated and underheated periods were shown in Figure 3.

CFD Simulation

Ventilation of occupied spaces in buildings has two primary purposes which are provide an acceptable indoor air quality with supply fresh air and removal indoor pollutions and provide thermal comfort by providing a heat transport mechanism. In this study, single sided ventilation system was chosen according to the architectural properties of classroom (Anon. C).

For a space with an upper and lower opening, a temperature difference between the indoor space and the outdoor environment causes a density difference, where the warm air is less dense than the colder air. As a result, a pressure difference occurs between the inside and outside air. The higher internal pressure at the upper opening drives outflow and the lower internal pressure at the bottom opening drives inflow. This buoyancy-driven flow is also known as stack effect (Allocca, C et al., 2013).

In this study, natural ventilation was assumed to be forced by thermal forces. Mainly indoor and outdoor temperature, solar and environmental radiation effect on the performance of ventilation (Anon. D) and these boundary conditions of CFD analysis are shown in Table 4.

Table 4: *CFD Analysis Conditions*

Boundary	Parameter	Condition
Indoor Operating Conditions	Pressure, temperature	1atm(101325Pa), 24℃(Classroom)
Outdoor Operating Condition	Pressure, temperature	Environmental Pressure bound with 33℃ summer / -3℃ winter
Wall condition	Real Wall	U Value (W/m2K) taken from ‘Table 2:Thermal properties of building elements’ 0mm of roughness height
Radiation	Solar and Environmental Radiation	Solar Radiation at 40°97' N time 12:00 average 850W/m2 summer / 400W/m2 winter
Opening	Face permeability	Operable Area 5,76 m2 Fixed Area12,24 m2

RESULT AND DISCUSSION

Energy Performance Analysis

Energy performance analyses were carried out by using eQuest software. For energy performance analysis, building was modelled by architectural and mechanical aspect. Lighting control and sensor systems were added to classroom for providing energy efficiency. Dimming control system was selected with 300 lux set point value.

The average daylight factor in a space is at least 5% then electric lighting is not normally needed during the daytime, provided the uniformity is satisfactory. If the average daylight factor in a space is between 2% and 5% supplementary electric lighting is usually required. Average daylight factor of existing condition is 2%, while moving away from window, this value approached to zero. Moreover, cooling load was increased with increasing window area. To overcome these problems, light shelves were added to window. When proposed design was examined, it can be seen that average daylight factor increase to 5% and lighting energy saving ratio was 63.1%. Cooling energy saving ratio was also 14.53% as shown in Figure 4.

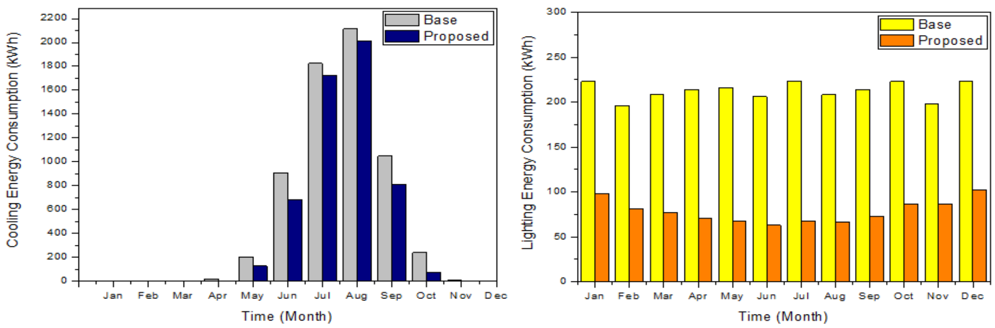

Figure 4: *Cooling and lighting energy consumption for exisitng and proposed model*

Daylighting Simulation

The daylighting simulation was carried out for obtaining results of the actual model and the proposed model. Moreover, the analysis of the effects of external shading devices on daylighting is conducted by comparing a model without shading device and the models with designed shading device for four different months (March, June, September and December) and three different time periods.

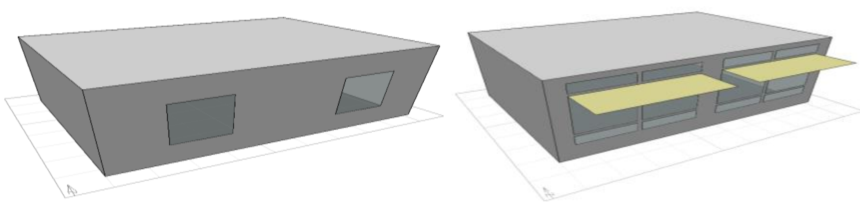

Figure 5: *Existing model and proposed model of window and shading devices for selected classroom*

According to daylighting simulation, maximum illuminance level was achieved as 41600 lux at June of 21st without shading device. At that day, minimum illuminance level was calculated as 210 lux. Glaring problems occurred because illuminance level should not be exceed 3000 lux (Bruin-Hordijk T., Groot E. 2010). Moreover, illuminance levels at September and March of 21st overpassed glaring limit. Minimum illuminance value should be 300 lux IESNA (2000), therefore, minimum illuminance levels for all selected days were analyzed and all results were under limit as shown in Figure 6. Shading devices are fundamental for the reduction of cooling needs and elimination of glare. Shading device were determined as a fixed light shelf based on climate conditions of school location. To overcome these problems, shading devices were replaced and dimensions of window size were changed and designed. The results showed that illuminance levels were not exceed 3000 lux when using shading devices as shown in Figure 6. Therefore, visual glare problem was prevented using shading devices on window.

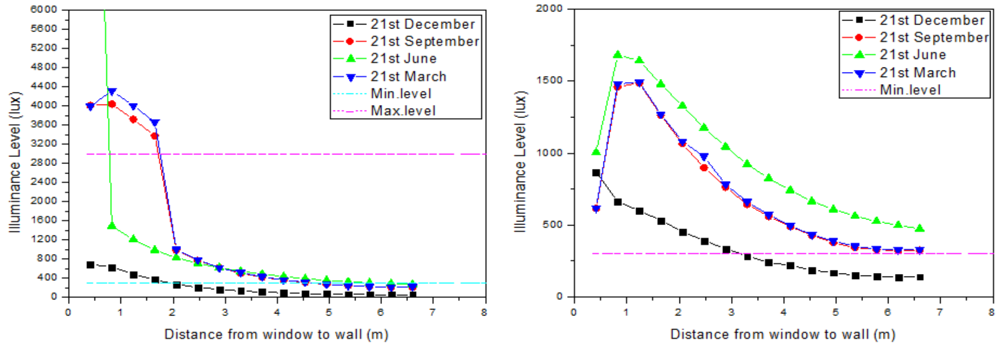

Figure 6: *Daylight distribution in classroom*

The differences between minimum and maximum illuminance levels were decreased on proposed model and uniformity was provided in classroom. Minimum illuminance levels were higher than existing model. This results could provide low energy consumption during school time period.

CFD Simulation

With CFD analysis, natural ventilation distribution and air flow rate in classroom was examined. In this study, single sided ventilation system was chosen according to the architectural properties of classroom.

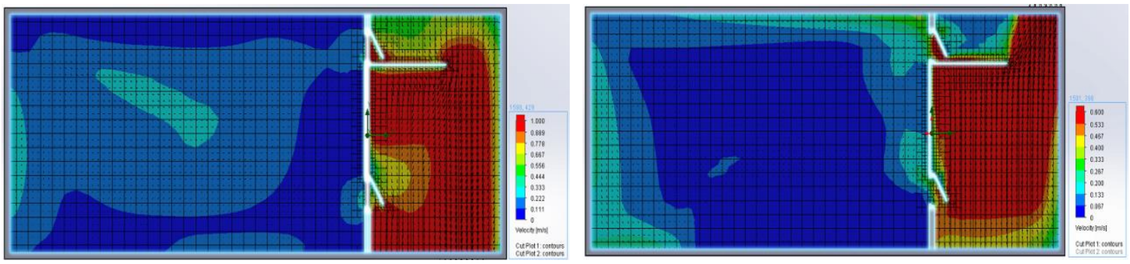

Figure 7: *CFD analyses for air velocity distribution*

According to the ASRAE 62.1 “Ventilation for acceptable indoor air quality” standard, minimum fresh air requirement is 3,8l/s per person in classroom and total fresh air requirement of selected classroom is 212,8l/s. Windows were design according to this value. CFD analyses were done to analyses the amount of inlet air flow rate for summer and winter conditions. According to results, fresh air was entered as 1249.48 l/s for winter and 702.32 l/s for summer time period. Air flow direction and air velocity distribution in classroom were shown in Figure 7.

CONCLUSION

In this study, university building was examined for providing better indoor environmental quality to affect students' performance on positive aspect and improving energy performance on building. With this scope, windows were changed to provide natural ventilation and shading devices were added for daylighting. Existing building and proposed building was compared according to their energy performance and comfort conditions.

Shading devices were replaced, dimensions of window size were changed and designed to ensure natural ventilation for preventing moisture problem on building. When existing building consumption examined, the proportion of solar cooling and lighting in total electric consumption were 20.65% and 44.1%, respectively. When proposed design was investigated, it can be seen that lighting energy saving ratio was 63.1% and cooling energy saving ratio was 14.53%. Natural ventilation was provided to supply healthy environment by proposed window type. Windows were design according to total fresh air requirement of classroom that was calculated as 212,8l/s. CFD analyses were done to analyses the amount of inlet air flow rate for summer and winter conditions. According to results, fresh air was entered as 1249.48 l/s for winter and 702.32 l/s for summer time period. Moreover, daylight analyses were done with using shading device (proposed model) and without using shading device (existing model). The average daylight factor was increased to 5% from 2% for electric consumption saving by increasing window area. Glare problems were solved and cooling needs were decreased by using shading devices. The results showed that illuminance levels were not exceed 3000 lux.

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