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# Sustainability in the Choice of Architectural Elements Coloring and its Relation to Natural Light Intensity in Internal Spaces of Psychiatric and Neurological Hospitals.

Kareem Eldaly
*Demonstrator at Architectural Engineering Department, Mansoura High Institute Of Engineering And Technology - MIET*, kokoaldali2001@yahoo.com

Nevin Zaki
*Lecturer and Manager of Sleep Research Unit, Department of Psychiatry, Faculty of Medicine, Mansoura University, Elmansoura EGYPT*, nevinfzaki@yahoo.com

Lamis El-Gezawy
*Professor and Head of Architectural Department; Faculty of Engineering; Mansoura University*, lamiselgizawi@yahoo.com



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# Sustainability in the Choice of Architectural Elements Coloring and Its Relation to Natural Light Intensity in Internal Spaces of Psychiatric and Neurological Hospitals

# تأثير اختيار ألوان العناصر المعمارية على شدة الإضاءة الطبيعية تحقيقا للإستدامة عند تصميم الفراغات الداخلية للمستشفيات النفسية و العصبية

Kareem Eldaly, *Nevin Zaki* and Lamis Elgizawi

**KEYWORDS:**
***Interior Spaces, Sustainability, Hospitals, Color criteria, Physiological impact and Daylight intensity***

*الملخص العربي*:-اختيار الالوان يعتبر من العناصر الهامة في التصميم الداخلي. حيث ان اختيار الالوان يعتبر فن ذو اسس جمالية ، تصميمية وتطبيقية ، الي جانب وظائفه المختلفة الاخري. وفي نفس الوقت ، فان للالوان اصول علمية وقواعد تعتبر مرتبطة بالاضاءة. تعتبر الاضاءة من العناصر الهامة في المستشفيات. حيث ان مستوي معين من الاضاءة الطبيعية يعتبر ضروري لتنفيذ المهام الضرورية في المستشفى. وللاضاءة الطبيعية دور واضح في المستشفيات النفسية ، حيث ان تصميم مميز للاضاء الطبيعية يمكنه تحويل مظهر فراغ اقامة المريض بجعل المريض يشعر بالترحيب، والارتياح في الفراغ.

ان تكلفة تشغيل المستشفيات النفسية ليست شئ يستهان به، وعلي الرغم من ذلك فان تطوير البيئة الشفائية وتخفيض معدلات استهلاك الطاقة في المستشفيات عن طريق استخدام مبادئ الاستدامه في الاضاءة الطبيعية سيكون له تاثير واضح علي التكلفة الكلية للطاقة المهدرة في المستشفيات.

الهدف الاساسي لهذا البحث هو مناقشة العلاقة بين اختيار الوان العناصر المعمارية مثل (الحوائط، الارضيات، الاسقف وعناصر الفرش) وشدة الاضاءة الطبيعية باستخدام ادوات محاكاه اداء المبني القائمه في عملها علي الكمبيوتر لخلق بدائل تصميمية مختلفة من فراغات اقامة المرضي في المستشفيات النفسية.

نتائج هذا البحث اشارت الي الطرق المثلي لاختيار الوان العناصر المعمارية بطريقة تحقق أعلي إضاءة طبيعية ممكنة في سبيل تحقيق الاستدامه داخل فراغات إقامة المرضى في المستشفيات النفسية.

***Abstract*—Color selection is one of the key areas of interior design. The coloring is an art that has its aesthetic moods, criteria, and applications, in addition to its different contrasting functions. At the same time, color has its pure scientific origins and rules that are closely linked to light. Lighting has its critical importance in hospitals. A sufficient level of daylight is essential to carry out the necessary tasks. Carefully designed day lighting can transform the appearance of the ward and make it attractive, welcoming and even calming.**

**The cost of patient treatment and hospital staff operating is considerable; therefore, measures to maximize performance through improved environments and saving energy by using sustainability principles in day lighting will be cost-effective.**

**The primary objective of this research is to discuss the relationship between architectural elements coloring like (walls, floor, ceiling and furniture colors) and daylight intensity using computer-based building performance simulation (BPS) tools to create comparable varieties in mental hospital wards.**

**The results of the study were figuring the optimum coloring for each architectural element based on the optimum daylight**

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*Kareem Eldaly, Department of Architecture, Faculty of Engineering, Mansoura University, Elmansoura, EGYPT. (e-mail: kokoaldali2001@yahoo.com)*

*Nevin Zaki, Lecturer and Manager of Sleep Research Unit, Department of Psychiatry, Faculty of Medicine, Mansoura University, Elmansoura EGYPT. (e-mail: nevinfzaki@yahoo.com )*

*Lamis Elgizawi, Professor & head of Architecture Department, Faculty of Engineering, Mansoura University, Elmansoura, EGYPT. (e-mail: lamiselgizawi@yahoo.com ).*

**intensity while seeking to achieve sustainability into mental hospital wards.**

## I. INTRODUCTION

Well-designed, ambient environments will have transitions of lighting and color design to allow the eye to adapt to changes in lighting levels. Sometimes relatively small changes in the lighting of spaces can solve an on-going, apparently unconquerable problem (for example, more daylight on walls with an accent color to brighten up a dark area (Alzubaidi, et al., 2013). Colour and lighting consultants can often pinpoint the reason why a place does not "feel" right. For example, a change in the size of the window or adding a skylight can affect a whole area dramatically and may lead to appropriate solutions (Boyce, et al. ،1995). For the healthcare industry, the issue of environmental impact is paramount. The profession is committed to not doing any harm, yet many issues related to the design and operation of healthcare facilities contradict this principle tenet (Ampt, et al., 2008).

*A Development Of Healing Environment through history*

Historically, European and Asian cultures have been receptive to holistic healing. Their treatments have incorporated at various times spa therapy, music, nutrition, herbs, vibrational medicine, and colored light. The five-element theory (fire, wood, earth, water, and metal) is the basis for Chinese medicine. (Michel ،1995)

Historians report that healing was a highly developed art in Atlantis (9500 B.C.) with three different schools of thought on the treatment of illness. Some healers used spiritual methods (flower essences, crystals, and light therapies); priests used homeopathy, an integration of spiritual and scientific methods; and the allopathic healers used herbs, drugs, and surgical treatments similar to practices used by today's orthodox physicians (Gerber, 1988). As new views evolve about the relationship between stress and illness and the influence of positive attitudes on healing, more emphasis will be placed on the design of the patient care environment. (Cho & Beltran, 2004).

*B Mental Hospital Users' Needs*

Psychiatric hospital design needs to reflect the wide range of their users, whether patients, visitors or staff. For patients and visitors, entering a hospital usually is a stressful and uncertain time. To meet their needs, the strategy is to provide flexibility in services and to adopt a patient-oriented attitude towards improving the hospital environment (HSJ for health care, 2010)

A UK study on improvements in patient recovery found that patients were let out one-and-a-half days earlier in a day-lighted environment compared with an artificially lighted one. A USA research project established eight consistent themes in what hospital visitors and inpatients look for in the hospital's built environment; they usually want an environment that (Lawson, et al., 2002):

- Makes it easy to connect with staff.
- Smoothes the connection to the outside world. This includes an indoor environment which reveals sights and scenes of nature
- Is Convenient and accessible which has clear signs, visual clues, and easy way finding. (check Fig. 1)

Figure 1 (Easy way finding & clear signs example form Children's Hospitals and Clinics of Minnesota)

- Is Conducive to a sense of well-being; that is "homely" (especially in long-term care), "attractive", "inviting", relaxing, with positive distractions in waiting and reception areas and an environment that facilitates autonomy and independence.

For patients and visitors, color and lighting design can bring a welcome distraction from the problems that have resulted in hospitalization. This can be accomplished with details of careful selection such as décor, landmarks, artwork, color, the skills of interior window design and garden landscaping combined with enough daylight and artificial lights (Benedetti, et al. ،2001).

*C Daylight Importance In Mental Hospitals*

Daylight from the sky is paramount in hospitals. It gives good color rendering, making it easy in many clinical tasks. It can also provide significant saving in energy by displacing the need for artificial lighting (Lawson, et al., 2002).

The variation in daylight can help inpatients (particularly those who spend a long time in hospital maintain their body clocks. Daylight is also constantly increasing and decreasing as the sun moves around in the sky and as clouds move and form. This short-term variation gives variety and interest in the interior environmental. A lack of windows makes a constant environment, which is specified as boring and depressing (Dijkstra, et al., 2006), (check figure 2).

Figure 2(Daylight helps in clinical judgments while avoiding mixing daylight with artificial light is recomanded)

Figure 3(Daylight helps in clinical judgments while avoiding mixing daylight with artificial light is recomanded)

The following strategies should be done to help the daylight entering a building:

- Suitable control of electric lighting is needed so that lighting can be turned off or dimmed when daylight is enough
- Controls should be zoned according to the available daylight.
- Choose shading devices and glazing so that daylight can still be admitted where possible.
- Zone spaces with activities that do not require daylight should be placed in the non-day-lit core when other areas could be attractively day-lit.
- Daylight distribution is considerable in hospital design. Many hospitals have large areas of roof glazing focused in a few areas; this can cause overheating in that areas and make surrounding areas look gloomy when compared to that area. But a smaller roof light at the back of a predominantly side-lit space can help to balance the lighting distribution (Helliwell, 2012).

*D Daylight Design Guidance*

Current design guidance on daylight is presented in the CIBSE Lighting Guide: 'Daylighting and window design' ((CIBSE), 2002) and BS 8206 Part 2 (British Standards Institution (BSI), 1992) for daylight in spaces, they recommend the following:

- There should be sufficient daylight in the interior spaces, measured by the average daylight factor DF. A DF of minimum 2% is needed for a space to appear shiny at daylight, and at least 3% is suggested for most hospital spaces. When areas with a DF higher than 15% may glare.
- It depends on the area of glazing, being unobstructed and the type of glazing. Tinted glazing often transmits lower lighting and give poorer daylight levels.
- A US research has presented that when transmittance falls below 30-35%, people feel that the view out looks dull and gloomy (Fontoynont, 2014). As well as, highly colored glazing have effects on clinical judgments, especially where some areas are lit by artificial light and others by daylight through the colored glass (check Figure 3). The daylight in a room also depends on the cleanliness of the windows. Besides, Maintenance is considerable, especially for skylights and high-level windows.
- The space depth should not be too high. In deep space, the interior will appear gloomy in comparison with low depth area [3.10]. In typical side-lit hospital rooms, areas over six to seven meters perpendicular from the perimeter (will increase if the window head is unusually high) will appear gloomy unless the extra lighting is provided.
- Every part of the working plane should receive direct sky light. As large outside obstructions will prevent this. This is a specific problem in courtyards (Taguchi, et al., 2007).
- In courtyards case, the depth of the room that can satisfy the daylight needed will change with floor level. Near the ground, daylight will not penetrate unless the window head is raised. Many improvements can be acquired if the courtyard surfaces have light colors (see Figure 4).

Figure 4(Even if courtyards are internal and do not receive much light, they can give a view out and contact with the outside, particularly if planting is provided)

*E Sunlight Significance In Mental Hospitals.*

Thoughts are divided about sunlight. Longmore and Neeman (Longmore & Neeman, 2011) research present that 91% of psychiatric hospital patients think that sunlight was a pleasure, when 62% of staff thought it was a nuisance.Patients prefer sunlight because it gives light and warmth, and believed

to have a therapeutic effect; there are many pieces of evidence for this (Hobday, 1999).

For many Psychiatric hospital areas, the appropriate design strategy is to let sunlight penetrate the area, besides providing adjustable shading for controlling overheating and glare. Sunlight access depends on window orientation and overshadowing by obstructions (Benedetti, et al., 2001). Usually, spaces that lit only by windows facing within 45 degrees of the true north will be perceived weak sunlight. Other windows within 90 degrees of the true north will give little sun if there are significant obstructions to the south (Aripin, 2007).

Sunlight over outdoor spaces around the hospital has significant value, as it helps patients sitting out and giving them pleasant outdoor views. The research was established with a questionnaire obtained to ask if patients would prefer a nice sunlit view with no indoor sun or indoor sunshine with an unpleasant view, the result was 60% of patients gone for the view (Shukor, et al., 2012)

F *Color psychology*

There is a considerable amount of published material, some empirical and much anecdotal, giving advice on the color application using theories of color psychology. However, from experience, it is suggested that this should not be followed indiscriminately. Contextual variables such as building materials used in construction, window positions or lighting, the size of space, the nearness of adjacent buildings or surface quality of materials can all dramatically affect the color appearance and behavior of color and override color psychology recommendations.

These problems can be solved by a well-planned color scheme which bases the colors selected for the building on a wide range of criteria which color psychology theories cannot always cover. Some guidance is given below and in recommendations on the usage of color should also be applied carefully as over-use of a certain color can cause problems. For example, overuse of green or blue colors, renowned for their calming effects, in mental healthcare environments may actually exacerbate depression (check fig. 5)

Fig 5 Adopt Room Headwall at the University of Minnesota Children's Hospital - Fairview, in Minneapolis, USA

Priority should be that color and lighting schemes should be developed to enhance the building performance and create spaces where harmony is visible.

Patient satisfaction is the new buzzword. It's the difference between providing what a patient needs and what a patient wants. It is important not only to satisfy clinical needs but also to meet psychological expectations, which includes comfort and compassionate care (MacRae & Michel, 1998)

As it is well documented that noise in hospitals can interfere with patient healing, lead to stressed and less satisfied healthcare workers, and raise the risk of medical errors, the acoustical design of the room played a key role in making that vision a reality

The combination of design elements and materials in these suites ensures that every noise that can enter or leave the patient room has been addressed and abated as much as possible," said Carol Fellows, nurse manager with the University of Minnesota Children's Hospital, Fairview. "As a result, these Adopt Room suites are promoting less patient and family anxiety, faster recovery, and improved patient satisfaction." (Spohn, 2009), Color and daylight do, of course, have a practical and functional use in patients' accommodation. Used with subtlety in all environments, it can be used to control reflected light, to make the most of the available daylight and to help reduce glare and material performance. (Hilary, et al., 2004)

## II. METHODOLOGY OF THE RESEARCH

The research will be done using the analytical and the comparison method.

At first, a computational model of a case study ward will be built with a BPS tool called Autodesk Ecotect; then a daylight simulation will be done on the base model.

The next step will be creating model varieties with changes in architectural elements color changes depending on Integrated Design Process (IDP). Then the varieties will be compared together depending on each element color change with the daylight factor all over the ward's floor to reach the optimum color that achieved the maximum possible daylight factor.

*A Integrating Design and Simulation*

According to the integrated design process (IDP) approach, it's so important to combine knowledge from engineering and architecture in order to solve very complicated problems connected to the design of buildings. The integrated design process works with the architecture, the design, functional aspects, energy consumption, indoor environment, technology, and construction (Hansen & Knudstrup, 2005) .In this paper the performance elements analyzed includes Energy consumption, Day-lighting and the view of interior space as an essential architectural quality, see Fig. (6).

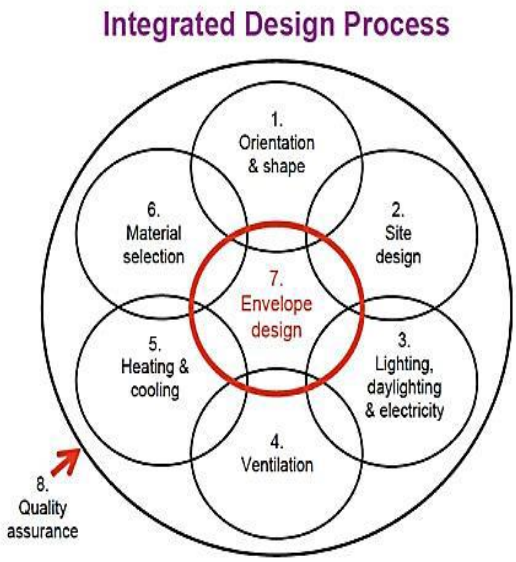



Figure 6 (integrated design process) (Howell, 2008)

*B Case study characteristics*

The selected case study is "Mental Hospitals and Clinics of Minnesota" which is located in Minneapolis, MN (44.9°, -93.2°) as shown in figure 7, then selecting a random room to be simulated to measure the effect of changing room colors on daylight factor, which is considered major factor in Physiological side for the patient The selected room is located on the north side of the hospital as shown in figure 8.

The room interior details were obtained for the base model as shown in figure 9.

All the daylight studies were made to measure the average daylight factor over the year assuming that the average overcast skylight is 8500 lux and the window transparency is 90% and assuming the thermal characteristics of the room as shown in figure 10.


Figure 7 (Mental Hospitals and Clinics of Minnesota)

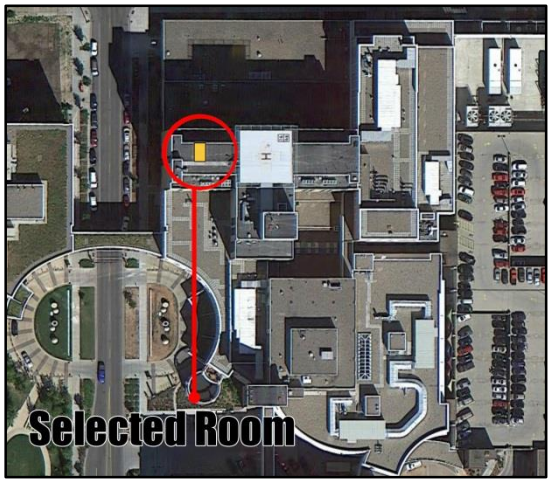



Figure 8 (location of the selected room for simulation)

Figure 9 (case study interior shots)

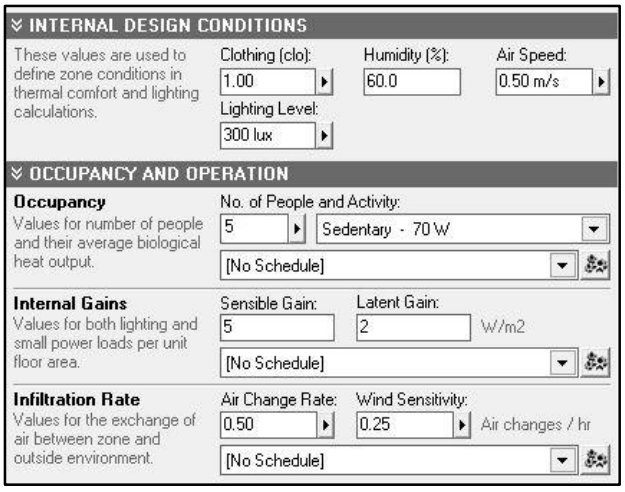



Figure 10 (the calculated Information of the thermal base case)

## III. RESULTS

*A Wall color study*

1. Current case:

Analyzing the current room with the current walls color which is pale yellow (216,216,178) with (.831) the result surface reflectivity is14.03% daylight factor.

2. Changing the walls color to green (170,221,173) with (.786) surface reflectivity is 12.41% daylight factor
3. Changing the walls color to red (233,156,128) with (.690) surface reflectivity and achieving 11.67% daylight factor
4. Changing the walls color to blue (165,185,243) with (.727) surface reflectivity and achieving 11.87% daylight factor So from the results it can be concluded that the pale yellow color in plaster walls achieved the best possible daylighting (see the next table1).

*B Ground color study*

1. From the previous study cases the yellow walls plaster was the optimum case for walls which has the color of walls that is yellow (216,216,178) with (.831) surface reflectivity and the ground color gray (151,151,151) with surface reflectivity (.592) is 14.03 % daylight factor.
2. Then changing the ground color to green (158,233,159) with (.794) surface reflectivity 15.71% daylight factor.
3. Then changing the ground color to silver (212,212,212) with (.831) surface reflectivity and achieving 16.09% daylight factor.

The results above concluded that the yellow color in plaster of walls achieved the best possible daylighting (see table2).

TABLE 1(WALL COLOR STUDY)

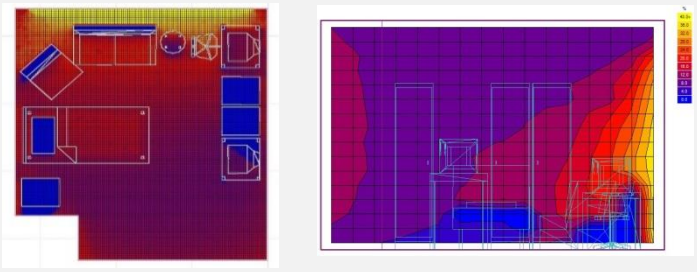
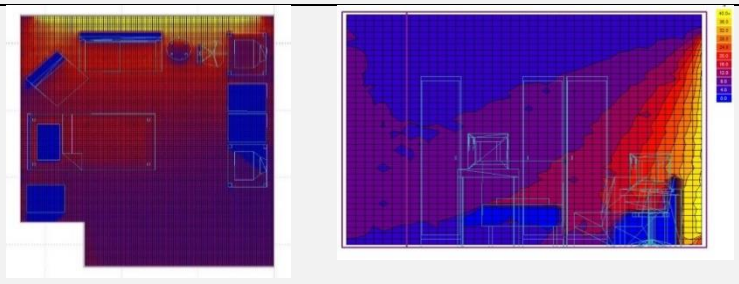
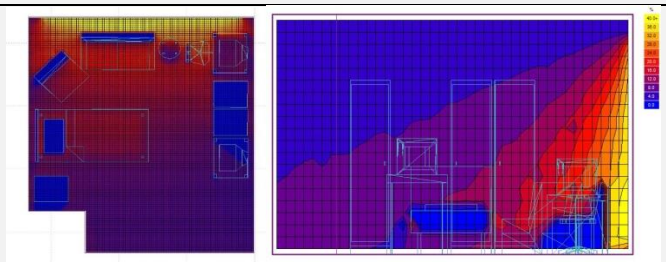
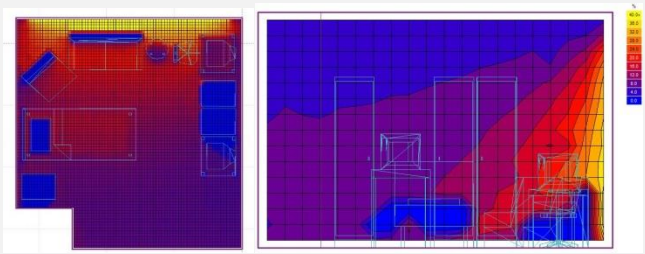
| Wall color | Daylight factor % | Daylight distribution |
|---|---|---|
| yellow (216,216,178) with (.831) surface reflectivity current case | 14.03 % |  |
| to green (170,221,173) with (.786) surface reflectivity | 12.41% |  |
| red (233,156,128) with (.690) surface reflectivity | 11.67% |  |
| blue (165,185,243) with (.727) surface reflectivity) | 11.87% |  |

TABLE 2(GROUND COLOR STUDY)

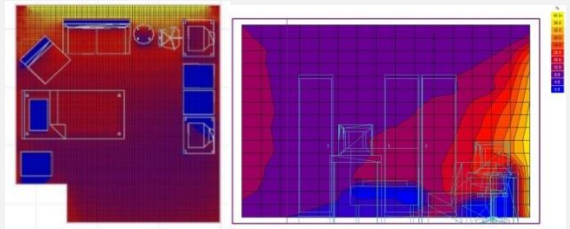
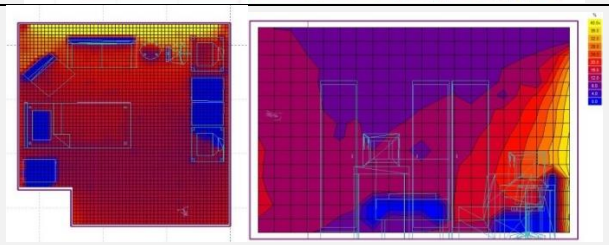
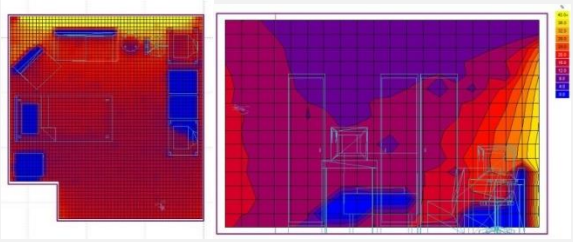
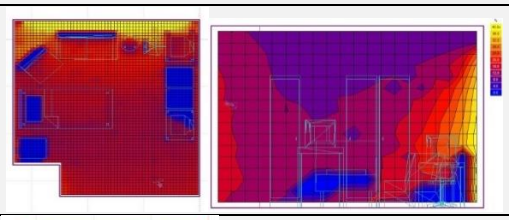
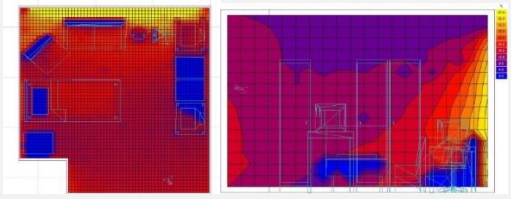
| ground color | Daylight factor % | Daylight distribution |
|---|---|---|
| yellow (216,216,178) with (.831) surface reflectivity | 14.03 % |  |
| green (158,233,159) with (.794) surface reflectivity | 15.71% |  |
| sliver (212,212,212) with (.831) surface reflectivity, current case | 16.09% |  |

TABLE 3(FURNITURE COLOR STUDY)

| furniture color | Daylight factor % | Daylight distribution |
|---|---|---|
| Yellow colors, current case | 16.09% |  |
| Green sofa + white bed + blue chair | 16.45% |  |

*C Furniture color study*

From the previous study cases. the case that has the color of walls that is yellow (216,216,178) with (.831) surface reflectivity and ground floor color that is silver (212,212,212) with (.831) surface reflectivity using yellow colors for furniture to achieve 16.09% daylight factor.

However, changing the furniture color to green and blue and white color which exists, and keeping the walls and ground colors as the previous case, the daylight factor changed to 16.45%

## IV. CONCLUSION

The paper aims to realize that the concept of mental hospitals' interior design is different than that of all other buildings. The selection of color, floors, ceilings, walls, furniture, and lighting has its great impact on the wellbeing of sick people and the medical staff. Therefore, the selection is based on certain criteria, specifications, and strong scientific causes that take under its consideration not only the psychological and physiological impacts but also the aesthetic effects on the concerned people.

With respect to the sustainability dimension, the research addressed the relationship between the design of interior space

colors and day lighting of hospitals and the users' psychological and physiological aspects to serve adult people.

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