Study on evaluation of civil engineering technique to global environment procedure*

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Abstract

The global problems of environmental breakdown, global warming, biodiversity conservation, ozone layer depletion and so on are recognized as extremely important. The ozone layer problem and climate change have been observed already. Still more, restraining population expansion, obtaining stable supplies of energy and food, and overcoming poverty are critical issues. Solving these problems is critical to continuation of the human race. Nowadays, civil engineers also recognize that those responsible for infrastructure development and the use of public money are also accountable for its effective use. We have a duty to state clearly the results we expect and how we think they can be achieved. It is necessary to ensure that infrastructure and civil engineering develop in an environmentally sensitive manner and that measures are taken to preserve nature.

The purpose of this research is to study how we can move toward harmonizing with the global environment and the sustainable development of civil engineering, both domestically and in developing countries, in order to actively maintain and redevelop the present infrastracture. In this study, areas of civil engineering which require evaluation for their influence on the global environment have been drawn from reports, laws and standards of the government, the United Nations, international organizations, non-governmental organizations (NGOs) and so on. Each case was investigated by carrying out interviews, on-the-spot researches and meetings. A tentative evaluation method was developed and this was used to evaluate the actual case studies. This basic study aimed at evaluating effective civil engineering methods under conditions of limited resources.

We need to ensure that infrastructure is developed in an environmentally sensitive manner and that measures are taken to preserve nature. To do so, it is important to understand the politics, civilization, society, national characters, and present level of economic development of the countries and the present state of their infrastructure, as well as to provide technical and economic assistance that allows local people to operate autonomously. Where beneficial, it is a good idea to ask suitable high-level NGOs with good local and international connections to play a role and provide them with the financial assistance they need to do so.

When providing technical assistance overseas, it is important to accurately evaluate

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local conditions and problems, as well as the needs of local people. We think that doing this in an appropriate manner with proper explanation, planning, and the participation of inhabitants is the key to successfully providing aid in a way that protects the global environment.

1. Introduction

Since the end of the 1980s, technology transfers and investment in the Association of South-East Asian Nations (ASEAN), accompanied by China's open-market policy have induced rapid economic growth. Still further, the collapse of the Soviet Union and the Warsaw Pact, and the consequent dissolving of the Cold-War tension between east and west, has reduced the rate of armaments in the industrial economy. Now, problems with the global environment such as environmental breakdown, global warming, loss of biodiversity, destruction of the ozone layer, have become recognized as important. Ozone layer destruction and climate change have been observed already. Still more, restraining population growth, obtaining stable supplies of energy and food, and reducing poverty are important issues. Solving these problems has become very important to the continued existence of the human race.

Nowadays, civil engineers also recognize that those responsible for development of the infrastructure and the use of public money are accountable for its effective use. We have a duty to state clearly the results we expect and how we think they can be achieved. It is necessary to ensure that infrastructure and civil engineering develop in an environmentally sensitive manner and that measures are taken to preserve nature.

The purpose of this research is to study the issues and begin moving in the direction of harmony with the global environment as regards the sustainable development of civil engineering domestically and in developing countries to require development and redevelopment in order to be active. In this study, areas of civil engineering which require evaluation for their influence on the global environment have been excerpted from reports, laws, and standards of the government, the United Nations, international organizations, non-governmental organizations (NGOs), and so on. Each case was investigated by carrying out interviews, on-the-spot research, meetings, and collecting reports and data. A tentative evaluation method was developed and this was used to evaluate actual case studies. This basic study aimed at evaluating effective civil engineering methods under conditions of limited resources and economy.

2. Method

The flow chart used to evaluate the impact and the effect of civil engineering techniques with respect to global environment is shown in Fig. 1.

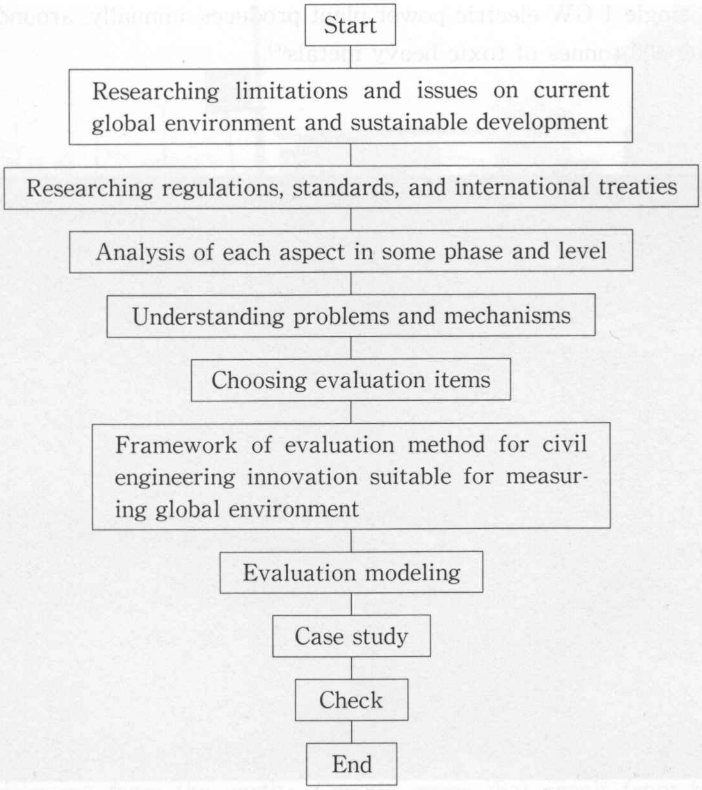

Fig. 1 Flowchart for evaluating civil engineering techniques with respect to the global environment

3. Research results and consideration

3.1 Global environment and sustainable development

3.1.1 Global environmental factors

(1) Environmental pollution

There has been progress in our ability to reduce environmental pollutants, such as noxious gases and toxic substances emitted by coal and oil power plants and so on, through costly pollution abatement technologies such as desulphurizers, nitrous oxide reducers, and precipitators. But, globally there remain serious environmental and health impacts arising from persistent release. In developed countries, the general trend is one of decreasing noxious gas and toxic substance releases, while in developing countries as a result, the trend is particularly high up-front cost of abatement techniques. Urban pollution in the developing countries, with their heavy reliance on fossil fuels and rapidly increasing transport emissions, is reaching harmful levels as exemplified by Bangkok, Kathmandu, and so on.

Globally, large quantities of fossil fuel waste containing toxic substances, particularly from coal combustion, pose a long-term problem in relation to water quality and food chain contamination. It is becoming increasingly common to categorize this waste as hazardous.

For example, a single 1 GW electric power plant produces, annually, around 320,000 tonnes of ash containing 400 tonnes of toxic heavy metals(6).

Photo-1 Modernization and polluted rivers in Bangkok

(2) Waste

The CO_2 emissions associated with consumption in Japan makes up 50% of the total Japanese emissions. If 10 kg of waste of average composition is burned, the carbon is converted into 2.4 kg of CO_2. So reducing waste means a reduction in CO_2. emissions(10). Nowadays, waste incineration is known to cause serious problems because of the discharge of dioxin when burnt at low temperatures.

On the other hand, in developing countries, such as Nepal, GTZ project (Solid Waste Management in Nepal supported by Germany) has been operating since 1980. The recent operation level in the present phase are education for improved solid waste management and hygiene, street sweeping in wide area municipalities, the institutional development of waste management and transfer of management function to national staff. These projects take very long time, depending on the characteristics of each development country's culture, increasing waste quantity due to population growth, especially urban area ; increasing construction of landfill sites, increasing claims by the residents near the site of waste quality changing, for example of non-decomposing plastic materials decomposing and so on. The assistance of technical advisory and training services were necessary as well as support for capital investment(2).

Photo-2 Cattle are grazing on the road and eating garbage in Kathmandu

(3) Greenhouse gases

The earth's temperature is determined by the balance between energy impact from the sun and heat escaping from the earth. Certain gases that result from human activity-(mspace do hyplen) the so-called greenhouse gases (GHGs) such as CO_2, methane, and CFCs-(mspace do hyplem) trap heat in the atmosphere and prevent them from escaping into space. As economic activites intensify, emissions of these gases increase, with the result in rising of earth's temperature. The concentration of CO_2 has increased to 355 ppm in 1992 from 280 ppm before the industrial revolution, and it is expected to rise to 500 ppm by 2050, and 700 ppm by 2100. Global emissions of CO_2 were 6.2 billion tons in converting Carbon in 1994. The can be broken doun as USA : 22.4% ; China : 13.4% ; Russia : 7.1% ; Japan : 4.9% ; and so on. Japan produce more CO_2 than the whole of South America or Africa. Global temperatures have increased by 0.3-0.6°C over the last 100 years, and an additional 1°C increase is expected to occur by 2060, and 2°C by 2100. Sea levels will rise by 15~95 cm by 2100 because of expansion of sea water and thawing of glaciers and icebergs. Even with a sea level rise of 50 cm, 70% of beaches in Japan will be lost. Around Japanese coast, an area of approximately 900 km² is under high tide level and supports a population of 2 millions. If the sea level rises by 1 m, this area will expand by 2.7 times for a population of 4.1 millions. Areas threateend by flood tides and tsunamis will expand by 1.4 times[10]. Under the Third Session of the Conference of Parties to the United Nations Framework Convention on Climate Change in December 1997 in Kyoto (UNFCCC-COP3 KYOTO), industrialized countries have agreed to take the lead in reducing greenhouse gas emissions. An analysis of economic growth scenarios by the OECD shows that in the year 2020, global energy-related emissions of CO_2 are likely to be more than double the 1990 levels. Emissions from industrialized countries in these scenarios continue to increase, possibly reaching levels 50% to 70% above 1990 levels by the year 2020. In developing countries, emissions are expected to increase even more rapidly, from the present share of roughly 30% of global emissions to just over 50% by 2020. Stabilizing atmospheric concentrations of greenhouse gases at target levels will require reversing current emission trends. The benefits of mitigating risks of climate change must be balanced against the potentially high costs of greenhouse gas reduction. The benefits should simulate a shift of investment towards more environmentally sound technologies and processes(5).

(4) Biodiversity

The world's ecosystems are of huge value to humans. Given the lack of our knowledge about biodiversity and the complexity of ecological relationships, it seems probable that their importance is even greater than we suppose. The disruptive effects on ecosystems may be a serious threat to human welfare. Especially, climate change is expected to affect biodiversity because the physiology, survival, and performance of every species studied in detail are determined by climate and environmental factors. These environmental factors include air, water, and soil temperature, humidity, soil moisture, and wind speed. Biodiversity is influenced not only by the direct effect of temperature and humidity, but also by the indirect effects of changes in competitors, predators, parasites, and diseases. The effects of climate change on individual species will be complex, and therefore even subtle changes may cause large changes in plant and animal communities. It is important to focus on changes in timing of the life cycles of interacting species of predators and their prey, such as the case of the increasing deer population an Japan's Hokkaido Island. We need to understand the impacts on endangered species, those of economic importance, and those responsible for infectious diseases, the rapid dissemination of findings is crucial(9).

According to the National Strategy on Biological Diversity implemented by a decision of Council of the Ministers of Government of Japan (GOJ) for Global Environment Conservation on 31 October 1995, the GOJ ensures that full consideration is given to the conservation of biological diversity in constructing social infrastructure through, inter alia, the implementation of appropriate environmental impact assessments and minimization of adverse impacts. The GOJ also actively promotes the restoration and provision of habitats for plants and animals mainly in the areas of countrysides, and parks for hiking, and urban areas(11).

3.1.2 Growth of underdeveloped countries and aid factor

(1) Poverty

Fully one-force of the word's population is afflicted with extreme poverty. About 1.3 billion people, mainly in Sub-Saharan Africa, live on incomes of less than $1 a day. People who live in extreme poverty, for the most part, lack access to clean water and adequate health facilities ; many do not receive sufficient nourishment to live a productive life ; and the majority do not possess basic literacy or numeracy skills. Their deprivation is unnecessary and its continuation is intolerable. The moral imperative of support for development is self-evident[12].

(2) Population expansion

World population expansion during the 21st century will occur overwhelmingly in the developing regions. Although progress is evident in restraining global population growth, which currently stands at 80 million per year, the medium-term projection from the United Nations World Population Prospects : 1996 revision forecasts a 50% increase to 9 billions by the middle of the next century, India's population will exceed China's with more than 1.5 billion, and populations greater than 250 million will inhabit Brazil, Indonesia, Nigeria, and Pakistan[6].

(3) ODA

Regarding future measures for preserving the global environment, field surveys in Thailand and Nepal have revealed the following problems and issues. The problems and issues are related to procedure for preserving the global environment while advancing development.

A developing country like Thailand, with a reasonably advanced economy and infrastructure, is in a situation similar to Japan's between the late 1960s and the 1970s. During that period, measures for preserving the environment were not actively implemented in Japan, either.

People in Thailand are now demonstrating. Their interests are not purely economic growth, but also in the regulation of wastewater and exhaust gases, and the adoption of technologies for reducing them, as well as measures for relieving traffic congestion. The need to monitor and the method of doing so are under study.

On the other hand, in Kathmandu, the capital of Nepal, water and air pollution, waste disposal, and traffic congestion have already become major problems. But the Nepalese economy is not very advanced, and there is little in the way of modern infrastructure. It does not seem that the Nepalese consider environmental preservation an important issue.

Therefore, quite naturally, what the government and government-related organizations in Nepal and Thailand are interested in and focus on, in terms of development and environmental preservation, are quite different. These differences were most evident during interviews with government officials in those two counties.

People involved in development projects in Thailand asked for technical assistance and financial support for environmental preservation and environmentally responsible infrastructure development. Their counterparts in Nepal, however, asked for technical assistance and massive infusions of funds to develop the country's primitive infrastructure. But in both countries, measures taken by NGOs for environmental preservation seem to be advancing quite well.

3.1.3 Policy and industrial factors

(1) Policy factors

Stronger domestic policies and international co-operation are necessary to reduce emissions in industrialized countries. Important issues are how industrialized countries can make the transition to new, cleaner energy sources; stimulate cost-effective changes that reduce industrial, agricultural and forestry emissions, and modify consumer behavior. Early response strategies should include domestic policies that exploit various profit options; research and development in technology; scientific research; and institution building. The expanded use of economic instruments, both at the international level and domestically, can ensure cost-effective abatement. Domestic strategies should draw on a broad mix of policies, adapted to national circumstance, to achieve long-term emissions reductions. Important among these are public awareness and education programs; improved information flows to capital markets and consumers; subsidy reform; green tax reform; full-cost pricing; performance-based regulations; and strengthened and new public-private partnerships. Government can play key role in encouraging technical and behavioral innovation. It is necessary to assess the potential of technologies to reduce energy demand, increase energy efficiency, and harness renewable and nuclear energy more effectively. Initiatives to accelerate implementation of the best available, most cost-effective technology to address climate change are needed(5).

(2) Industrial factors

Industry strongly influences the pace and the direction of economic development. To ensure that industrial growth contributes effectively and efficiently to national and international policies, governments must strengthen partnerships with industry. It is important to work closely with industry in a number of ways, including a partnerships aimed at assessing the potential of the concept of "eco-efficiency" to break the link between economic growth and greenhouse gas, etc., emissions.

As an indication technology's impact, take the electricity generating capacity of Brazil, China, India, Indonesia, and Russia, in aggregate, it could more than quadruple between now and 2020. In this same period, 80 per cent of the existing electricity capacity in these countries will be replaced through normal turnover. Installation of cleaner, more efficient technology as capacity comes up for replacement could lead to dramatic reductions in the growth of greenhouse gas emissions and so on in these counties, particularly as older, dirtier plants are retired(5).

(3) Shortage of energy

Half of the world's people now live in intensive energy-consuming urban areas and this percentage will increase as urbanization in some regions expands to include 80% of the population.

A 1995 study carried out by the World Energy Council (WEC) and the International Institute for Application Systems (IIASA) considered three global energy scenarios for the next century : high, middle, and ecologically driven low growth scenarios. The study projects by mid-century a range of energy demand increases from some 50% for the low economic growth case to more than 250% for the high growth case, with the latter meaning a 50% increase before 2020. The United States Department of Energy (DOE) in its recently released International Energy Outlook 1997 projects a 54% increase in global energy demand as early as 2015, some half of this being due to rising demand in newly emerging Asian economies, including China and India. It warns that if the transport sector demand in China follows the trend seen in Thailand and the Republic of Korea, this projection could be a dramatically underestimate[6]. Electric power failure happens are common during periods of the peak demand in urban areas in developing countries, such as Kathemandu.

(4) Shortage of resources

There are proven reserves of coal sufficient for more than 200 years, of natural gas for 60 years, and of oil for 40 years at current levels of use. Efforts are under way to increase oil and gas resources and to develop oil-shale and tar-sand processing and these are expected to be capable of at least doubling the resource base. Depending on their specific economics, new technologies to further increase fossil fuel extraction could be developed. Known uranium reserves with reactors operating primarily on a once-through cycle without re-processing of spent fuel assure a sufficient fuel supply for 50 years at current levels of use, the same order of magnitude as today's proven resources of natural gas and oil. Estimates of additional undiscovered (speculative) resources could add more than 100 years[6].

3.2 Consideration

3.2.1 Relation between civil engineering and issues of global environment and sustainable development

The human race is currenthy facing limitations as described above. The relationship between global environment issues, and sustainable development is indicated in Fig. 2. Solutions are demanded which are good for both the global environment and sustainable development. Civil engineering, which plays an engineering role between society and the natural environment, plays an importanret role. The relationship between civil engineering, the global environment, and sustainable development, as well as the changes that have taken place over the past quarter century, are shown in Fig. 3. Civil engineering procedures must strike a balance between the global environment and sustainable development in a systematic way.

The relationship between global environment issues and the infrastructure in civil engineering is shown in Table 1. Environmental pollution and waste issues relate to each civil engineering step closely. Issues of greenhouse gases, industry, resource shortages and energy shortage relate to most civil engineering steps. Therefore consideration of these issues must take place in association with industrial activity. Still more, the planning steps relates to all issues. Good planning effects good design step. These qualities affect the construction step and maintenance & management step. The evaluation of the efficiency of measures in planning step is important.

Global environment & sustainable development issues and examples of measures in civil engineering is shown in Table 2.

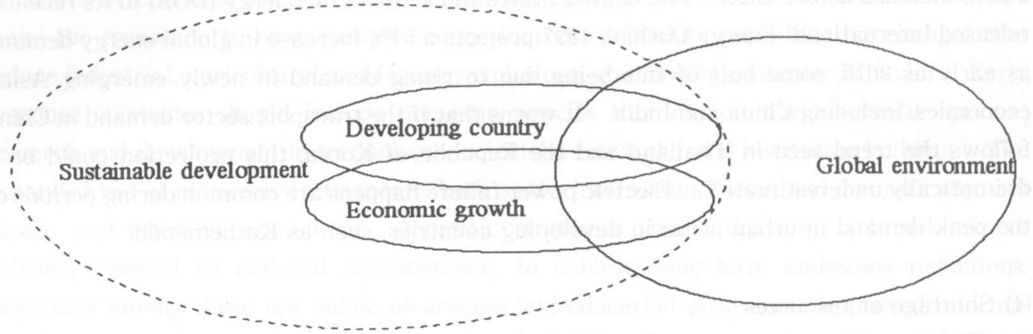

Fig. 2 Relationship between global environment issues and sustainable development

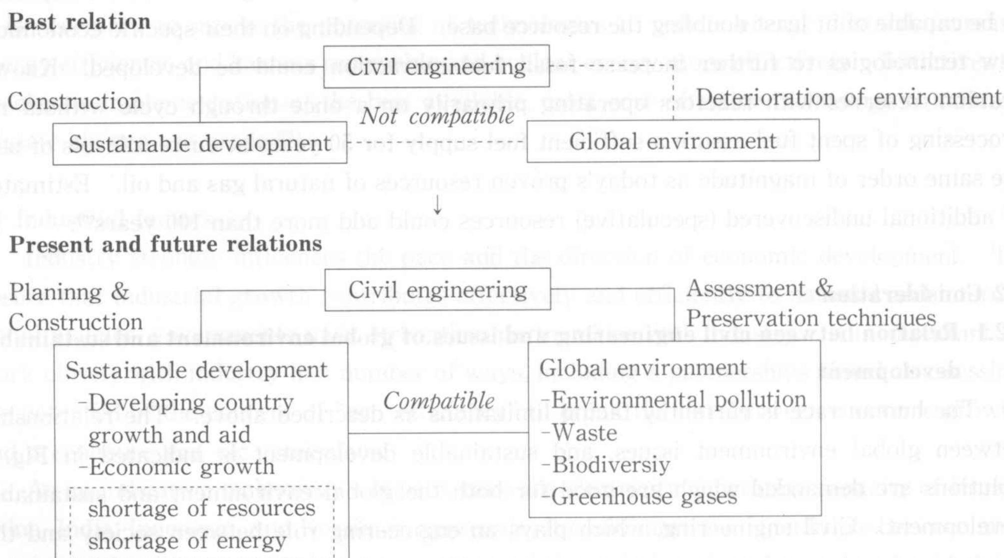

Fig. 3 Relations between civil engineering, global environment, and sustainable development past, present, and future.

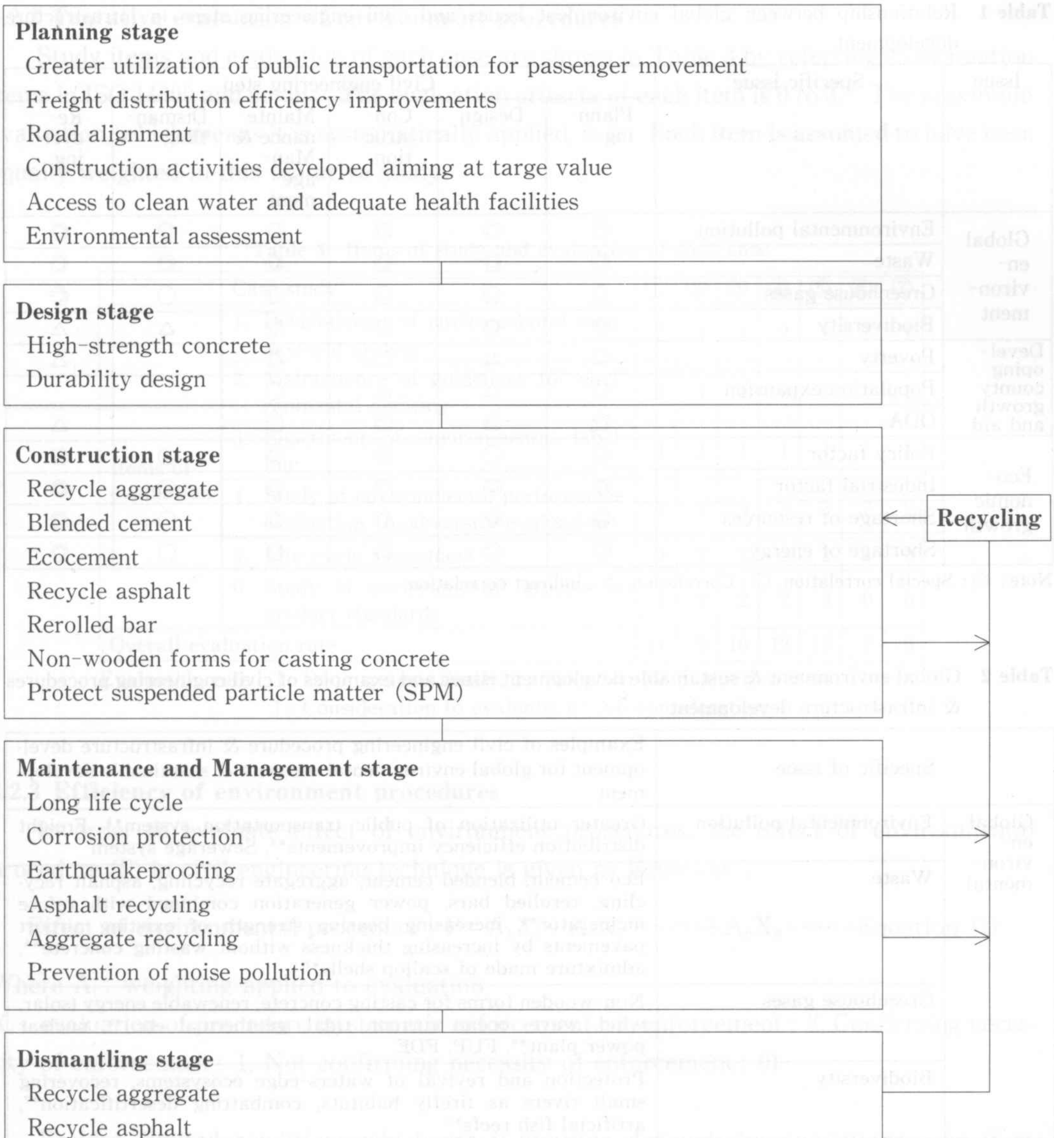

Fig. 4 Steps for development of infrastructure and examples for global environment measure in civil engineering

Table 1 Relationship between global environment issues and civil engineering steps in infrastructure development

Issue	Specific issue	Civil engineering step					
		Plann-ing	Design	Con-struc-tion	Mainte-nance & Man-age-ment	Disman-tling	Re-cycl-ing
Global en-viron-ment	Environmental pollution	◎	◎	◎	◎	◎	◎
	Waste	◎	◎	◎	◎	◎	◎
	Greenhouse gases	◎	◎	◎	◎	○	◎
	Biodiversity	◎	◎	◎	◎	△	△
Devel-oping county growth and aid	Poverty	◎	△	○	◎		△
	Population expansion	◎	△	△	○		
	ODA	◎	◎	◎	○		△
Eco-nomic growth	Policy factor	◎	○	◎	◎	○	◎
	Industrial factor	◎	◎	◎	◎	○	◎
	Shortage of resources	◎	◎	◎	◎	○	◎
	Shortage of energy	◎	◎	◎	◎	○	◎

Note : ◎ : Special correlation, ○ : Correlation, △ : Indirect correlation

Table 2 Global environment & sustainable development issues and examples of civil engineering procedures & infrastructure development

	Specific of issue	Examples of civil engineering procedure & infrastructure development for global environmental measure & sustainable development
Global en-viron-mental	Environmental pollution	Greater utilization of public transportation system*1, Freight distribution efficiency improvements*2, Sewerage system
	Waste	Eco-cement, blended cement, aggregate recycling, asphalt recycling, rerolled bars, power generation combined with refuse incinerator*4, increasing bearing strength of existing airport pavements by increasing thickness without wasting concrete*A, admixture made of scallop shells*B
	Greenhouse gases	Non-wooden forms for casting concrete, renewable energy (solar, wind, wave, ocean current, tidal, geothermal etc.)*5, nuclear power plant*6, FUP, FDE
	Biodiversity	Protection and revival of waters-edge ecosystems, recovering small rivers as firefly habitats, combatting desertification*7, artificial fish reefs*C
De-velop-ing county growth and aid	Poverty	Growth management*8, access to clean water and adequate health facilities*9 profit restoration of development to public, development of irrigation and restoration of depleted farmland*10, CD, AFGR
	Population expansion	Public consensus, GM, ATC, DIRRF, AFGR, CD
	ODA	GM, Environmental ODA,
Eco-nomic growth etc.	Policy factor	Development plan, public investment, GM, recycling plan 21*11, eco-community, assessment of efficiency of public investment at present time*12
	Industrial factor	Management of symbiosis, inverse manufacturing
	Shortage of resources	Aggregate recycling, asphalt recycling, rerolled bars, IBSEP, AMSA, AFGR, recycled water
	Shortage of energy	Energy conservation, Cogeneration system, district heating and cooling (DHC), RE, NP, FUP, FDE, PGCRI, IBSEP

Note: As follows by abbreviation *1: FUP, *2: FDE, *4: PGCRI, *5: NP, *6: RE, *7: CD, *8: GM, *9: ATC, *10: DIRRF, *A*: IBSEP, *B: AMSA, *C: AFGR, 11: By the Ministry of Construction, Japan, *12: Hokkaido prefecture government in Japan

3.2.2 Tentative evaluation of environment procedures

Study items and evaluation of each case are shown in Table 3 by referring to evaluation items in ISO 14000 and so on. The evaluation criteria of each item is 0 to 3. The maximum evaluation, which means it is systematically applied, is 3. Each item is assumed to have been equally weighted in this tentative study.

Table 3 Items of study and evaluation of each case

Case study		①	②	③	④	⑤	⑥	⑦
Items of evaluation	1. Development of environmental management system	2	1	1	2	2	1	1
	2. Maintenance of guidelines for environmental auditing	2	1	1	2	2	1	1
	3. Enactment of environmental labelling	1	1	1	1	1	1	1
	4. Study of environmental performance evaluation (biodiversity 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
Overall 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 consideration

3.2.3 Efficiency of environment procedures

In order to evaluate effect of environment procedures, the effect of environmental procedure (P) in civil engineering technique is given as Equation[1].

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

Where A_i : weighting applied to evaluation

X_i : evaluation of procedure (systematic enforcement : 3, enforcement : 2, Confirming necessity of enforcement : 1, Not confirming necessity of enforcement : 0)

Besides, limited conditions which are i) securing demands by regulations even if at lowest, ii) possible realization procedure at the present and so on are existing. If the procedure which each evaluation point is large as possible in limited conditions such as regulation, weighting and economic condition saying later, P_{max} can be obtained.

Total cost : C to require for environmental procedures is defined as Equation[2].

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

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

Wi : cost of a procedure (total, unit price, and so on)

C_{max} is the limitation cost from budget, even if another procedure expected large effect is capable. As a suitable effect level, C_{min} is naturally demanded.

Therefore the efficiency of civil engineering to environmental procedure is defined as

Equation[3].

$$\text{Efficiency}: E=P/C \cdots\cdots\cdots\cdots \text{Equation (3)}$$

The good efficiency procedures to environment are sustainable, or course. At all times, the efficiency or civil engineering techniques to global environment and sustainable environment must be examined. And their efficiency must be high level.

3.2.4 Evaluation of case study

As a case study, ① in Table 3 , how the thickness of an existing airport apron pavement can be increased without wasting concrete was examined. Three cases were studied, as shown in Table 5. And the calculation of cost C of environment procedure is shown in Table 5. The study of environmental performance is shown in Table 7. The life cycle assessment in case study ① is shown in Table 6. The evaluation of case study in ① of each procedure is shown in Table 8. The effect of environmental procedure of cost (P/C) and cost per rate (¥/rate) is shown in Table 6. The effect of environmental procedure of cost (T/C) and cost per rate (¥/rate) is shown in Fig. 5.

According to the results, case a is the most efficient procedure. Procedure method a is sustainable under these conditions.

Table 4 Calculation of cost : C of environment measure
(Construction area : 18000m², Volume of solid concrete waste : 18000m²×0.32m=5760m³
Y : Constant of a unit money)

Case study	a	b	c
Procedure method	Increasing depth by adding new concrete old plate to concrete plate	Dismantling & removing old concrete plate, and replacing with new concrete plate using recycled aggregate from solid concrete waste to road bed material	Dismantling & removing old concreteplate, and replacing with newconcrete plate using normal aggregate to road bed material
Cost of removing solid concrete waste	–	¥3.5Y/m³	¥3.5Y/m³
Aggregate[1] (road bed material)	–	(Recycling aggregate from solid concrete waste) ¥1.5Y/m³	(Normal aggregate) ¥2.8Y/m³
Aggregate 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
Subtotal 2	¥108,000Y (¥6000×18000m²)	¥360,000Y (¥20000×18000m²)	¥360,000Y (¥20000×18000m²)
Total	¥108,000Y	¥400,320Y	¥413,568Y

1), 2) : Using road bed material

Table 5 Life-cycle assessment in case study ①

Life cycle assessment (Aiming at discharge to environment, especially during construction cycle)	Case		
	① a	① b	① c
Amount of raw material and energy saved	3	2	1
Waste saved per completion	3	2	1
High rate of recycling	3	3	1
Average (rounded off)	3	2	1

Table 6 Life-cycle assessment in case study ①

Life cycle assessment (Aiming at discharge to environment, especially during construction cycle)	Case		
	① a	① b	① c
Controlling discharge to the air (dust particle)	3	2	2
Controlling discharge to water (diry water)	3	2	1
Controlling solid waste	3	2	1
Controlling others (noise and vibration pollution)	2	1	1
Average (rounded off)	3	2	1

Table 7 Evaluation of case of study ① to each procedured method

Case study		① a	① b	① c
Evaluation Items	1. Development of environmental management system	2	2	2
	2. Maintenance of guidelines for environmental auditing	2	2	2
	3. Enactment of environment labelling	1	1	1
	4. Study of environmental performance evaluation (biodiversity evaluation)	2	1	1
	5. Life-cycle assessment	3	2	1
	6. Study of environmental aspects in product standards	1	1	1
Overall evaluation		11	9	8

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

Table 8 Effect of environmental procedure on cost (T/C) and cost per rate (¥/rate)

Case	Effect of environmental procedure on 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

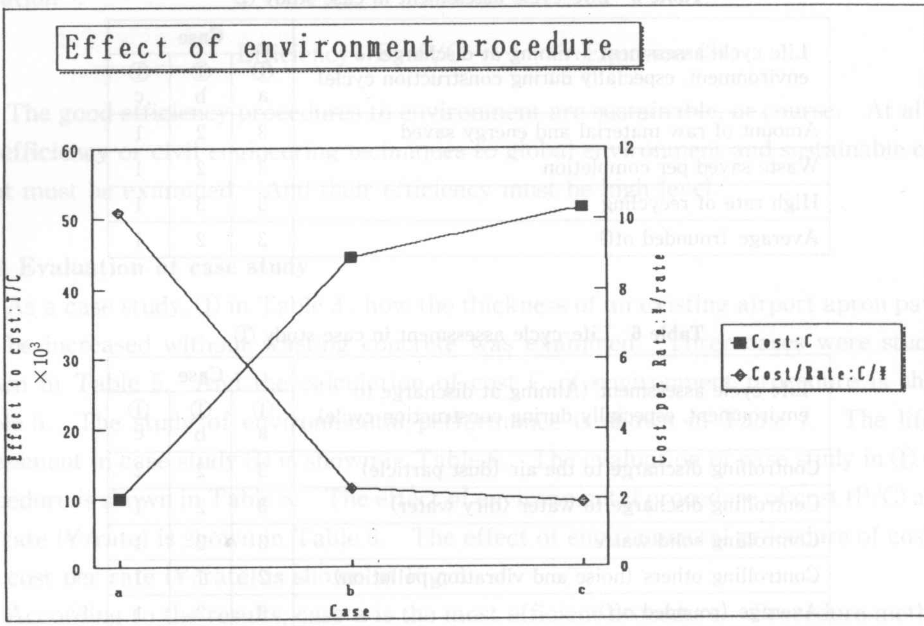

Fig. 5 Effect of environmental procedures on cost (T/C) and cost per rate (¥/rate)

4. Conclusion

The following conclusion can be drawn from the study of evaluation of civil engineering techique to global environment procedure.

1) It should be ensured that infrastructure is developed in an environmentally sensitive manner and that measures are taken to preserve nature. So it is important to understand the politics, civilization, society, national character, and present level of economic development in each country and each region, and the present state of their infrastructure, as well as to provide technical and economic assistance that allows local people to operate autonomously. It would be a good idea to request and appeal to high-level NGOs with good local and international connections to play roles and to provide them with financial assistance to carry out the tasks. When technical assistance is provided from overseas for global environment, it is important to accurately evaluate the local conditions and problems, as well as the needs of local people. We think that carrying these out in an appropriate manner with proper explanation, planning, and participation of the inhabitants is the key to successfully providing aid.

2) The evaluation on the efficiency of the measurement for doing well both in global environment measures and sustainable development is needed at each step of civil engineering, which are planning, design, construction, maintenance & management and dismantling by appropriate method and rational mathematical method because they are interactive relation in each issue.

3) The effect of environmental procedures: P in civil engineering technique is given by evaluation points and weighting applied to each evaluation, besides limited conditions which are demands secured by legulations even if at lowest, possible realization procedure at the present, cost C within the budget and so on are existing. The efficiency: P/C of civil engineering techniques for global environment and sustainable environment must be examined and promoted to a high level.

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