B-14.2.4 Evaluation of Countermeasures against Global Warming in the Public Works Field

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Abstract

The first steps of this study were a survey of the relationship of the quantity of CO_2 emitted with the average rise in the global temperature and a survey of the cost of damage caused by global warming, followed by a study of the critical social costs of CO_2 emissions based on the results of the first two surveys accompanied by a study using the inter-industry relations table to find the quantity of CO_2 emitted for each product item used as building construction material. The next step was the use of the results of this research to perform comparisons of the quantity of CO_2 emitted using conventional construction methods with the quantity emitted using low CO_2 emitting construction methods for a number of structures including bridges and dams throughout the life cycle of these structures. This was followed by studies of differing structures with similar functions: comparisons of both the CO_2 emitted as they are constructed and that emitted as they are used. Based on the results, a macroscopic study was performed to determine to what extent it would be possible to reduce the total CO_2 emitted by all future construction projects. The results reveal that simply comparing costs including the calculated social costs accompanying the emission of CO_2, does not offer any incentive to reduce CO_2 emissions, and that from a macroscopic perspective, it will be necessary to introduce measures to provide additional incentives if emissions of CO_2 are to be reduced in the future.

Key words: construction , social costs, CO_2 emissions, inter industry transactions

1. Introduction

Global warming caused by greenhouse effect gasses is expected to raise the level of the oceans and transform the world's climate, which will in turn, cause changes in moisture cycles and vegetation. CO_2, which is one of these gasses, is emitted in large quantities and plays a big role in global warming. Reducing the quantity of CO_2 emitted by construction projects in order to help prevent global warming is considered a public duty of the construction industry. So to make this contribution to society, we must calculate the social costs of various materials used for building construction projects accounting for their impact on the global environment and investigate the extent to which CO_2 emissions caused by construction projects would be reduced by selecting construction methods, materials, and the like accounting for their social costs.

2. Goals of the Research

Any study of the effects of global warming on global environmental problems must establish standards for the evaluation of construction projects which maximize profits while minimizing global scale social costs. So this research project calculated the social costs of various materials and construction methods used as part of construction projects accounting for their effects on the global environment at the same time as it assessed the feasibility of the introduction of these construction methods and materials and the extent to which their introduction would contribute to a reduction in the quantity of emissions of CO_2.

3. Research Method

In order to achieve the goals of the research project, a survey of the relationship of the quantity of CO_2 emitted with the average rise in the global temperature and a survey of the cost of damage caused by global warming were carried out. The next step was a study of the critical social costs of CO_2 emissions based on the results of the first two surveys accompanied by a study to find the quantity of CO_2 emitted for each product item used as building construction material.

This was followed by a trial calculation of the quantity of CO_2 emitted and its social costs, as assessed throughout the life cycle--the construction stage to the final demolition stage--of [1] a structure (+ construction methods) incorporating measures to restrict CO_2 emissions and [2] a low CO_2 structure constructed as a substitute for another type of structure.

The final phase of the project was a study of the extent to which it would be possible to reduce total CO_2 emissions of all future construction projects accounting for changes in the quantity of construction projects performed and the feasibility of introducing low CO_2 emitting construction methods.

The findings of this research project reveal the extent to which CO_2 emissions by construction projects throughout Japan would be reduced and permit the clear indication of its social costs.

4. Results of the Research

4.1 Quantity of CO_2 Emissions - Average Rise in the Global Temperature Relationship

4.1.1 The Survey

Two mechanisms have been proposed to represent the relationship of the quantity of CO_2 emissions with the average rise in the global temperature. One approach divides the temperature increase by CO_2 emissions process into 2 steps (Nordhaus, 1991 a) [10] while another divides this process into 3 steps (Fankhauser, 1994) [1].

Step 1, which coincides in the approaches of Nordhaus (1991) and Fankhauser (1994) was modeled in the same way as it was by both researchers. At Step 2, where their methodologies diverge, Step 2 was assumed to be the stage at which the average global temperature increase is found from the quantity of CO_2 accumulated in the atmosphere, and a new modeling formula was hypothesized based on the results of a climatic change simulation performed by analyzing the increase in CO_2.

4.1.2 Quantity of CO_2 Emissions - Quantity Accumulated in the Atmosphere Relationship

Based on Maier-Reimer and Hasselmann (1987) 2), a study used as source material by Nordhaus (1991 a), Fankhauser (1994), and others, it was hypothesized that the quantity of CO_2 accumulated in t years is represented by the following formula

$$Q(t) = \int_{-\infty}^{t} G(t - t')\, E(t')\, dt' \quad (1)$$

$E(t)$: Quantity of CO_2 emitted in t years
$Q(t)$: Quantity of CO_2 accumulated in t years
$G(t-t')$: Response of the atmosphere to δ - function type emissions, when t = t'

$$G(t) = A_0 + \sum_{j=1}^{N} A_j exp\left(-\frac{t}{\tau_j}\right)$$

Where N = 4

$(A_0, A_1, A_2, A_3, A_4)$ = (0.131, 0.201, 0.321, 0.249, 0.098)

$(\tau_1, \tau_2, \tau_3, \tau_4)$ = (362.9, 73.6, 17.3, 1.9) years

4.1.3 CO_2 - Average Rise in the Global Temperature Relationship

The results of simulations of the gradual increase in CO_2 performed by 6 research groups in 4 countries were organized and studied based on the following reports to hypothesize the average temperature increase $\Delta T(t')$ based on formula (2).

(1) GISS - Hansen et al. (1988) [3]
(2) GFDL - Manabe et al. (1991) [4]
(3) GFDL - Manabe and Stouffer (1994) [5]
(4) NCAR - Washington and Meehl (1989) [6]
(5) MPI - Cubasch et al. (1992) [7]
(6) Meteorological Research Institute - Tokioka et al. (submitted) [8]

$$\Delta T(t) = C_0 \, ln \frac{Q(t)}{Q(0)} \qquad (2)$$

C_0 is the temperature increase parameter, and the average value of the CO_2 gradual increase simulation is 2.88, and if it is assumed to be 3.4, the results coincide almost exactly with the IPCC (1990) [9].

4.1.4 Quantity of CO_2 Emissions - Average Increase in the Global Temperature Relationship

Figure 1 shows the temperature increase when the quantity of CO_2 emissions is increased by formula (3) (corresponds roughly to the BaU Scenario of the IPCC (no counter-measure)).

$$E(t) = 2.83 + 0.071\ t \qquad (3)$$

4.2 Survey of Cost of Damage Caused by Global Warming

4.2.1 The Survey

Research to assess the cost of damage caused by global warming is represented by three studies: Nordhaus (1991 a [10] and b [11]), Cline (1992) [12], and Fankhauser (1992 [13], 1993 [14]). All three hypothesize that when the quantity of CO_2 accumulated in the atmosphere has reached a level twice as high as that prior to the industrial revolution, the average global temperature will rise 2.5 ℃, and each assessed the damage this would cause as comprehensively as possible.
This survey also required the cost of damage during the period up to the time the quantity of accumulated CO_2 doubles, but this hypothesis was established in accordance with Fankhauser (1994).

4.2.2 Cost of Damage When Accumulated CO_2 has Doubled

For this survey, the value selected was \$304.2 billion, a figure proposed by Fankhauser (1993) based on a detailed study performed with reference to Nordhaus (1991 a and b) and Cline (1992). Incidentally, according to the three researchers, the total annual cost of damage in terms of 1988 dollars in the United States when the quantity of accumulated

CO_2 has doubled is estimated as \$68 billion by Fankhauser (1993), as \$53.5 billion by Cline (1992), and as \$48.6 billion by Nordhaus (1991 a, b).

4.2.3 Value of Damage During the Period Required for the Quantity of Accumulated CO_2 to Double

Because no research has been performed to determine the cost of damage for any case other than one in which the quantity of accumulated CO_2 has doubled from the level prior to the industrial revolution, changes in the value of damage up till now D(t) were hypothesized using the same formula as that proposed by Fankhauser (1994).

$$D(t)=H\left(\frac{\Delta T(t)}{\Lambda}\right)^{\gamma}\cdot(1+\phi)^{(t_d t)} \qquad (4)$$

In this formula, H, Λ, and t_d represent the cost of damage when the quantity of accumulated CO_2 has doubled, the average temperature increase, and year respectively, and γ and ϕ are the constants assuming that γ = 1 to 3 and ϕ = 0.006. Figure 2 represents changes in the cost of damage in a case where the average temperature increase is as shown in Figure 1.

4.3 Study of the Marginal Social Costs of CO_2 Emissions

The marginall social costs of CO_2 emissions were calculated based on the results described in the previous section. The results of this calculation are shown in Table 1 along with the results of previous studies. In two cases, one case where the increase in the quantity of accumulated CO_2 resulted in a temperature increase almost identical to that of the IPCC (1990) (C_o = 3.4) and another case combined with a gradual CO_2 increase experiment

Table 1 Marginal Social Costs of CO_2 Emissions

(Unit : US\$/C-t、 1988 Prices)

Document Etc.		1990-2000	2001-2010	2011-2020	2021-2030
This Survey	C_o = 3.0	10.3	11.2	12.0	12.6
	C_o = 3.4	13.1	14.2	15.1	16.0
Nordhaus (1991a,b)		-	7.3	-	-
Ayres and Water (1991)		-	30-35	-	-
Nordhaus (1992)		5.3	6.8	8.6	10.0
Peck and Teisbery (1993) [5]		10-12	12-14	14-18	18-22
Fankhauser (1994)		20.3	27.8		

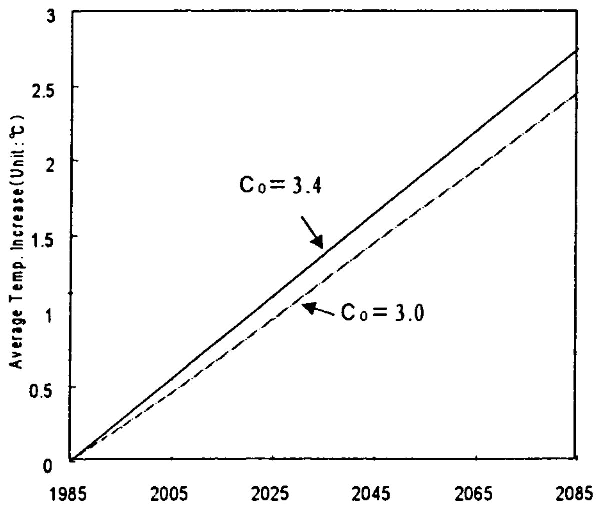


Figure 1. Average Temperature Increase in the BaU Scenario

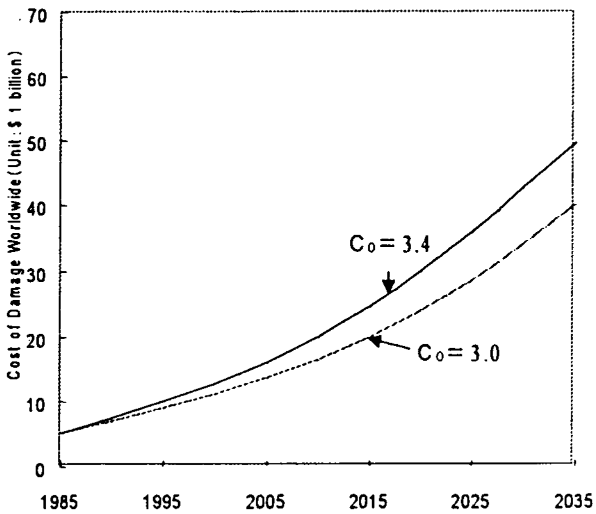


Figure 2. Changing Cost of Damage (1988 Price)

(Co = 3.0), the calculation results obtained are almost midway between those of the previous cases.

4.4 Study of Quantity of CO_2 Emissions for Individual Products Used as Construction Material

When a single unit (m, m^3, t, etc.) of a construction material is produced, the quantity of CO_2 which is directly and indirectly emitted is called the CO_2 EPU(EPU: emission per unit). The CO_2 EPU for a meter (m) of material, represented by λ_m, is calculated using the following formula.

$$\lambda_m = \mu_j \times p_m \quad (5)$$

Where:

μ_j: Quantity of CO_2 emissions per unit value of production of material m by industry j (C-t/yen).

p_m: Unit price of material m (yen/unit)

The quantity of CO_2 emissions per unit value of production μ_j by industry j is calculated using the following formula premised on the law of conservation of inter-industry transactions.

$$\mu_j X_j = \Sigma \mu_j X_{ij} + \Gamma_j \quad (6)$$

Where:

X_j : Total value of production of industry j (yen)

X_{ij}: Value of transactions from industry i to industry j (yen)

Γ_j: Quantity of CO_2 either taken from nature or produced from energy obtained from imports by industry j converted to carbon (C-t)

Table 2 presents examples of CO_2 EPU calculated from (5) and (6).

4.5 Social Costs of CO_2 Calculation Method

4.5.1 Life Cycle Concept

To compare the cost and the quantity of CO_2 emissions during the life cycle of a structure, the calculation hypothesized the lifetime of the structure. A single life cycle was divided into three stages: construction, maintenance/management, and demolition.

In a case where the lifetime differed for a conventional construction method and a low CO_2 emitting construction method, the comparison was performed for a life cycle which exists within the period of the least common denominator of the two lifetimes, and with the construction, maintenance/management, and demolition steps repeated a number of times.

A lifetime was not fixed for tunnels or other structures whose lifetime is difficult to determine because there is no concept of demolishing such structures. For those with no concept of demolition or for cases where the proposed construction method is repair work performed to improve roads, etc., the cost and CO_2 produced during the life cycle were

Table 2 Sample of Calculated CO_2 Emission per Unit

(Unit : C-t/Unit Amount)

Material	Unit	CO_2 Emission	Material	Unit	CO_2 Emission
I-steel (Large)	t	5.74×10^{-1}	PC Steel Bars	kg	1.54×10^{-3}
Structual Round Steel Bars	t	3.63×10^{-1}	Reinforcing Metal Mesh	m^2	4.79×10^{-4}
Ready-mixed Concrete	m^3	6.07×10^{-2}	Cedar Support Logs	Quant.	7.19×10^{-5}
Crusher-run	m^3	4.16×10^{-3}	Substrate Rust Protection Paint	kg	1.39×10^{-3}
Asphalt Mixtures	t	2.68×10^{-2}	PVC Waterproof Panels	m	1.83×10^{-3}

calculated as that produced following the completion of the construction work.

4.5.2 Cost Calculation Method

Costs were calculated by finding the sum of the cost represented as the total costs and by the social costs produced by the emission of CO_2. The social costs were calculated for the three stages of a life cycle with social costs: during construction, during maintenance and management, and during demolition. To calculate the costs for each stage, the discount rate was set at 3%, and the times when the action was performed were calculated considering the discount rate in 10 year units. The cost was calculated using present prices assuming that the rate of increase in construction costs would be almost the same as the rate of discount.

4.6 Estimation of Costs of Low CO_2 Emitting Construction Methods

Construction methods employed to restrict CO_2 emissions (hereafter referred to as "counter-measure construction methods") were selected, and the cost of realizing each method, the quantity of CO_2 each would emit, and its social costs were calculated and studied. These estimations included the calculation of the input materials, input machinery, and fuel used to operate this machinery for each construction method divided into three stages: construction, maintenance and management, and demolition and disposal. The results reveal that many of the counter-measure construction methods reduce overall costs throughout the lifetime of the structure by generating little cost at the maintenance/management and demolition stages. Table 3 presents examples of the calculation and comparison of the costs of counter-measure construction methods and of the conventional method each is intended to replace.

4.7 Establishment of Structures With Substitute Functions and CO_2 Emission Estimation Results

To provide sample comparisons, quantities of CO_2 emitted by interchangeable structures with similar functions--a tunnel and a roundabout road or a concrete bridge and steel bridge-were compared. Because the designation of the lifetime for each construction method is difficult, the demolition costs were not considered in this comparison. And in the case of the tunnel and roundabout road comparison, the social costs of the CO_2 emissions produced while the structures are in service were accounted for.

4.7.1 Construction of a Tunnel and a Road Around the Mountain

Trial calculations were performed and the results compared for two cases: the construction of a tunnel linking two sides of a mountain and the construction of a road around the mountain. The calculations accounted for the CO_2 which would be produced by motor vehicles using the two routes. And for the sake of simplicity, the tunnel length was set at 100 meters with one lane running in each direction. The number of lanes, width, etc. of the road around the mountain were assumed to be identical to those of the tunnel road, with its length set at 300 m assuming that traffic would have to travel further to go around a mountain than it would to pass through a tunnel (detour rate: 300%).

The CO_2 emitted per 10,000 vehicle-kilometers by motor vehicles was set at 2.52 CO_2-t for passenger cars and at 3.51 CO_2-t for trucks. With the traffic volume assumed to be 20,000/day, the truck ratio set at 30%, the period for the trial calculation assumed to be 30 years, and the discount rate set at 3%, the quantity of CO_2 emissions and the social costs accompanying these emissions were calculated.

The results of this trial calculation revealed that building the road would result in the emission of more CO_2 than constructing the tunnel: 112 C-t more per year and 3,367 C-t more during the entire 30 year period. (Table 4)

4.7.2 Steel Bridge and Concrete Bridge

A two-span continuous steel girder bridge was compared with a pretension type PC girder bridge hypothetically constructed to replace the steel girder bridge during a road improvement project. For this comparison, the calculation accounted for the repainting necessary to maintain the steel bridge. The results indicate that there would be little difference in the quantity of CO_2 emissions produced by a PC girder and a steel girder bridge.

4.7.3 Grade Separated Crossing

The next example is a trial calculation of the effects of a grade separated roadway crossing. Table 5 presents the premises for this trial calculation.
The premises for the calculation resulted in estimates of the project's effects that were very much on the safe side (smaller than actual effects). In fact it would be sure to provide much greater emission control effects. Nevertheless, the results for this case study have revealed that the quantity of CO_2 emitted as a direct result of the construction of the grade separated crossing (about 900 C-t) would be equal to the reduction in the quantity of CO_2 emitted by cars using the intersection over a two year period.

4.8 Quantity of CO_2 Emissions From a Macroscopic Perspective

The first step in preparing a forecast of the quantity of CO_2 emitted by all public works

Table 3 Comparison of the Costs and Social Costs of Low CO_2 emitting Construction Methods and Conventional Construction Methods

			Execution Technology for Slope Reconstructio	Multi-circled Shield Tunnel	Composite Paving	PC Steel Bar PC Strrand	Oval PC Digesting Tank
	Specifi- cations		Slope hight = 20	Area (H × W) = 7.4 × 11.2	Lane width = 14 Sidewalk width = 8	Width = 10.4 (Effectiv = 9)	Side wall thickness = 0.4
		(Unit : m)	Slope area = 2,000 m²	Length = 619	length = 530	Length = 256.4	Capacity = 3,500
Conventional Method	Cost (Unit:1,000yen)	Construction	64,500	4,940,000	67,800	162,000	291,000
		Maintenance	0	0	126,000	0	343,000
		Demolition	0	0	8,470	0	162,000
	CO2 emission (Unit:C-ton)	Construction	1140	12500	211	428	235
		Maintenance	0	0	682	0	10100
		Demolition	0.522	169	91.3	0	121
	Cost of CO2 emission (Unit:1,000yen)	Construction	1,109	16,515	206	565	310
		Maintenance	0	0	666	0	10,797
		Demolition	0	55	71	0	81
	Total (Unit:1,000yen)	Construction	65,609	4,956,515	68,006	162,565	291,310
		Maintenance	0	0	126,666	0	353,797
		Demolition	0	55,154	8,541	0	162,081
Counter-measure Method	Cost (Unit:1,000yen)	Construction	18,900	4,810,000	94,700	150,000	350,000
		Maintenance	0	0	52,600	0	82,000
		Demolition	0	0	16,000	0	15,100
	CO2 emission (Unit:C-ton)	Construction	44.5	11400	301	386	137
		Maintenance	0	0	272	0	3120
		Demolition	0	146	60.8	0	32.9
	Cost of CO2 emission (Unit:1,000yen)	Construction	59	15,061	398	510	181
		Maintenance	0	0	232	0	3,335
		Demolition	0	48	32	0	220
	Total (Unit:1,000yen)	Construction	18,959	4,825,061	95,098	150,510	350,181
		Maintenance	0	0	52,832	0	85,335
		Demolition	0	48	16,032	0	151,220

Table 4 Comparison of Tunncl with Road

		Road	Tunnel
Cost (Unit: 1, 000yen)	Construction	105, 000	232, 000
Quantity of CO_2 Emission (Unit : C -t)	Construction	173	205
	Exhaust Gas	5, 051	1, 684
	Total	5, 224	1, 889
Social Cost of CO_2 (Unit: 1, 000yen)	Construction	229	271
	Exhaust Gas	390, 611	130, 204
	Total	390, 840	130, 475
Total (Unit: 1, 000yen)	Construction	105, 229	232, 271
	Exhaust Gas	390, 611	130, 204
	Total	495, 840	362, 475

Table 5 Preconditions for the Gradc Separated Cross Scction Study

Scale of Crossing	Two four-lane streets
Traffic Volume	Both principal directions: 2,077 vehicles/hour・direction
Fluctuations of Congestion	2,600 m → 150 m
Range Considered	Elimination of congestion in the principal direction during the morning rush hour (2 hours)

projects in the future is to forecast the quantity of such projects executed. The next step is a forecast of the percentage of all projects in categories which can incorporate low CO_2 emitting construction methods. Finally the quantity of CO_2 which will be emitted by all construction projects is calculated based on the results of the previous step.

4.8.1 Forecast of Total Construction Work

To estimate the quantity of construction work performed in the future, the rate of increase in projects value was found with reference to project plans collected respective categories shown in Table 6 and to past changes in the amount of construction performed by the category. The estimates were made for two points in time: 2000 and 2010.

Table 6 Forecast of Project Value (Actual) by Category (Unit of Value: trillion yen)

Category	Rate of Increase	Project Value (2000)	Project Value (2010)
Road	4. 11%	9 . 4	1 4 . 1
Rivers	1. 31%	1 . 1	1 . 2
Dams	2. 69%	0 . 53	0 . 70
Seacoast	5. 22%	0 . 08	0 . 13
Sewerage	3. 54%	2 . 3	3 . 2
Parks	4. 56%	0 . 44	0 . 69

4.8.2 Forecasting the Reduction of CO_2 Emissions Achieved by Introducing Substitute Construction Methods and Materials By Work Category

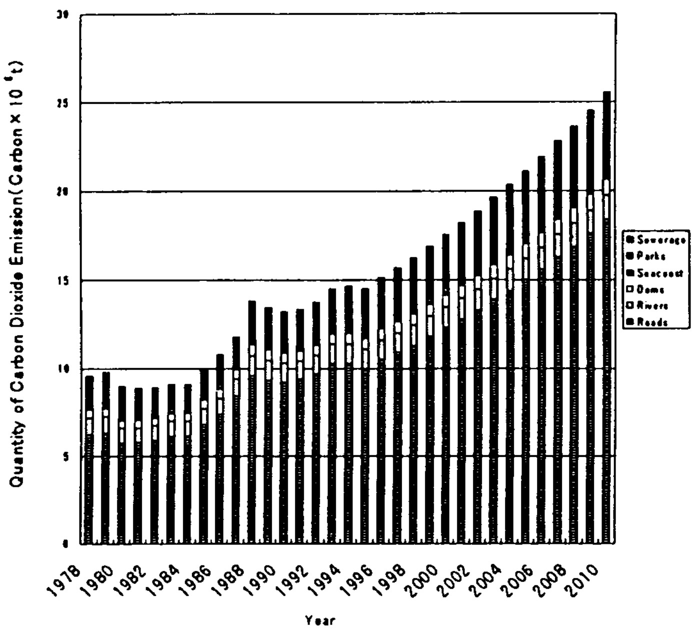
Based on the results of a 1995 fact-finding survey of construction methods etc. which

Table 7 Reduction Potential of Low Carbon Dioxide Emitting Construction Method

Construction Method	Reduction R (%/Work)	CO2 EPU (C-t / Work)		Reduction Potentiol (C-t) 1997	2000	2010	Caluclation Premises
Composite Paving	35. 61		351	25. 804	23, 068	56, 969	Applied to 5% of road paving work
Out cable Method	20. 59		14	15. 716	19. 435	39. 447	Applied to 20% of concrete bridge construction
Surfice Covering Method	9. 23		54	7. 661	9. 473	19. 228	Applied to 10% of steel bridge work
Mulch-circled Shield Method	8. 86		1. 123	4. 131	4. 661	6. 973	Applied to 10% of tunnel work
Slope Reconstruction Method	96. 10		1. 096	9. 738	10. 989	16. 438	Applied to 0.01% of road work
Use of Recycled Concrete	36. 20		12	24. 509	30. 308	61. 517	Applied to 10% of concrete bridge work
Use of Recycled Asphalt Concrete	41. 34		53	81. 893	82. 731	85. 589	Applied to 30% of road paving work
Replacem ent of Roundabout Road with Tunnel	67. 00	Expressway	273	691, 000	780. 000	1, 166, 000	Reducing traveling distance in the section by 67%
		National Highway	182				
		Prefectural Highway	90				
Replacemnt of Steel Bridge by Concrete Pridge	4. 60	per 100m	26	1. 120	1. 386	2. 812	5% of future steel bridge replacements
Replacement of Gravity Dam by Enbankment Dam	18. 00		13. 609			136. 090	Replacemnt of 10 gravity dams with embankment dams

restrict CO_2 emissions, the rate of penetration of each of these construction methods was hypothesized in order to estimate the extent of the CO_2 reduction each would bring considering the forecast quantities of construction work obtained in section 4.8.1. To do so, the rate of penetration of each construction method was hypothesized by clarifying its potential application ratio (percentage of all construction in its category now performed which could be performed using the low CO_2 emitting construction method) based on the results of interviews at companies which had proposed the new construction methods. Table 7 summarizes the results. The potential of replacing roundabout roads with tunnels in the table is based on a hypothetical life cycle of 30 years, and the quantity of reduction is found by accounting for the quantity of CO_2 emitted by motor vehicles using the route in that period.

Figure 3 Estimation of Quantity of CO2 Emissions by Project Category



The reduction potential for low CO_2 emitting construction methods other than the roundabout road to tunnel case in Table 7 is slightly more than 420,000 C-t overall (2010). Figure 3 presents an estimation of the total quantity of CO_2 emissions produced by the construction industry, indicating that in 2010, the construction industry will emit a total of 25.5 million C-t. This means that the total reduction achieved by the use of low CO_2 emitting construction methods would be no more than 1.6%.

5. Summarization

This research project evaluated effective methods of reducing emissions of the green house effect gas, CO_2, in the construction industry as a way to help prevent global warming. The first step was a survey of the relationship of the quantity of CO_2 emissions with the average increase in the global temperature with reference to the method proposed by Nordhaus (1991) and that proposed by Fankhauser (1994). The results of past research on the cost of damage caused by global warming were then used to study the critical social costs of CO_2 emissions. The results were calculated values standing midway between those obtained by the prior case studies. The inter-industry tables were used to study the quantity of CO_2 emissions per unit of products used as construction materials.

The next step was the addition of the social costs to the construction costs for a number of construction methods proposed as ways to reduce the emission of CO_2 and a comparison of the resulting costs with those incurred by the conventional construction methods now in use. The results reveal that because the social costs of CO_2 emissions account for a relatively small share of total costs, there are few cases where adding social costs would result in a cost reversal. Thus the use of these methods would clearly not be a persuasive incentive to lower emissions of CO_2.

A tunnel project and a grade separated crossing plan were cited as sample cases of comparisons performed to determine the ability of the new structure to reduce overall CO_2 emissions during its life cycle by accounting for changes in the quantity of CO_2 emitted while the new structure is in use. The results revealed that assuming that motor vehicles powered by internal combustion engines consuming fossil fuels will continue to use the tunnel, crossing, etc., if a certain volume of traffic uses a certain lane, any reduction in the driving time will result in a CO_2 emission reduction effect sufficient to allow the recovery of the CO_2 emitted by the construction work in only a few years, and the trail calculation demonstrated that in this case, the standards for deciding to implement a certain project will change when the social costs of CO_2 emissions are added to the other effects of the project.

An attempt was made to forecast the extent to which the quantity of CO_2 emitted by the entire construction industry would change based on past trends and plans for future construction work. The results indicate that if no measures are introduced to hold down CO_2 emissions, they will increase, and even if the low CO_2 emitting construction methods which have been proposed are put into practice, they will do little to reverse the overall rise in total emissions.

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