Lifecycle assessment considering longevity of bridge

S.Tsubouchi, Y. Itoh, & I.T.Kim
Nagoya University, Nagoya, Japan

ABSTRACT: The interest of the environmental problem has been increased world widely, it is required to reduce the environmental impact. And it is also recommended that civil engineers should pay attention to not only lifecycle cost (LCC) but also lifecycle CO_2 emission ($LCCO_2$) of civil infrastructures. In this study, the lifecycle assessment (LCA) were performed on newly developed types and conventional types of bridges, and compared with each other.

Since the service life of bridge had been set about 60 years in Japan. In 2002, the Specifications for Japan Highway Bridge (2002) recommends that the service life of constructions is 100 years. For this reason, the service life of bridge is set 100 years in this study.

In LCA, three types of bridges, I-girder bridge, box-girder bridge and truss bridge constructed in the mountain areas, are considered. It is also assumed that the bridges have the same width of 10.5m and the same span allotment. In this study, the bridge lifecycle contains the construction, maintenance and replacement stages. Therefore, the lifecycle environmental impact and cost can be calculated by summing the corresponding content in each stage. In the maintenance stage, five components of the bridge; the deck, painting, bearing, expansion joint and pavement, are considered for the lifecycle evaluation of the bridge. The service life of these components are defined as that, each component are replaced as soon as facing their service lives and it is assumed that the exchange of them is continued with a fixed life period until the end of the service life of the bridge.

Estimations of costs and environmental impacts from maintenance activities of those bridge components are difficult for the time being and the values used in this study are abstracted from the previous literature (JASBC 2001 & 2003) and interview with the practical bridge engineers. Figure 1 shows the comparison of the $LCCO_2$ between a conventional and a rationalized truss bridge, divided by area of deck and written in dimensionless form. The vertical axis of Figure 1 represent the relative values by taking the CO_2 emission of conventional bridge at the construction stage as one. Reference span length of the conventional truss bridge is 60m. The $LCCO_2$ of the new type is much less than that of the conventional bridges. At 100 years after construction, the index of the new type is reduced by 30% compared with that of the conventional type. In the proportion of the $LCCO_2$ during 100 years shown in Figure 2, it can be seen that the $LCCO_2$ during maintenance stage of the new truss bridge is reduced by about 27% as compared with that of the conventional bridge. As a result, the whole $LCCO_2$ at 100 years is reduced by 30%.

Figures 3 and 4 show the results of LCC and $LCCO_2$ during the 100 years after construction versus span length for the three types of bridges, ... es represents the res... by the CO_2 emission and cost of conventional I-girder bridg... which is 3... e 3, when the span length ... or slightly ... is said that no significant e... observed.

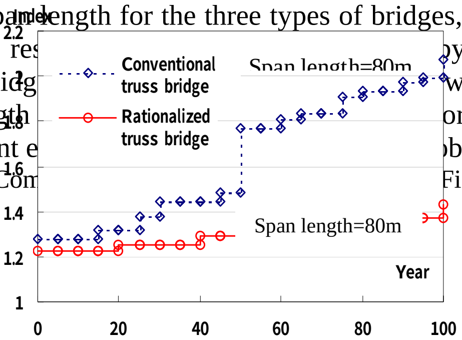

Figure 1 Com...

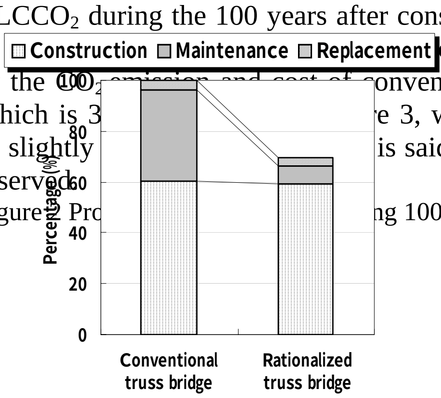

Figure 2 Pro... ng 100 years

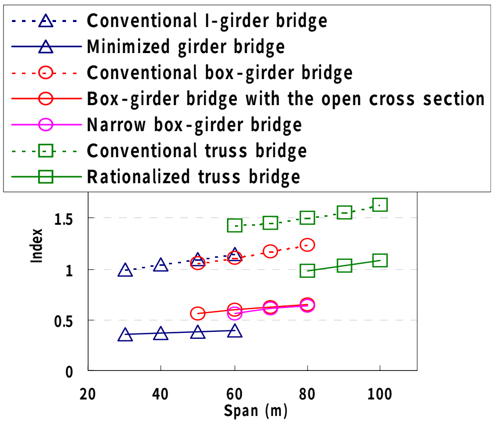

Figure 3 LCC versus span length

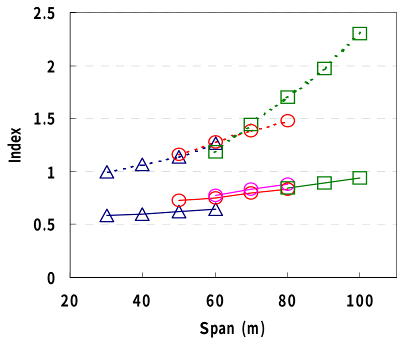

Figure 4 $LCCO_2$ versus span length

From Figure 4, it can be seen that the increase in $LCCO_2$ of the conventional bridges according to the span length is larger than that of the newly developed bridges. So, it is assumed that $LCCO_2$ of the conventional bridge depends on span length, but that of the newly developed bridges is independent on the span length.

In this study, both the conventional and the newly developed types of bridges in Japan were applied to the lifecycle assessment. Three types of bridge, I-girder, box-girder and truss bridges, were taken into consideration. The following conclusions are obtained:

1) The LCC and $LCCO_2$ of the three bridge types were calculated, and those for conventional and newly developed bridges were compared with each other.
2) The LCC and $LCCO_2$ of the new types of bridges are less than those of the conventional bridges. The LCC and $LCCO_2$ of the newly developed truss bridge at 100 years after construction are reduced by 35% and 30% respectively, as compared with those of the conventional truss bridge. The reduction of the whole LCC and $LCCO_2$ of the bridges is due to the maintenance stage of the bridge.
3) The $LCCO_2$ of the conventional bridge depends on the span length, but no significant effect of the span length on LCC and $LCCO_2$ of the newly developed bridges was observed.

REFERENCES

Japan Association Steel Bridge Construction (JASBC). 2001. *Book of design data*: Tokyo.

Japan Association Steel Bridge Construction (JASBC). 2003. *Produce a new type of steel bridge Ⅱ*: Tokyo.