Experimental study on global environment and sustainable development in concrete engineering*

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Abstract

Nowadays, it is necessary to ensure that infrastructure and concrete engineering are developed in environmentally sensitive manner and that measures are taken to preserve nature.

The purpose of this research is to study the direction of the harmonizing with environment and the sustainable development of concrete engineering are taking. In this study, items requiring evaluation of influence and effects of concrete engineering in global environment are have been excerpted from law and standard such as ISO-14000 series. Each case was investigated by carring out interview and the spot researches. A tentative evaluation method was developed which was used to evaluate actual case study. The basic study was done to evaluate effective concrete engineering method for global environment method in the condition of limited resources and economy.

1. Introduction

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Each case was investigated by carrying out interview and spot researches. The tentative evaluation method is constructed and examined to evaluate actual case study. The basic study was done to evaluate effective concrete engineering method for global engineering method in the condition of limited resources and economy.

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2. Method

The flow chart of study is shown in Fig. 1.

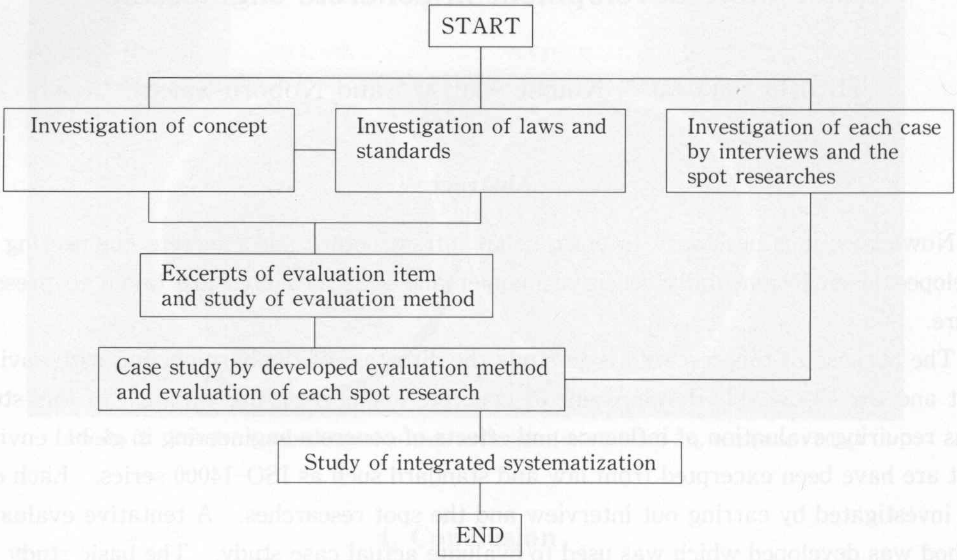

Fig. 1 Flow chart of study

3. Result and Consideration

3. 1 Result

3. 1. 1 Evaluation of environment procedure

Study items and evaluation of each case are shown in Table 1.

Table Itom of study and evaluation of each case

	Case of study	①	②	③	④	⑤	⑥	⑦
Item of evaluation	1. Construction of environmental management system	2	1	1	2	2	1	1
	2. Maintenance of guideline for environmental auditing	2	1	1	2	2	1	1
	3. Enactment of environmental labeling	1	1	1	1	1	1	1
	4. Study of environmental perfomance evaluation (bio-diversity evaluation)	2	2	3	3	3	2	2
	5. Life cycle assessment	3	2	2	2	2	1	0
	6. Study of environmental aspects in product standards	1	2	2	2	3	0	0
Total of evaluation rate		11	9	10	12	13	7	6

Evaluation rate: 3: Done systematically, 2: Adoption for evaluation item
1: Consideration to evaluate, 0: No consieration

The evaluation criterion level of each item is 0 to 3. The maximum evaluation point which is systematic environment procedure is 3. Each item is assumed to have been equally graded equal in this tentative study.

3. 1. 2 Efficiency of environment procedure

The effect of environmental procedure (P) in concrete engineering is shown as Equation (1).

Effect of environmental procedure : $P = A_1X_1 + A_2X_2 + \cdots\cdots + A_nX_n$ ··············Equation (1)

Where Ai : weight to evaluation point of an item

Xi : evaluation point of an item (Enforcement of systematic procedure : 3, Enforcement of procedure : 2, Confirming necessity of procedure : 1, Not confirming necessity of procedure : 0)

P_{max} Can be obtained in limited condition such as regulation and economic condition at later statement and so on.

Cost : $C = B_1W_1 + B_2W_2 + \cdots\cdots + B_mW_m$ ············Equation (2)

Where Bi : weight to cost of an item (or volume, area, quantity and so on)

Wi : cost of an item (total, unit price, and so on)

There is C_{max} which is the limitation cost. As a regular level, C_{min} is demanded naturally.

Therefore the efficiency of concrete engineering to environmental procedure is defined as Equation (3).

Efficiency : $E = P/C$ ···Equation (3)

3. 2 Consideration

As a case study in Table 1 ①, how the thickness of existing pavement of air port apron can be increased without wasting concrete was examined. Three case were studied as shown in Table 2. And the calculation of cost : C to environment procedure is shown in Table 2. The study of environmental performance is shown in Table 3. The life cycle assessment in case study in ① is shown in Table 4. The evaluation of case study in ① to each procedures is shown in Table 5. The effect of environmental procedure to cost (P/C) and cost per rate (¥/rate) is shown in Table 6. According to the results, case a is most efficient procedure.

Table 2 Calculation of cost : C to environment measure
(Construction area : 18000 m², Volume of solid conrete waste : 18000m² × 0.32 m = 5760 m³
Y : Constant of a unit money)

Case of study	a	b	c
Procedure method	Increasing depth by new concrete plate to old concrete plate	Dismantling & removing old concrete plate, and replacing new concrete plate using recycled aggregate from solid concrete waste to road bed material	Dismantling & removing old concrete plate, and replacing new concrete plate using normal aggregate to road bed-material
Cost of rid of solid concrete waste cost	—	¥3.5Y/m³	¥3.5Y/m³
Aggregate[1) (the road bed material)	—	(Recycling aggregate from solid concrete waste) ¥1.5Y/m³	(Normal aggregate) ¥2.8Y/m³
Agregate transportation cost[2)	—	¥2Y/m³	¥2Y/m³
Subtotal 1	—	¥40,320Y (¥7Y/m³ × 5760m³)	¥53,568Y (¥9.3Y/m³ × 5760m³)
Concrete working	(Increasing depth) ¥6Y/m²	(Replacing) ¥20Y/m²	(Replacing) ¥20Y/m²
Subtotai 2	¥108,000Y (¥6000 × 18000m²)	¥360,000Y (¥20000 × 18000m²)	¥360,000Y (¥20000 × 18000m²)
The total	¥108,000Y	¥400,320Y	¥413,568Y

1), 2) : Using road bed material

Table 3 Study of environmental performance evaluation in case study ①

Study of environment performance evaluation	Case		
	① a	① b	① c
Quantity saving of raw material and energy	3	1	1
Waste saving per completion	3	3	1
Large rate of recycle waste	3	3	1
Average rate (rounding off)	3	2	1

Table 4 Life cycle assessment in case study in ①

Life cycle assessment (aiming at discharge to environment in especially constructing cycle)	Case		
	① a	① b	① c
Controlling discharge in the air (Particle of dust)	3	2	2
Controlling discharge in water area (Filthy water)	3	2	1
Controlling Solid waste	3	3	1
Controlling others (Noise and vibration pollution)	2	1	1
Average rate (rounding off)	3	2	1

Table 5 Evaluation of case of study ① to each procedured method

Case of study		① a	① b	① c
Evaluation item	1. Development of environmental management system	2	2	2
	2. Maintennce of guideline for environmental auditing	2	2	2
	3. Enactment of environment labelling	1	1	1
	4. Study of environmental performance evaluation (bio-diversity evaluation)	2	1	1
	5. Life cycle assessment	3	2	1
	6. Study of environmental aspects in product standards	1	1	1
Total of evaluation rate		11	9	8

Evaluation rate: 3: Done systematically, 2: Adoption for evaluation item
1: Consideration to evaluate, 0: No consideration

Table 6 Effect of environmental procedure to cost (T/C) and cost per rate (¥/rate)

Case	Effect of environmental procedure to cost (T/C)	Cost per rate (¥/rate)
a	10.2×10^{-8}	9,818Y
b	2.3×10^{-8}	44,480Y
c	1.9×10^{-8}	51,696Y

Photo-1 Old concrete plate of the airport apron.

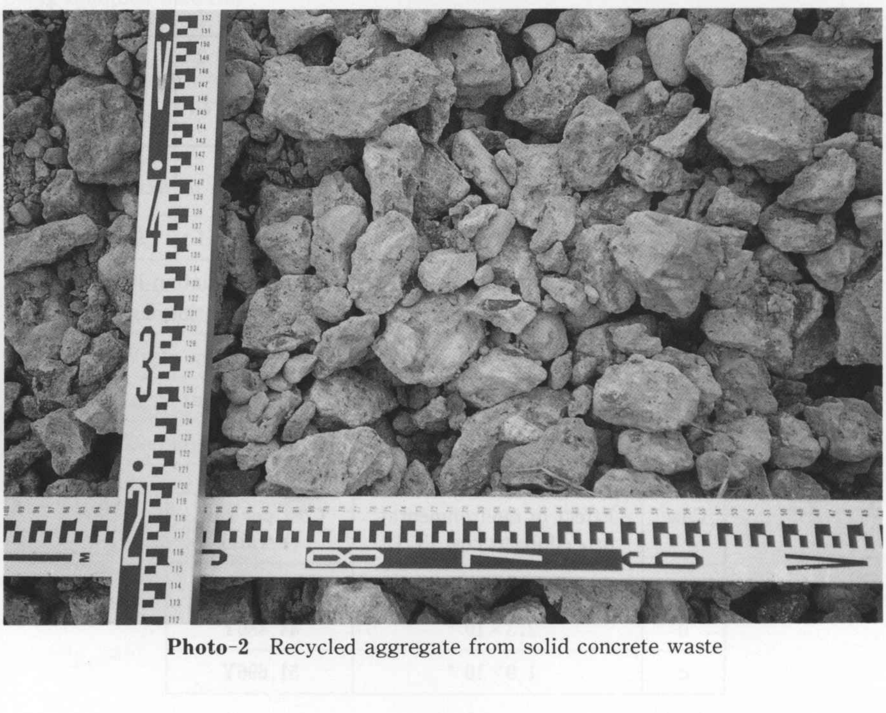

Photo-2 Recycled aggregate from solid concrete waste

4. Conclusion

The following conclusion can be drawn from the analysis and consideration of this study. The sustainable development of concrete engineering procedure to environment is need to take a count of relationship between effect of environmental procedure to cost (P/C) and cost per rate.

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