Studying CO_2 Balance through the Life Cycle of Infrastructure

INOUE Ryuji, Head
NAGAHAMA Yosuke, Researcher
KANDA Mayumi, Researcher
Road Environment Division, Road Traffic Department

(Key words) Infrastructure LCA, CO_2 emissions by road work, Carbonation of concrete

1. Introduction

The NILIM has developed a calculation method and carbon dioxide (CO_2) emission basic unit to be applied at each decision-making stage including design, construction, and materials selection to calculate the quantity of CO_2 emitted from the materials manufacturing stage through transport and construction on site, as a technology to appropriately evaluate CO_2 emission reduction technologies in the provision of public capital. [1)]

This report introduces the state of research on quantity of CO_2 emitted at the planning stage (before the design stage) and quantity of CO_2 fixed by use and recycling (after the construction stage on site), which is a remaining challenge facing infrastructure LCA.

2. Study of CO_2 emissions at the planning stage

It is assumed that at the planning stage, there are no quantitative data for each category of work beginning at the design stage, so it is necessary to compute CO_2 emissions based on length for each type of road structure (earthwork, bridges, tunnels) work. So we obtained design documents for road projects on government managed roads (total of 172 works) and based on quantitative data for each work category, aggregated the quantity of CO_2 emitted by each category of work using the infrastructure LCA method, to calculate the quantity of CO_2 emitted by type of road structure per 1km of each traffic lane. The results revealed great scattering between earthwork, bridges, and tunnels as shown in Table 1. The study analyzed the relationship of filling and cutting (earthwork) and width (bridges or tunnels) with CO_2 emissions, but wide scattering remained, and it was not possible to directly discover a correlation that would permit its adoption as the CO_2 emission basic unit.

The planning stage is divided into the concept stage (general route and structures etc. study stage) and the detailed planning stage (specific route and structure etc. in a city plan etc. study stage) of an actual road project. In the future, we will study the CO_2 emission calculation method in order to be able to use it as an evaluation item for each decision based on data obtainable at each stage.

Table 1 Results of Calculation of Quantity of CO_2 Emissions by Road Work

	Emission basic unit of CO_2 per vehicle-km [t-CO_2/km/vehicle lane]						
	Average value					Max.	Min.
	Material	Transport	Moving construction machines	Wear on construction machines	Totals		
Earthwork (106 works)	491	69	113	47	697	3,394	100
Tunnels (23 works)	4,850	174	302	179	5,390	6,642	4,098
Briges (43 works)	12,085	360	382	288	13,116	45,547	5,320

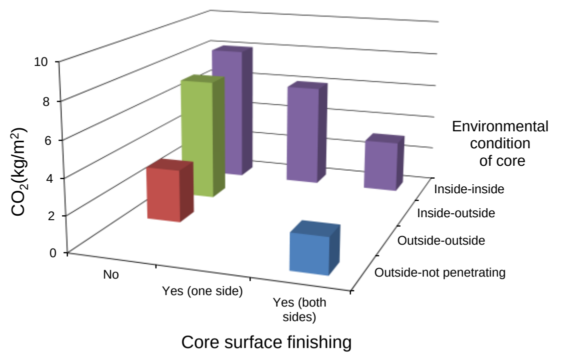
3. Fixing CO_2 in concrete through use and recycling

Decarboxylation during cement manufacture emits CO_2, but part of this is recovered by use and recycling of structures through so-called carbonation of concrete. We consider the carbonation of concrete to be a CO_2 absorption action, and believe it is appropriate to incorporate its effects in evaluations of CO_2 emissions during use and recycling of concrete structures. (But, carbonation of a reinforced concrete structure is a major deterioration mechanism, so it is necessary to be careful to definitely not recommend this process).

Little is known about using the carbonation of concrete as a CO_2 absorption action, and the quantity of CO_2 fixed is unknown.

So assuming that it is important to first clarify approximate impacts of CO_2 fixing, the quantity of CO_2 fixed in a concrete core taken from an actual structure and

Figure 1 Quantity of CO_2 fixed by wall members estimated from concrete cores taken from wall surfaces of concrete structures between 26 and 50 years old
(Approximately 5kgCO_2/m^2 of CO_2 fixed by wall member materials.)



The following is a categorization of conditions
■ Finished
- No: Both surfaces of the core are planed or lightly finished with cloth or by spraying
- One side: One side is heavily finished with mortar tile etc. and one side is lightly finished
- Both sides: Both surfaces of the core are heavily finished (non-penetrated surface categorized as heavy finishing)

■ Environmental conditions
- Inside: indoors, Outside: outdoors

in a concrete specimen prepared simulating recycling was measured, (Fig. 1, Table 2).

In the future, we will study life cycle CO_2 balance considering the CO_2 emissions from the construction to the recycling stage of a structure.

Table 2 Quantity of CO_2 fixed per 1 ton of concrete estimated based on a concrete sample prepared to simulate recycling
(The more cement and smaller its particle diameter, the larger the quantities of CO_2 fixed by each recycled product)

Product	Fixed quantity (kg CO/ton)
Recycled aggregate H (mechanical method)	30.0
Recycled aggregate H (thermal method)	24.7
Recycled aggregate M	26.1
Recycled aggregate L	15.2
RC40	10.0

※ Case where the samples were exposed to the atmosphere for 28 days under alternate dry-wet conditions
※ CO_2 was not measured in tiny particles of recycled aggregate M and L, so tiny particles of recycled aggregate H (mechanical method) were substituted during production.

[Sources]
1) NILIM Project Research Report 36, Development of Life Cycle Assessment Methodology on Sustainability of Infrastructures
http://www.nilim.go.jp/lab/bcg/siryou/kpr/prn0036.htm