

A Proposal on Estimation Method of CO₂ Emission in Apartment Removal Project

Donghoon Lee¹, Sunkuk Kim²

¹ Donghoon Lee: Graduate Student, Dept. of Architectural Eng., Kyunghee Univ, Suwon, Korea, ttette00@hanmail.net

² Sunkuk Kim: Professor, Dept. of Architectural Eng., Kyunghee Univ, Suwon, Korea, kimskuk@khu.ac.kr

ABSTRACT: As global concerns about environmental pollution are on the rise, CO₂ emission control is also a hot issue. In the wake of Kyoto Protocol, many economies are enforcing initiatives to reduce CO₂ emission and CO₂ regulation will increase the CO₂ emission credit trading volume, as demands for emission credit multiplies. Accounting for 42% of total industrial CO₂ emission in Korea, CO₂ emission regulation will be sure to weigh heavily on construction businesses. As demands for apartment removal projects will soar on the heels of rapid increase in apartment construction projects in Korea, estimation of CO₂ emission in structure removal projects warrants attention in the broader framework of reducing CO₂ emission by construction industry. This research is intended to propose estimation method of CO₂ emission in structure removal project by analyzing CO₂ emission volume therefrom.

Keywords: Removal Project, Wastes, Recycling, CO₂, Apartment, CO₂ Emission Volume

1. INTRODUCTION

1.1 BACKGROUND & PURPOSE

After an official warning against global warming in the 1972 report of Roma Club, the World Meteorological Organization and the UN Environmental Program announced officially that CO₂ emission was the principal cause of global warming in 1985 and an inter-government panel on climate change was born in 1988 to study climate change and propose counter strategies. In addition, UNDP pointed out in 2007 that the world would have to cut CO₂ emission 50% from the level of 1990 by 2050 to contain environmental disasters following climate change. Accordingly, the Rio Environmental Summit in 1992 and the Kyoto Protocol in

1997 established an international regulatory architecture to reduce CO₂ emission.

Korea ranks the world's 9th as of 2001 in terms of CO₂ emission volume and the per capital CO₂ emission volume is rising the fastest in the world together with China, which is likely to call for stronger international pressure to enforce applicable regulatory regime. In response, the Korean government established a variety of policy measures and initiatives in the fields of energy, transportation, agriculture, forestry and waste disposal and is requiring businesses in each industrial sector to build an environment-friendly production system (Kim, Ji-Hye & 2 others, 2007).

In Korea, 42% of total industrial CO₂ emission comes from building construction,

production and removal phases (Chosun Daily, 2007), Assuming the average service life of apartment to be 25 years on the basis of the average reconstruction limit (22.4 years), structure removal projects will increase 25% rapidly to 2015 and 21% to 2025 on annual average (Kim, Chang-Hak 2007).

This research is intended to propose estimation method of CO₂ emission in structure removal project by analyzing CO₂ emission volume therefrom on the basis of reduction of wastes volume from structure removal projects.

1.2 SCOPE & METHOD

This research limits its subject to apartment buildings in Korea on the grounds that apartment housing accounts for the biggest portion or 37.7% of the aggregate permitted building area and is one of the most energy-intensive structure across the entire life cycle including maintenance phase. A CO₂ emission reduction platform relying on recycling of wastes from apartment housing will be applicable to removal projects of not only commercial buildings but also civil structures as well (See Fig. 1).

This research is conducted in the following sequences.

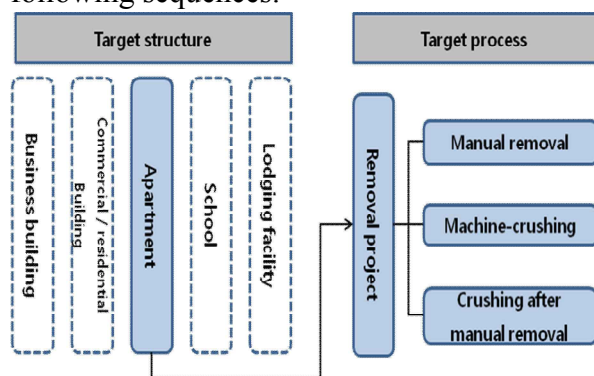


Fig1. Research Scope

First, structure removal technologies and wastes are studied by examining reference literatures. And methods to estimate total wastes volume are studied. In addition, structure removal technologies used in Korea are examined and classified and the

effects of waste recycling on CO₂ emission is analyzed.

The research sequences and methods above are as in the flow chart of <Fig. 2>.

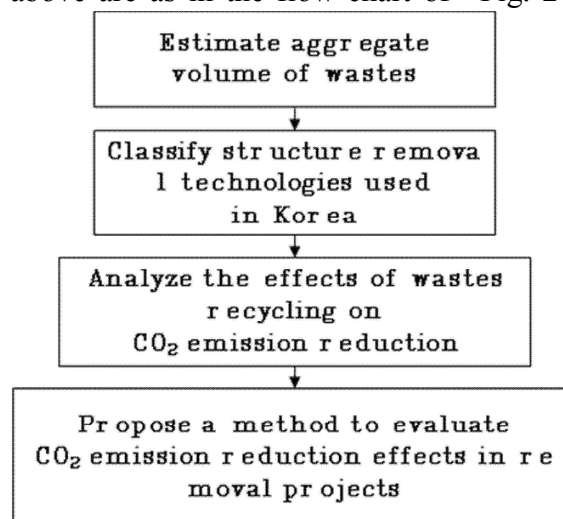


Fig2. Research Scope

2. RELEVANT RESEARCH TRENDS

Most studies by Korean researchers dealt with construction wastes issues and mitigation strategies and some researches suggested methods to estimate and quantify CO₂ emission volume (Kim, Jong-Yeop, 2004; Jeong, Young-Sun, 2007) or minimize environmental pollution during construction phase (Park, Ji-Ho & 2 others, 2007) in relation to CO₂ emission reduction.

In other countries, many researchers focused on estimation of CO₂ reduction costs (Tiwari & Parikh, 1995), CO₂ emission reduction evaluation cases during construction projects (Gonzalez & Navarro, 2006) and analysis of energy consumption and carbon emission of building in production phase (Nassen et al., 2007), etc.

3. ANALYSIS OF WASTES FROM STRUCTURE REMOVAL

3.1 AGGREGATE WASTES VOLUME

To estimate CO₂ emission from wastes of structure removal project, it is necessary to understand the volume of construction

materials consisting of apartment building, as the total volume of wastes from apartment is the same as the aggregate volume of constituent materials. Without extraordinary overhaul or addition, aggregate volume of materials used in apartment construction is deemed to be the same as the total volume of wastes. Of course, materials may exist in different forms, as they are mixed, cut, crushed or exploded in removal process. However, as the aggregate volume of constituent substances remains the same, it is fair to assume that the aggregate volume of materials used in apartment construction is no different from the same as the total volume of wastes.

However, some apartments may be too old and the bill of construction materials may be already gone. In such case, volume of removal wastes can be estimated by generating WBS with WBS Generator and, if CDA drawing is still available, importing the WBS with Viewer function of existing CAD drawing and giving elevation to create 3D CAD drawing or, if CAD drawing is missing, utilizing 3D CAD objects. Even in the absence of CAD drawing, objects consisting of building can be leveraged in estimating the volume of constituent material. (Kim, Chang-Hak, Kim, Hyo-Jin 2007).

3.2 ESTIMATION OF CO₂ EMISSION FROM WASTES

Many wastes including steel, aluminium, other metals, concrete, wood, paper and plastic from structure removal are recyclable. However, much of them are simply buried or incinerated. To estimate CO₂ emission from structure removal, it is necessary to divide aggregate wastes volume into removal wastes and recyclable materials. Removal wastes are again divided into reclamation and incineration wastes and CO₂ emission from reclamation and incineration can be estimated. Recyclable materials may emit CO₂ while being recycled. However, such emission is not

considered on the assumption that it is similar to CO₂ emission from processing or production of ordinary material rather than recycled material. As materials classified as recyclable ones are excluded from reclamation or incineration, CO₂ emission from them being disposed of as wastes in such forms as reclamation or incineration is reduced and corresponding CO₂ volume can be included in reduced amount (See Fig. 3).

3.2 UNIT OF CO₂ EMISSION ESTIMATION

CO₂ emission from wastes can be expressed in terms of weight as described in Equation (1).

$$\text{CO}_2 \text{ Emission (Ton)} = \text{Waste weight} \times \text{CO}_2 \text{ Emission rate} \dots(1)$$

Namely, CO₂ emission equals to classified waste weight multiplied by CO₂ emission rate applicable to such waste. If waste is described in terms of area, volume or length, waste volume must be estimated in reference to product specification. For example, stone quantity is often described in area and it can be converted to volume in reference to thickness in product specification. Converted waste volume is again converted to weight in reference to density of applicable waste type and CO₂ emission weight can be estimated therefrom.

4. REMOVAL & RECYCLING

4.1 STRUCTURE REMOVAL PROJECTS IN KOREA

In structure removal projects in Korea, wastes inside structure are removed manually and structure itself is crushed or removed by heavy duty breaker. As for interior removal, removed wastes mostly consist of wood, plastic and non-ferrous metals. Unless specifically required, structures are usually removed by hydraulic crusher that is highly efficient, low on noise and vibration (Kim, Hyo-Jin 2007).

4.2 CLASSIFICATION OF REMOVAL TECHNOLOGIES

Most finishing materials are removed usually manually in Korea and, if finishing material and structural material are removed simultaneously, crushing, cutting, explosion or flame jet firing is used (See Fig. 3).

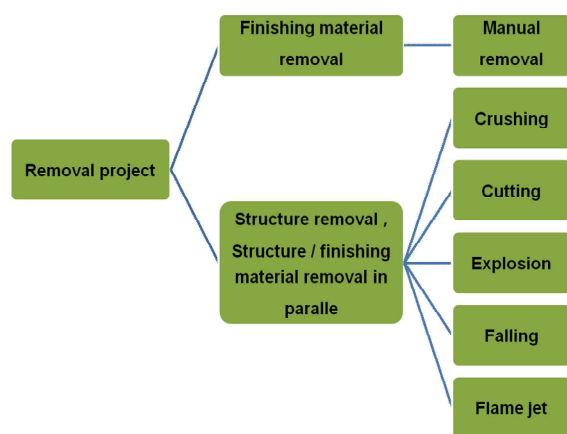


Fig3. Classification of Removal Technologies

Manual removal or advance screening is effective in reusing or recycling finishing material, but, not efficient, as it requires considerable amount of time and efforts. In addition, steel or other metals can be recycled in part via cutting or crushing and waste concrete can be used as aggregates.

However, recycling ratio is bound to be lower than manual removal. As recycling ratio or efficiency of removal technology can vary, subject to application scope or sequence, sufficient consideration needs to be incorporated in removal project plan and cost-effectiveness in terms of CO₂ emission reduction must be considered as well.

5. EMISSION OF CO₂ EMISSION

As noted in the above, recycling ratio varies, subject to removal technology and CO₂ emission amount from removal project is subject to variation of recycling ratio. Therefore, CO₂ emission amount can be estimated in reference to selected removal technology, recycling ratio and method. In other words, CO₂ emission amount can be determined in advance during removal

project planning in reference to recycling ratio.

If CO₂ emission reduction volume per recyclable material type is I₁(steel), I₂(non-ferrous metal), I₃(wood),... I_n, CO₂ emission reduction volume I_n of each type is:

$$I_1 = F_1(x_1) = a_1 c_1 x_1 + b_1 (x_1 - c_1 x_1)$$

$$\text{Total} = \sum I_n \dots (2)$$

Where, a₁=CO₂ emission rate from incineration

b₁=CO₂ emission rate from reclamation

x₁=Amount of recyclable material

c₁=Material incineration ratio

In estimating CO₂ emission from removal project, aggregate CO₂ emission reduction amount is the sum of reduction amounts of all recyclable materials (I₁, I₂ ..., I_n).

When planning removal project, structure integrity, efficiency and applicability of removal technology needs to be determined in reference to member cross section thickness as well as space available on site, noise, vibration and neighbor complaints, etc. (Lee, Han-Min 2008). In addition, environmental impacts of CO₂ emission must be reduced and resource waste minimized via CO₂ emission estimation method based on recycling amount analysis.

6. CONCLUSION

This research has recognized the following environmental limitations in selection of removal technology.

Firstly, there is no method to estimate waste volume in removal project. Secondly, criteria for CO₂ emission estimation is limited to several items such as noise or dust. To address such issues, bill of quantity or quantity estimation SW application is used and CO₂ emission estimation method using recycling ratio as indicator of CO₂ emission estimation is proposed.

As pressure from international community for reduction of CO₂ emission which is the major cause of global warming

is mounting, it is pressing for construction industry of Korea to develop countermeasures to reduce CO₂ emission. CO₂ emission estimation is an inevitable preceding step to reduce CO₂ emission and worth consistent research & development. CO₂ emission estimation method herein is expected to address impacts on environment during removal projects and, as a subsequent research initiative, database containing CO₂ emission data from waste needs to be established and removal technology selection system studied with considerations for environment by analyzing available removal technologies.

REFERENCES

- [1]. Kim, Jong-Yeop & 2 others (2004). Estimation of Energy Consumption & CO₂ Emission Unit in Building Construction Phase, Collection of Architectural Institute of Korea Papers (Planning Dept.), Vol.20, Ed.10, pp.319 ~ 326
- [2]. Kim, Jong-Yeop & 2 others (2005). Assessment of Energy Consumption & CO₂ Emission Features in New Apartment Construction, Collection of Architectural Institute of Korea Papers (Planning Dept.), Vol.21, Ed.4, pp.199 ~ 206
- [3]. Kim, Ji-Hye & 2 others (2007). CO₂ Criteria for Construction Waste Management Strategy Considering Emission Features : Case Study of High-Rise Residential Building Construction Project, Collection of Korea Construction Management Society Papers, Vol.8, Ed.6, pp.150 ~ 158
- [4]. Kim, Chang-Hak, Kim, Hyo-Jin (2007). Development of Automatic Construction Waste Volume Estimation System , Collection of Korea Construction Management Society Symposium Papers, pp.743 ~ 746
- [5]. Kim, Hyo-Jin & 3 others (2007). Removal Project Implementation Status & Selective Apartment Removal Test, Collection of Papers for Korea Architectural Construction Society Academic/Technological Symposium, v.7 n.1 Ed.12, pp.113 ~ 118
- [6]. Park, Ji-Ho & 2 others (2007). Strategy to Ensure Environment-Friendliness in Construction Management per Construction Work Type, Collection of 한국 건축 관리 학회 Symposium Papers, pp.961 ~ 966
- [7]. Lee, Han-Min & 1 other (2008). A Study of System Development for Selection of Optimum Removal Technology , Collection of Architectural Institute of Korea Papers (Structure Dept.), v.24 n.5, pp.193 ~ 200
- [8]. Jeong, Young-Sun & 4 others (2007). A Study of Greenhouse Gas Emission Estimation in New Apartment Construction Targeting Key Materials, Collection of Architectural Institute of Korea Symposium Papers, Vol.27, Ed.1, pp.797 ~ 800
- [9]. Chosun Daily (2007). Building is a CO₂ repository, Weekly Chosun Online Article, July 30, 2007 (weekly.chosun.com)
- [10]. Piyush Tiwari, Jyoti Parikh (1995). Cost of CO₂ Reduction in Building Construction, Energy, vol.20, No.6, pp.531 ~ 547
- [11]. María Jesús González (2006). Justo Gracia Navarro, Assesment of the decrease of CO₂ emissions in the construction field through the selection of materials: Practical case study of three houses of low environmental impact, Building and Environment, vol.41, pp.902 ~ 909
- [12]. Jonas Nässén et al (2007). Direct and Indirect Energy Use and Carbon Emissions in the Production Phase of Buildings: An Input-output analysis, Energy, vol.32, pp.1593 ~ 1602