

## Compare two atrium with plant and without plant In cold and dry winter

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### Abstract

Solar penetration through the transparent cover can severely useful indoor thermal environment inside an atrium building particularly in cold and dry winters. This paper reports of the application two different atrium building in a clinic center balance to thermal performance on the two levels inside the atriums in Kerman, where winter is cold and dry. A site test was undertaken one day covering clear day in November 2010. Measurement of indoor thermal environmental parameters was conducted on two levels in the atriums and the recorded data represent the internal conditions: with plant and without plant in ground floor, and with color glass and without color glass. This study will investigated about different temperature of atrium levels with and without plant and color glass. This study has shown that on cold and clear winter days, with color glass and plant the average temperature difference between first and second floor, and second floor and external were 2 C and 13 C respectively with in 24 hrs; while with clear glass and without plant the average air temperature difference were 1.5 C and 8 C respectively.

**Key words:** Atrium, Solar radiations, plant effect, Thermal stratification.

### 1. Introduction

The term “atrium” refers to a sheltered courtyard or glazed garden within a building. It is usually a high interior covered by a glass roof and walls surrounded by several stories or galleries. The atrium is incorporated into the built environment more free quietly regardless of cultural and climatic conditions (Abdullah, *et al.*, 2009). Atriums have also been reported to increase the marketing values of many buildings, besides their psychological and physiological effects on increasing the morale of people and exposure to daylight. (Laouadi,

*et al.*,2003) Architects and engineers have often used atria as a sustainable design strategy to achieve benefits such as passive heating and cooling, ventilation and day lighting (Du, *et al.*, 2009).

Atrium space normally consists of large glass walls and roof. Due to the high transmittance characteristics of glass materials for both solar and heat, the atrium indoor thermal environment is greatly influenced by the outdoor conditions (Abdullah, *et al.*, 2009). Therefore, there is a need to develop design tools to take full advantage of atrium potential day lighting, improve thermal performance, and optimize the total energy consumption for lighting, heating and cooling.

This paper reports the results of a field study carried out for one day during 12 and 14 November (each day for one atrium) on the two atriums of a clinic building in Kerman. The site test was done during cold and dry winter, when the outdoor air temperature averaged 10 °C and relative humidity in the afternoon was generally above 18 %. In order to optimize the possible over-heating comfort in the three-storey high atrium with use plant in atrium floor.

The study method was a site measurement and monitoring of indoor thermal environmental parameters which include indoor/ outdoor air temperatures, relative humidity and daylight illuminance. The recorded data represented the atrium indoor conditions with plant and without plant and color glass in atrium. The primary aim of this study was to evaluate the effectiveness of the two measures and to seek response of the indoor thermal environment to the improvement of physical behaviors of the atrium envelope.

Many researchers (Atif, 1995, Laouadi, *et al.*,2001 and Göçer,2006) have suggested that the main design guidelines for cold climates to developing thermal and energy performance in atrium. One of the passive thermal techniques that can possibly use plants in the atriums is chosen from suitable species, mainly for dry climate (Tencar, ---- and Baker *et al.*, 1993).

The atrium due to its high glazing ratio works like a greenhouse providing suitable environment for plants except very cold months. Plants are not only passive object, in the atrium that they utilize available solar radiation for their growth. This involves assimilation of carbon dioxide and some other gasses, evaporation of supplied water and particles flowing in the air are trapped on leaves. Then they can increase relative humidity in atrium envelope. (Littlefair, 2002)

## **2.Data and Material**

Two existing atrium spaces are located in two buildings of one clinic center in Kerman (latitude 30.15, longitude 56.58, altitude 1753.8 m)

### **1.2 Description of case study 1: color glass and with plant**

One building is a tree –storey rectangular structure with exterior dimensions of 36m × 23m and a maximum height of 11.5m.

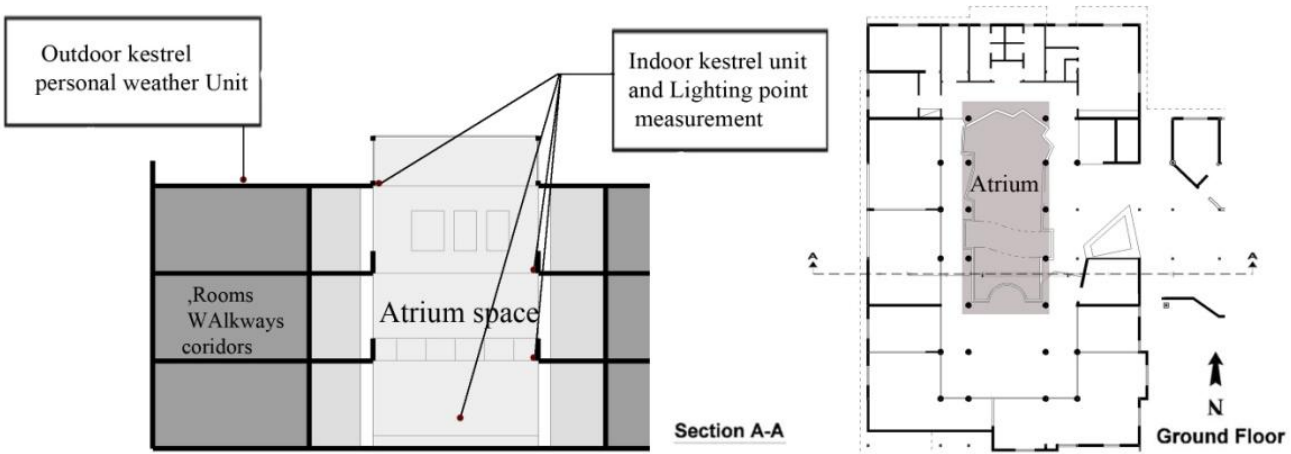


Fig. 1 Case study 1: Plan and section view of the atrium space with measurement position



The atrium space is located in the center of the building and is primarily used for circulation to different location within building. Walkways surround the atrium and connect to interior offices. The atrium has a maximum height of 13.5m.

Fig.1 show a plan view of ground floor and a section view of the building through the east-west axis. In the ground floor plants were placed and the atrium roof covered with green Faber glass (Fig.2).

## 2.2 Description of case study 2: clear glass and without plant

The second case study is a two-storey square construction located at the main entrance of building. The monitored atrium is surrounded by walkways leading to adjacent offices and meeting rooms. The ground floor houses the entrance and reception desk and stairs. Fig.3 shows the ground floor plan and a section view of the building.

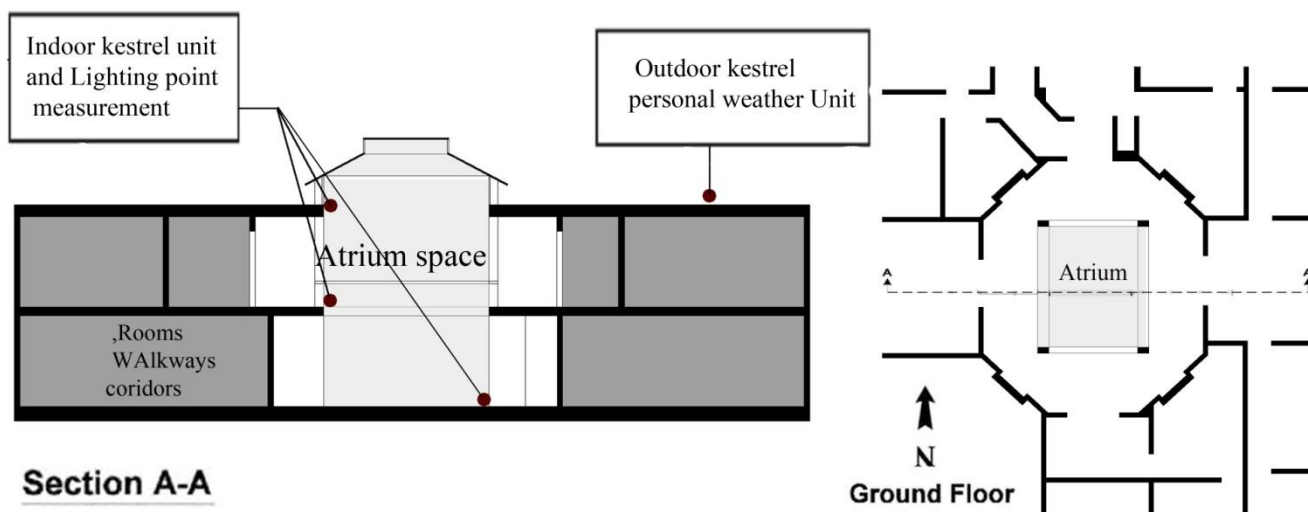


Fig. 3. Case study 2: plan and section of the atrium space with measurement position



The atrium skylight has a sided rectangle and ridge shape (including the frame) Fig.4 shows exterior and interior views of atrium sky light.

## 3. Research Methodology

The site measurement and monitoring work were carried out for one day covering clear day in November 2010. Measured variables included indoor and outdoor air temperatures and relative humidity. indoor and outdoor horizontal illuminance at selection locations distributed uniformly throughout the atrium space (Fig.1 and 3). Indoor illuminance measurement with manual light meter which were recorded at intervals of 20 min and outdoor horizontal illuminance is recorded by digital data logger were monitored from 8a.m to 5p.m at top of the building roof (fig.5).

Fig. 4. Case study 1: exterior and interior view of the atrium skylight



Fig. 5. Picture showing the light meter and kestrel unite in the roof building.

Both Indoor and outdoor air temperatures and relative humidity were measured by kestrel personal weather, which were recorded at intervals of 20 min. They were placed at four locations inside the each building and one location outside the building (Fig.1 and 3).

The measurement started about 5 h after the units were located and the surrounding air had reached the heat balance state. On each floor, the indoor air temperature unit was located at center of atrium. The kestrel on the ground floor were placed at about 1m height above the floor level whilst for the upper floors, they were placed at the floor levels (Fig.5). The outside kestrel personal weather was placed at the roof about 5cm height above the floor.

#### 4. Results and Analysis

The weather conditions during the day measuring period were stable and heating system was off. The weather on this day was cold and dry sky was sunny. Fig.6 presents the indoor air temperatures on the three levels atrium including outdoor air temperatures. The indoor air temperature at a particular time is the measuring point on each floor. On the other hand, Fig. 7 shows the relative humidity of each level with outside relative humidity while Fig.8 and Fig.9 shows the relative between air temperature and relative humidity on the three atrium levels in two case study. And finally Fig. 10 presents the same lighting point in the ground floor of two case study.

Generally, Fig.6 shows that the internal thermal environment on the second floor was not affected by both the outdoor weather conditions and the application of the solar heat gain control strategies. The air temperatures on the second floor were slightly warmer than the ground floor and first floor air temperatures during the day but in the case study1 air temperature changing range in to the indoor atrium levels was more Coordinator than case study2 and it was between 18 to 28 while the outdoor temperature normally occurred between 8:00 to 17:00 was 4'c to 15'c.

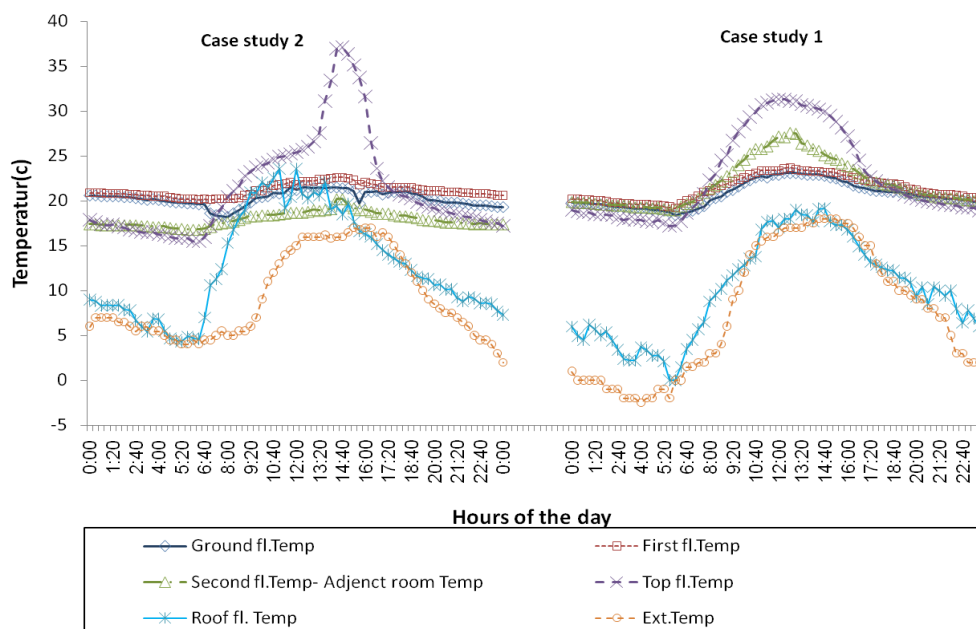


Fig. 7. Indoor/ Outdoor Relative Humidity

Fig.7 shows that the relative humidity of ground floor of case study1 during the 5:00 to 18:00h generally greater than 16% during the day whilst this values for ground floor of case study 2 was fewer than 15% for all the day. In this state the relative humidity values for Days 1 and 2 at the most was around 13%. In the other hand average range of relative humidity of case study 1 in all the floors was similar and it was 15% while average of external relative

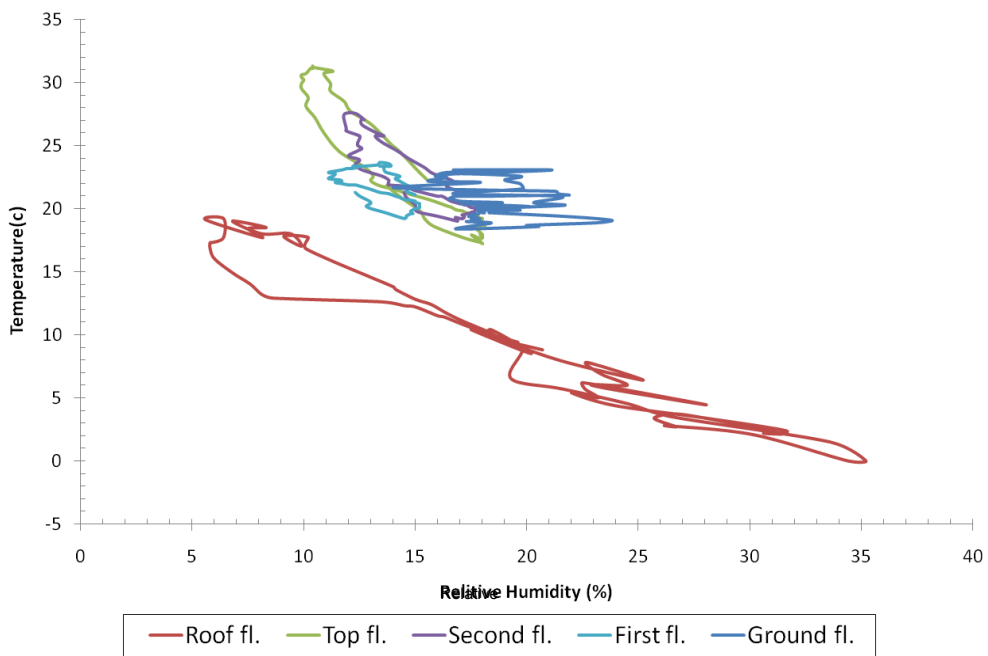


Fig. 8. Case study1: typical day comfort chart

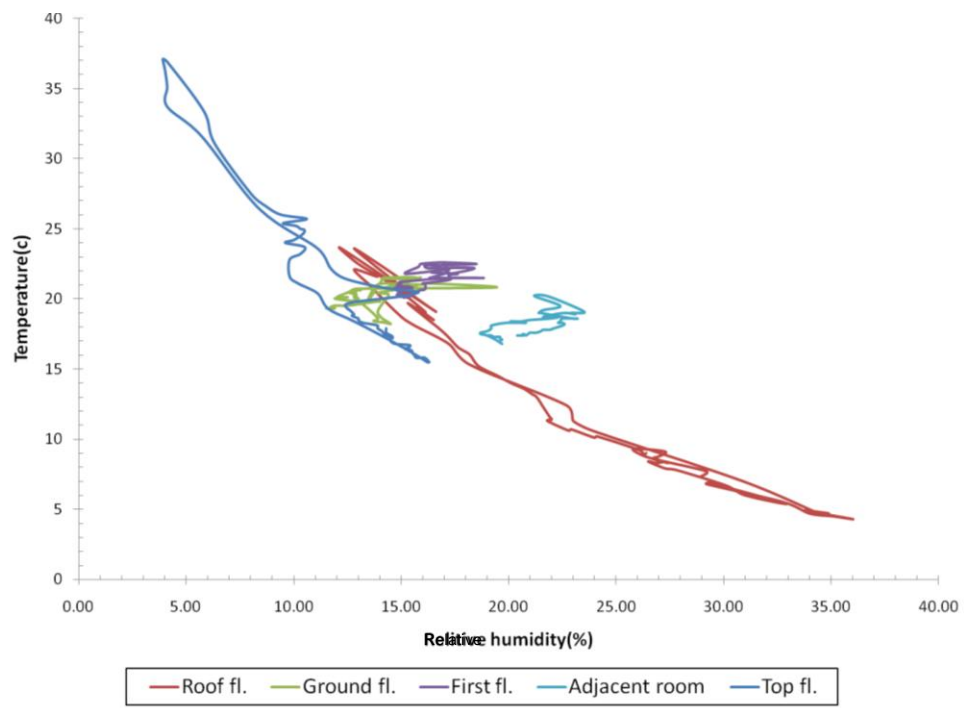


Fig. 9. Case study 2: Typical day comfort chart

humidity in this day was around 9%. In compare to average indoor relative humidity of case study 2 that it was around 13% and 17% for external.

Fig.8 and 9 show the changes relative humidity and temperature in each case study. With compare result of the both chart, know that in case 1 when range relative humidity between 10%- 22% , total temperature in atrium level were changed between 18'C-28'C. whilst in the case 2 this range were between 3%-23% and 15'C-35'C respectively. In fact in case 1 air

humidity efficiency to kept space in thermal comfort zone seen clearly.

Fig.10 shows lighting distribution in ground floor of two case studies at the same time. This chart gives information about the detail distribution of light which is also important (Littlefair, 2002 and Giovannopoulou, *el.at*, 2005)

In the casel changes illuminance in same light point from 100 lux-800 lux were fewer and slower than case1, so that in the ground floor of the atrium space in case1 receive at list 100 lux in the same time was more than 50%. While this value for case2 was including only 30% atrium space.

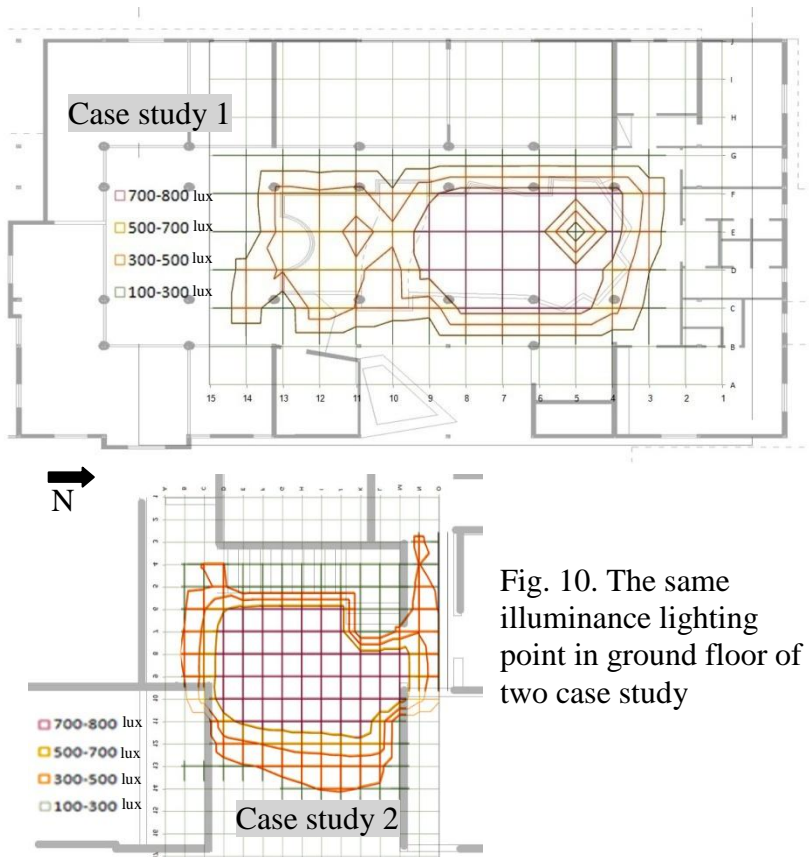


Fig. 10. The same illuminance lighting point in ground floor of two case study

## 5. Conclusions

Results of the study indicated that in cold and dry climates, partially when air conditioned three levels were stop, would suffer high-temperature stratification on the atrium floors causing comfort to the occupants. There is also an indication that the plants had improved the thermal condition inside the atrium. However, due to the short monitoring periods it was difficult to approximately quantify the degree of contribution made by the two measures. Generally on cold and dry weather, without plant in atrium floor and clear glass the average air temperature difference from 24h between both first floor and second floor, and second floor and external were 1.5 C and 8 C, respectively; whilst with color glass and plant the average temperature difference between first and second floor, and second floor and external were 2 C and 13 C, respectively. These results clearly show that plant in atrium save and produce humidity in surround our environment and the color glass, on the other hand, had useful to reduce sun glare in peek illuminate in to atrium space. However, the clear glass was good to get more illuminate from skylight of atrium but however the distribution of this light

is also very important. In this state day light distribution was uninformed but although the color glass atrium reduced entry illuminance to spaces but it distributes this light with fewer glares.

Even though considerable discrepancies were observed among the daily measured thermal parameters on the one day monitoring period, this study is expected to provide a clearer picture of the indoor thermal environmental performance of the atrium in the cold and dry. As the measuring period was rather short, it is therefore recommended that longer monitoring periods be conducted in order to provide stronger justification of the results.

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