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Daylight Parameters and Operation Quality Case Studies: Public Office Buildings in Kerman, Iran

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Abstract
Most of existing government office building in Iran were designed and built without enough consideration to the daylight design. Therefore a lot of electricity energy should be used to provide visual comfort in office rooms in government office buildings. Due to location of Kerman City of Iran, There are a lot of solar radiation in whole year during working hours in exterior spaces. In this research daylight quality of 4 office rooms in 2 government office buildings in Kerman city of Iran were investigated through experimental measurement and calculating some daylight parameters such as mean Work PlaneIlluminance (WPI), Work Plane Illuminance Ratio (WPI Ratio) and daylight Ratioin two conditions when lights were on and off. Finding of this research reveals that most of office building in government building cannot reach the acceptable range of different parameters of daylight even though lights were on. Therefore research about daylight quality in office rooms in this region is an important issue to be investigated to find different methods and solutions for improving daylight quality in office rooms.
Keywords: Daylight Quality, Government Office buildings, Working Plane Illuminance, Working Plane Illuminance Ratio, Daylight Factor

1. Introduction

In order to provide convenience condition from different aspects such as Thermal comfort, lighting and ventilation, a lot of energy should be used (Yeang, 1996).Around 20 to 30% of energy is consumed in building for providing visual comfort (Lam and Hui, 1996, Lam, 2000). Daylight utilization is one of possible methods for minimizing electricity for artificial lighting(Lam, 1995, Li and Lam, 2001). Daylight utilization not only causes a lot of energy for building but also it is considered as a source of heat generation in buildings. Therefore proper use of day lighting, minimize energy use for cooling system. Furthermore most of people prefer daylight due to the more beauty ofdaylight (Baker and Steemers, 2000). Daylight is considered as an important parameters for reduce energy consumption in buildings(Galasiu et al., 2004, Li and Lam, 2000, Huang et al, 1989, Li, et al.,2008).Daylight utilization is an important strategy for energy saving as well as visual comfort. There are several parameters to evaluate daylight quality in office rooms.Working Plane Illuminance, Working Plane Illuminance Ratio and Daylight Factor are some of daylight parameters to evaluate daylight quality.Dubois (2001) had studied some of lighting quality standards from different sources. Some of recommended values for different parameters are tabulated in table 1.In order to have daylight utilization and visual comfort, a lot of parameters of Daylight should be considered.

1.1 Work Plane Illuminance

Work plane Illuminance as an indicator of daylight, is used to check the quality of daylight in spaces. Different places need different amount of WPI due to different activities in different places(IES, 1993). WPI should be 500 Lux to have enough potential for reading and writing. Acceptable range for Work Plane Illuminance is 300 – 500 lux for offices (CIBSE,1994).
If Work Plane Illuminance is less than 100 lux, the office room is considered too dark for paper and computer work. If the amount of work plane illuminance is between 100-300 lux, the office room has acceptable range of daylight for computer work but this is not acceptable for paper work. If work plane illuminance is between 300-500 lux, thisamount of Work Plane Illuminance is acceptable for paper work and ideal for computer work. The light of office roomis suitable for paper work and too bright for computer whenWork Plane Illuminance is higher than 500 lux (Dubois, 2001).

1.2 Work Plane Illuminance Ratio

Work plane Illuminance can be calculated by dividing minimum WPI which is recorded in a specific point by average WPI or maximum WPI at any given time. The indicator shows the uniformity of light inside the room. Acceptable range of WPI ratio means suitable distribution of light inside office room. WPI ratio is considered acceptable when (minimum / average) of WPI is less than 0.8 CIE (1986) and CIBSE (1994). According to Dubois (2001) the acceptable range of WPI ratio (minimum/maximum) is 0.5(Dubois, 2001).

1.3 Daylight Factor

Daylight factor can be determined by dividing the mean WPI by global illuminance in a same time(Robbins, 1985).The Daylight Factor is an indicator for evaluating the potential of space for daylight utilization. Daylight factor between 2 and 5 % means the space has enough potential for use of daylight Dubois (2001).

Table 1: Performance indicators and their interpretation (Dubois, 2001)

#	**Performance indicator**	**Interpretation**
1	DAYLIGHT FACTOR < 1 % 1-2 % 2-5 % > 5 %	unacceptable acceptable preferable ideal for paper work / too bright for computer work
2	WORK PLANE Illuminance < 100 lx 100-300 lx 300-500 lx > 500 lx	too dark for paper and computer work too dark for paper work / acceptable for computer work acceptable for paper work / ideal for computer work ideal for paper work / too bright for
3	WORK PLANE Illuminance Ratio Emin/Emax > 0.5 Emin/Emax > 0.7	acceptable ideal ideal

2. Research Methodology

In order to evaluate daylight quality in government office buildings, 4 office rooms in 2 government office buildings (Judicial complex of Kerman and Department of Telecommunication of Iran) in Kerman city, were selected for experimental measurement in terms of WPI, WPI ratio and daylight Factor. Kerman is located on a high margin o*f Kavir-e Lut* (*Lut Desert*) in the central south of Iran.FurthermoreKerman is located at latitude 30.29 and longitude 57.06.

At first physical characteristics of each room such as Length, Width, Height, Window area and orientation were recorded. In order to record Working plane Illuminance (WPI), with respect to the room index, 4 or 9 points were specified to install Luxmeter on the work plane height.Room index can be calculated by the following equation.

Room Index = (lengths × width)/[Mountingheight ×(length + width)]

Table 2: Room Index and No. Measuring Positions

Room index	**minimum number of measuring positions**
Less than 1	4
1 to below 2	9
2to below 3	16
3 or greater	25

At the same time as recording internal Working plane Illuminance, the external Illuminance was recorded by another Luxmeter which has been installed outside building without any obstruction. Work plane illuminance for each room and external Illuminance were recorded in different time of working hours (9 a.m., 12 p.m. and 3 p.m. to find out the Quality of daylight in different times of working hours.

3. Finding and Discussion

Physical Characteristics of 2 government office buildings, judicial complex of Kerman and Department of Telecommunication of Kerman are shown in figure 1 and figure 2 respectively.

Figure 1: A view of judicial complex of Kerman

Figure 2: Department of Telecommunication

Two rooms, office room No.215 and No.222 were selected in judicial complex of Kerman for experimental measurement and another two rooms, office room No.2 and No.8 inDepartment of Telecommunication of kerman were selected for daylight measurement. Physical characteristics of these office rooms are tabulated in table 3. Figure 3 and 4 are views of Office room No. 222 and No. 2respectively.

Table 3: Physical and Geometric characteristics of measured rooms

No.	Floor Level	Window Height (mm)	Cill Height (mm)	Window Orientation	Ceiling Height (mm)	Geometry (W x L x H) (mm)	WWR
215	1	1670	900	West(N45°)	3800	4400 x 7440 x 3800	0.17
222	1	2200	900	East (S45°)	3800	4200 x 7550 x 3800	0.29
2	3	1600	900	East (N23°)	3600	6400 x 7700 x 3600	0.23
8	3	1600	900	West(N23°)	3600	6400 x 10000 x 3600	0.22

Figure 3: A view of office room No. 222

Figure 4: A view of office room No. 2

Mean external Illuminance during measurement in different hours for each selected room are shown in table 4.

Table 4: Mean external Illuminance in different hours for different office rooms

Office rooms	External Illuminance (LUX)		
	9 a.m.	12 p.m.	3 p.m.
No. 215 , No.222	80418.6	83310.2	40590
No.2 , No.8	79744	78642	35030

Mean work plane illuminance and external Illuminance for different office rooms in different times during working hours are tabulated in table 5.

Table 5: Mean work plane illuminance for different office room

Office rooms	WPI (LUX)					
	9 a.m		12 p.m		3 p.m	
	Lights on	Lights off	Lights on	Lights off	Lights on	Lights off
No. 215	590.8333	130.8333	701.1667	169.5	665.8333	141.8333
No.222	1166.667	662.1667	772	275	633.3333	160.1667
No.2	1845	1745.222	764.8889	673.6667	376.1111	299.6667
No.8	469	236.3333	527.2222	306	485	258.3333

Figure 5 reveals the amount of WPI in different office rooms in different hours when lights were on.

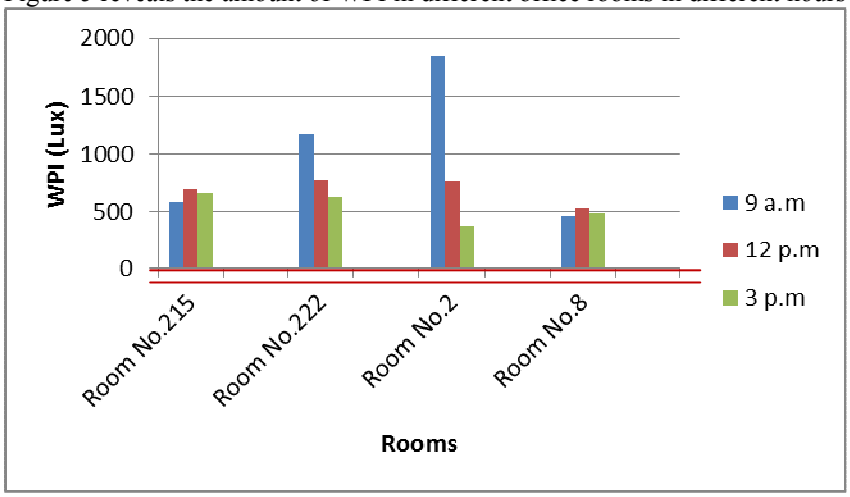

Figure 5: WPI in different Office rooms in different hours when lights were on

Figure 5 reveals that when lights were on during working hours, Most of office rooms have had WPI higher than 500 lux in different hours which is considered too bright for computer work. Only Room No.2 at 3 p.m. and Room No.8 at 9 a.m. and 3 p.m. have WPI between 300 and 500 lux which is considered acceptable for paper work and ideal for computer work. Therefore none of office rooms could not achieve acceptable light in all hours during working hours while lights were on.

Figure 6 reveals the amount of WPI in different office rooms in different hours when lights were on.

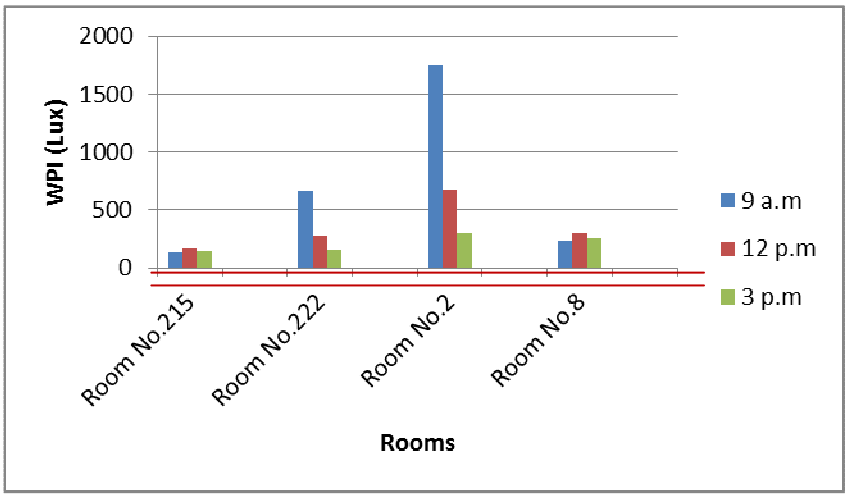

Figure 6: WPI in different Office rooms in different hours when lights were off

As it is shown in Figure 6, among all measured rooms, only room No.8 at 12 p.m. reach the recommended value in term of work plane illuminance when lights were off. The amount of work plane illuminance in room no.8 at 9 a.m. and 3 p.m. are 236 and 258 lux respectively when lights were off which is too dark for paper work howeverthis amount of work plane illuminance is acceptable for computer work. When lights were off, the amount of work plane illuminance is less than 300 lux in office room No.215 in all hours

during working hours.Room No.222 and No.2 could not reach the acceptable light during working hours at all, when lights were off. Therefore it can be concluded that none of office room has ability to achieve acceptable daylight during working hours when lights were off.

Table 6 shows the amount of WPI Ratio (Min/ Max) in different office rooms in differenttimes during working hours when lights were on and off

Table 6: work plane illuminance Ratio for different office rooms in different hours

Office rooms	WPI Ratio (Min/Max)					
	9 a.m		12 p.m		3 p.m	
	Lights on	Lights off	Lights on	Lights off	Light on	Lights off
No. 215	0.46	0.49	0.43	0.38	0.38	0.31
No.222	0.40	0.46	0.32	0.25	0.38	0.2
No.2	0.3	0.32	0.3	0.3	0.33	0.31
No.8	0.38	0.34	0.3	0.21	0.25	0.17

As it can be seen in table 6, none of office rooms in different times could reach the acceptable range of WPI ratio (Min/Max) with 0.5 for both conditionswhen lights were on and off. Therefore it can be concluded the office rooms in government office buildings don't haveuniformity of light during working hours even though lights were on.

Table 7 shows daylight Ratio in different office rooms in different hours when lights were on and off.

Table 7: Daylight Ratio for different office rooms in different hours

Office rooms	Daylight Ratio					
	9 a.m.		12 p.m.		3 p.m.	
	Lights on	Lights off	Lights on	Lights off	Light on	Lights off
No. 215	0.73	0.16	0.84	0.2	1.6	0.3
No.222	1.4	0.82	0.92	0.33	1.56	0.39
No.2	2.3	2	0.97	0.85	1.07	0.85
No.8	1.45	0.82	0.92	0.33	1.5	0.39

According to table 7, most of office rooms have more daylight ratio when lights were on respect to the condition when lights were off in different hours during working hours. Table 8 shows surface reflectance of surfaces such as wall, ceiling and floor in different office rooms.

Table 8: Surface Reflectance of different surfaces for different office rooms

Office rooms	Surface Reflectance		
	Wall	Ceiling	Floor
No. 215	70	50	40
No.222	70	40	40
No.2	80	50	60
No.8	80	50	60

According to IES(1993), the recommended values for surface reflectance of wall, ceiling and floor are 50%, 70% and 20% respectively. Surface reflectance of wall and floor in all office rooms is more than recommended values which is specified in IES (1993). Surface reflectance of ceiling in all office room is lower than 70%.

4.Conclusion

It can be concluded that however some of office rooms can achieve acceptable daylight quality in a specific time during working hours but all office rooms could not reach the acceptable daylight quality in term of work plane illuminance during working hours in term of different parameters such as work plane illuminance and uniformity of light (WPI Ratio) in both conditions when lights were on or off. Surface reflectance of different surfaces has significant effect on daylight quality. However surface reflectance of walls in all office rooms in government office building is more than recommended values but surface reflectance of ceiling in all office rooms are less than recommended values which is suggested by IES (1993). Therefore all government office buildings were not designed for using daylight. Therefore, proper daylighting design is required for visual comfort in government office buildings.

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