Paper's No. BUE-FISC2010 – 159

Sustainability of Residential Apartment Buildings with Green Frame

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ABSTRACT:

This paper introduces a Green Frame construction method that can replace the bearing wall system for longer service life of residential apartment buildings, which are now one of the representative residential types in Korea, and to analyze application of the Green Frame type to energy efficiency and CO_2 reduction. Energy consumption and CO_2 emission of a residential apartment building to be constructed and the average value of the residential apartment building using bearing wall type were calculated and analyzed respectively. As a result of this analysis, energy efficiency and CO_2 reduction of the Green Frame type were superior to those of the bearing wall type, which is expected to make residential apartment buildings with longer service life.

Conference Topic: The Earth/Desert/Green and Sustainable Buildings
Keywords: CO_2, Energy, Green Frame, Apartments, Sustainability

1. INTRODUCTION:

Residential apartment buildings that were constructed to address the population density issue at major cities in Korea are now one of the representative residential types in the country. Residential apartment buildings that are divided by complex were initially spread in 1960s and they were constructed in Rahmen structure. However, the bearing wall system that enables easy construction and lower construction costs was developed in the late 1980s and it has been the main structure type until now. However, this bearing type has the disadvantage that it is difficult to remodel and replace which lead to reduction of service life for residential housings. Currently, average sustainability of local housings in Korea is about 26 years. This is about 1/4 of that of the USA (103 years) and about 1/5 of that of the England (141 years). In addition, service life of residential apartment buildings is approximately 20.5 years, which is more than 10 years shorter than that of detached housings (32.1 years). Thus, it is imperative to introduce a residential system with longer service life and Rahmen structure in Korea. It has been determined that the essential elements to have for next generation residential apartment buildings are CO_2 reduction and energy-efficiency capabilities since they are high-interest environmental problems. Thus, this paper proposes the Green Frame

system to construct long-life residential apartment buildings and to analyze energy-efficiency and CO_2 reduction of the suggested system.

2. METHODOLOGY:

2.1 Green Frame:

Green Frame is a composite structure with steel and reinforced concrete. The Green Frame is partially manufactured using pre-cast concrete. Structural tee steel is encased in the end section with a large flexural moment and the deflection of the middle due to reduction of the moment of inertia is solved by applying pre-stressing to the bottom reinforcement.

In order to deal with the story height of the Rahmen structure, slabs are constructed on top of the edges of the U-shaped pre-cast concrete as shown on Figure 1, reaching the same story height as that of the bearing wall structure. Columns of Green Frame are SRC columns manufactured using pre-cast concrete. Columns are manufactured in up to 3 separate parts at the factory, so it is possible to shorten construction periods. Connection between the column and the composite beam is easy since a steel connection is used. Green Frame residential apartment buildings compose the plan with a long-span module of 8m×8m. When the 8×8 module is applied, columns are not installed inside the apartment. Therefore, architectural plan flexibility can be maximized. Figure 2 is a view on the residential apartment building applied with the 8×8 module.

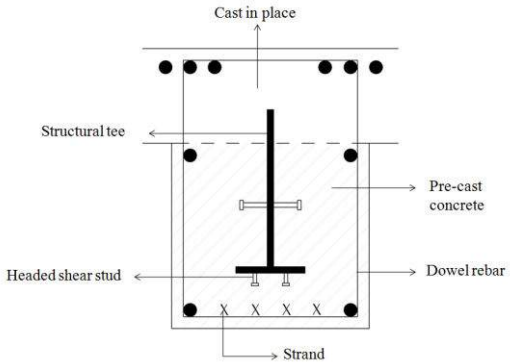

Fig.1 Section of Green Beam

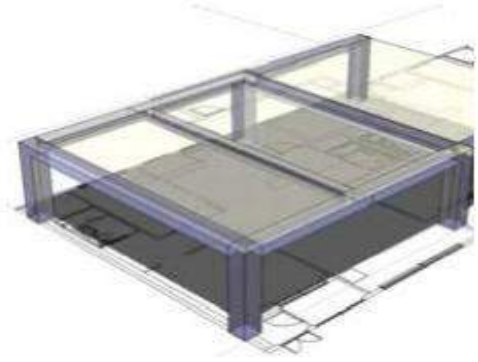

Fig.2 3D view of Green Frame system

2.2 Simulation method:

One residential apartment building to be constructed was selected as a model for analysis. A floor plan of the target multi-residential apartment buildings is given in Figure 3, and energy consumption and CO_2 emission were calculated after it was designed into a Green Frame structure. By comparing calculated energy consumption and CO_2 emission with the average value of bearing wall type, its energy efficiency and CO_2 reduction capability were analyzed. In case of the green frame structure, a partition wall was installed to form a space similar to that of the bearing wall type. Table 1 shows the major materials in the original unit used to calculate CO_2 emission and energy consumption. (Hong et al., 2010)

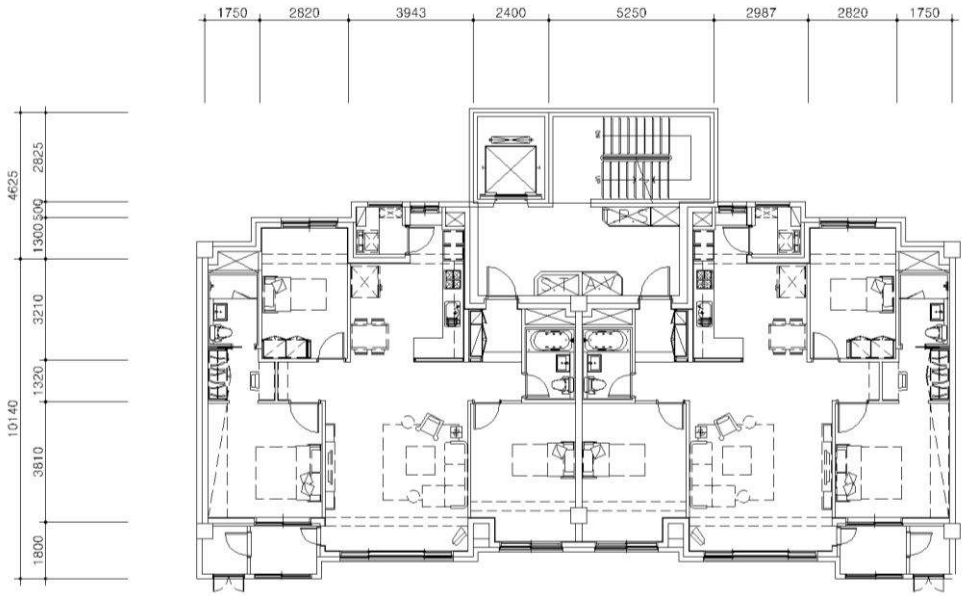

Fig.3 Floor plan of the Green Frame apartment

Table.1 Energy consumption and CO_2 emission per original unit from major construction materials (Hong et al., 2010)

Materials	CO_2 emission per original unit	Energy consumption per original unit
Concrete	140.43 kg-CO_2/㎥	2,406.393 MJ/㎥
Reinforcing bar	408.09 kg-CO_2/kN	3,522.222 MJ/kN
Structural steel	377.23 kg-CO_2/kN	4,065.782 MJ/kN
Gypsum board	33.75 kg-CO_2/㎡	1178.566 MJ/㎡
Form-work	3.83 kg-CO_2/㎡	240.672 MJ/㎡

3. Results:

As a result of analysis, CO_2 emission per unit area of Green Frame residential apartment building is 270.65ton-CO_2/m^2 whereas for bearing wall type residential apartment building is 335.30ton-CO_2/m^2, which is about 23.8% higher than that of the Green Frame residential apartment building. By comparing these results based on the amount of steel used, CO_2 emission per unit area was reduced to 161.35ton-CO_2/m^2, about 29.6%, for the Green Frame residential apartment building compared to the bearing wall type. Therefore, the main factor that reduced CO_2 emission is the reduction of reinforcement and steel amount. Figure 4 shows the comparison on CO_2 emission per unit area of the main materials.

Figure 5 represents the comparison on energy efficiency between bearing wall type and Green Frame residential apartment building. Energy consumption based on input materials was calculated as 4,078.17GJ/m^2 and 4,650.13GJ/m^2 for Green Frame and a bearing wall apartment respectively. Thus, it was analyzed that Green Frame showed energy efficiency of about 12.3%, superior to that of the bearing wall type. Considering the decrease in the amount of temporary materials by applying pre-cast concrete, it is expected that CO_2 reduction and energy efficiency will be far better in real construction.

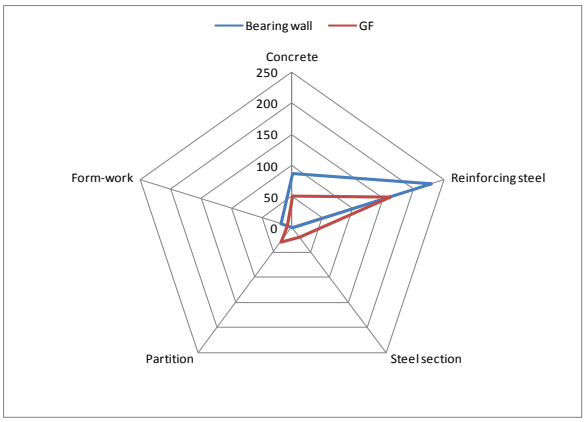

Fig.4 CO_2 emission per unit area for each structural type

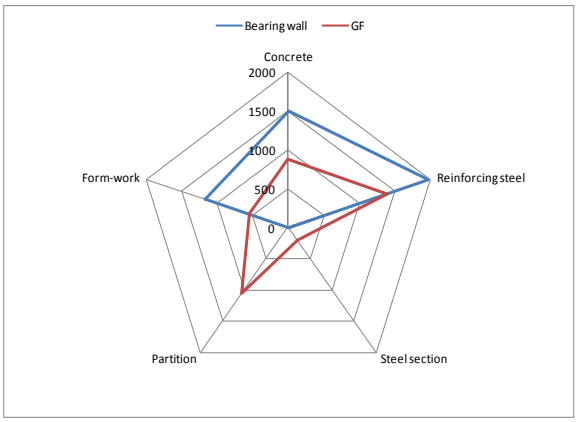

Fig.5 Energy consumption per unit area for each structural type

4. Conclusion

This paper analyzes energy efficiency and CO_2 reduction of the Green Frame residential apartment building and analysis results are the following. Compared with bearing wall , the Green Frame apartment reduced CO_2 emission to 80.7% and energy consumption to 87.7%. It is believed that the reduction will be far greater when temporary materials input during the real construction are considered. Thus, it is expected that the Green Frame system will contribute to make the next generation residential apartment building with longer service life and maintaining eco-friendly capabilities. Furthermore, when the Green Frame is applied to the residential apartment buildings, it will also result in reduction of construction schedule and less manpower.

Acknowledgment

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (No. 2010-0001860)

This work was supported by the Korea Science and Engineering Foundation (KOSEF) grant, funded by the Korea government (MEST) (No. 2010-0028262).

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