Comparative Research of Residents' Satisfaction Level Between Green Building-Certified Apartment Complexes and General Apartment Complexes in Korea

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Abstract
As international considerations concerning the environment increase, various concrete efforts have been attempted, and in response to this, KGBCC (Korean Green Building Certification Criteria) was developed and has operated since 2002. The objective of this study is to research residents' understanding regarding KGBCC and conduct comparative research on residents' satisfaction level and the cause of dissatisfaction concerning KGBCC assessment standards, based on KGBCC-certified apartment complex and general apartment complex. For the research, a questionnaire regarding the awareness of the KGBCC, satisfaction level, and cause of dissatisfaction were conducted with residents of a KGBCC-certified apartment complex and a general apartment complex in the Samsan district, Incheon. The survey results were compared and analyzed, and improvements to the KGBCC are suggested.

Keywords: green building certification system; residents' satisfaction level; assessment standard; KGBCC

1. Introduction
1.1 Background and Aim of the Research
As the world becomes more concerned about green buildings, various green building certification systems such as BREEAM, LEED, and CASBEE have been operating internationally, and Korea also has been running the Korean Green Building Certification Criteria (KGBCC) since 2002. However, no studies regarding the understanding or satisfaction level of residents living in the certified buildings have been carried out, so verification concerning the effect of the certification is needed.

With this background, the aim of the research is to compare KGBCC-certified apartment complex and general apartment complex, and to verify the effect of the certification through research into the satisfaction level and cause of dissatisfaction of KGBCC assessment standards. For this study, apartment complex with KGBCC certification and general apartment complex constructed in a similar period and condition were selected in the Samsan district, Incheon, Korea, and a questionnaire regarding the awareness of the KGBCC, satisfaction level, and cause of dissatisfaction with KGBCC assessment standards was taken by the residents. Finally, comparative studies and analysis concerning the survey was carried out, and the effect and means of improving the KGBCC were found.

1.2 Methodology
A satisfaction-level questionnaire regarding the assessment standards of the KGBCC was conducted with residents of the selected apartment complexes as subjects. The questionnaire responses ranged from 'very dissatisfied' (-3 points) to 'very satisfied' (3 points), on a 7-point scale, and if the respondents answered dissatisfied (-3 ~ -1), the cause of dissatisfaction was also selected. With the results, satisfaction level and cause of dissatisfaction were compared and analyzed, and the effect and means of improving the KGBCC assessment standards were collected.

2. Research Trends
Studies concerning the KGBCC include 'The Introduction of the KGBCC and Present Condition' (Kim, 2007), 'The Present Condition and Means of Improving the KGBCC' (Jo, 2007), 'An Analysis of Domestic Environment-Friendly Building Design Certifications' (Han et al., 2007), 'A Study on Comparing and Analyzing Items of Foreign Green Building Certification Criteria' (Lee et al., 2007), and 'The Present Condition of National and International Green Building Certification Systems' (Jo et al., 2007), which studied the present condition of the KGBCC and suggested improvements focused on the system. There were also studies that suggested improvement in the KGBCC assessment standards such as 'A Study on the Environment-Friendly Quality Evaluation of High-Rise Residential Architecture in Korea by Environment-Friendly Certification' (Kim, 2008), 'A Study of Case Analysis on Green Building Certification Criteria for Advanced Methods' (Mo et al., 2008), and 'A Study on Indoor Environmental Ratings by Comparing Green Building Certification Systems Through Case Studies' (Tae et al., 2007). Finally, there is research on the economic effects of KGBCC certification such as 'Value of Environment-Friendly Characteristics in Apartment Complexes' (Lee et al., 2007).
Establishment of Systematic Urban Planning

### 3.1 KGBCC System

The certification of KGBCC is divided into two grades: pre-certification and certification. Pre-certification is certification for plans that have obtained prior certification before construction. Explaining the design of plans or submitting related references for obtaining assessment target points by official assessment standards are required. A certification is a process that confirms a building was precisely constructed based on the standards or plans on pre-certification (Lee et al., 2008).

KGBCC ratings consist of two grades, 'Good' and 'Excellent'. The score system has a total of 100 points and there are an additional 36 incentive points (20 incentive points before 2006). A 'Good' grade is over 65 points and 'Excellent' is over 85. The assessment standards of the KGBCC for apartment complexes are listed in Tables 1 and 2 (Lee et al., 2008).

#### 3.2 The Present Condition of the KGBCC

From January 2002 to March 2009, a total of 481 cases were certified. Pre-certification certification for school buildings has been increasing, especially certification for school buildings because the Ministry of Education, Science and Technology tried hard to increase, especially certification for school buildings because the Ministry of Education, Science and Technology tried hard to obtain such certification.

#### 4. Questionnaire Analysis Items

To determine residents' satisfaction with KGBCC assessment standards, survey items for a questionnaire were devised, and after analyzing the preliminary survey results, the answers that residents had difficulty with were excluded. The excluded assessment standards are shown in Table 3.

#### 5. Summary of the Research Cases

For the selection of the research cases, apartment complex

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**Table 1. Number of Assessment Standards and Points**

| Category          | Level I (Points) | Level II (Points) | Total (Points) |
|-------------------|------------------|-------------------|---------------|
| Land Use          | 5 (15)           | 3 (9)             | 8 (24)        |
| Transportation    | 3 (9)            | 1 (3)             | 4 (12)        |
| Façade            | 1 (3)            | 1 (3)             | 2 (6)         |
| Materials and Resources | 3 (9)         | 2 (6)             | 5 (15)        |
| Water Resources   | 3 (9)            | 1 (3)             | 4 (12)        |
| Environment Pollution | 3 (9)        | 1 (3)             | 4 (12)        |

**Table 2. KGBCC Assessment Standard**

| Category          | Item                                                                 | Assessment Standard Type/Points |
|-------------------|----------------------------------------------------------------------|--------------------------------|
| Ecological Value  | Ecosystem Value of Site                                              | Assessment Standard (Type) (Point) |
| Land Use          | Appraisement of Water planners’ understanding (A)                    | Assessment Standard (Type) (Point) |
| Transportation    | Evaluation of Transit Plan (A)                                       | Assessment Standard (Type) (Point) |
| Façade            | Evaluation of Land Use Plan (A)                                      | Assessment Standard (Type) (Point) |
| Materials and Resources | Evaluation of Material use Planning for Recycling (A)            | Assessment Standard (Type) (Point) |
| Water Resources   | Evaluation of Water Conservation Plan (A)                             | Assessment Standard (Type) (Point) |
| Environment Pollution | Evaluation of Land Use Plan (A)                                      | Assessment Standard (Type) (Point) |
| Ecological Environment | Evaluation of Space Planning (A)                                     | Assessment Standard (Type) (Point) |

**Table 3. Excluded Assessment Standards and the Reason for Exclusion**

| Category          | Item                                                                 | Reason for Exclusion |
|-------------------|----------------------------------------------------------------------|----------------------|
| Ecological Value  | Ecosystem Value of Site                                              | Residents have difficulty understanding |
| Water Resources   | Evaluation of Water Conservation Plan (A)                             | Residents have difficulty understanding |
| Environment Pollution | Evaluation of Land Use Plan (A)                                      | Residents have difficulty understanding |
| Ecological Environment | Evaluation of Space Planning (A)                                     | Residents have difficulty understanding |

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Fig.1. [Top Left] The Present Condition of KGBCC Certification for Apartment Complex.

Fig.2. [Top Right] The Number and Ratio of Certified Apartment Complex to General Ones.

(Pre-certification: 395, Certification: 86) were certified through KGBCC (The Ministry of Land, Transportation, and Maritime Affairs, April 2009). In 2002 and 2003, certification was not active (only 2 or 3 cases were certified each year, respectively); however, the number of certified cases increased from 2004 and showed a rapid increase in 2006. Also, the law on housing changed so that 3% of the construction fee was added as an incentive to sales prices for KGBCC-certified apartment complexes, which accelerated the certification. After that, the number of certified cases rose to 143 in 2007 and 135 in 2008, which showed that the KGBCC has been operating steadily since 2006. The proportion of certified apartment complexes to general ones was an insignificant number in 2004; however, it increased to 10.40% in 2006, and showed a rapid increase to 28.08% in 2008. This proved that KGBCC certification for apartment complexes is increasing, and its administration is settled in the market. The certifications for uses other than apartment complexes were relatively inactive, but showed a steady increase, especially certification for school buildings because the Ministry of Education, Science and Technology tried hard to obtain such certification.

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with KGBCC certification certified with high points were chosen. General apartment complex was also chosen for comparison if they had a similar construction period, density, scale, and close distance with the certified ones. As a result, M and G apartment complexes in the Samsan district, Incheon, were selected as research cases (Tables 4. and 5.). The M apartment complex achieved pre-certification on 30 August 2002 and the certification on 27 June 2005 with 71.13 points out of 120. The certification points for assessment standards in the questionnaire are shown in Table 6.

Table 4. Apartment Complex M - Certification Achieved

| Address | 7 Block, Samsan-dong, Bupyeong-gu, Incheon, Korea |
|---------|--------------------------------------------------|
| Site Plan | 1,030 |
| Site Area (m²) | 48,947 |
| Building Area (m²) | 9,176, 56 |
| Building coverage ratio | 45.3% |
| Per Space Index | 171.3 |
| Structure | 01 - 24-22 |
| Number of Building | 1 |
| Unit Size (m²) | 67.49, 156.77, 178.02, 180.63, 181.72, 265.87 |
| Heating | 1,761 |
| Heating System | District Heating |
| Heating Resources | Conservation |
| Completion Date | 2005.05 |
| Moving-in Date | 2005.05 |

Table 5. Apartment Complexes G - General Apartment Complexes

| Address | 1 Block, Samsan-dong, Bupyeong-gu, Incheon, Korea |
|---------|--------------------------------------------------|
| Site Plan | 1,112 |
| Site Area (m²) | 55,634 |
| Building Area (m²) | 1,540 |
| Building coverage ratio | 42.2% |
| Per Space Index | 139.4 |
| Structure | 01 - 30-22 |
| Number of Building | 17 |
| Unit Size (m²) | 116.8, 131.8 |
| Parking | 1,461 |
| Completion Date | 2004.05 |
| Moving-in Date | 2004.05 |
| Heating System | District Heating |
| Heating Resources | Conservation |

Table 6. KGBCC Assessment Standards Index and Achieved Points by Assessment Standards for M Complex

| Category | Index | Assessment Standards | Achieved (Achieved) |
|----------|-------|-----------------------|---------------------|
| 1. Land Use | 1.1 | Preservation Ratio of Existing Natural Features | 2 |
| | 1.2 | Establishment of Community Oval or Facility Planning | 1.5 |
| | 1.3 | Establishment of Pedestrian Pathway Construction of Pedestrian Pathway in the Outer Pedestrian Network | 3 |
| 2. Transportation | 2.1 | Distance to Public Transportation | 1.6 |
| | 2.2 | Installation of Bicycle Path and Bicycle Parking Lot | 2 |
| | 2.3 | Distance to the Local Center and City Center Cemetery | 2 |
| 3. Energy | 3.1 | Using Alternative Energy | 1 |
| 4. Resources and Materials | 4.1 | Design Plan for Life Cycle Change | 1 |
| | 4.2 | Natural Use of Furniture | 2 |
| | 4.3 | Square Living Space Collection of Recycling | 1 |
| | 4.4 | Food Waste Reduction | 2 |
| 5. Water Resources | 5.1 | Using Rainwater and Utilization of Grey Water | 4 |
| | 5.2 | Reduction Plan for Water Use | 6 |
| 6. Maintenance and Management | 6.1 | Providing User Manual | 1 |
| 7. Architectural Environment | 7.1 | Establishment of Geometric Axis | 1 |
| | 7.2 | Space Area Ratio | 2.5 |
| | 7.3 | Application of Artistic Green Space Plan | 2 |
| | 7.4 | Acoustic Design Planning | 1 |
| | 7.5 | Outdoor Design Planning | 3 |
| 8. Indoor Environment | 8.1 | Level of Ventilation Plan | 1.2 |
| | 8.2 | Installation of Thermostatic System | 1.5 |
| | 8.3 | Sound Absorption Level of Walls | 1.5 |
| | 8.4 | Noise Environment in Apartment Complex | 1.5 |
| | 8.5 | Daylight Ratio | 0.8 |
| | 8.6 | Design Plan for the Walk-Safety | 2 |

6. Analysis of Survey Results

6.1 General Information of the Respondents

The preliminary survey was carried out on 12 April 2008, and after further developing the questionnaire, the main survey was carried out from 25 April to 31 May 2008. 111 (M) and 107 (G) questionnaires were surveyed, and except for two that were disqualified, a total of 216 questionnaires were analyzed.

The number of respondents was 69 (male) and 147 (female); thus there were twice as many female respondents as male. The majority of the respondents were in their 40s (35.6%), and the others were in their 30s (31.9%), 20s (17.6%), 50s (10.6%), and over 60 (73.1%), which showed a varied distribution. Seventy three point one percent of the respondents were educated higher than undergraduate degrees, and 51.9% answered 'more than $4,000 per month' in monthly income, which are high standards. Regarding the number of family members, 4 was the majority (56%), while the others were 3 (19.4%), 5 (14.8%), and 'other' (9.7%). Eighty four point seven percent answered that they owned their home. For 'Period of Residence', most of the respondents have been living in the complex since the moving-in date (M - 3~4 years: 46.9%, 2~3 years: 31.5% / G - more than 4 years: 18%, 3~4 years: 49.6%), so most of the residents were analyzed as having lived in their apartments long enough for POE (Post Occupancy Evaluation).

6.2 Residents' Understanding of the KGBCC

The analysis result of the questions on the awareness of the KGBCC were: M (Aware: 47.7%, Unaware: 51.4%, etc: 0.9%) and G (Aware: 32.4%, Unaware: 67.6%). This shows that residents of M (certified apartment complex) were more aware of the KGBCC. Regarding the awareness of KGBCC certification on respondents' apartment complex, it showed that residents of M were also more aware of KGBCC certification of their apartment complex: M (certified: 46.8%, not-certified: 5.4%, don't know: 46.8%, etc: 1%) and G (certified: 1%, not-certified: 22.8%, don't know: 75.2%, etc: 1%). Ninety point three percent of the total respondents answered that the KGBCC is necessary, and considering KGBCC certification when choosing their present apartment complex, 55.1% of the total respondents answered they did not know whether it was certified or not (M: 42.3%, G: 68.6%). However, in the case of M, the analysis result was that it was 'considered important' (9%) and 'It has an effect at some level' (33.3%), which showed a difference to G residents ('considered important' 1.9%, 'It has an effect at some level' 11.4%) so that certification has an effect concerning the choice of apartment complexes. Analysis of the relationship between certification and increase in real estate value showed 81.5% of the total respondents answered positively, so it appears that most residents think KGBCC certification is related to an increase in real estate value. Finally, 88.4% of the total respondents (M: 88.3%, G: 88.5%) answered they will consider KGBCC certification when they move to other apartments complex, so it was analyzed that KGBCC certification affects the choice of apartment complex.

6.3 Analysis Results

6.3.1 Total Satisfaction Level and Satisfaction Level by Categories

The total satisfaction level concerning KGBCC assessment standards appeared as M: 0.74 and G: 0.14, which determined that apartment complexes M showed a higher satisfaction level (t=15.858, P=0.000).

In Fig.3., the satisfaction level regarding ecological environment category was the highest of all categories (1.49) for M, which showed residents are satisfied with it.
The land use category also appeared at 1.18, which is also considered positive. In G complex, the highest satisfaction level was in the transportation category at 0.39; however, satisfaction levels were generally lower than M. Especially in the ecological environment category, the difference between M (1.49) and G (0.12) was significant, and the land use category also showed a big difference (M: 1.18 and G: 0.15), so ecological environment and land use categories in M complex are considered better planned than in G complex. However, the T-test showed that the differences between M and G on transportation, energy, and maintenance and management categories are meaningless. The energy category also appeared at a very low satisfaction level (M: -0.60, G: -0.46), so obviously this area needs urgent improvement.

6.3.2 Satisfaction Level for Apartment Complexes and Analysis of Cause of Dissatisfaction

The analysis results for residents' satisfaction level on KGBCC assessment standards are shown in Fig.4. M complex showed higher satisfaction levels than G in general, so it was determined that these assessment standards positively affect residents' satisfaction.

Fig.4. Response Rate for Dissatisfaction by Category

In M complex, the 'Green Space Area Ratio' of the ecological environment category attained the highest satisfaction level at 1.94, and 'Establishment of Pedestrian Pathway' (1.64) and 'Preservation Ratio of Existing Natural Features' (1.50) in the land use category also achieved high satisfaction levels. 'Using Alternative Energy' (-0.60) in the energy category and 'Sound Absorption Level of Floor' (-1.05) in the indoor environment category, however, showed that most residents are dissatisfied with it, so development is needed there.

In G complex, 'Daylight Ratio' in the indoor environment category had 1.23 as the highest, but the satisfaction level on other assessment standards appeared at less than 1. 'Sound Absorption Level of Floor' (-1.05) and 'Establishment of Community Center or Facility Planning' (-0.59) were two of the 11 assessment standards that showed minus points on satisfaction level, so the study demonstrated low satisfaction with the general residential environment. G complex, however, attained higher points than M in 'Distance to Public Transportation' and 'Distance to the Local Center and City Center' in the transportation category. The reason for this result was analyzed as the transportation category being limited by site selection, which is different from other categories.

The assessment standard which showed the biggest gap was 'Aquatic Biotope Planning' (M: 1.25, G: -0.53) in the ecological environment category. Even though both apartment complexes planned an ecological aquatic biotope, it still showed a 1.78 difference, so aquatic biotope planning by KGBCC assessment standards is considered positively by the residents. However, 'Reduction Plan for Daily Water Use' in the water resources category was 0.40 for M and 0.36 for G, which turned out to be meaningless (t: 0.89, P: 0.850); and additionally, the difference in satisfaction level on 'Distance to the Local Center and City Center', 'Using Alternative Energy', 'Separate Living Waste Collection for Recycling', 'Food Waste Reduction', 'Providing User Manual', 'Level of Ventilation Plan', and 'Sound Absorption Level of Floor' were also meaningless based on the T-test results.

The analysis results of the causes of dissatisfaction are shown in Fig.5. The total number of dissatisfaction responses was 676 for M and 1,020 for G. The average dissatisfaction response rates were M: 23.3% and G: 35.2% which showed residents of G complex expressed more dissatisfaction than residents of M.

The analysis results showed that the response rates of every category except transportation and energy were higher in G complex, which showed a similar tendency with satisfaction analysis. Especially, 6 categories of M showed less than 30% of dissatisfaction responses, however, 6 of G showed more than 30% which reveals that the dissatisfactions of G complex are relatively higher than M complex. The highest response rate was 44% in the energy category for M complex, and ecological environment category of G also showed a high rate at 39%. The biggest difference appeared in the ecological environment category (M: 39%, G: 11%), while the land use category also showed a big gap between complexes (M: 34%, G: 14%), so the dissatisfactions of M complex are relatively low in these categories. However, both transportation and energy categories showed a more than 30% response rate in both complexes, so these need to be improved.

6.3.3 Satisfaction Level by Assessment Standard and Analysis on Cause of Dissatisfaction

(1) Land Use

Fig.5. The Total Satisfaction Level by Category
The satisfaction level by assessment standards and cause of dissatisfaction in the land use category are as shown in Fig.6. and Table 7.

As an analysis result, M complex showed higher points than G on satisfaction level through every assessment standard in land use category. In M complex, the satisfaction level was generally high in most areas; however, 'Establishment of Community Center or Facility Planning' appeared relatively low as 0.43. In G complex, every satisfaction level was lower than 0.5, and particularly, 'Establishment of Community Center or Facility Planning' was -0.59, revealing that most residents were dissatisfied with the planning.

In the analysis on cause of dissatisfaction, 'Maintenance not well-managed' was the majority answer (M: 58%, G: 45%) for 'Preservation Ratio of Existing Natural Features', and also 'Not enough preserved natural features' (27%) was one of the main reasons in G complex. For 'Establishment of Community Center or Facility Planning', even though both complexes planned one, 83% of M respondents and 80% of G answered 'Not enough facilities and spaces'. For 'Establishment of Pedestrian Pathways', respondents of M mainly answered, 'Disconnected in the middle' (45%) and 'Not planned' (27%), and respondents of G mostly were dissatisfied with ' Planned but too narrow' (51%) and 'Safety (from vehicles or crime)' (29%), so it showed a different view of dissatisfaction regarding planning. For 'Connection of Pedestrian Pathways to the Outer Pedestrian Network', both complexes picked 'Connected, but inappropriate location' (M: 64%, G: 62%), which demonstrated that location of plan is a major cause of dissatisfaction.

Table 7. Cause of Dissatisfaction in the Land Use Category

| Assessment Standard | M | G |
|---------------------|---|---|
| Establishment of Community Center or Facility Planning | 0.43 | 0.11 |
| Establishment of Pedestrian Pathways | 0.38 | 0.47 |
| Establishment of Bicycle Path and Bicycle Parking Lot | 0.14 | 0.13 |
| Preservation Ratio of Existing Natural Features | 0.36 | 0.38 |
| Not enough preserved natural features | 8% | 24% |
| Maintenance not well-managed | 58% | 45% |
| Quality of ecological environment in low | 15% | 15% |
| Safety (from vehicles or crime) | 18% | 29% |
| Obstacle for using other outdoor space | 17% | 5% |
| Not connected with other facilities | 1% | 8% |
| Maintenance not well-managed | 5% | 13% |
| Not enough facilities and spaces | 83% | 80% |
| Not close enough to reach on foot | 38% | 25% |

(2) Transportation

The satisfaction level in assessment standards and cause of dissatisfaction in the transportation category are shown in Fig.7 and Table 8.

After the T-test, the satisfaction level on 'Distance to Public Transportation' (M: 0.09, G: 0.61) in the transportation category was higher in the G complex, and the research shows that subway construction near G complex affected the results. 'Distance to the Local Center and City Center' (M: 0.13, G: 0.47) appeared meaningly based on the T-test, and 'Installation of Bicycle Path and Bicycle Parking Lot' (M: 0.63, G: 0.10) showed higher satisfaction in M complex, so the KGBCC standard works well in this category.

Table 8. Cause of Dissatisfaction in the Transportation Category

| Assessment Standard | M | G |
|---------------------|---|---|
| Distance to Public Transportation | 0.09 | 0.61 |
| Installation of Bicycle Path and Bicycle Parking Lot | 0.63 | 0.10 |
| Distance to the Local Center and City Center | 0.47 | 0.13 |

(3) Energy

The assessment standards of the energy category, 'Using Alternative Energy' demonstrated dissatisfaction for both apartment complexes (M: 0.60, G: 0.46), and the difference between M and G was analyzed as meaningless based on T-testing (t = -0.633, P = 0.528).

'Not enough facilities' was the majority answer for both M (88%) and G (76%), so the planning concerning this standard turned out to be generally insufficient (Table 9).

Table 9. Cause of Dissatisfaction in the Energy Category

| Assessment Standard | M | G |
|---------------------|---|---|
| Using Alternative Energy | 0.60 | 0.46 |
| Not enough facilities | 88% | 76% |
| Maintenance not well-managed | 4% | 16% |
| Noisiness | 2% | 3% |
| Not good for the landscape | 0% | 3% |
| Eq. | 6% | 5% |

(4) Resources and Materials

The satisfaction level by assessment standards and cause of dissatisfaction in the resources and materials category are as shown in Fig.8. and Table 10.

In this category, the satisfaction concerning 'Design Plan for Life Cycle Change' and 'Minimal Use of Furniture' were higher in M complex. The differences in satisfaction regarding the other two standards were analyzed as meaningless by T-testing. Both complexes showed the highest satisfaction in 'Design Plan for Life Cycle Change' (M: 1.17, G: 0.70), 'Food Waste Reduction' had the lowest satisfaction for both M (0.07) and G (-0.16).

'Not easy to change' was the main cause for both M
(67%) and G (79%) in 'Design Plan for Life Cycle Change'. On 'Minimal Use of Furniture', which asked about built-in furniture, 48% of M and 41% of G answered 'Storage space is small' as a main reason, so that concern needs to be addressed. For 'Separate Living Waste Collection for Recycling', both M and G picked 'Not well managed, so it is unsanitary' (both M: 40%, G: 58%), and 'The number of separate collection facilities' (M: 23%, G: 15%) was also considered important. In 'Food Waste Reduction', the major cause was 'Not well-managed, so it is unsanitary' (M: 55%, G: 71%) for both, and additionally, 28% respondents of M picked 'Uncomfortable to use', showing that these matters need to be more carefully considered in KBGCC assessment standards.

Table 10. Cause of Dissatisfaction in the Resources and Materials Category

| Category                        | M (%) | G (%) |
|---------------------------------|-------|-------|
| 4.1 Design Plan for Life Cycle Change |       |       |
| Storage space is small          | 12%   | 6%    |
| Quality of storage space        | 12%   | 7%    |
| The location of storage space   | 12%   | 7%    |
| Too much built-in furniture     | 12%   | 7%    |
| The cause of dissatisfaction    |       |       |
| Not enough information about planning | 11%  | 5%    |
| Not enough knowledge about planning | 11%  | 5%    |
| Not enough durability           | 10%   | 4%    |
| 4.2 Minimal Use of Furniture   |       |       |
| Storage space is small          | 55%   | 35%   |
| Quality of storage space        | 23%   | 17%   |
| The location of storage space   | 23%   | 17%   |
| Too much built-in furniture     | 23%   | 17%   |
| The cause of dissatisfaction    |       |       |
| Not enough knowledge about planning | 11%  | 5%    |
| Not enough information about planning | 11%  | 5%    |
| Not enough durability           | 10%   | 4%    |

(5) Water Resources

As a result of the satisfaction analysis for the 'Water resources category (Fig.9)', 'Reduction of Rainwater Load' in M complex appeared at 0.92 as the highest satisfaction level, and 'Using Rainwater and Installation of Grey Water Use System' showed the lowest at -0.23 in G, demonstrating that residents of G complex are not satisfied with this planning.

Fig.9. The Satisfaction Level on Water Resources Category

For 'Using Rainwater and Installation of Grey Water Use System', respondents of M picked 'Quality of water' (40%) for the cause of dissatisfaction, and answers were spread evenly among the choices for G complex. In 'Reduction Plan of Rainwater Load', the majority reason was 'Water absorption capability' (M: 50%, G: 37%), and for the 'Reduction Plan for Daily Water Use', 'Other' (50%) was the major reason for M, writing 'Ineffective water saving' and 'No water saving facility', and in G complex, 60% of the respondents answered 'Weak water pressure' as a main reason (Table 11).

6. Maintenance and Management

Table 11. Cause of Dissatisfaction in the Water Resources Category

| Reason of Dissatisfaction | M (%) | G (%) |
|---------------------------|-------|-------|
| Water absorption capability | 50%   | 40%   |
| Not well-managed, so it is unsanitary | 30%   | 35%   |
| Storage space size is small | 20%   | 15%   |
| The cause of dissatisfaction |       |       |
| Not enough knowledge about planning | 10%  | 5%    |
| Not enough information about planning | 10%  | 5%    |
| Not enough durability | 10%   | 4%    |

The satisfaction levels were 0.48 for M and 0.21 for G; however, T-testing determined it meaningless (t=1.88, P=0.060). The major cause of dissatisfaction for 'Providing User Manual' was 'Hard to store and read' (M: 64%, G: 35%), so the convenience of the manual needs to be considered, and 'Difference between manual and reality' (30%) in G and 'The contents of manual are difficult to use' (29%) in M were also analyzed as important.

Table 12. Cause of Dissatisfaction in the Maintenance and Management Category

| Reason of Dissatisfaction | M (%) | G (%) |
|---------------------------|-------|-------|
| The contents of manual are difficult to use | 29%   | 15%   |
| Difference between manual and reality | 30%   | 25%   |
| Hard to store and read | 64%   | 35%   |

(7) Ecological Environment

The satisfaction level and cause of dissatisfaction in the ecological environment category by assessment standards are as shown in Fig.10 and Table 13.

In the analysis of satisfaction level and T-test result, the satisfaction of every assessment standard for M in the ecological environment attained higher points than G complex. Particularly, except for 'Application of Artificial Green Space Plan', the satisfaction level for every other standard showed a big difference of more than 1 point. Especially in the case of 'Aquatic Biotopes Planning' (M: 1.25, G: 0.53) and 'Territorial Biotopes Planning' (M: 1.30, G: 0.45), the gap in satisfaction level was significant, and most of the respondents in G were dissatisfied with this. Also, 'Green Space Area Ratio' (M: 1.94, G: 0.47) showed a huge difference, so the KBGCC assessment standards for the ecological environment category are analyzed as very effective.

In cause of dissatisfaction, for 'Establishment of Connected Green Axes', 80% of M answered 'Becoming obstacles for using outdoor space' as a major reason and 57% of G picked the cause 'No connected green or not enough'. The main reason for the 'Green Space Area Ratio' dissatisfaction was 'Insufficient Green Space' (45%) and 'Monotonous green space' (55%), which is similar in G complex. However, 63% of respondents in M picked the major reason as 'Monotonous green space'. The main cause of dissatisfaction
for 'Application of Artificial Green Space Plan' was 'Not good looking' for both M (56%) and G (52%). In 'Aquatic Biotope Planning', the major reasons in M were 'Not working as a habitat space' (39%) and 'Not well managed, so it is not clean' (35%). In G complex, 'Not well managed, so it is not clean' (41%) and 'Not working as a habitat space' (24%) were chosen, so there were differences. In 'Terrestrial Biotope Planning', both complexes also answered 'Not working as a habitat space' (M: 35%, G: 39%) and 'Not well managed, so it is not clean' (M: 24%, G: 24%) which showed similar tendencies on this one. As a result, for 'Aquatic Biotope Planning' and 'Terrestrial Biotope Planning' in KGBCC, there is much room for improvement in planning habitation space and management.

Table 13. Cause of Dissatisfaction in the Indoor Environment Category

| Assessment Standard | Use of Low-Toxic Materials | Level of Ventilation Plan | Installation of Thermostatic System | Sound Absorption Level of Floor | Sound Absorption Level of Walls | Noise Environment in Apartment Complexes | Daylight Ratio | Design Plan for the Weak and Elderly | M (%) | G (%) |
|---------------------|----------------------------|---------------------------|-------------------------------------|-------------------------------|---------------------------------|-------------------------------------------|---------------|-------------------------------------|------|------|
| M                   | 35%                        | 50%                       | 70%                                 | 50%                           | 30%                             | 70%                                       | 60%           | 60%                                 | 59%  | 50%  |
| G                   | 50%                        | 60%                       | 50%                                 | 50%                           | 50%                             | 50%                                       | 50%           | 50%                                 | 52%  | 50%  |

Fig.11. Satisfaction Level in the Indoor Environment Category

In the analysis by assessment standards, 'Daylight Ratio' had the highest satisfaction level for both M (1.44) and G (1.23) complexes, and for 'Sound Absorption Level of Floor', most respondents were dissatisfied with it (M: -0.68, G: -1.05). In particular, this assessment standard showed the lowest satisfaction level of all, so that dissatisfaction regarding noise between floors needs to be seriously considered.

The cause of dissatisfaction for 'Indoor air quality' was listed as the major reason (M: 59%, G: 50%) in 'Use of Low-Toxic Materials'. The cause of dissatisfaction for 'Level of Ventilation Plan' was 'Performance of ventilation facilities' at 67% for M and 60% for G, and 'Maintenance and management fee' was the main reason in 'Installation of Thermostatic System' (M: 62%, G: 56%).

For 'Sound Absorption Level of Floor', the main cause of dissatisfaction was found to be 'Noise from upstairs' (M: 82%, G: 72%) and 'Noise from downstairs' (M: 15%, G: 24%). This standard, especially, showed the lowest satisfaction level and the most dissatisfied respondents, so it needs urgent improvement. For 'Sound Absorption Level of Walls', the major cause was 'Noise from neighbors' at 95% for M and 90% for G, and this standard also needs to be improved with 'Sound Absorption Level of Floor'. The major reason for 'Noise Environment in Apartment Complexes' was 'Noise from outside of complex' (M: 63%, G: 64%), and for 'Daylight Ratio', 'Short daylight time in winter' was the main reason (M: 64%, G: 67%). In 'Design Plan for the Weak and Elderly', both M (92%) and G (78%) complexes picked 'Not enough facilities' as a main cause of dissatisfaction, so considerations for facility expansion are needed.

Table 14. Cause of Dissatisfaction in the Ecological Environment Category

| Assessment Standard | Use of Low-Toxic Materials | Level of Ventilation Plan | Installation of Thermostatic System | Sound Absorption Level of Floor | Sound Absorption Level of Walls | Noise Environment in Apartment Complexes | Daylight Ratio | Design Plan for the Weak and Elderly | M (%) | G (%) |
|---------------------|----------------------------|---------------------------|-------------------------------------|-------------------------------|---------------------------------|-------------------------------------------|---------------|-------------------------------------|------|------|
| M                   | 35%                        | 50%                       | 70%                                 | 50%                           | 30%                             | 70%                                       | 60%           | 60%                                 | 59%  | 50%  |
| G                   | 50%                        | 60%                       | 50%                                 | 50%                           | 50%                             | 50%                                       | 50%           | 50%                                 | 52%  | 50%  |

7. Conclusions

This study sought to discover residents' understanding of KGBCC, satisfaction level for assessment standards, and cause of dissatisfaction in comparison between KGBCC-certified apartment complex and general complex, and with comparative studies and analysis, the effects and suggestions for improvement for KGBCC were presented. To do this, residents of apartment complex with KGBCC certification and general apartment complex were surveyed by questionnaire, and the survey results compared and analyzed. The final conclusions of the study are as follows.

1) The residents of M complex understood the KGBCC better, and residents of M complex were more aware of certification for their apartment complex. Ninety point three percent of the total respondents answered that the KGBCC is necessary, and for M complex, it was analyzed that certification had a slight effect on choosing apartment complexes. Eighty one point five percent of the respondents answered that KGBCC certification positively affects real estate value, and 88.4% answered they will consider certification when they move to another apartment complex. As a result, this study showed residents' awareness for KGBCC and its effects are positive.

2) As an analysis result of the satisfaction level of KGBCC assessment standards (M: 0.73, G: 0.14), the satisfaction level of the certified apartment complex was very high, so certification affects satisfaction level in a positive way. In analysis by category, the difference in satisfaction level grew on land use and ecological environment categories, so these
categories were evaluated positively by residents. However, in the energy category, both M and G complexes showed a low satisfaction level, and there was no meaningful difference between the results of each complex, so it showed that KGBCC has little effect in the energy category.

3) In comparative analysis of the satisfaction level by assessment standards, the satisfaction level of M appeared higher than G complex for every assessment standard in land use and ecological environment categories, and the difference in satisfaction was great, so that assessment standards of KGBCC in these categories are analyzed as very effective. Also, 'Installation of Bicycle Path and Bicycle Parking Lot' in the transportation category, two assessment standards in the water resources category including 'Designing Rainwater and Installation of Grey Water Use System', and five assessment standards in the indoor environment category including 'Use of Low-Toxic Materials' showed that KGBCC certification has a positive effect on resident satisfaction. However, except for the assessment standards mentioned above, the other 11 assessment standards in KGBCC certification appeared ineffective including 'Using Alternative Energy', 'Food Waste Reduction', 'Reduction Plan for Daily Water Use', 'Level of Ventilation Plan', etc, so these assessment standards need to be improved. As a synthetic result, a total of 16 assessment standards, which achieved points on certification positively affected the residents' satisfaction level. However, the other 13 assessment standards were not effective, so these need to be improved.

4) The cause of dissatisfaction by assessment standards were analyzed, and the major reason for dissatisfaction for 29 assessment standards were found to be, for example, 'Maintenance is not well-managed for preservation of Low-Toxic Materials' showed that KGBCC certification is not well-managed, so it is unsanitary. Not enough facilities and spaces, Not enough public transportation, etc, so these assessment standards need to be improved. As a synthetic result, a total of 16 assessment standards, which achieved points on certification positively affected the residents' satisfaction level. However, the other 13 assessment standards were not effective, so these need to be improved.

Table 15. Synthetic Analysis Results

| Category                  | Assessment Standards                                                                 | Benefit Level | Similar Level | Dissimilar Level | Compare     | The cause of Dissatisfaction                                                                 |
|---------------------------|--------------------------------------------------------------------------------------|---------------|---------------|------------------|------------|---------------------------------------------------------------------------------------------|
| Environment and Management| Accessibility of Environment-Friendly Characteristics in Apartment Complexes         | M 1.78        | G 0.74        | M/G              | M/G        | Not connected or not enough facilities or not enough space                                  |
|                           | Accessibility of Environment-Friendly Characteristics in Apartment Complexes         | M 0.94        | G 0.88        | M/G              | M/G        | Not enough facilities or not enough space                                                    |
|                           | Accessibility of Environment-Friendly Characteristics in Apartment Complexes         | M 1.43        | G 0.31        | M/G              | M/G        | Not enough facilities or not enough space                                                    |
|                           | Accessibility of Environment-Friendly Characteristics in Apartment Complexes         | M 1.14        | G 0.30        | M/G              | M/G        | Not enough facilities or not enough space                                                    |
|                           | Accessibility of Environment-Friendly Characteristics in Apartment Complexes         | M 0.43        | G 0.06        | M/G              | M/G        | Not enough facilities or not enough space                                                    |
|                           | Accessibility of Environment-Friendly Characteristics in Apartment Complexes         | M 0.36        | G 0.08        | M/G              | M/G        | Not enough facilities or not enough space                                                    |
|                           |Accessibility of Environment-Friendly Characteristics in Apartment Complexes         | M 1.14        | G 0.30        | M/G              | M/G        | Not enough facilities or not enough space                                                    |
|                           |Accessibility of Environment-Friendly Characteristics in Apartment Complexes         | M 0.94        | G 0.31        | M/G              | M/G        | Not enough facilities or not enough space                                                    |
|                           |Accessibility of Environment-Friendly Characteristics in Apartment Complexes         | M 0.36        | G 0.08        | M/G              | M/G        | Not enough facilities or not enough space                                                    |

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