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Aims and Scope

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Comparison of Efficient (Effective) Stress Analysis Methods on Highway Fill Constructed on Clay Ground

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ABSTRACT

In the developing world, the use of land and the raise of building loads increase the importance of slope stability day by day. Changing the position of soil or rock units forming the slope by tilting downward along the slope until they reach equilibrium with the effect of shear deformation or gravity is called landslides. Landslides cause economic and cultural loss and also threaten the safety of life. In this study, Effective Stress Analysis Methods for circular and non-circular failure surfaces in slopes have been examined.

Keywords: Landslide, Slope Stability, Effective Stress Analysis Methods, Failure Surface.

I. INTRODUCTION

In recent years, the increase in the number of deep- hole excavations and the construction of highways and also various engineering constructions has necessitated that the stability of slopes in rock, soil, in the transition materials and rock masses between them should be well known by geology mining and civil engineers.

Changing the position of soil or rock units forming the slope by tilting downward along the slope until they reach equilibrium with the effect of shear deformation or gravity is called landslides. The accurate way to control the landslides is through slope stability calculation and application.

On a slope, slide types are observed geometrically in three ways. Circular, planar and combined slide shapes are the most common types of slides. Combined slide shape includes both planar and circular slide shapes and calculating combined slide is more complex than circular and planar slide shapes.

Analysis methods for circular and non-circular failure surfaces can be summarized in three sections. They are: Total Stress Analysis, Efficient (Effective) Stress Analysis Methods and Graphical Method for Circular Sliding.

In this study, it is aimed to explain the usage fields of Efficient (Effective) Stress Analysis Methods and compare them with each other.

II. DETAILS EXPERIMENTAL

2.1. Materials and Procedures

2.1.1. Total Stress Analysis

This method is the simplest method of analysis for circular slide surfaces. It is used for the evaluation of the stability condition (short term stability) at which the excavation process is completed. The shear strength used without drainage (undrained) is constant along the shear surface. General stability of ground mass; the moment of the forces around the center of the sliding chamber is taken and determined according to their equilibrium.

2.1.2. Efficient (Effective) Stress Analysis Methods

In these analysis methods, the sliding mass between the slope surface and the slip surface is divided into slices in the vertical direction. Separation of sliding mass by slices and effective forces is shown in Fig 1. Firstly, each slice is conditioned separately, then all the slices are evaluated together to calculate the slope safety factor for the sliding mass.

Generally, the number of slices ranging from 10 to 40 times the mass provides realistic results. In the separation process of slices; it carefully must be taken to ensure that the base of each slice is kept in a single material, especially in slopes containing more than one soil material.

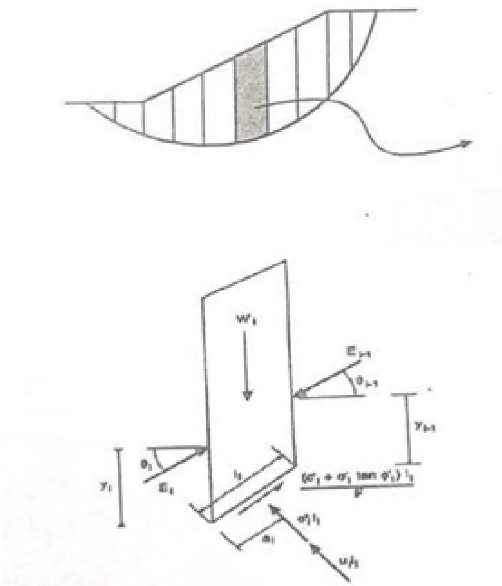

Fig.1. (a & b) Separation of sliding mass by slices and effective forces

The forces that effect the slices are:

W: Weight of slice

S: Effective shear force on the base of the slice

P: Normal force effecting on the base of the slice

U: Water pressure on the base of the slice

X: Strength between the slices that effect in the vertical direction

E: Strength between the slices that effect in the horizontal direction

In all methods, it is assumed that the force P is effective at the middle point of the slice base, and the solutions are simplified.

2.1.2.1. Swedish Slice Method or Fellenius Method

This method, developed by Fellenius, is the simplest method of slicing slopes. Fellenius Method also allows analysis without using a computer. The Mohr- Coulomb failure criteria is used in the method and the slope is divided into slices. The method only takes into account the moment balance of the sliding forces and against the sliding forces around the slide center and used for circular slides. Forces effecting the slices in Swedish Slice Method (Nash, 1987) is shown in Fig 2.

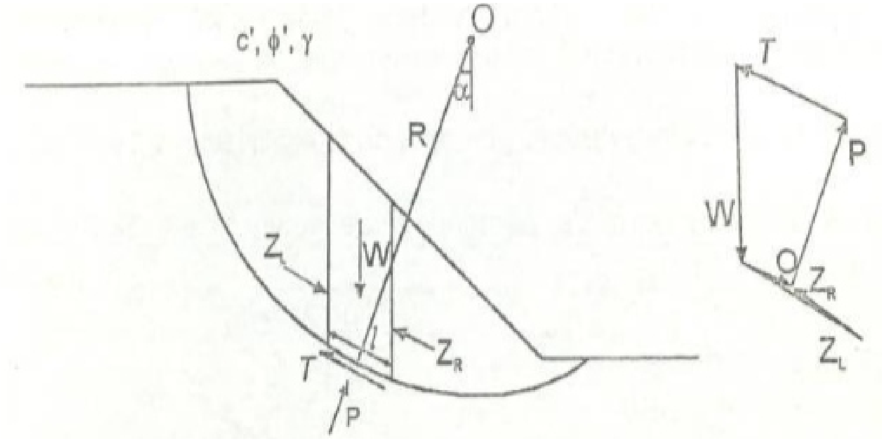

Fig.2. (a & b) Forces effecting the slices in Swedish Slice Method (Nash, 1987)

The water pressure must be low for the calculated safety factor to be used. When the water pressure is high, the safety factor is 50-60% lower then calculated and this method should not be used. However, the calculation applied in the Bishop method can be taken as an initial value in stages (Whitman and Bailey, 1967).

2.1.2.2. Bishop Method

This method, developed by Bishop (1955) for circular slip surfaces, is the most widely used method of analysis. There are two kinds of Bishop method; Simplified Bishop method based only on moment evaluates the balance of forces together with moment. Forces effecting the slices in Bishop Method is shown in Fig 3.

The forces that effect the slices are:
W: Weight of slice
P: Normal force effecting on the base of the slice
T: Shear force effecting on the base of the slice
Z: Height of slice
B: Width of slice
L: The width of the slice base
α: Angle of vertical force P
X: Distance from the center of the slice to the center of rotation

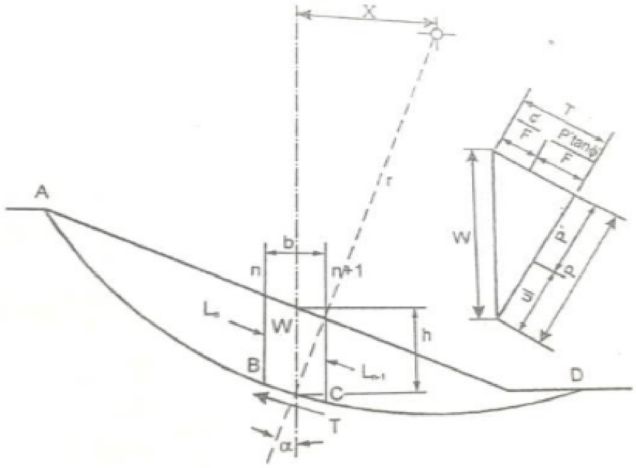

Fig.3. Forces effecting the slices in Bishop Method (Bishop, 1955)

2.1.2.3. Spencer Method

This method is mainly used for circular slide and non-circular slide surfaces. In this method, it is assumed that the inter-slice forces are affected by an angle such as Θ. Forces effecting the slices in Spencer Method is shown in Fig 4.

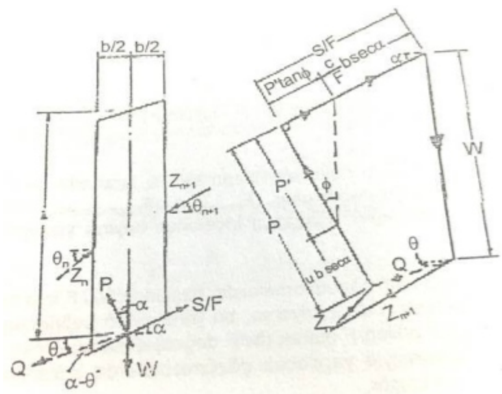

Fig.4. Forces effecting the slices in Spencer Method (Spencer, 1967)

In order to determine the normal force, perpendicular forces are added to the forces between the slices, and the force between the slices in the horizontal direction is also calculated.

With Spencer method, two different safety factors are calculated:

a. F_m for moment equilibrium

b. F_f for equilibrium forces in the direction parallel to the inter-slice forces

2.1.2.4. Morgensten-Price Method

This method, proposed by Morgenstern-Price (1965), is also applied to circular and non-circular sliding surfaces.

In this method it is assumed that the forces are constantly changing along the sliding surface. Equilibrium equations are obtained by solving the vertical and horizontal forces acting on the base of each slice. Due to the fact that all static equilibrium conditions are taken into consideration, as Spencer method, this method is also a complicated method and solution by computer is necessary.

2.1.2.5. Simplified Janbu Method

This method, proposed by Janbu (1973), is used for non-circular sliding surfaces. In the analyzes, the balance of the forces in the horizontal direction is investigated and the uncorrected safety factor (Fo) is calculated.

The slope safety factor (corrected) is found by multiplying by the safety factor and correction factor to take into account both the effect of circular forces and the effect of forces between the slices. Forces effecting the slices in Simplified Janbu Method is shown in Fig 5.

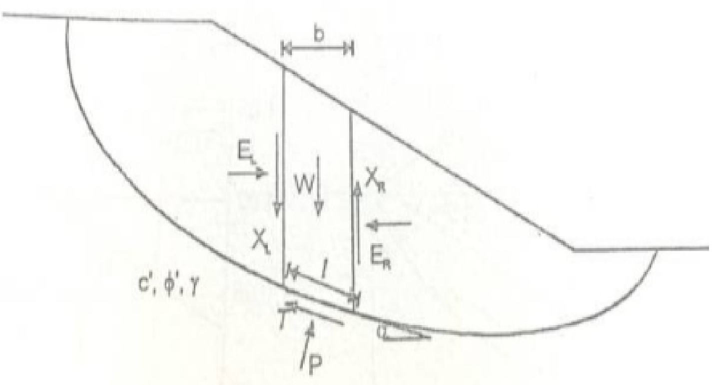

Fig.5. Forces effecting the slices in Simplified Janbu Method (Janbu, 1973)

III. RESULTS AND DISCUSSION

Being known which method of slope stability to use is as important as correct calculation of the slope stability safety factor.

Many methods are used to calculate the safety coefficient correctly. These methods include differences due to; the geometric condition of the slope, the equilibrium conditions and the assumptions. Comparison of effective stress analysis methods are shown in Table 1.

Table1: Comparison of effective stress analysis methods

Name of Method	Geometry of Sliding Surface	Equilibrium Conditions Provided	Application
Fallenius	Circular	Moment	Manual Calculation and Computer
Simplified Bishop	Circular	Moment	Manual Calculation and Computer
Complex Bishop	Circular	Moment and Force	Manual Calculation and Computer
Spencer	Circular and Non-Circular	Moment and Force	Computer
Morgensten-Price	Circular and Non-Circular	Moment and Force	Computer
Simplified Janbu	Non-Circular	Force	Manual Calculation and Computer
Complex Janbu	Non-Circular	Moment and Force	Computer

CONCLUSIONS

Comparing the smallest safety factor in the methods described, it is seen that each method has its strengths and weaknesses. It is important to calculate with the appropriate method in the problem of slope stability being worked on.

It is a definite solution for the Fellenius method, especially for deeply sliding surfaces. If high water pressures are developed, it actually gives a 60% lower safety factor. For this reason, it is not very preferred. The error margin is low in dry conditions. For the Bishop method, the calculated safety factor is not very sensitive to the assumptions contained in the method. The safety factors calculated with complex methods are obtained with very close safety factors with a difference of 0.1%. For this reason, it is the most preferred method.

Janbu method is applied only on non-circular surfaces, this should be taken into account when making comparisons.

Almost the same safety factor is obtained for all equilibrium conditions. The difference between them is around 5%.

In slope stability problems; in order to calculate the safety factor, the geometric condition of the slope, the presence of high water pressure and the ease of calculation must be considered.

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Application of Frequency Response Function Method for Detection of Damage in A Cantilever Beam Structure

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ABSTRACT

Damage detection in structures is a major concern for scholars all around the world nowadays. It provides a quantitative and qualitative data of any structure which can be used to predict the condition of a structure. Many numerical and experimental approaches have already been established by various authors, which have their respective advantages and disadvantages. Howsoever the experimental studies have been proved more efficient than numerical models. In this study the concept frequency response function and change in natural frequency has been used. The experiment is carried out on a cantilever mild steel beam and different damage scenarios are being induced and studied and the data is recorded, analyzed and finally compared to obtain the results. Data is recorded with the help of an accelerometer and the excitation force is given by a hammer. The data is analyzed in a FFT analyzer and responses are shown in the BRUEL & KJAER PULSE LABSHOP software. Lastly the obtained FRF curves are compared and results show that the damage is effectively detected in the steel structures. This method is more efficient in higher modes rather than lower frequencies.

Keywords - Modal parameters, Natural Frequency, Frequency Response Function (FRF), Damage Detection, Accelerometer, Hammer and FFT Analyzer

I. INTRODUCTION

As we live in a country which is developing in a very fast rate and growth of urbanization is very rapid. New structures are taking place of old structures. So it is very necessary for us to have such methods with the help of which we can successfully and effectively assess the condition of a structure. So that we can get to know that which structure is still useful and can be used, which one can be used with some remedial measures and the extent of the remedial measures and which structures should be completely demolished.

Detection of damage in structures can be classified in two methods; destructive methods and non-destructive methods. And due to its non-destructive nature and easiness of application it is preferred over destructive methods. In destructive methods both static and dynamic methods have been extensively studied and used for damage analysis. As we already know changes in geometric and material parameters which are associated with the health reduction of structures is known as damage and these geometric and material parameters are associated the modal parameters of a structure. As the damage increases more and more modification of these modal parameters take place. These modal parameters are stiffness, natural frequency and mode shapes. Most of the damage detection methods have been based on these parameters in most of the studies. But dynamic method of damage detection is becoming popular these days, as it is more effective and direct approach than the other older methods.

Dynamic response of a structure can be defined as response of the system to an impulse loading or forced vibration. In the dynamic method of damage detection these responses of the structures are measured in the form of displacement, velocity or acceleration. And these responses are being plotted with respect to frequency and time. Instead of using a traditional response parameter of a structure the damage detection with help of frequency response function is used nowadays. Here in this study a direct experimental approach of damage detection is being carried out and the response of the structure in the form of frequency response function versus frequency is obtained. A frequency response function is nothing but a ratio of response of a structure to applied force. The experiment which is being carried out on a mild steel cantilever beam clearly shows that apart from some difficulties associated with the experiments, it is completely able to detect the damage in the structure. The results are obtained by comparing different health scenarios of the beam structure and this approach proved quite satisfactory in comparison to numerical model approaches. This experimental approach is unaffected by the data pollution due to noise. Coherence is also checked during the experiment to check the quality of the measurements. Change in modal parameters of the structures is noticed with increasing damage, as we know change in stiffness of a structure leads to change in the modal parameters. And this change of modal parameters signifies the damage present in the structure. This approach proved less efficient in lower modes of structure but quite significant in higher modes.

As this study is successfully carried out on a local damage case for a steel structure, it can be efficiently used for damage detection in steel structures. And further investigations are required for localization of damage and detection of damage globally in a structure.

II. DETAILS EXPERIMENTAL

2.1. Specimen Description

For the experimental study a mild steel beam specimen is taken. The specification of the specimen and the support condition is given in the Table 1.

Table 1: Beam specimen description

S.NO.	DISCRIPTION	BEAM 1
1	Material	Mild Steel
2	Support condition	Cantilever
3	Mass (gm)	205.7
4	Length (mm)	300
5	Width (mm)	17.8
6	Depth (mm)	5
7	Section Modulus (cc)	74.2
8	Modulus Of Elasticity (GPa)	192.8

2.2. Experimental Setup

Apart from the beam the experimental procedure requires particular accessories along with the software. Experimental setup consists of following parts:

1. Front end module (Type- 3560 C)
2. Hammer (Type- 8206 003)
3. Accelerometer (Type- 4507 01)
4. Pulse Labshop analysis software
5. Laptop
6. Dongle
7. Others

In above setup the hammer (Type- 8206 003) is an exciting force agent and is used to apply the force in specimen. The response of a structure is measured by the accelerometer (Type- 4507 01), which is a unidirectional response measurement transducer.

Both of the hammer and the accelerometer1. is connected to the front end setup. This front end module is the heart of the system. It measures the data, analyze it and represent the output in desired and orderly manner with the help of Labshop software. Accelerometer is connected on different points of a structure on which the response is to be measured and excitation force is applied on the respective points with hammer.

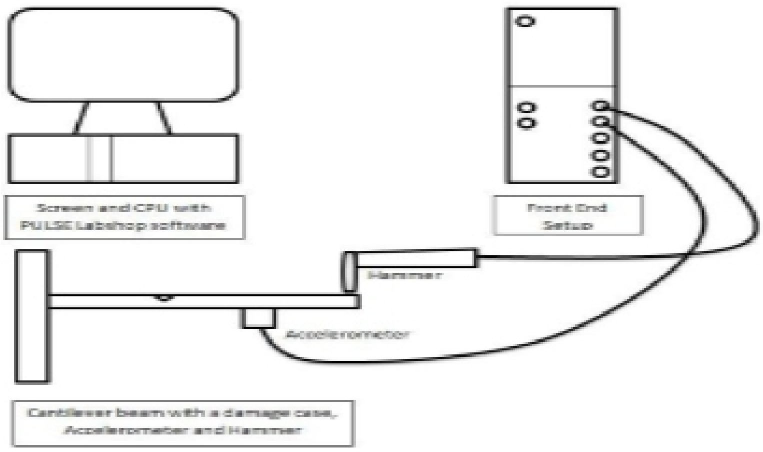

Fig.1. Complete experimental setup with all major parts

2.3. Experimental procedure

First the support condition of the structure is checked and desired degree of freedoms is defined. This study is done by defining three degree of freedoms in beam specimen. The points are defined equidistant. On all these points both the force is applied with hammer and response of structure is measured. We can do this in two ways; either fix the position of accelerometer and move the hammer or fix the point of application of load and move the position of accelerometer. Data is collected on a healthy beam (0% Damage case) at first. After taking these measurements the damage is induced in the beam specimen in a direction perpendicular to longitudinal direction of beam in the form of a vertical groove. The damage is induced in progressive manner in three stages (20%, 40% and 60% Damage case) and the response is measured and saved. While measuring the response of the specimen we have to take care of the coherence value of the structure and it is also measured simultaneously with other readings and is nothing but a qualitative parameter, which shows the quality of the reading taken during the experiment. The cantilever beam setup is shown in the figure 2.

Fig.2. Cantilever beam setup (With an accelerometer and a damage level)

RESULTS AND DISCUSSION

After the measuring response data of the tested beam specimen the data is analyzed. Primarily the data is collected for healthy beam, in other words for 0% damage case. This acts as the reference data for the further analysis of the beam for different damage levels. After this the 1 mm groove is cut which shows the 20% damage case followed by 2 mm groove showing 40% damage case and subsequently 3 mm groove showing 60% damage case is recorded. This data is arranged in a matrix format, known as receptance matrix or frequency response function matrix. Here the data is presented in tabulated manner. The data presented here belongs to first two modes of the beam specimen. Data shows the different elements of a matrix and also shows the modal frequencies of the different damage scenarios,as well as the response are also presented along with it.

As we can clearly see from the table 2 which is the response at mode 1 with different damage cases that there is very little change in the frequency of the structure as the damage is increasing the beam and the data is not reliable for detecting damage in a structure. But in the case of higher mode as the damage is increasing from 0% to 20% there is a significant change in the modal frequency of the specimen. This behavior in the beam of change in modal frequency is also present with the 40% damage case and 60% damage case as well. And these changes in the frequencies are considerable and easily detectable. There is a definite pattern in the results that the change in the modal frequency is increasing with the increasing damage. The change in not so significant in small damage cases and is very less but as the damage is very high this change in the modal frequency is notable.

Finally the data for the higher mode is presented in graph to compare the different damage scenario; here the graph for P22 and P32 is presented. We can compare the data at any given point, like here graph for 2 points are shown. In graph blue line is showing 0% damage, red line is showing 20% damage, green line is showing 40% damage and the purple line is showing 60% damage in the beam. We can clearly see in both the figure 3 and figure 4 that as the damage is increasing in the beam specimen the graph is shifting to the left, it means that there is a change in the modal frequency of the beam with the increasing damage.

Table 2: Response data of beam with different damage scenarios (Mode 1)

S. NO.		MODE 1							
		FREQUENCY(Hz)				FREQUENCYRESPONSE FUNCTION (m/N)			
	POINTNAME	BEAM2	BEAM2 D(1mm)	BEAM2 D(2mm)	BEAM2 D(3mm)	BEAM2	BEAM2D(1mm)	BEAM2D(2mm)	BEAM2D(3mm)
1	P11	41	41	40	40	4.90m	5.43m	4.59m	5.71m
2	P12	41	41	40	40	3.21m	3.61m	2.39m	3.52m
3	P13	41	41	41	40	1.02m	995u	797u	1.02m
4	P21	42	41	42	42	3.16m	4.18m	2.59m	3.68m
5	P22	42	42	42	42	1.68m	1.62m	1.48m	1.85m
6	P23	42	42	42	42	558u	660u	435u	614u
7	P31	43	42	43	42	832u	996u	971u	1.02m
8	P32	43	43	43	42	659u	831u	480u	415u
9	P33	42	42	43	42	141u	182u	155u	191u

Table 3: Response data of beam with different damage scenarios (Mode 2)

S. NO.		MODE 2							
		FREQUENCY(Hz)				FREQUENCYRESPONSE FUNCTION (m/N)			
	POINTNAME	BEAM2	BEAM2 D(1mm)	BEAM2 D(2mm)	BEAM2D(3mm)	BEAM2	BEAM2D(1mm)	BEAM2D (2mm)	BEAM2D (3mm)
1	P11	269	265	259	252	414u	301u	170u	207u
2	P12	270	265	260	252	305u	370u	232u	126u
3	P13	269	265	259	252	401u	347u	313u	150u
4	P21	276	272	265	256	465u	202u	424u	313u
5	P22	276	272	265	255	286u	256u	244u	148u
6	P23	276	272	265	256	245 u	283 u	263 u	211 u
7	P3 1	276	271	265	253	277u	230u	462u	106u
8	P3 2	275	271	264	255	296u	265	240u	280u
9	P3 3	275	271	264	255	305 u	292 u	267 u	233

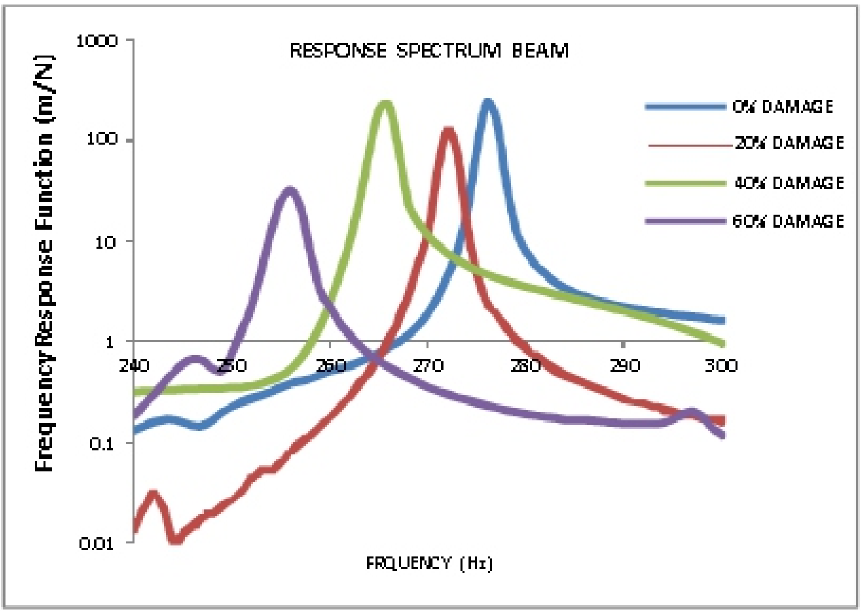

Fig.3. Frequency response function curve (P22) and different damage scenarios

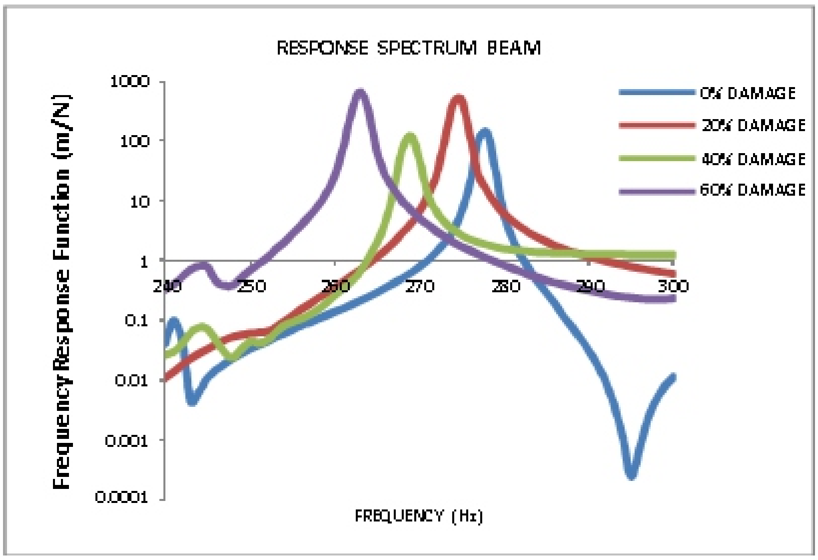

Fig.4. Frequency response function curve (P32) and different damage scenarios

CONCLUSIONS

From this study of damage detection in cantilever beam specimen we can bring out following conclusions:

1. The method is completely successful and reliable in detecting damage in a steel structure as the experiment is being done on a mild steel beam.
2. As the damage increases in the beam there is an increase in the change in the modal frequencies of frequency response function the cantilever beam specimen, thus we can say that it implies that the increase in the change in frequency shows the increase in the deterioration of the structure.

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Firstly and most importantly, I would like to thank my parents for their blessing, love and support. I am deeply indebted to my thesis guide Dr. R. P. Sharma, Professor, Department of Civil Engineering, National Institute Of Technology, Agartala for his sincere guidance, valuable suggestion and much appreciated correction at every step of this project work. Finally, I would like to thank the almighty god who helped me to overcome all the problems which came across me during this work.

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A Standard Remodeling System for Existing Housing Units Integrated with the Energy Production Module using Algae Activation

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ABSTRACT

This research proposes an optimal energy remodeling improvement plan which can be applied to existing apartment houses by simulating the energy performance and reclassifying the technology elements applied to existing passive houses and energy saving building in domestic and foreign cases. The Korea diffusion ratio of house has exceeded 100% in 2008 by the National Statistical Office. Korean construction systems including housing have been transformed from quantitative to qualitative. The construction trend is focusing existing buildings through reconstruction and remodeling rather than new construction due to the physical limitations: limited land use, decreased demand, changes in the economic structure, changes in the resident's mind, etc. In addition, most of the domestic energy housing systems (Zero energy house, Bio-housing, Green building, Passive house, etc.) and related researches have done only for new construction. In this situation, the purpose of this research is to analyze the situation in Korea objectively and to study the suitable method applicable to the existing building and house and to suggest a direction through the research result.

Index terms- Algae Energy, Algae Façade, System of energy production housing, existing housing and buildings, changes in elevation, Applicable platform for existing housing, Apartment

I. INTRODUCTION

The total consumption of households in Korea accounts for more than 10.5% of total domestic energy consumption. Therefore, energy saving efforts has been variously researched and developed in the residential area.

As part of energy saving efforts, it is also important to reduce energy consumption of existing buildings and to use them efficiently. Government also was enacted the "Greenhouse Gas Emission Trading Act" on January 1, 2015 to reduce greenhouse gas emissions, purchase emission credits, and established a green building certification system (G-SEED) for buildings that contributed to energy conservation and environmental pollution reduction based on certification standards.

Also, the government aims to provide Million of Green Homes by serve some of the installation fee when installing new and renewable energy facilities in homes until 2020. And recently, Korea's diffusion ratio of house exceeded 103 percent, among which apartment houses occupy about 75 percent. In addition, Korea regulations about the performance of housing energy have been gradually strengthened.

In the case, constructed houses in the 1970s (1.04W/m2K), there are four times the difference, constructed houses in the 1980s (0.58W/m2K), there are twice the difference. But today Korean researches of energy housing system are focused only new building and construction. Therefore, this research aimed to analyze the Korean housing situation and to propose the applicable technologies and simulation result data for existing buildings.

II. RESEARCH METHOD AND SCOPE

The purpose of this research is analysis the change of energy performance according to the change of elevation shape by the remodeling of apartment house using simulation. For this research, this research reviewed basic method and advanced research by case studies on energy performance remodeling of national and international buildings. And this research reorganized factor of Zero Energy House System, which was limited to new and single houses, to be applicable to the existing apartment and suggested a system that can improve the energy performance on existing apartment.

Through this process, this research simulated the energy performance by 3D modeling representative form of apartment unit in the 1970s and 1990s for comparative evaluation of reorganized factors and suggested system. Also this research compared the energy performance before and after the remodeling of the existing apartment by the simulation using the REVIT Energy analysis program, OPEN STUDIO, ENERGY PLUS and the heating and cooling load using the ECOTECT. And I finally aim to propose a best solution and method of remodeling by comparison of the result values.

In addition, this research planed about the application of algae energy system and algae façade system. Now, previous studies and case studies about algae are analyzed and thermal data is earned necessary to simulation by The University of North Carolina's Algae research. So this research will analyzes the performance improvement and the energy production through the application of Algae Energy System, Algae Façade System.

III. PRELIMINARY RESEARCH

1) Analysis of Basic Statistics

Prior to the study, most of the energy efficient residential systems (Zero Energy House System, Passive House System, Green House System) serve to newly constructed and single- family houses. On the contrary, the current Korea housing situation shows that new construction is steadily decreasing.

Table 1: Increase / Decrease in Number of Single-family houses and apartments by year

Year	Number of Apartments	Increase /Decrease	Number of Single houses	Increase /Decrease
1975	89,248		4,381,772	
1980	373,710	+284,462	4,652,127	+270,355
1985	821,606	+447,896	4,719,464	+67,337
1990	1,628,117	+806,511	4,726,933	+7,469
1995	3,454,508	+1,826,391	4,337,105	-389,828
2000	5,231,319	+1,776,811	4,069,463	-267,642
2005	6,626,957	+1,395,638	3,984,954	-84,509
2010	8,185,063	+1,558,106	3,797,112	-187,842

The number of apartments still shows a steadily increase, but the number of single-family houses is on the decline. Also, Domestic Housing new construction is decreasing. Domestic housing construction has exploded in the 1970s and has experienced rapid quantitative growth until the 1990s. However, it started to decline gradually in the 2000s, and now is sharply decreasing.

2) Study of Previous Research

The current trend of domestic research on apartment remodeling can be seen before and after the change of the characteristics of apartment remodeling to the improvement of energy performance. Studies of the apartment remodeling before the change of the energy performance improvement are mainly focused on the status, situation of remodeling and policy improvement for aged apartment. Jeong-yoon Bae (2004) researched to the status of remodeling of apartment and institutional improvement policy, and Eun-soon Kim (2010) researched on growth plans and improvement prospects.

After the change, many studies focused on the remodeling plans for improving the energy performance of existing houses such as green remodeling. The Ministry of Land (2013) proposed a remodeling plan for revitalizing the energy performance of existing buildings.

IV. REORGANIZATION AND SIMULATION

1) Reorganization of Factor

First step of Experimental is reorganization to applied factors of Smart Energy House by previous and case studies. And applied factors are divided into the passive technology group, active technology group and renewable energy technology group. And these classified factors are re-organized with applicable to existing housing, apartment housing. Divided factors are as shown in the following Table 2.

Table 2: Divided Factors by Previous Studies and Case Studies

Group Name	Factor Name	c1	c2	c3	c4	c5
Passive Technology Group	Location of Southern	•	•	•	•	•
	Rectangular Shape	•		•	•	•
	Shading Device	•	•	•	•	•
	Skylight					•
	Green Wall & Roof	•	•	•	•	•
	High Insulation	•	•	•	•	•
	High Efficiency Window	•	•	•	•	•
	High Airtightness	•	•	•	•	•
	Thermal Mass			•		
	Natural Ventilation	•	•	•	•	•
	Daylight Duct System	•				
	Rainwater Recycling			•	•	
Active Technology Group	High Efficiency LED	•	•	•	•	•
	High Efficiency Boiler	•			•	
	Interruption of Power	•	•	•		
	Heat Recovery Ventilator	•	•	•	•	•
Renewable Energy Technology Group	Solar Energy Generation	•	•	•		
	Solar Heat Energy System	•	•	•	•	•
	Wind Energy System			•	•	
	Geothermal Energy System	•	•	•	•	•

As a result re-organized factors are as follows: Shading Device, Green Wall & Roof, High Insulation, High Airtightness, High Efficiency Window, Natural Ventilation, Solar Energy Generation, Wind Energy System. These factors have commonly features like easy to apply, fewer limit of apply and high efficiency energy saving.

2) Type of Apartment House

Look at the standards for remodeling in Korea, remodeling is extend a building within 3/10 of the private housing area of each household when 15 years have passed after obtaining approval for use. Therefore, the type analysis of this paper targets are focused on apartment houses built by Korea National Housing Corporation from 1990s to 2000s, which has been over 15 years old. The 1980s and 1990s are period of quantitative growth centering on apartment complexes in Korea. Also after 1993, when the Construction of 2 million Houses Plan was completed, the apartment complex business and plan continually focused on large-scale residential development projects in the surrounding areas of the metropolitan area. Therefore, the apartment complexes that were supplied at the time still occupy a large proportion and need to be analyzed as an object of immediate remodeling. But, the type analysis focuses on apartment complexes built by Korea National Housing Corporation.

Table 3: 1990s Projects by Korea Housing Corporation

Region		Name of Apartment Complex	Area(m²)	Year Completed	Number of household
1	Panam-dong, Daejeon	Jugong-2	64-105	1990.01	1130
		Jugong-1	63-105	1990.03	1016
		Jugong-5	50-78	1992.08	1436
2	Haan-dong, Gyunggi	Jugong-10	60-105	1990.03	2032
		Jugong-6	52-71	1990.03	1260
		Jugong-7	63-105	1990.03	1342
		Jugong-8	63-105	1990.03	1680
		Jugong-5	63-105	1990.05	2176
		Jugong-11	52-69	1990.06	1080
		Jugong-9	63-105	1990.09	1818
		Jugong-12	59-104	1990.11	2392
3	Munheung-dong, Gwangju	Woosan-2	63-82	1990.06	1138
4	Sunbu-dong, Gyunggi	Jugong-11	49-58	1990.08	1190
		Jugong-15	49-68	1993.04	1210
⋮	⋮	⋮	⋮	⋮	⋮
88	Gyo-dong, Gangwon	Gyodong Jugong-1	65-110	1999.12	1019
89	Damgam-dong, Busan	Baeyang Purenchae	68-101	2000.02	1116
90	Busan-dong, Gyunggi	Unam Jugong-1	61-105	2000.03	1755
		Unam Jugong-2	102-102	2000.11	1036
		Unam Jugong-3	62-108	2000.05	1651
91	Gojan-dong, Gyunggi	Neobill-6	92-103	2000.05	1043
92	Jungbu-dong, Yangsan	Yangsan Jugong	52-77	2000.06	1248
93	Sinlim-dong, Seoul	Samsungsan Jugong-3	75-146	2000.08	1482
94	Dukjung-dong, Gyunggi	Bongwoo Jugong-5	69-82	2000.08	1732
95	Goam-domg, Gyunggi	Juwon Jugong-2	70-84	2000.11	1935

3) Simulation

3D Models are constructed by reflecting the thermal data and representative plan type in the process of typification. They are commonly set south, corridor apartment, RC + wall structure, 210mm of floor slab, 150mm outside and intergenerational wall.

In this paper, this research classified the apartment houses of 1990s-2000s into area and plan types, and then constructed to 3D modeling for simulation. After reflecting common data to the five types, this research tested performance and effect of energy saving technology factors applicable to the existing apartment houses and analyzed increasing and decreasing of energy usage by REVIT, and will more test on light, heat and energy performance by ECOTECT and ENERGY PLUS.

Figure 1: Process of Simulation on REVIT

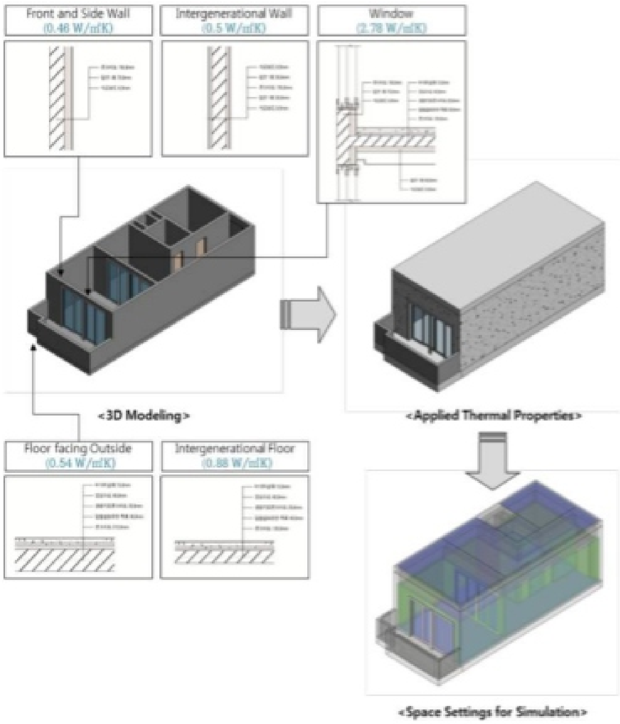


Figure 2: Compare of Energy Performance to 1990 and 2016

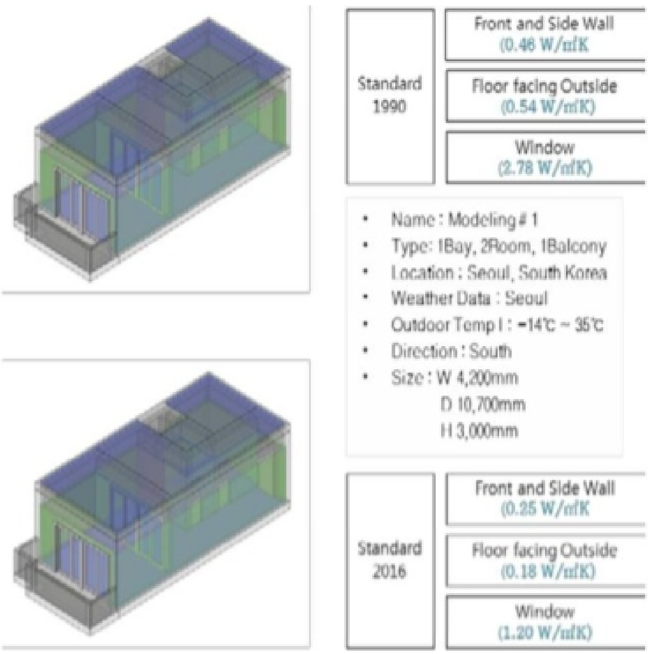
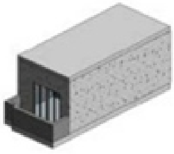
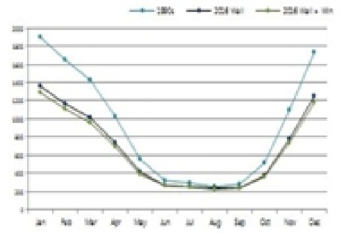
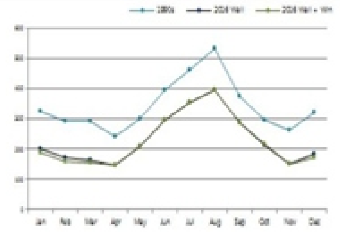
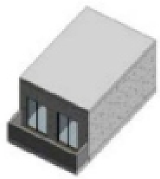
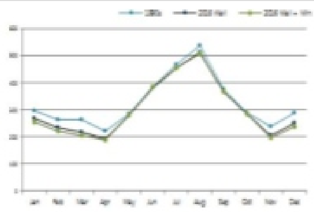
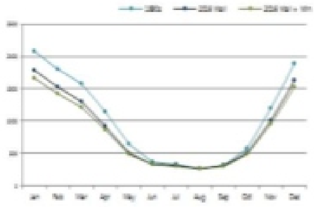
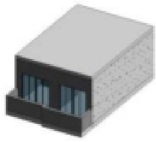
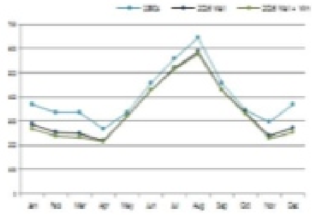
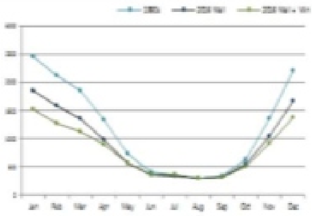
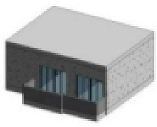
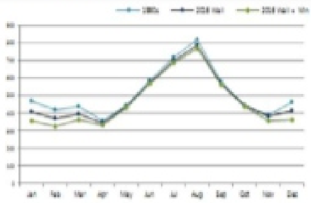
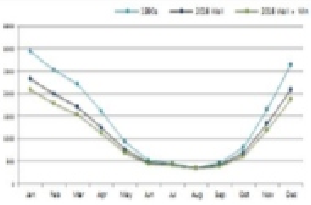


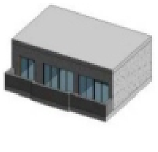
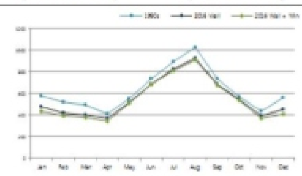
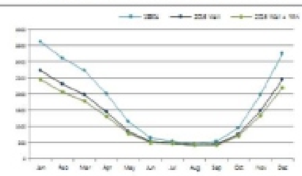
Table 4: Result Data of Energy Performance Simulation

3D Model#1 (1Bay, 2Room, 1Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m²K Floor : 0.54 W/m²K Intergeneration Floor (Roof) : 0.75 W/m²K Win : 2.85 W/m²K	Wall : 0.25W/m²K Floor : 0.18 W/m²K Intergeneration Floor (Roof) : 0.48 W/m²K Win : 1.45 W/m²K
Consumption (elec)	120 kWh/m²/y	90 kWh/m²/y
Consumption (fuel)	1,172 MJ/m²/y	922 MJ/m²/y
Consumption (Total)	1,606 MJ/m²/y	1,248 MJ/m²/y
Graph of Consumption (Monthly Electricity)		
Graph of Consumption (Monthly Fuel)		

3D Model#2 (2Bay, 2Room, 2Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m²K Floor : 0.54 W/m²K Intergeneration Floor (Roof) : 0.75 W/m²K Win : 2.85 W/m²K	Wall : 0.25W/m²K Floor : 0.18 W/m²K Intergeneration Floor (Roof) : 0.48 W/m²K Win : 1.45 W/m²K
Consumption (elec)	105 kWh/m²/y	92 kWh/m²/y
Consumption (fuel)	1,184 MJ/m²/y	909 MJ/m²/y
Consumption (Total)	1,563 MJ/m²/y	1,240 MJ/m²/y
Graph of Consumption (Monthly Electricity)		
Graph of Consumption (Monthly Fuel)		

3D Model#3 (2Bay, 3Room, 2Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m^{2}K Floor : 0.54 W/m^{2}K Intergeneration Floor (Roof) : 0.75 W/m^{2}K Win : 2.85 W/m^{2}K	Wall : 0.25W/m^{2}K Floor : 0.18 W/m^{2}K Intergeneration Floor (Roof) : 0.48 W/m^{2}K Win : 1.45 W/m^{2}K
Consumption (elec)	106 kWh/m^2/y	91 kWh/m^2/y
Consumption (fuel)	1,132 MJ/m^2/y	821 MJ/m^2/y
Consumption (Total)	1,515 MJ/m^2/y	1,149 MJ/m^2/y
Graph of Consumption (Monthly Electricity)		
Graph of Consumption (Monthly Fuel)		

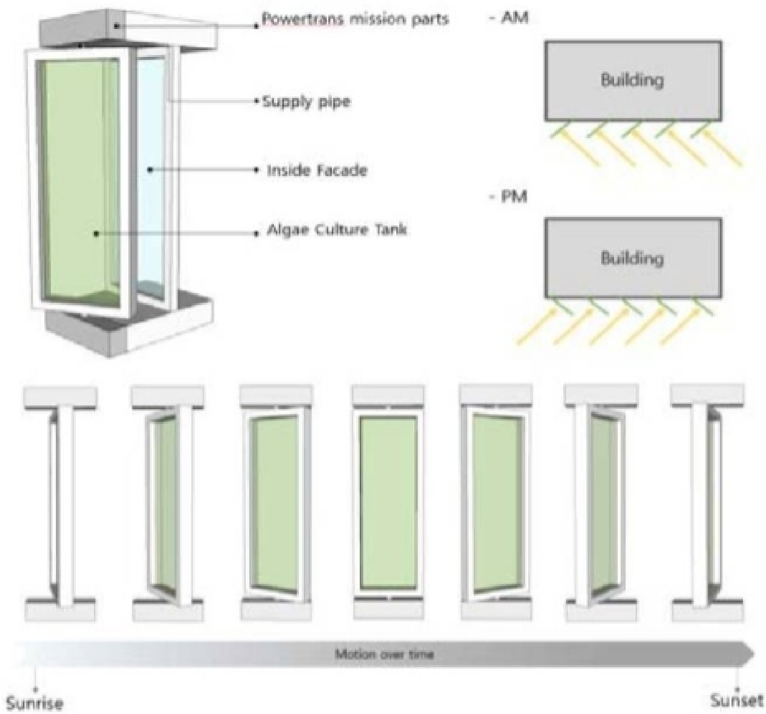
3D Model#4 (3Bay, 3Room, 2Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m^{2}K Floor : 0.54 W/m^{2}K Intergeneration Floor (Roof) : 0.75 W/m^{2}K Win : 2.85 W/m^{2}K	Wall : 0.25W/m^{2}K Floor : 0.18 W/m^{2}K Intergeneration Floor (Roof) : 0.48 W/m^{2}K Win : 1.45 W/m^{2}K
Consumption (elec)	107 kWh/m^2/y	97 kWh/m^2/y
Consumption (fuel)	1,070 MJ/m^2/y	782 MJ/m^2/y
Consumption (Total)	1,454 MJ/m^2/y	1,131 MJ/m^2/y
Graph of Consumption (Monthly Electricity)		
Graph of Consumption (Monthly Fuel)		

3D Model#5 (3Bay, 3Room, 3Bal)	Modeling Settings(1990)	Modeling Setting(2016)
	Wall : 0.46W/m²K Floor : 0.54 W/m²K Intergeneration Floor (Roof) : 0.75 W/m²K Win : 2.85 W/m²K	Wall : 0.25W/m²K Floor : 0.18 W/m²K Intergeneration Floor (Roof) : 0.48 W/m²K Win : 1.45 W/m²K
Consumption (elec)	100 kWh/m²/y	91 kWh/m²/y
Consumption (fuel)	1,003 MJ/m²/y	731 MJ/m²/y
Consumption (Total)	1,362 MJ/m²/y	1,059 MJ/m²/y
Graph of Consumption (Monthly Electricity)		
Graph of Consumption (Monthly Fuel)		

4) Application of Algae Technology

this research will analyzes the performance improvement and the energy production due to the application of the new renewable energy (Algae energy, in this study) among the applicable remodeling technologies that have already been reorganized.

Figure 4: Images and Principle of Algae Façade



And, with conducting the energy simulation, thermal data are essential. Especially, the research of the thermal performance of the algae façade was almost hard to find because they are not commercialized. The University of North Carolina in the U.S.A recorded thermal energy distribution grasped using infrared camera by producing mock-up for algae façade. In the result of this research, algae façade was shown to have same energy efficiency as Low-e Coated IGU (Insulated Glass Unit). This research will simulates using this thermal energy data.

CONCLUSION

In this study, this research reclassified and reorganized the applicable factors into the existing apartment houses, due to some limitations of existing Energy House System such as low applicability with existing houses and high-rise houses. And this research analyzed the types of apartment houses in the 1990s-2000s that need be remodeled immediately. Through this, constructed 3D modeling and simulated energy performance, energy effectiveness of each changes (change of thermal standard, heat insulation property of wall and floor).

And, this research analyzed the change of electricity and fuel consumption according to the change of insulation standard. As a result of the above simulation, it is confirmed that electricity is saved 4,330.7 kWh per year, fuel is saved 17,160 kWh per year, total of 21,490 kWh per year. It is expected that energy savings will also increase when the area is increased because simulation unit is smaller area in houses unit. And this research will do additional simulation and test the performance improvement and the energy production due to the application of the Algae energy system or Algae façade.

Finally, this research has expected that this study may serve as fundamental findings of new trials for energy housing systems and suggest new methods applicable to the existing housings and buildings.

ACKNOWLEDGMENTS

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An Integrative Prototype Model for Container Space Module and Algae Facade System

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ABSTRACT

- In this study, problems scattered in the building sector were picked up, using the method of applying Algae Façade to the structure of container. As a first step, analyzed the transition of energy performance by fusing container construction and algae system and considered the possibility of application. More than 10 cases were analyzed, the optimum outer skin composition was selected, and the composition of the fittings was decided based on the building law and recommendation. By applying this, energy performance analysis of various combination types of containers was carried out. Comparative analysis was made between cases where the known Façade was applied and cases where normal fittings were applied. This study aims at investigating the adaptability towards the future sustainable building with algae technology and testifying the energy efficiency of the algae skins by operating a couple of simulation tools to measure building performances for the proposed prototype of the façade system.

Index terms- Container architecture, Algae system, Energy performance, Technology integration

I. INTRODUCTION

To date, the interest of houses was mainly the construction of 3 to 4 households and the center of apartment, but recently one household has shown a sharp increase trend, a new floor plan and construction system is necessary. As a major problem that can't overlook energy problems, in the past, in the case where research on energy conservation was the main focus, research to produce energy voluntarily in each field is actively underway.

In this study, problems scattered in the building sector were picked up, using the method of applying algae façade to the structure of container. For that purpose, it is important to generate synergistic effects by fusion of technologies rather than making solutions with one technology. In this research, recently, it began with interest in container construction which expanded its range to housing complex, housing, dormitory, cafe and other complex facilities. The structure of a container clearly different from the existing building system has a unique appearance at a glance, and it has various features such as a construction method, an internal configuration, a unit price, and the like.

What kind of shape and system should be applied when applying the unique energy production system of these container constructions? Also, how much performance should you demonstrate in terms of energy? What should we do to provide more versatile functions? In order to find the answer to the question of and, the following research is necessary.

Firstly, unless research on the specialty of container construction is accompanied, secondly, research on the principle of Algae System to be applied and applicability to Façade is necessary. Third, it is the method of technology fusion. In this paper, representative types by number of combinations of containers were selected for eight cases, and the

difference in energy performance when general fittings and Algae Façade were applied were compared and analyzed.

II. THEORETICAL BACKGROUND

1) Container Construction

Container, the main component used for container construction, is a box-shaped container welded with durable steel manufactured for safely transporting cargo. This container regulates the structure and strength so that permanent repetition can be used, and it is excellent in durability. Just because of these characteristics, containers can be used as building materials.

The container structure can be divided into two according to the container supply and demand method, the first is the method used to build the old shipping container and the second is the method of manufacturing at the factory for the use of the building. Both methods require further insulation, electricity, water, and other processes for use in residential and commercial facilities. And both of all has features such as reusing materials, using the structural strength of the container itself and ease of maintenance by standardized size.

2) Algae Technology

Algae is a photosynthetic organism that produces biomass utilizing light and carbon dioxide in an aquatic environment.

Unlike food crops and woody biomass, it is clear that certain algae have the function of producing and accumulating naturally oil by photosynthesis, it is one of the most influential resources for production of algal biofuels has emerged rapidly.

Algae technology has the following features.

Firstly, breeding is quick and second, the area required for foam is 30 times less than what is necessary to cultivate other plant resources. Third, control of production process and product quality is easy. Various methods have been developed for culturing the microalgae, basically it is classified into two types, an open pond system and a closed photobioreactor system, and according to each system, advantages and merits have disadvantages.

3) Technology Integration

First of all, the current state of technology at present is grasped for fusion of technologies, and concrete implementation method was proposed.

Estimated result of Korea's renewable energy amount in 2020 Solar power generation 552,000 TOE, wind power generation 2,035,000 TOE, bio energy 4,211,000 It was found that the possibility of bioenergy development is quite high in TOE. Among them, the production of bioenergy using seaweed belongs to the low rank of 907,000 TOE, but its growth rate ranks first among 49.6% from 2008 to 2030.

In terms of production volume it possesses the world's fourth-class infrastructure and technology, and it has conditions suitable for applying Algae Fuel. And the possibilities of Algae Fuel have already been demonstrated in developed countries like Germany, Brazil and Japan.

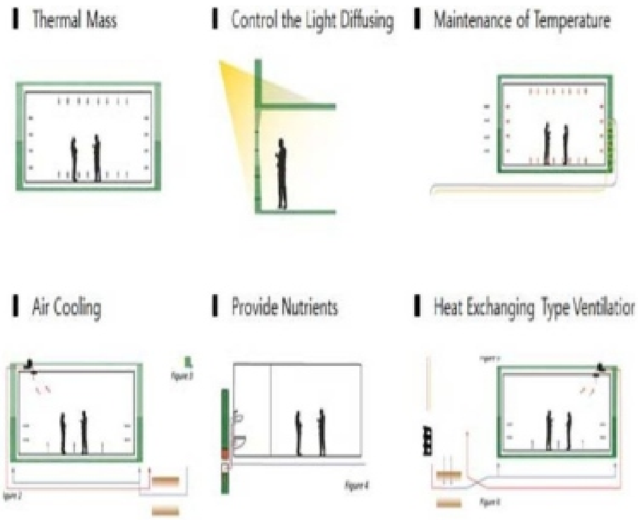


Figure 1: Applied to building of Algae system

On the other hand, the container structure is typically made by reusing lung containers used for cargo transportation, and it is sometimes manufactured for use in field offices, shops, and toilets.

These container structures are accurately unitized according to standards, and their deformation and combination are easy, and the construction term can be shortened through prefabricate. Also, its structural stability and durability is an advantage that it can be obtained as it is built. Thanks to the construction of the container, which is a combination of structural frame and panel, various elevation and spatial configurations can be created via panel change.

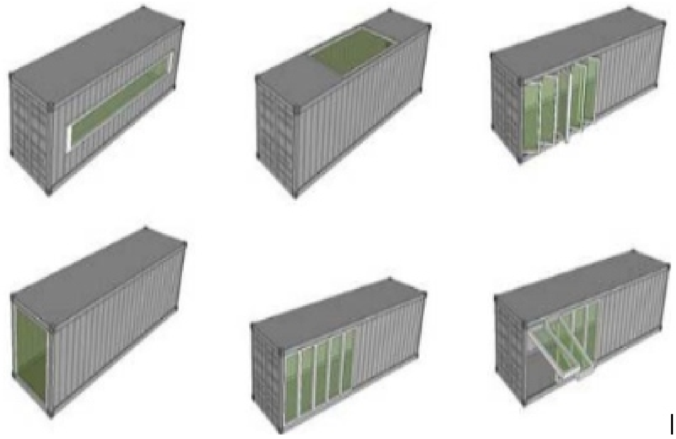


Figure 2: Applied to container of Algae façade

Against this background, the elevation of container construction is replaced by Algae Façade, various modules are created, and energy efficiency is grasped through simulation.

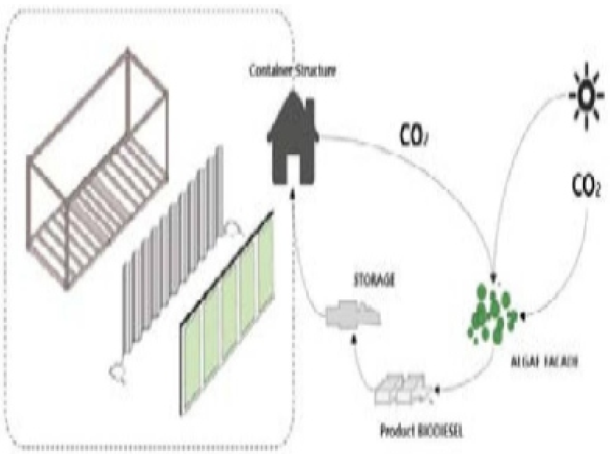
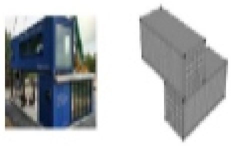
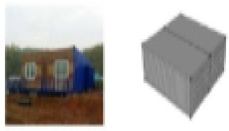
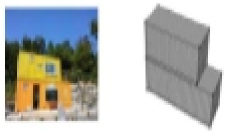
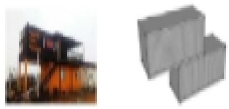
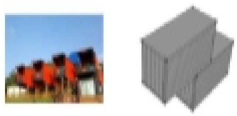
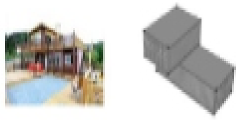
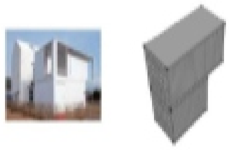
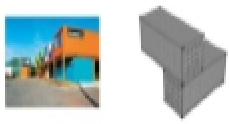


Figure 3: Container and Algae façade fusion concept

III. SIMULATION METHOD

Based on the eight cases for simulation, the type of combination of containers, representative type of ceiling, wall, floor and representative type of windows were set.

Table 1: Container combination example

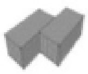
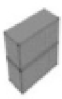
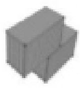
Case 1	Case 2
	
Case 3	**Case 4**
	
Case 5	**Case 6**
	
Case 7	**Case 8**
	

It analyzes the energy performance displayed when combining the two most basic containers, selects the result value as a representative type, and shows the difference when applying the following general glass and Algae Façade It will be analyzed.

1) Container Combination Type

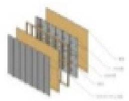
When two containers are combined, five types can be confirmed, and it can be divided into one-story type and duplex type. Various forms can be confirmed according to the design, but five types are typically revealed.

Table 2: Representative type of container

Type ①	Type ②	Type ③	Type ④	Type ⑤
				

2) Representative Type of Ceiling, Wall and Floor Types of representatives according to the composition of the ceiling, wall and floor are as follows and the most efficient configuration was chosen.

Table 3: Representative type of container construction

	Representative type	Information	
Ceiling		•Iron bending panel •Polyurethane foam •50 mm glass wool •Squared timber 50* 50 •3 mm gypsum boar d •Ceiling finish	•overall thickne ss: 77.2 mm •Thermal resist ance: 1.905 m^2k/W •U-Value : 0.52 W/m^2k
Wall		• Iron bending panel •18 mm plywood •30 mm styrofoam •Wakamatsu square material 30 * 30 •3 mm plywood •Wall interior finish	•overall thickne ss: 58.4 mm •Thermal resist ance: 1.533 m^2k/W •U-Value : 0.65 W/m^2k
Floor		•Iron bending panel •50 mm extrusion m ethod thermal insula tion board •hot water ondol hea ting •Wood crate plywoo d floor	•overall thickne ss: 56.2 mm •Thermal resist ance: 1.849 m^2k/W •U-Value : 0.54 W/m^2k

3) Typical Window Type

In order to set the representative type of the fittings, reference was made to "Guidelines for Fittings for Energy Conservation of Buildings" published by the National Land Department.

In the case of the southern region of South Korea, southward orientation is the most advantageous from the viewpoint of energy requirements of buildings when applying windows of legal level (40% window area ratio), the trend of northward > eastward > westward.

Therefore, in the experiment, the ratio of the wall and the window was set to the southward window 40%, the northward window 40%, and the basic value of the triple glass was applied to the performance of windows.

Table 4: Performance factor of windows

	Performance factor of windows
U-Value	0.75
SHGC	0.45

4) Algae Façade

In order to know the physical performance of fittings with Algae applied, experiments conducted at the University of North Carolina in Charlotte, USA were helpful. This is a measurement of thermal energy efficiency with an infrared camera after making Mock-up of Algae Façade. From this experimental result, Algae Façade was found to have energy efficiency equivalent to Low-e Coated IGU (Insulated Glass Unit).

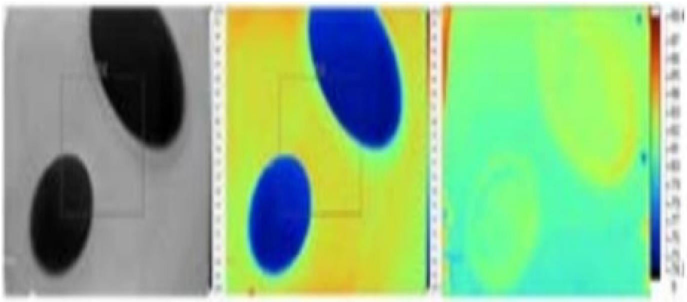


Figure 4: Algae façade thermal performance output (Source: T. Kim, O. Lim, S. Kim and S. Han, 2014)

Table 5: Performance factor of Algae façade

	Low-E Coated IGU
U-Value	0.29
SHGC	0.27

IV. RESULT OF SIMULATION

In each simulation, the composition of the representative material of the ceiling, the wall, and the floor of 3.2 is similarly applied based on the combination type of the container of 3.1, the property value of the fitting representative type of 3.3 and the property value of Algae Facade of 3.4 are applied, And compared with each other.

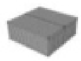
Table 6: Performance factor of windows

CLIMATE INFORMATION	LOCATION	GWANG-JU, SOUTH KOREA
	AVERAGE TEMPERATURE (℃)	20.0
	DIRECTION OF BUILDING	MAKE WIDE SIDE TO SOUTH
DEFAULT SETTING	BUILDING TYPE	RESIDENCE
	HEAT SOTRAGE (Wh/ m^2K)	60
	HEATING TEMPERATURE (℃)	20
	COOLING TEMPERATURE (℃)	26
INTERNAL HEAT GENERATION	RESIDNETS	2
	INTERNAL HEAT GENERATION (W/ m^2)	4.38
VENTILATION	HEATING EFFICIENCY	71%
	COOLING EFFICIENCY	71%

4) Application of Triple Glass

First, it is known that the energy capacity decreases as the outer cover area increases, and as the outer cover area becomes wider, the heating energy demand increases widely, but on the contrary, the cooling energy requirement shows a slight difference.

Table 7: Application to triple window glass Simulation result

	①	②	③	④	⑤
TYPE					
OUTER COVER AREA (m^2)	66.3	81.9	82.8	100.3	100.3
HEATING ENERGY DEMAND (kWh/m^2)	143.34	165.33	168.69	190.16	190.41
COOLING ENERGY DEMAND (kWh/m^2)	58.02	57.99	57.39	57.58	58.09
ENERGY PERFORM ANCE (L/m^2)	14.3	16.5	16.9	19.0	19.0
ENERGY COST (KOREAN WON)	689,800	733,000	738,700	781,100	782,400

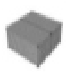
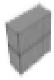
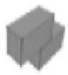
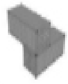
In addition, although not explained in the paper, it can be seen that as the number of combinations of containers increases, the value of the outer skin area increases, and the heating performance improves accordingly. This seems to be due to the increased number of containers used and to naturally expand the internal space.

As a conclusion, the amount of energy loss is the smallest when combining in such a way as to reduce the outer skin area to the maximum, and the difference decreases as the number of containers increases.

6) Application of Algae Façade

Comparing general triple glass and Algae facade, heating energy requirement increased by 4.04 kWh / m2 based on type 1, whereas cooling energy requirement decreased by 14.18 kWh / m2.

Table 8: Application to Algae facade Simulation result

	①	②	③	④	⑤
TYPE					
OUTER COVER AREA (㎡)	66.3	81.9	82.8	100.3	100.3
HEATING ENERGY DEMAND (kWh/㎡)	147.38	169.64	173.04	194.77	195.00
COOLING ENERGY DEMAND (kWh/㎡)	43.84	44.07	43.59	43.97	44.40
ENERGY PERFORMANCE (L/㎡)	14.7	17.0	17.3	19.5	19.5
ENERGY COST (KOREAN WON)	678,500	722,400	728,300	771,400	772,500

This is because the transmittance is lowered, the acquisition of solar radiation decreases (SHGC: 0.45 →0.27), the heating energy demand increases, whereas the cooling energy demand relatively decreases. For this reason, the overall energy performance increased to 14.7 L / m2 at 14.3 L / m2, but the energy cost decreased from 689,800 won to 678,500 won per year.

CONCLUSION

This paper is an analysis of the transition of energy performance displayed when the container construction and Algae system are merged. Based on the eight cases, the optimal outer skin composition was decided, and the composition of the fittings was decided based on the building law and recommendation. By applying this, energy performance analysis of various combination types of containers was done.

The simulation compares the case where algae facade is applied and the case where normal window is applied, and the result is as follows. First, the amount of energy loss is smallest when combining in a form that reduces the outer skin area to the maximum, and as the number of containers increases, the difference decreases. Second, heating energy demand increases when comparing the triple glass window with Algae facade, whereas the cooling energy requirement decreases. This is because the transmittance decreases and the solar radiation acquisition amount decreases. Third, since the adiabatic value of Algae facade is higher than that of general fittings, cooling energy demand remarkably lowered and showed a monetary advantage.

In conclusion, algae facade has low transmittance due to algae inside the facade and can reduce loss to some extent with high adiabatic value instead of reducing solar radiation acquisition. If the algae system that will produce energy is applied to the facade, we can expect a highly efficient facade. In this paper, since only the adiabatic value of glass and SHGC value are taken into account in the aspect of energy performance analysis, it was possible to obtain fragmentation result values. Considering not only the performance of the glass but also the performance of the fittings, even more significant results will be obtained.

ACKNOWLEDGMENTS

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A Standardized Mechanism for Color Modulation of Building Skins Associated with Algae Facade Units

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ABSTRACT

At the moment interest in the global energy problem is rising. Also, many energy problems arise from buildings. These energies can solve the energy problem by applying the algae facade system in the building. Algae can generate environmentally friendly energy and apply the algae system and LED system to change the color of the building. The algae façade system changes energy saving and the building environment comfortably and can change the space of various atmospheres using LED lamps.

Index terms- Algae, Algae Façade, Building Colors, LED lamp, Photobioreactor System, Building Envelopes.

I. INTRODUCTION

Most of the current energy is dependent on fossil energy. Fossil energy has the disadvantage that regeneration is impossible and environmental contamination is caused, and the world faces energy problem due to depletion of fossil energy. The world is increasingly interested in environmentally friendly energy that can replace fossil energy. Buildings also have a lot of influence on energy problems. 40% of the global energy consumption and 35% of carbon dioxide emissions are occurring in buildings. Algae can give environmentally friendly energy while giving visual changes in buildings. Algae Facade is a system that requires continued light even at night. This part can be supplemented with LED lamp to achieve continuous growth irrespective of weather. It also gives various color changes to buildings using LEDs. Algae Facade is a system that can express not only the existing green but also various colors, and is environmentally friendly and can produce visual changes.

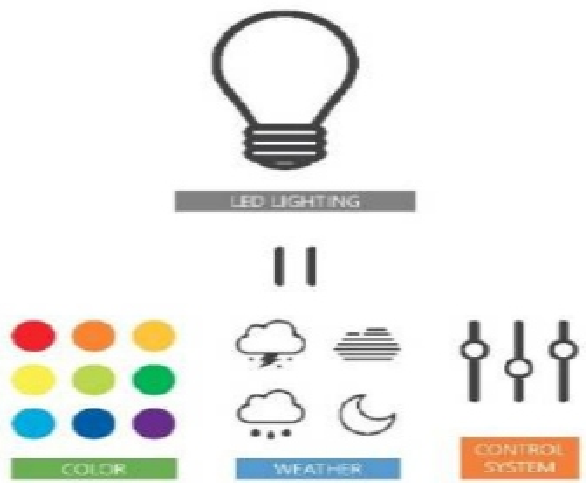

Figure 1: LED lighting system for making color effects

In this thesis I would like to talk about Algae Facade of building symbolism and various space changes through improvement of outdoor energy production and indoor environmental performance through environmentally friendly energy and color effect of building.

II. THEORETICAL SPECULATION

2.1. Algae as Promising Building Energy Resources-

Algae cells are filled with droplets of oil, and oil is a very abundant resource. Algae cell oil can be converted to biodiesel fuel, Algae is useful for improving the comfort of the room by consuming carbon dioxide (CO 2) in the culturing process and converting it to oxygen (O 2) is there. Seaweeds are classified as Macro algae and microalgae. Large birds are commonly known as seaweed. Microalgae are unicellular organisms, and like large birds, growth in seawater and freshwater environments has the advantage of rapid growth by vegetative cell division. Oil production of microalgae is more than 100 times that of soybeans. These microalgae can be cultivated selectively according to domestic climate, because the optimal culture conditions vary depending on the species. It is composed of fine cells which are invisible, in particular, and it is excellent in applying it to a building which is advantageous from a visual viewpoint. There are two main methods currently used. It is divided into an open pond system and a closed photo bio reactor system. It is majorly divided into an open pond system and a closed photo bio reactor system. Open pond system means an open culture, the cells of the algae in the tank in such a way as to depths of less than 30 meters to be passed well in the microalgae PV (Photovoltaics). [1] This system should be maintained at a certain temperature, and in Korea where the temperature difference is large, this system is difficult to apply. Closed photo bio reactor system is a method of cultivating using transparent figures, microalgae has an average 13 fold higher biomass productivity and 30 fold higher concentration than open pond. Closed photobioreactor systems of the Algae system are suitable systems for application to buildings.

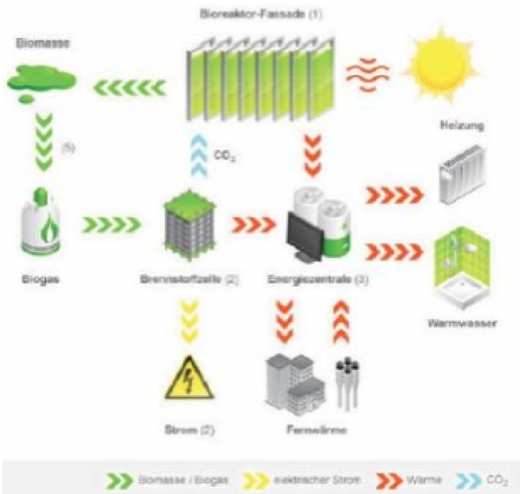

Figure 2: Energy Production by the Algae Facade (Source: Kim and Han, 2014)

2.2. Energy Production with Algae Facade System

The Algae Facade system is a factor that greatly affects the energy saving and comfort of buildings. It is expected to be able to play a role of changing people's health and sensibility by changing the environment such as indoor light, air and heat. The Algae Facade system applies Algae culture equipment in the form of aquarium to the front of the window. This will be able to play a role of prolonging the life of the building and reducing the cost by expanding the algae growth and the diversity of space utilizing sunlight and the aesthetic function of the building.

Figure 3: BIQ apartment complex in Hamburg (Source: Photo by IBA-Hamburg)

2.3. LED Lighting towards Building Colors

Applying LEDs to this system can change the color of the architecture. Color is a factor that determines the human senses and the environment. Color is a major factor that can give stimulus stronger than shape and material, and can determine the image of building. In urban environments, the colors of buildings change the mood and mood of the city indefinitely. The meaning of color is different depending on the situation and place, it can change in positive or negative meaning depending on the country and region, and it is difficult to make an accurate definition of color. However, color representation in architecture often uses colors of material properties. Looking at the color of Algae, it is roughly green with low saturation. When utilizing the color that Algae possesses, the saturation is low, giving a dark image to the building. Moreover, when Algae is applied to the whole building, it is low in one color and color saturation, it can change not only the building but also the surrounding environment into a dark and boring space. Such a problem will try to change the color of Algae with LED.

Figure 4: Universal color of algae façade system

Figure 5: problem-solving for color limitation of algae facade

The LED system can be grafted onto the transparent plate to produce the growth and color of the Algae. Algae will grow through the transparent plate, through natural light during the day, using LEDs at night. Since it is not affected by the environment, uniform growth of Algae may be sustained, and LEDs can be used to give visual changes in buildings with various color expressions. Since the LED can adjust the intensity of the light, there is an advantage that the LED can be controlled according to the time and surrounding environment.

2.4. Case Analysis

Currently, there are cases where Algae and LED are applied in various fields. First, there is a case where Algae and LED are used as one lighting. This also works as an interior accessory while improving the indoor environment to the environment-friendly through Algae. Algae is also used for food. The second is 'Latro Lamp' which uses Algae with a portable lamp. It is a lamp made with Algae, sunlight, carbon dioxide and water, and energy is generated through human breathing. The third is which applied Algae of the building. This is a method of applying a tank type bioreactor to the exterior of the building. 'Flower Street Bioreactor' applied Algae and LED to a transparent acrylic water tank.

Figure 6: 'Flower Street Bioreactor' (Source: Images from archello.com)

Applying LEDs with different colors and different bright ness, changed the color of the building. It is used to store the generated energy in the battery and to operate various systems at night. Besides this, there are various cases such as 'Car' using Algae, 'Algae Solar Panels', 'Algae Room', 'Garden'.

III. ALGAE FACADE ANALYSIS

3.1. Algae Facade towards Urban Moods

Algae Facade and LED lighting can be applied to form a glamorous and attractive building, but it is necessary to form a building that can be in harmony with the color of the city that the area has and the color of nature has been done. Currently, benchmarking examples of other countries and good areas often applies similar designs in outline form. Therefore, the cultural mood and characteristic landscape that the area had had disappeared and it changed uniformly. In order to maintain the individuality and cultural color of existing areas, it is necessary to think about respecting and maintaining the image of existing areas. Also, in order to make use of the image and personality that the area possesses, it is necessary to use a regional color. Even for the same object, the meaning and preference it has will change depending on the situation, so we need to extract the regional color matching the culture of the region and apply it to the Algae Facade system.

A city is not a space of a single color but a space that combines several colors. Therefore, there must be a plan concerning the hue of color arrangement. Due to the colors that the surroundings have, the colors of the buildings may be intense or soft. Even if a color of about 5% of the surface of the building enters, the impression given by the building changes so that the color can produce various atmospheres and spaces with a slight change. The color that Algae has is low- saturation green. The color that Algae has is low in color saturation and low in lightness. Green can give comfortable feeling with neutral color, but because it is low saturated color, it gives a dark image instead of a bright image, it can also give a heavy feeling due to the color of low lightness. It is also composed of a single color, giving the surrounding environment a boring feeling. These color problems can be solved with LED lamps and at the same time up to Algae growth by artificial light can be applied. Algae Facade is an environmentally friendly building that will be a system that can make use of regional color of the area.

Figure 7: Local identity with color extraction

3.2. Algae color change

Using Algae's green, you can apply various color changes. In order to give a color change, it is necessary to think what kind of color it is blended with and what proportion to represent. Algae is green and liquid, but color change appears variously depending on the concentration of Algae. Therefore, the amount of light transmitted may be different depending on the Algae concentration and the color being expressed may be different, Where the opacity of Algae is 20%, that is, the transparency is 80%, when LED illumination is illuminated, it can be confirmed how the color changes.

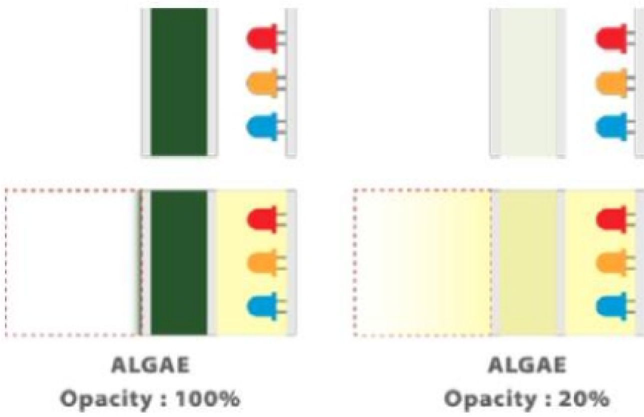

Figure 8: Algae color change

The stronger the LED lighting, the more vivid colors are expressed. However, there are colors and saturation that Algae possesses and you can see the phenomenon that saturation decreases due to the color of Algae even if it illuminates a high chroma LED. The color of Algae and the red color of complementary color are lower in color saturation than other colors, giving a sense of turbidity.

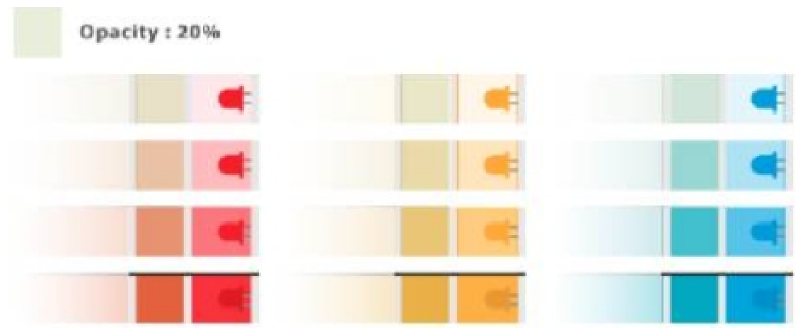

Figure 9: Change in color according to opacity of Algae (20%)

Next, the color change according to the concentration will act as an important factor. Changes in color of Algae will also occur in different ways if you can illuminate a high saturation LED to Algae with high opacity. It can be confirmed through the figure 10 how the color change occurs based on 20%, 40%, 60%, 80% opacity (concentration) of Algae.

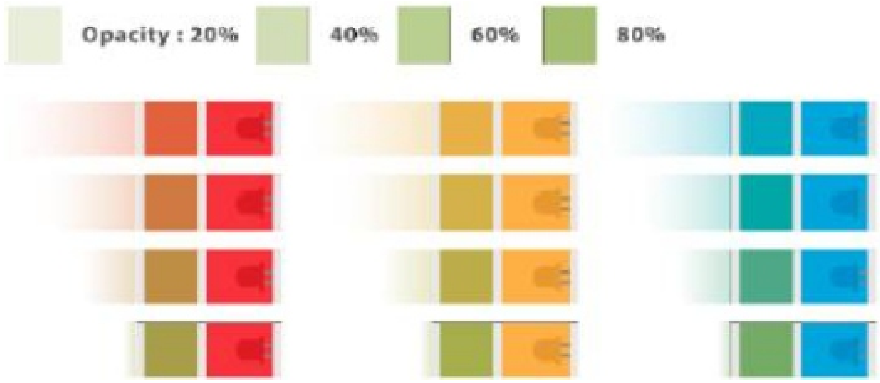

Figure 10: Change in color according to opacity of Algae (20%, 40%, 60%, 80%)

As the concentration of Algae becomes lower, color change is not performed. When the density becomes high, the same color is shown irrespective of the color of the LED, and the phenomenon occurs that the saturation decreases as the density gets higher. The most important factor for expressing colors using Algae and LEDs is the concentration of Algae. If the concentration of Algae is low, you can use LEDs to express various colors. However, when the Algae concentration gets higher, the color of the LED has no meaning. Also, because it is a task to raise another color to the green background and make another color, restriction of expression is set up. It is difficult to express vivid colors. In order to express vivid colors, the concentration of the culture device should be low.

3.3. Algae in culture apparatus

Algae can see the sedimentation and the phenomenon of the body being sedimented in the culture vessel. The concentration of the top and bottom parts of Algae cultured on the device is different.

In that case, colors expressing colors are not evenly represented by LEDs. Also, there is a high possibility that the color change does not occur in the part being precipitated. When the culture apparatus is large, the precipitate is also produced in large quantity, so it is difficult to make the concentration of Algae in the culture apparatus as a whole constant, so it is difficult to express the color. In order to represent Algae with a certain color, it is necessary to prevent deposits from precipitating in the culture apparatus.

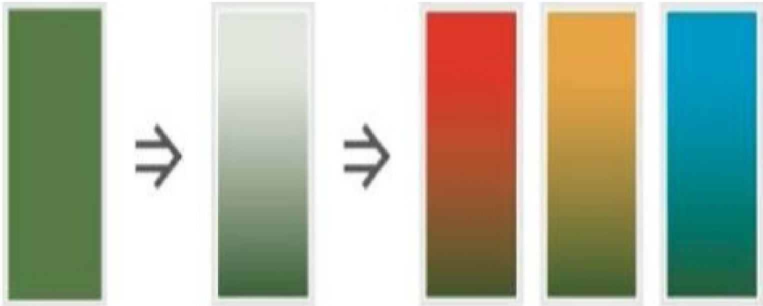

Figure 11: Changes in color due to sediment

3.4. Propose guidelines for the application of buildings- In order to apply Algae to buildings, a large amount of Algae must be cultivated. However, when culturing with a large plate on Facade it is difficult to manage Algae sediments and LEDs. Also, due to the LEDs and Algae in the device, sunlight will not be transmitted evenly indoors. Therefore, in order to apply Algae of a building, it must be designed taking such a point into account. In order to effectively apply Algae to buildings, several modules can be provided. First of all, there is a way to apply Algae to the bottom of the window so that the light can often enter the room through the top of the window. In such a method, when changing the color using Algae and LED at night, various emotional changes can be made not only outdoors but also indoors due to various color changes. Secondly, Algae is applied to the parts excluding the window. In this case, the person in the room will feel almost unaffected by Algae, You can feel the various ambiance of the building through the color change of Algae of the people outdoors.

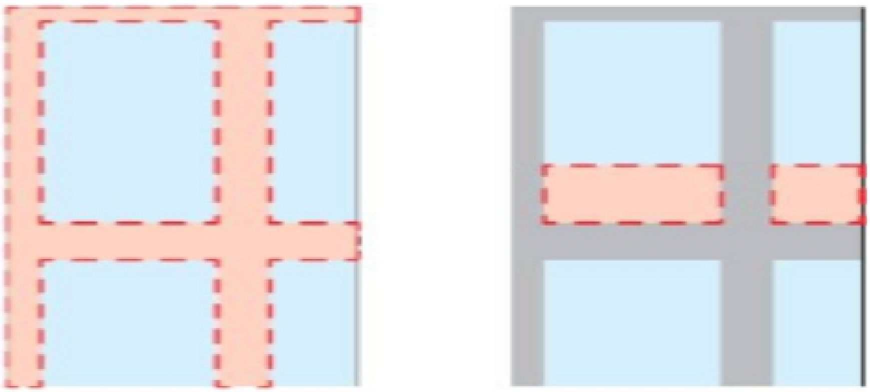

Figure 12: A module that applies Algae to buildings

CONCLUSION

In this paper, we apply environmentally friendly energy to the building field and try to present new application system to energy efficiency and building sheath. It is expected to be useful for improving human and nature's environment by ensuring energy performance and environmental comfort through Algae Facade system installed outside the building. At the same time as improving the environment, it is the greatest advantage that we can give a change in the esthetics of the building. Algae Facade and LED system try to direct various image changes of buildings, effect of infinite change of space. Depending on how Algae and LEDs are applied to what part of the building, various expressions can be made. Algae indoor and outdoor as a whole can be influenced by Algae color change and can be designed so that outdoor people can feel color change only. Various changes can be made via the Algae Facade system, which can give a change in the esthetics of the building and the sensitivity of the people.

In order to apply this system not only to new buildings but also to existing buildings, if research continues with ongoing research being conducted, various changes will be expected in saving energy and creating a building environment It seems to be able to do.

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