

## ENVIRONMENTAL IMPACT OF RIVER CROSSINGS BRIDGES FOR TYPE SELECTION

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### 1. Introduction

Construction of infrastructures causes depletion of natural resources and emission of CO<sub>2</sub>. This paper discusses about the consideration of environmental impact due to construction of bridges in river crossings. A bridge type selection system has been prepared to consider environmental impact of various types of bridges in preliminary selection process. Environmental impact is considered as one of the selection factors in addition to (1) Cost, (2) Driving comfort, and (3) Landscape or aesthetics of the bridge.

### 2. Bridge Type Selection System

The input data of the system are : bridge geometry and soil conditions and so on [5]. The present version of extended system is using a personal computer. The knowledge base of the system has rules from design specifications used in Japan such as River Crossing Structure Law (1974) [4] and Specifications for Highway Bridges (1984) [3], in addition to heuristic rules taken directly from the design experts.

The system displays a number of candidate bridge types with different span arrangements of suitable superstructure and substructure types. It gives the estimated costs of superstructure and substructure. The estimation of the cost is carried out by the system according to the chart information of design manuals used in the preliminary stage.

The system also evaluates driving comfort and landscape of the candidate bridges. Driving comfort is evaluated using the vibration and the obstruction of view felt by the driver. The landscape of the candidate bridges are evaluated by assigning scores to each bridge type according to its harmony with the surrounding environment.

### 3. Environmental Impact of Bridges

New part has been added to the system for the evaluation of environmental impacts. Two indicators have been used to measure the environmental impacts: (1) the amount of consumed energy(kcal), and (2) the CO<sub>2</sub> emission (tons of equivalent coal) during the bridge construction stage. The consumed energy and CO<sub>2</sub> emission are estimated by first calculating the amount of materials and construction equipment's fuel. Then these values are multiplied by the unit impact values of consumed energy (kcal/unit) and emission of CO<sub>2</sub> (tons/unit). The unit impact values in this research were found using input-output table [6].

In the case of concrete component, the environmental impact is calculated for the materials of concrete, reinforcement bars, pre-stressing cables, and molds. For the case of steel component, the environmental impact of different types of steel are calculated. By considering these materials, more than 90% of environmental impacts of materials is evaluated [6]. The statistical data of previous concrete bridges are used to find the concrete volume [1], and approximated to a polynomial equation of the third order using least square method. The weight of steel in steel bridges is calculated using an approximation equation [5]. The equipment used in each construction stage is found by interviewing a number of bridge engineers and using previous data [2]. The movable equipment is assumed to be powered by electric power generators, and its environmental impact is taken into account by calculating the impact of fuel used for generators. Fig. 1 shows the components of environmental impact of a bridge.

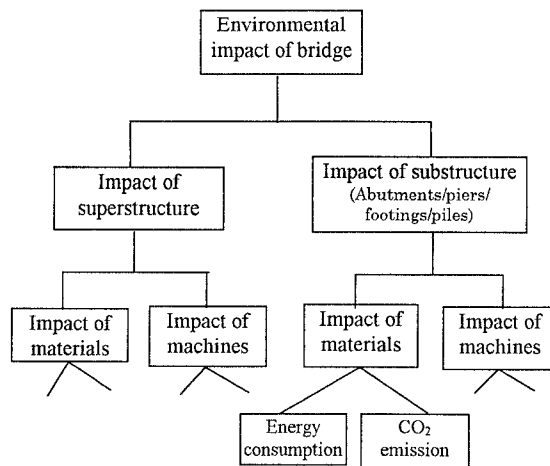


Fig. 1 Components of Environmental Impacts of a Bridge

#### 3.1 Comparison of Environmental Impact by Materials and Machines

Figure 2 shows the proportion of environmental impact of materials and machines in superstructures and substructure in the case of steel simple non-composite I girder bridge and steel simple non-composite box girder bridge. Both examples

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are taken for a bridge length of 135 m with three equal spans. The width of the bridge is 12m. In both cases the environmental impact of machine is relatively smaller than the impact by the materials used. It has been found that the portion of environmental impact caused by the construction equipment is less than 5% of total impact. This is why the bridge having more cost will also have more environmental impact. The reason is that larger the volume or weight of materials, more will be the cost of the bridge, consequently greater environmental impact.

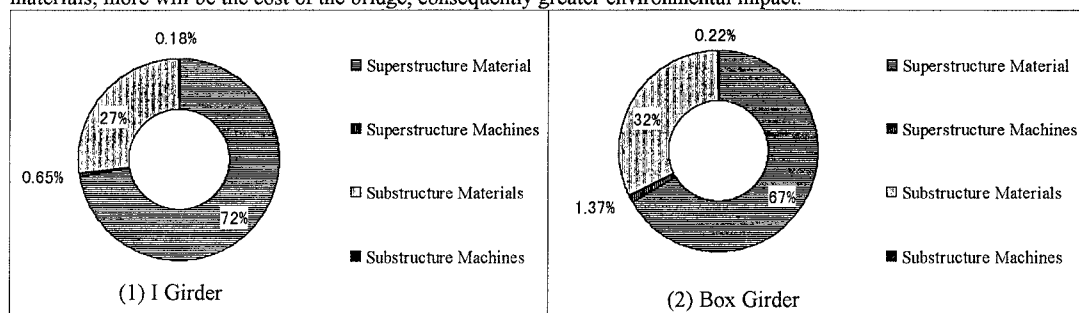
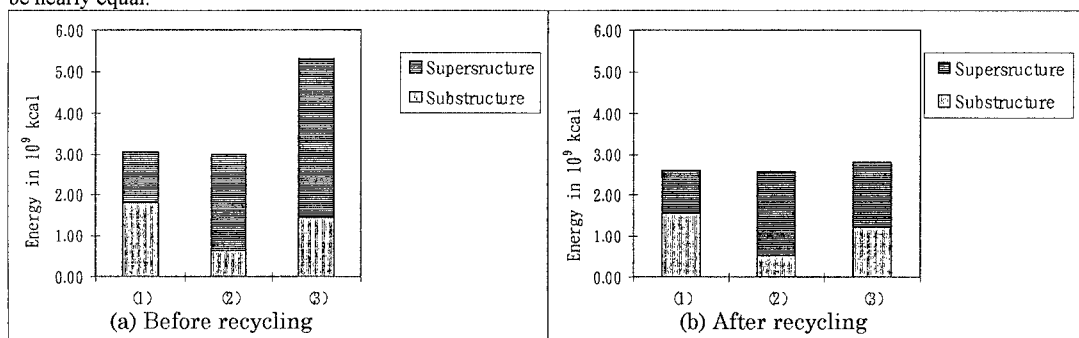


Fig. 2 Proportion of Environmental Impact of Materials and Machines in Steel Simple Girder Bridges

### 3.2 Reduction of Environmental Impact by Recycling

Steels of steel bridges can be recycled with a ratio of 95% [6], however, recycled steel is not used at present. Recycled steel can be used instead of virgin iron extracted from mines, which results in about 60% energy saving resulting reduction in environmental impact. Concrete can be recycled as aggregate for new concrete and materials for road basement. Recycling of concrete can reduce up to 14% of environmental impact of new concrete. Figure 3 shows the effect of recycling on environmental impact. It is assumed that the environmental impact is reduced by 60% and 14% in the case of steel and concrete respectively. It can be observed that after recycling the impact of steel and concrete bridges comes out to be nearly equal.



(1) PC Simple Pre-Tensioned Girder Bridge (2) PC Simple Box Girder Bridge (3) Steel Simple Non-Composite Box Girder Bridge

Fig. 3 Effect of Recycling on Environmental Impact

### 4. Conclusion

A system for calculation of environmental impact has been developed as one of the selection factors of bridge type selection. The environmental impact of materials used in the construction is much more than that of the construction equipment. Recycling of materials can reduce the environmental impact at greater extent.

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