Advanced Science and Technology Letters
Vol.32 (Architecture and Civil Engineering 2013), pp.31-34
http://dx.doi.org/10.14257/astl.2013.32.07

Development of a Carbon Emission Evaluation Index for Apartment Buildings

Doo-Sung Choi[1] , Hung-Chan Chun[2] , Kyun-Hyong Cho[2] , Yong-Shik Kim[3] , Yong-Ho Jung[1]

[1] Department of Building Equipment & Fire Protection System, Chungwoon Univ., Incheon, Korea [2] Department of Architectural Engineering, Suwon Univ., Hwaseong, Korea [3]Division of Architecture and Urban Planning, Incheon National Univ., Incheon, Korea trebelle@chungwoon.ac.kr, chun4575@nate.com, khcho@suwon.ac.kr, newkim@incheon.ac.kr, coil@chungwoon.ac.kr

Abstract. In this study, numerous apartments in South Korea were analyzed in order to develop an evaluation index to evaluate carbon emission quantities from apartments. Our results show the following carbon emission quantity indexes per evaluation area (average emission rates): 992kg-CO_2/㎡·yr for energy consumption, 507kg-CO_2/㎡·yr for material consumption, 41kg-CO_2/㎡·yr for waste generation, and 70kg-CO_2/㎡·yr for water resource consumption.

Keywords: Apartment Building, $LCCO_2$, CO_2 Emission, Evaluation Index, Life Cycle Assessment

1 Introduction

The present study aims to suggest a method to quantitatively evaluate and manage the carbon emission quantity in all stages throughout the life cycle of a structure, from production and construction to maintenance and destruction. Therefore, this study determines the major evaluation categories related to carbon emission quantity throughout the life cycle of a structure, and establishes evaluation indexes to determine evaluation criteria (emission rates) for carbon emission quantity per category.

2 Analysis Outline

2.1 Range of Analysis

This study computes Life Cycle CO_2 ($LCCO_2$) through a case analysis of a representative housing structure in Korea, which is an apartment, using life cycle assessment (LCA) methods [1] defined in the ISO 14000 series. The life cycle of a structure is classified into four stages: production, construction, use phase, and dismantling and destruction. Life cycle inputs for carbon emission quantity analysis are energy and water resources, while the output is the carbon emitted by the input [2]. Use phase and sources of all data applied in the analysis was limited to South Korea. Thirty years was taken to be the duration of the use phase stage as this is the legal apartment reconstruction term in South Korea. Data from 274 apartments in 26

ISSN: 2287-1233 ASTL

apartment buildings constructed between 2008 and 2009 were used for the case analysis.

2.2 Analysis method

After determining the carbon emission quantity evaluation categories (item) from the international standards suggested by the Common Carbon Metric (2011) of UNEP (United Nations Environment Programme) [3] for the evaluation of carbon emission quantity per stage of the life cycle of an item, the evaluation index per item of each category (potential carbon emission quantity rates) was computed. Table 1 shows the selected carbon emission quantity evaluation categories (item) with the sources of the reference data (method).

Table 1. Carbon emission quantity evaluation categories (Item)

Evaluation category	Evaluation item	Life cycle phase	Analysis method and source
Energy consumption	Heating energy carbon emission quantity	Use phase	The Construction Standard on Low-Energy Green House and Performance (MOLIT)[4]
	Hot water supply carbon emission quantity	Use phase	
	Electric energy carbon emission quantity	Use phase	
	Construction machinery and site carbon emission quantity	Construction phase	The Guideline calculation of CO_2 emissions from facilities (MOLIT)[5]
Carbon offset by new/renewable energy		Use phase	The Construction Standard on Low-Energy Green House and Performance (MOLIT)
Material consumption	Carbon emission quantity of input material	Material production phase	Input-Output Tables (BOK)[6]
	Carbon emission quantity of input material when substituting/repairing	Use phase	
	Carbon offset by tree planting	Material Production phase	Annual CO_2 Uptake by Trees (KFS) [7]
Waste production	Construction stage waste carbon emission quantity	Construction phase	National Air Pollutant Emission Calculation Method Manual II (NIER)[8]
	Dismantling stage waste carbon emission quantity	Dismantling and destruction	2011 Generation and Treatment of Waste in Korea (ME)[9]
Water resource consumption	Water consumption carbon emission quantity	Use phase	Guideline calculation of CO_2 emissions from facilities (MOLIT)

3 Analysis Results

3. 1 Carbon emission quantity during the life cycle

Figure 1 shows the results of analyzing carbon emission rates according to the direct/indirect energy input per stage of the life cycle of the apartment buildings (274 apartments) targeted in this study for the development of the carbon emission rates evaluation index.

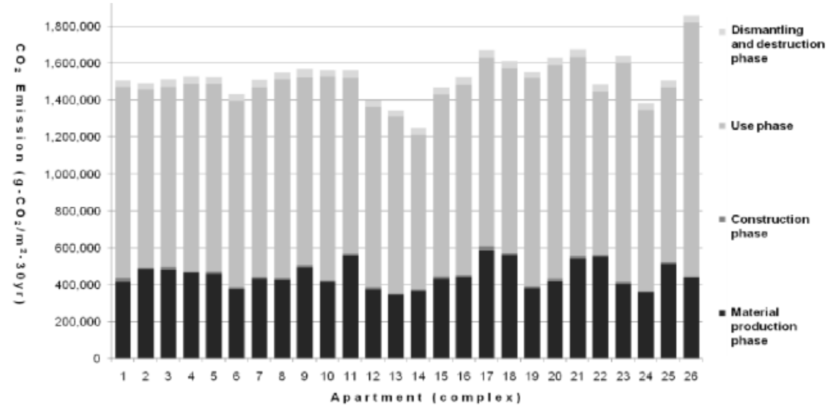

Fig. 1. $LCCO_2$ analysis result (/㎡ ·30yr)

As shown in Figure 1, the total life cycle carbon emission rate per unit area (/㎡

- 30yr) was 1,610kg-CO_2, with the use phase contributing the highest at 1,109 kg-CO_2 (68.9%), followed by material construction at 449kg-CO_2 (27.9%), dismantling and destruction at 40kg-CO_2 (2.5%), and the construction stage at 10kg-CO_2 (0.7%)

3. 2 Carbon emission index per evaluation category

Table 2 lists the analysis results of the carbon emission evaluation index (emission rate) per evaluation category and item suggested by the aforementioned Table 1 and the results of the life cycle carbon emission rates analyzed in Figure 2.

Table 2. Analysis results of the carbon emission evaluation index

Evaluation category (Contribution%)	Evaluation item	CO_2 Emission quantity (kg-CO_2/㎡·30yr)		
		Max	Mean	Min
Energy consumption (61.6%)	Heating energy carbon emission quantity	834	660	595
	Hot water supply energy carbon emission quantity	411	267	183
	Electric energy carbon emission quantity	72	54	40
	Construction machinery and site carbon emission quantity	20	11	6
	Carbon offset by new and renewable energy*	(-)	(-)	(-)
Material consumption (31.5%)	Carbon emission quantity when inputting material for new construction	586	449	343
	Carbon emission quantity when replacing or repairing	53	58	43
	Carbon offset by tree planting*	(-50)	(-40)	(-26)
Waste production (2.5%)	Construction phase waste carbon emission quantity	2	2	1
	Dismantling phase waste carbon emission quantity	47	39	35
Water resource	Water consumption carbon emission quantity	105	70	30

consumption (4.3%)		
	Total	2,130 1,610 1,276

* The carbon offset by new renewable energy and tree planting were excluded from the total

As shown in Table 2, the average carbon emission quantity per unit area (/㎡·yr) is ranked in the following order: energy consumption at 992kg-CO_2 (61.6%), material consumption at 507kg-CO_2 (31.5%), water resource consumption at 70kg-CO_2 (4.3%), and waste production at 41kg-CO_2 (2.5%). The maximum and minimum emission rates were 2,130kg-CO_2 and 1,276kg-CO_2, respectively.

4 Conclusion

In this study, a life cycle carbon emission quantity evaluation index for apartment buildings was developed to quantitatively evaluate and manage carbon emission quantities from structures. Our results show that the life cycle carbon emission quantity per unit area of apartment buildings is (/㎡·yr) approximately 1,610kg-CO_2, with the use phase contributing the most at 1,109kg-CO_2 (68.9%), followed by the dismantling and destruction phase with 40kg-CO_2 (2.5%), and the construction phase with 10kg-CO_2 (0.7%). In addition, the evaluation index used to suggest the objective criteria (emission rates) for the carbon emission quantity analysis results was classified into 4 categories in order to suggest an average carbon emission quantity level per category (item) per unit area. Analysis of the carbon emission rates per category gave the following results: 992kg-CO_2 for energy consumption, 507kg-CO_2 for material consumption, 41kg-CO_2 for waste production, and 70kg-CO_2 for water resource consumption.

Acknowledgements. This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Korean Government (MOE) (Grant Number : 2011-0017656)

References

1. ISO : ISO14040 Environmental management - Life Cycle Assessment – principles and frame (2006)
2. IPCC : Global Warming Potential (2006)
3. UNEP : Common Carbon Metric – for Measuring Energy Use & Reporting Greenhouse Gas Emissions from Building Operations (2011)
4. Ministry of Land, Infrastructure, and Transport : The Construction Standard on Low-Energy Green House and Performance (2012)
5. Ministry of Land, Infrastructure, and Transport, Guideline calculation of CO_2 emissions from facilities (2011)
6. The Bank of Korea : 2008 Input-Output Tables (2009)
7. Korea Forest Service : Annual CO_2 Uptake by Trees (2013)
8. National Institute of Environmental Research : National Air Pollutant Emission Calculation Method Manual II (2010)
9. Ministry of Environment, 2011 Generation and Treatment of Waste in Korea (2012)

