ARTICLE

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Assessment of LEED Green Building Certificate Indoor Evironmental Quality Parameters from the Perspective of Occupant Satisfaction and Cost Performance

LEED Yeşil Bina Sertifikası İç Ortam Kalitesi Parametrelerinin Kullanıcı Memnuniyeti ve Maliyet Performansı Bakımından Değerlendirilmesi

Zeynep IŞIK

ABSTRACT

This paper presents a comparative analysis of different stakeholders' view of LEED certified building projects' Indoor Environmetal Quality (IEQ) parameters from the perspective of such key performance indicators (KPIs) as "occupant satisfaction" and "project cost performance". Within this context, a comprehensive literature review respresenting the studies on Indoor Environmental Quality with a relationship to occupant satisfaction in terms of thermal comfort, daylighting, acoustic control and project cost premium and investment performances etc. was conducted and an Analytical Hierarchy Process (AHP) model was constructed indicating the effects of IEQ parameters on Occupant Satisfaction and Project Cost Performance. The ratings of the effects of the parameters were collected by a brainstorming workshop with the participation of different stakelholders of sustainable design such as researchers, practitioners and LEED consultants. The data were analysed conducting AHP analysis which is a multi crtieria decision method. The analysis results revelaed that thermal comfort, interior lighting, daylight, acoustic performance and environmental tobacco smoke control parameters had the highest rankings among occupant satisfaction whereas low emitting materials, daylight, thermal comfort and acoustic performance were the ones for project cost performance.

Keywords: *Analytical hierarchy process (AHP); indoor environmental quality (IEQ); LEED Certification; occupant satisfaction; project cost performance; stakeholder perceptions.*

ÖZ

Bu çalışma, LEED yeşil bina sertifikalı bina projelerinde "İç Ortam Kalitesi" parametrelerinin farklı paydaşların bakış açıları ile "kullanıcı memnuniyeti" ve "proje maliyet performansı" gibi anahtar performans göstergeleri bakımından karşılaştırmalı bir analizini sunmaktadır. Bu bağlamda, "İç Ortam Kaliesi"nin, "kullanıcı menuniyeti"ni belirleyen ısı konforu, gün ışığı, akustik kontrol vb. unsurlar ile olduğu gibi proje maliyet primleri ve performansı ile ilişkilerini temel alan kapsamlı bir literatür çalışması gerçekleştirilmiş ve buna bağlı olarak "İç Ortam Kalitesi" parametrelerinin "Kullanıcı Memnuniyeti" ve "Proje Maliyet Performansı" üzerindeki etkilerini göstergeleyecek bir Analitik Hierarşi Süreci (AHS) Modeli oluşturulmuştur. Konu hakkında uzman araştırmacı, sektor profesyoneli ve LEED danışmanı kişiler düzenlenen çalıştayda bir araya getirilerek parametrelerin etkileri değerlendirilmiş, çalıştayda toplanan veriler bir çoklu karar verme yöntemi olan AHS ile analiz edilmiştir. Analiz sonuçları ısı konforu, aydınlatma, gün ışığı, akustik performans, çevresel tütün kontrolü gibi parametrelerin kullanıcı memnuniyeti bakımından, düşük salınımlı malzemeler, ısı konforu ve akustik performansın porje maliyeti bakımından etkili olduğunu göstermiştir.

Anahtar sözcükler: *Analitik hierarşi süreci; iç ortam kalitesi; LEED Sertifikası; kullanıcı memnuniyeti; proje maliyet performansı; paydaş algısı.*

Department of Civil Engineering Construction Management Division, Yıldız Technical University, İstanbul, Turkey.

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Correspondence: Zeynep IŞIK. **e-mail:** zeynep@yildiz.edu.tr

Introduction

During the last decades, sustainable movement rapidly gained momentum as the climate change and decrease in the natural energy resources forced sector practitioners and researchers in various industries and disciplines to scrutunize and develop new methods to reduce energy consumptions. According to UN Conference Of Parties 21 (COP21, 2015[1]), buildings increased their share on greenhouse emissions, energy use, water use and waste reaching 40% of the global use. Building and construction sectors also remodeled the way of thinking on 'built environment' integrating it with social, environmental and economical aspects. Recently, many green building rating systems and certifications were developed to reduce energy consumptions of the buildings. These systems include, Leadership in Energy and Environmetal Design (LEED) in US, Building Research Establishment Environmental Assessment Method (BREEAM) in UK, Comprehensive Assessment System fo Built Environment Efficiency (CASBEE) in Japan, Building Environmental Performance Assessment Criteria (BEPAC) in Canada, Green Building Certification Criteria (KGBCC) in Korea and Green Building Tool (GB Tool) in an international collaboration framework. Among these rating and certification systems, LEED established by the U.S Green Building Council to reduce negative impacts of the buildings gained attention of the sector practitioners not only in US but in so many industrialized countries such as Turkey, China, India, Brazil, Germany, Sweden, Canada etc (USGBC, 2016[2]). According to USGBC's countries market brief, Turkey is among top ten countries in the world on the implementation of LEED with a number of 149 certified and 378 registered projects (USGBC, 2016). Among 149 certified projects, 102 of them achieved a gold level, 27 of them silver, 11 of them platinum and 9 of them achieved certified level. 60% of the total projects have been certified for New Construction (NC), 24% for Core and Shell (CS), 6% for Existing Buildings: Operations and Maintenance (EBOM), 6% for Commercial Interior (CI) and 4% for schools and higher education centers. The ratio of achievement for office buildings out of the grand total was 44% whereas, multi family residential follow it with a ratio of 19%, industrial manufacturing 8%, Lodging 8%, Retail 5%, Public assembly 4%, higher education 4%, health care 3%, K12 3% and other 2% respectively (USGBC, 2016).

This increasing demand in Turkish construction industry brought the main idea of this study to consider LEED certified projects' key performance indicators (KPIs) upon the perspectives of different stakeholders such as the "contractors", "occupants" and "LEED consultants". Though the main aim of LEED was determined as creating a specific kind of built environment consuming minimal resources and producing minimal waste (Cidell, 2009[3]), it was hypothesized for this study that contractors occupying LEED in their projects were focused more on cost and company reputation than its environmental results whereas the occupants were more comfort focused in terms of thermal, acoustic, lightning quality etc. and the consultants were sticked to the LEED parameters defined in the rating system.

In the light of an in depth literture survey, "Indoor Environmental Quality (IEQ)" was selected as one of the main indicators of the rating system from the perspective of the LEED consultant, which have significant effects on "Occupant Satisfaction (OS)" compared to "Project Cost Performance (PCP)" from the perspective of the "contractor". "LEED v4 New Construction and Major Renovation (LEED NC) Rating System" was used to determine the parameters' effects. Adopting Analytical Hierarchy Process (AHP) as a Multi Criteria Decision Making Tool, the effect of those parameters associated with IEQ on OS and PCP were calculated and compared. The findings of the research aim to provide construction practitioners and researchers for a better understanding of LEED implementation on projects giving the awareness for post-project effects of it from different perspectives such as the "contractor", the "consultant" and the "occupant".

An Overview of the LEED Rating System and Indoor Environmental Quality

LEED is a green rating system developed by US Green Building Council (USGBC) as a response to social awareness and concerns regarding the increase in energy resources consumptions due to buildings. Since it was developed first in 1990's, the rating system has been improved with necessary modifications and extensions in order to achieve long-term effectiveness of green design. As a third party certification program, LEED can be applied to new and existing buildings, multi-family residentials, industrial manufacturing establishments, lodgings, higher education, health care, K-12 institutions, warehouses, laboratories, educational facilities and public assemblies under programme titles such as LEED BD+C: New Construction, LEED BD+C: Core and Shell, LEED BD+C: Schools, LEED BD+C: Retail LEED BD+C: Data Centers, LEED BD+C: Warehouses and Distribution Centers, LEED BD+C: Hospitality, LEED BD+C: Healthcare (Cotera, 2011[4]; USGBC, 2016[5]). There are four levels for potential LEED projects to target: certified (40-49 LEED points), silver (50-59 LEED points), gold (60-80 LEED points) and platinum (80-120 LEED points). According to the latest modified version LEED V4, a building can earn credits from criteria such as "location and transportation", "sustainable sites", "water efficiency", "energy and atmo-

[1] COP21, 2015.
[2] USGBC, 2016.
[3] Cidell, 2009, p. 202.
[4] Cotera, 2011.
[5] USGBC, 2016.

sphere", "materials and resources", "indoor environmental quality", "regional priority and "integrative process credits" of which are presented in Table 1.

Indoor Environmental Quality (IEQ) Credentials

Indoor environmental quality (IEQ) is one of the major components of the certification system since it is critical for occupant's comfort, health and productivity and consisting 15% of the available points as being the second highest category in LEED v4 New Construction and Major Renovation (LEED NC) Rating System. The parameters of IEQ and their explanations are as follows and presented in Table 2.

- Minimum Indoor Air Quality Performance; provide indoor air quality including ventilation and monitoring for a better and healthier indoor environment satisfying the occupants is provided by this parameter of IEQ.
- Environmental Tobacco Smoke Control; protects the occupants, building surface and air condition system from the negative effects of tobacco. It requires no smoking inside of the building.
- Enhanced Indoor Air Quality Strategies; can be enhanced by improvement of circulation between air inside and outside of the building.
- Low-Emitting Materials; sets threshold to eliminate the harm caused by Volatile Organic Compound (VOC) contained by building materials and release harmful emission, which causes health problems of building occupants.
- Construction Indoor Air Quality Management Plan; intends to protect the air quality during construction and after occupancy by implementing an indoor air quality management plan.
- Indoor Air Quality Assessment; focuses on the indoor air quality during or after construction stages.
- Thermal Comfort; intends to enhance the occupants' indoor air quality by providing thermal comfort.
- Interior Lighting; intends to enhance the occupants' indoor experience by providing better lighting quality.
- Daylight; intends to allow more daylight with manual or automatic control systems into the building to reduce the use of electrical lighting.
- Quality Views; intends to create more connections with building occupants and natural outdoor views.
- Acoustic Performance; intends to promote building occupants' well being, productivity and communicate efficiency by providing advance acoustic designs (USGBC, 2016[6]).

[6] USGBC, 2016.

Table 1. LEED v4 New Construction and Major Renovation Rating System Criteria

Location and Transportation	Materials and Resources
Sustainable Sites	Indoor Environmental Quality
Energy and Atmosphere	Water Efficiency
Innovation	Regional Priority

Table 2. LEED v4 Indoor Environmental Quality Criteria

Abbr.	Indoor environmental quality
IEQ1	Minimum Indoor Air Quality Performance
IEQ2	Environmental Tobacco Smoke Control
IEQ3	Enhanced Indoor Air Quality Strategies
IEQ4	Low-Emitting Materials
IEQ5	Construction Indoor Air Quality Management Plan
IEQ6	Indoor Air Quality Assessment
IEQ7	Thermal Comfort
IEQ8	Interior Lighting
IEQ9	Daylight
IEQ10	Quality Views
IEQ11	Acoustic Performance

Key Performance Indicators of LEED Certificated Buildings for IEQ

There are several studies in the literature focusing especially on IEQ since it was assumed that sustainable design strategies enhancing IEQ will improve occupant satisfaction and comfort and therefore work performance in the office buildings whereas project cost performance will be highly effected by IEQ (Feige et al., 2013[7]). In this study, "Occupant satisfaction" and "project cost performance" were hypothesized as the key performance indicators for the success of IEQ parameters. Thus a literature review has been held indicating the relationships between those KPIs considered and IEQ.

Occupant Satisfaction

The relationship between occupant satisfaction and indoor environmental quality has been highlighted in the literature both for LEED and non-LEED buildings. Paul and Taylor (2008)[8] argued that green buildings with better indoor environmental quality leads to more satisfying workplaces for the occupants or not. Lee and Guerin (2009)[9] identified the fact whether indoor environmental quality and its related criteria such as thermal comfort, lighting, acoustics etc. have significant effects on workspace satisfaction and overall performance. Hua et al. (2011)[10] re-

[7] Feige, 2013, p. 8.
[8] Paul and Taylor, 2008, p. 1860.
[9] Lee and Guerin, 2009, p. 295.
[10] Hua et al., 2011, p. 60.

ported a post occupancy study of the visual environment in a laboratory building on a university campus and identified the effectiveness of daylight design and occupant visual satisfaction. Hwang and Kim (2011)[11] investigated the effects of indoor lighting on occupants' visual comfort and eye health in a green building. Lee (2011)[12] made a comparison between certification levels of LEED certified buildings in terms of indoor air quality and thermal comfort quality. Zhang and Altan (2011)[13] made a comparison of the occupant comfort in a conventional high-rise office building and a contemporary green building. Tha basic physical parameters were air temperature, humidity, luminance and sound level. It was found out that there was a noticeable difference in terms of thermal and visual environment of two buildings. Frontczak and Wargocki (2011)[14] presented a paper aiming to explore how different factors influence human comfort in indoor environments. The study highlighted the fact that creating a thermal environment is considered to be the most important factor for achieving satisfaction. Choi (2011)[15] investigated the relationship among indoor environmental quality, occupant satisfaction, work performance and sustainability ethics in sustainable buildings. Kamaruzzaman et al. (2011)[16] investigated occupants' opinion of the indoor environmental quality of the building based on a range of discrete factors. Sulochana et al. (2012)[17] developed a multi criteria decision making model to improve performance of construction projects with LEED certification which has the ability to distinguish uncertainty between parameters such as project cost variation, environmental impact, impact on schedule and construction productivity. The simulation tool developed was to optimize the benefits and minimize the negative impacts of LEED implementation in a new project. Frontczak et al. (2012)[18] examined the quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design. Ofori-Boadu et al. (2012)[19] provided a framework to enhance the success of LEED projects. Ranasinghe et al. (2012)[20] evaluated occupant satisfaction on indoor environment in a green building, questioning the occupants and focusing on the aspects of thermal comfort as the person's psychological state of mind. Kim et al. (2013)[21] developed a method for evaluating the performance of green buildings with a focus on user experience. Newsham et al. (2013)[22] conducted a research on green and conventional buildings related to environmental satisfaction, job satisfaction and organizational commitment, health and well-being, environmental attitudes and commuting. Altomonte and Schiavon (2013)[23] investigated the correlation between indoor environmental quality in office buildings with job performance and overall company productivity. In another study, Schiavon and Altomonte (2014)[24] examined the influence of factors unrelated to environmental quality on occupant satisfaction in LEED and non-LEED certified buildings. Brown and Gorgolewski (2014)[25] assessed occupant satisfaction and energy behavior in LEED gold high-rise residential buildings. Miller et al. (2014) conducted a field study for occupant comfort in a LEED Platinum Office Building with an underfloor air distribution system. Doczy (2014)[26] conducted Analytical Hierarchy process to analyze cost, LEED credits and carbon neutrality utilizing a building information modeling platform. Driza and Park (2014)[27] defined occupant satisfaction for LEED certified higher education buildings. Cheng and Ma (2014)[28] developed a decision support system for LEED based on climate factors. Chokor et al. (2015)[29] show cased the variation of LEED certified buildings' assessment results from micro and macro perspectives. Khashe et al. (2015)[30] examined the influence of branding a building as LEED certified on occupants' pro-environmental behavior. Chokor (2015)[31] evaluated the performance of LEED certified facilities using data-driven predictive models for energy and occupant satisfaction with indoor environmental quality.

Project Cost Performance

The cost performance of LEED certified buildings have been depicted in the literature several times. Mao (2016)[32] established a web-based framework for estimating premium costs of potential LEED new construction projects. Nyikos et al. (2012)[33] analysed cost premiums associated with sustainable facility design. Freybote et al. (2015)[34] assessed the impact of LEED neighborhood certification on condo prices. Kats et al. (2003)[35] found that productivity and health benefits accounted for about 70 and 82% of the respective Net Present Value (NPV) when classifying LEED certification into two groups such as Certified/Silver and Gold/Platinum. US Department of Energy (DOE) asserted that utility savings from sustainable designs accounted for 12% of the total savings, while emissions for 4% (DOE, 2003).[36] The majority of the benefits came from incorporating design strategies that minimize costs. Weber and Kalidas (2004)[37] concluded that the NPV of sustainable design exceeded the planned costs of the project consider-

11 Hwang and Kim, 2011, p. 80
12 Lee, 2011, 568
13 Zhang and Altan, 2011, 537
14 Frontczak and Wargocki, 2011, p. 925.
15 Choi, 2011.
16 Kamaruzzaman et al., 2011, p. 410.
17 Sulochana et al., 2012, p. 1900.
18 Frontczak et al., 2012, p. 120.
19 Ofori-Boadu et al., 2012, p. 150.
20 Ranasinghe et al., 2012, p. 274.
21 Kim et al., 2013, p. 205.
22 Newsham et al., 2013, p. 420.
23 Altomonte and Schiavon, 2013, p. 70.
24 Schiavon and Altomonte, 2014, p. 151.
25 Brown and Gorgolewski, 2014, p. 495.
26 Doczy, 2014.
27 Driza and Park, 2014, p. 230.
28 Cheng and Ma, 2014, p. 1911.
29 Chokor et al., 2015.
30 Khashe et al., 2015, p. 477.
31 Chokor, 2015.
32 Mao, 2016.
33 Nyikos et al., 2012, p. 51.
34 Freybote et al., 2012, p. 590.
35 Kats et al., 2003.
36 DOE, 2003.
37 Weber and Kalidas, 2004.

ing a college residence hall case. Kats et al. (2003)[38] found out that cost increases as the level of LEED certification increases. Lee et al. (2000)[39] indicated that project cost would increase about 2% to achieve LEED certification. Stegal (2004)[40] examined the cost of new construction and found that the cost increases between 1 and 2.8%. Mathiessen et al. (2004)[41]; Fowler and Rauch (2008)[42] found similar results in different years with different data as those with Kats et al. (2003).[43] On the contrary Hydes and Creech (2000) proved that increasing the thermal and energy efficiency reduce the initial capital cost. However it didn't change the general perception of construction industry as green buildings cost about 10% to 15% more than conventional buildings (Hiltz, 2010)[44]. Later on, as the green industry developed and the material production accordingly increased in volume, lower percentages showed up in terms of cost premiums. Kaplan et al. (2009)[45] completed a research on 107 projects and the results indicated that, 59% of those projects obtained LEED certification with 1% cost increase. Stuart (2010)[46] indicated that there were zero additional costs for LEED Silver level construction projects. It showed that later researches did not comply with the ones at the beginning of 2000s. However, it was still questioning the minds of the practitioners' perceptions for sustainable design cost of the projects.

Research Methodology and Data Collection

In this research, Analytical Hierarchy Process (AHP) was adopted to determine the ratings of the factors according to the perceptions of different stakeholders from the viewpoint of key performance indicators such as "occupant satisfaction" and "project cost performance". The AHP is a decision-making method developed by Saaty (1980).[47] It aims to quantify relative priorities for a given set of alternatives and stresses the importance of the intuitive judgments of the decision maker and the consistency of the comparison of alternatives. The decision maker compares the alternatives according to its own judgment based on experience and knowledge. The strength of this method is that it organizes soft parameters of which rating are based on the perceptions of different parties. Saaty (1980)[48] developed following steps to apply AHP in any decision-making problem. First the problem and the goal is defined, then the hierarchy is structured from top to bottom considering the goal at the top, the criteria in the mid level and the alternatives in the bottom level. In this study the goal was defined as "occupant satisfaction" and "project cost performance" separately and the criteria were taken as the Indoor Environmental Quality parameters as depicted in previous parts and presented in Table 3 (Figure 1, 2).

Table 3. Fundamental scale for judgement

Fundamental scale for judgement	Numeric variables
Equally importance	1
Moderate importance of one over another	3
Strong or essential importance	5
Very strong or demonstrated importance	7
Extreme importance	9
Intermediate importance	2, 4, 6, 8

Constructing the set of pair-wise comparison matrices for each of the levels, matrices are then questioned to the decision makers using a relative scale measurement as shown in Table 3. There are n(n-1) judgments in each matrix for the decision makers. The matrices are developed using the scale measurement and the reciprocals are assigned for each pair wise comparison.

Hierarchical synthesis is then used to weight the eigenvectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of hierarchy. After all, pair wise comparisons are fulfilled and the matrices are developed, the consistency is determined by using the eigen value, λ_{max}, to calculate the consistency index (CI) as follows, $CI=(\lambda_{max}-n)/(n-1)$, where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value. The CR is acceptable if it does not exceed 0.10. These steps are performed for all levels in the hierarchy.

In this study, pair wise comparisons data were collected from nine experts of sustainable design each representing a stakeholder in green construction industry. Experts were selected among experienced stakeholders who have worked on those kinds of projects and researchers throughout their careers. Commonly, there's no minimum number for the number of participants in AHP method, representation of the parties are assessed with their experiences and qualities rather than the numbers (Powell, 2003;[49] Dikmen et al., 2010[50]). Among "nine experts", "two of them were 20 years and more experienced project managers in construction industry", "three of them were researchers from different institutes", "two of them were LEED accredited professionals" and "two of them were occupants of a LEED certified building". Ulti-

38 Kats et al., 2003.
39 Lee et al., 2000.
40 Stegal, 2004.
41 Mathiessen et al., 2004.
42 Fowler and Rauch, 2008.
43 Kats et al., 2003.
44 Hiltz, 2010.
45 Kaplan et al., 2009.
46 Stuart, 2010.
47 Saaty, 1980.
48 Saaty, 1980.
49 Powell, 2003, p. 379.
50 Dikmen et al., 2010.

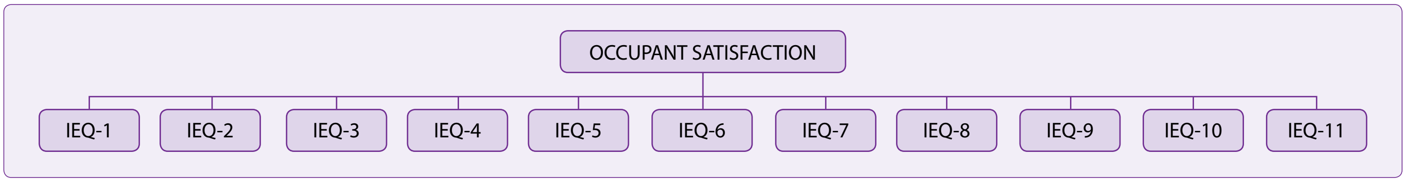

Figure 1. Occupant satisfaction.

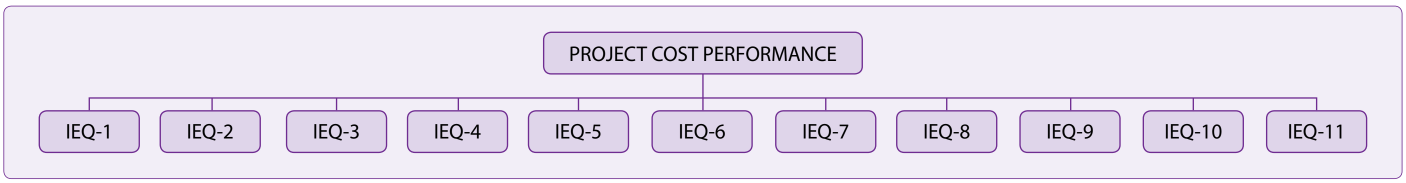

Figure 2. Project Cost Performance.

Table 4. AHP Ranking Results

Abbr.	Indoor environmental quality	Occupant satisfaction	Project cost performance
IEQ1	Minimum Indoor Air Quality Performance	0.0256	0.0874
IEQ2	Environmental Tobacco Smoke Control	0.1123	0.0028
IEQ3	Enhanced Indoor Air Quality Strategies	0.0178	0.0798
IEQ4	Low-Emitting Materials	0.0184	0.2113
IEQ5	Construction Indoor Air Quality Management Plan	0.0215	0.0584
IEQ6	Indoor Air Quality Assessment	0.0125	0.0356
IEQ7	Thermal Comfort	0.2485	0.1338
IEQ8	Interior Lighting	0.1698	0.0741
IEQ9	Daylight	0.1516	0.1478
IEQ10	Quality Views	0.0901	0.0456
IEQ11	Acoustic Performance	0.1319	0.1234

mately, judgments of representing stakeholders' opinions were used as the final data.

Analysis and Discussion of the Results

AHP analysis was conducted from the viewpoint of two key performance indicators namely, "Occupant satisfaction" and "Project cost performance" and the results representing the weights of each of the parameters according to the two KPIs were analyzed with an AHP software named "Superdecisions" and presented in Table 4.

According to the results of AHP analysis, it was revealed that "thermal comfort" with a weight of 0.2485 was the leading parameter for "occupant satisfaction" whereas "low-emitting materials" with a weight of 0.2113 was the leading one for project cost performance. "Interior lighting", "Daylight", "Acoustic Performance" and "Environmental tobacco smoke control" followed "Thermal comfort" with values 0.1698, 0.1516, 0.1319 and 0.1123 respectively for occupant satisfaction; "daylight", "thermal comfort", "acoustic performance" followed ""low emitting materials" with values 0.1478, 0.1338 and 0.1234 respectively. Lee and Guerin (2009)[51]'s findings also showed that indoor air quality affected only the occupants' performances. Hua et al. (2010)[52] stated that daylight is primary light source reducing energy consumption and enhancing work environment as well as the indoor environmental quality. Hwang and Kim (2011)[53] proved that daylight could improve the occupants' psychological health and productivity. Zhang and Altan (2011)[54] studied the occupant comfort in a conventional and a contemporary green building and inferred that there's a huge difference between the thermal, visual, acoustic satisfaction levels. Frontczak and Wargocki (2011)[55] suggested that when developing systems for controlling the indoor environment, the type of building and outdoor climate should be considered to improve thermal and visual comfort as well as satisfaction with the air quality. According to Frontczak and Wargocki (2011)[56] it was pointed out that thermal quality influence a

51 Lee and Guerin, 2009, p. 297.
52 Hua et al., 2010, p. 63.
53 Hwang and Kim, 2011, p. 87.
54 Zhang and Altan, 2011, p. 540.
55 Frontczak and Wargocki, 2011, p. 930.
56 Frontczak and Wargocki, 2011, p. 932.

higher degree of overall satisfaction compared to other indoor environmental quality conditions. Kamaruzzaman et al. (2011)[57] presented an assessment of occupants' opinion of the internal environment of buildings and found out that daylight and electric light were the most dissatisfied parameters of the IEQ. Ranasinghe et al. (2012)[58] asserted that there some factors effecting the thermal comfort which was not discovered in the standards or guidelines so it was suggested that design aspects beyond those guidelines should be considered to improve it. Frontczak et al. (2012)[59] observed that highest level of satisfaction was related with the amount of daylight and dissatisfaction was observed for sound privacy, temperature, and noise level and air quality. Sulochana et al (2012)[60] proved that LEED achievement in buildings has various positive effects on work performance and productivity, construction cost and schedule and the environment. Its effects on project cost performance was mainly not of IEQ but energy and atmosphere prerequisites. Newsham et al. (2013)[61] supported that green buildings will produce higher ratings of occupant environmental satisfaction will have temperatures closer to thermally neutral and will have lighting conditions closer to recommended practice and provide more access to daylight satisfying the occupants. Chokor et al. (2015)[62] examined occupant satisfaction and revealed significant results exhibiting higher occupant satisfaction in terms of thermal comfort, lighting level and acoustic quality. The only study different than those mentioned in the literature and in this study was Altomonte and Schiavon (2013)[63] resulting an equal satisfaction for LEED certified and non-LEED buildings.

Conclusion

This study revealed a comparative analysis of Indoor Environmental Quality (IEQ) of LEED certified buildings in terms of their key performance indicators (KPIs) such as "occupant satisfaction (OS)" and "project cost performance (PCP)". For this purpose, a theoretical investigation of the background of the work has been held with a comprehensive literature review. After determining the KPIs of Indoor Environmental Quality as "Occupant satisfaction" and "Project Cost Performance", Analytical Hierarchy Process (AHP) was conducted to analyze the rate and ranking of those IEQ parameters depicted in the LEED scorecard on already determined KPIs. In AHP analysis, different stakeholder views were collected with a brainstorming workshop in participation of nine experts in sustainable design. The analysis results were generated with an AHP software and the results of the analysis was supported with the literature indicating also original comparative results from different stakeholder perspectives of LEED mentioned in the text as indicators of project cost from the contractors' perspective and satisfaction indicators from the occupants' perspective. "Interior lighting", "Daylight", "Acoustic Performance" and "Environmental tobacco smoke control" followed "Thermal comfort" for occupant satisfaction whereas "Daylight", "Thermal comfort", "Acoustic performance" followed ""Low emitting materials" for project cost performance.

Findings of this study would be beneficial for both researchers and practitioners since stakeholder management is of great importance nowadays and understanding the needs and requirements of different stakeholder views would lead practitioners for better management of their projects. Besides, investigation of LEED certification as being the most widely implemented green certification system also in Turkey is of an interesting topic for researchers to understand the improvement needs of the parameters.

[57] Kamaruzzaman et al., 2011, p. 411.
[58] Ranasinghe et al., 2012, p. 278.
[59] Frontczak et al, 2012, p. 129.
[60] Sulochana et al., 2012, p. 1907.
[61] Newsham et al., 2013, p. 434.
[62] Chokor et al., 2015.
[63] Altomonte and Schiavon, 2013, p. 75.

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