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# A SPACE INFORMATION MODEL FOR SUSTAINABLE HEALTHY BUILDING

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**ABSTRACT:**

*A sustainable healthy building can be realized by measuring and improving the factors such as light, sound, heat and air that influence the indoor environment. Among these factors, the health performance of indoor air quality is highly affected by materials that compose the building. So, it is possible to evaluate the health performance based on the types and application methods of materials used. Currently, a method based on the measurement and a health performance evaluation method for each material were mainly used as the methods to evaluate the health performance of indoor air quality, however, the study suggests Space Information Model that analyzes the combination of elements which compose the space and considers the types of pollutants and the health-effectiveness. Space Information Model provides the information on indoor air quality from the project planning stage by interconnecting to the indoor air quality evaluation application which is based on IFC.*

**Conference Topic: The Earth/Desert/Green and Sustainable Buildings**
**Keywords: Health performance, Sustainable healthy building, Combination of elements, Indoor Air Quality**

## 1. INTRODUCTION

The health performance of indoor air quality is highly influenced by the materials that compose the building, so it is possible to evaluate the health performance based on the types of materials used and their application methods. In order to predict the health performance of a building, a systematic evaluation model is necessary. The evaluation model is formed based on the concept of BIM (Building Information Model) and this concept of BIM began to be actualized when IAI, a non-profit international organization, was organized in 1996. IAI suggested the information standard (IFC: Industry Foundation Classes) to enable the multidimensional virtual design in the building construction field and diverse relevant software is being developed (I.H.Kim, 2010). However, it is difficult to come up with a design considering the health performance since an evaluation model which can predict the health performance of the indoor space of building was not developed till now.

As an existing study on the health-performance evaluation model, Lee et al.(2010) introduced LHT (Lifecycle Health-performance Tree) Module, an indoor air quality evaluation concept based on the combination of materials that compose a space. But, it simply introduced the concept of the indoor air quality evaluation through an analysis on space

composition and material combination. Thus, it is necessary to conduct additional studies on the effectiveness of pollutants and more for a practical evaluation. This study suggests Space Information Model considering the types of pollutants and health-effectiveness by developing the concept of LHT Module. Space Information Model provides the information on indoor air quality from the project planning stage by interconnecting to the indoor air quality evaluation application which is based on IFC.

## 2. Preliminary Study

There is a variety of causes to the deterioration of indoor air quality and the variables are indefinite which makes it difficult to develop an accurate evaluation model and method (Zhu, et al., 2007). Examining the existing studies, there are studies based on the indoor pollutants including volatile organic compounds (VOCs), formaldehyde and carbon monoxide (CO) (Uhde, 2007, S.S. Kim, 2008), studies based on the source of pollutants such as cigarettes, construction materials and physical activities (WHO, 2000, Jamrozik, 2005) and studies based on the thermal environment and ventilation conditions (Sekhar, 2002). However, there is still no study on the comprehensive evaluation on the health-performance of indoor air quality (Zheng et al., 2010). The study of Zheng(2010) suggested a model to evaluate an overall indoor air quality by putting weight for each air polluting cause. But, it is impossible to predict the health-performance at the planning stage using the post occupancy evaluation method. Therefore, it is necessary to perform a study on BIM-based evaluation model that enables prediction of the health-performance at the planning stage.

I.H. Kim (2010) conducted a study on the performance analysis of building environment based on BIM, which was the relevant study on the evaluation model, but it was a study to introduce the concept and application of BIM, not the health-performance evaluation model, which is different from this study. In addition, a study of Kim & An (2010) introduced a method to analyze the building environment performance using the 3D modeling of BIM, yet it shows difference in terms of health-performance analysis concept of the spatial unit.

## 3. Analysis on Combination Unit of Elements Composing Space (LHT Module)

A building is composed of a unit space combination such as the households or rooms. Generally, the unit space that forms the building is in the same structure or limited to 2-3 types of structures. In other words, the building is a collection of several unit spaces that are classified based on the structure and the indoor air quality of each space can represent the same spaces (D.H. Lee, 2010). As shown in Figure 1, the combination of materials for each element that composes the ceiling, wall and floor for the separated unit space is analyzed to identify the type and amount of indoor air pollutants

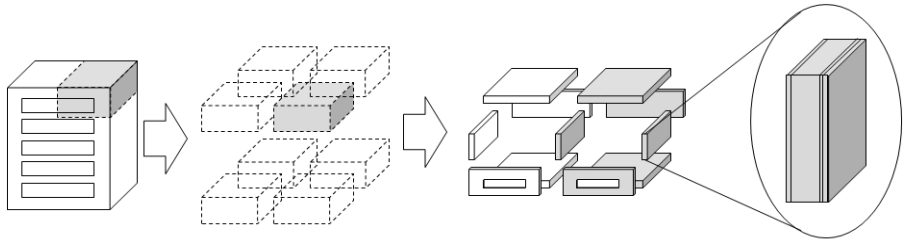

**Figure 1. Analysis on Combination Unit of Element Composing Space (D.H. Lee, 2010)**

The analysis on combination unit of element composing the space requires 2 main types of information for the evaluation of health performance. Firstly, it is the information on materials, emissions of harmful substances per unit area for each material used in the building. Secondly, it is the information on combination of each part for walls, ceilings and floors, which allows it to calculate the emission of harmful substances for each part by interconnecting to the information. The emission of harmful substance for the interior material can be restrained or delayed due to the finishing material. This should be adjusted by applying the delay. Formula 1 shows the concept to calculate the emission of harmful substance for each material by applying the delay based on the overlapping of materials.

$$P_i = \sum_{i=1}^{n} (E_j \times (1 - D_j)) \qquad \text{(Formula 1)}$$

Here, $P_i$ is the emission of harmful substance per unit area of material and $E_j$ is the surface emission of harmful substance of material. $D_j$ is the emission delay based on the material combination

As shown in formula 2, the air quality of relevant space is calculated based on the emission of harmful substance per unit area of material and dimensions of each material and then divided by the size of space. In the first stage, the emission of harmful substance per unit area for each material is calculated using the materials for each process type and combination data and the details on space is analyzed and the quantity of relevant part is drawn out to calculate the total amount of harmful substances. Then, the sum of emissions of each part that composes the space and the size of space are analyzed to calculate the concentration of harmful substances at the relevant space (D.H. Lee, 2010).

$$H_i = \frac{\sum_{i=1}^{n} (P_i \times A_i)}{V_k} \qquad \text{(Formula 2)}$$

Here, $H_l$ is the air quality of the relevant space and $P_i$ is the emission of harmful substance per unit area of material. $A_i$ is the dimension of material and $V_k$ is the size of space

## 4. Space Information Model

Space Information Model can predict the air quality of the unit space by measuring the pollutant emission based on the combination of materials that compose the space and considering the importance of each pollutant. Figure 2 shows the concept of Space Information Model that evaluates the indoor air quality of space (a) through the pollutants that are generated from the combination of materials (b) which compose the element.

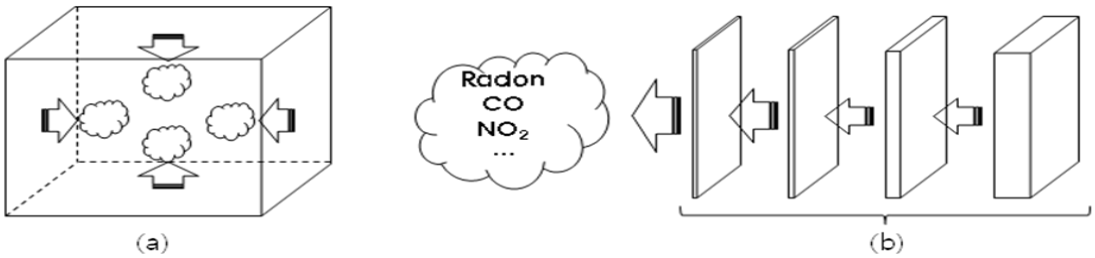

**Figure 2. Concept of Space Information Model**

Space Information Model is formed by the concept of spatial composition of LHT Module and the weight for each variable as shown in Figure 3 and it can provide the information on the indoor air quality at the planning stage by interconnecting with IFC.

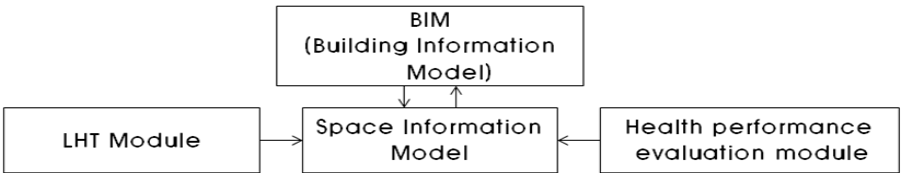


**Figure 3. Composition of Space Information Model**

As shown in Figure 4, Space Information Model provides the information on indoor air quality throughout all stages, from the project planning stage to the construction and maintenance stages by interconnecting with IFC. This information is objectively evaluated based on the unified standard to help not only the project planning but also customers with the purchase decisions.

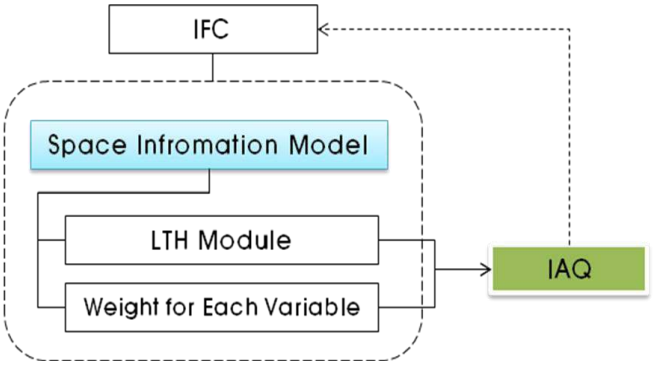


**Figure 4. Interconnection between Space Information Model and IFC**

## 5. Conclusion

This study suggested Space Information Model that can predict the indoor air quality at the project planning stage. Space Information Model can predict the indoor air quality of the unit space by measuring the emission of pollutants based on the combination of elements that compose the space and the importance of each pollutant. In addition, it provides the information on indoor air quality throughout all stages of project in interconnection with IFC. This information is objectively evaluated based on the unified standard to help not only the project planning but also the customers with purchase decisions of a house.

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