

## **ESTIMATION OF IN-USE STOCK AND FUTURE DEMAND OF STEEL FOR WORLD RAILWAY**

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### **ABSTRACT**

In recent years, the construction of a sustainable society has been promoted from the view point of environmental protection and conservation of natural resources. Steel is the most widely used metal in the world, and numerous studies have investigated its flow and stock. However, the flow of steel for world railways has not been investigated. Although railways have been minor products for steel use, but have influence on the use of vehicles, major products for steel. So we estimated in-use stock and future demand of steel for world railways during 1980-2010. As a result, the in-use steel stock for railway vehicles and tracks in the 58 countries was estimated as 47 and 100 million ton in 2010, respectively.

### **INTRODUCTION**

In recent years, the construction of a sustainable society is being promoted from the view point of environmental protection and conservation of natural resources. Therefore, it is necessary to use the in-use stock as secondary resources. Steel is the most widely used metal in the world, so it is important to estimate the flow and the amount of steel in the society.

Material flow analysis (MFA) is a method to calculate the flow and stock of materials in a society, which has been applied to various materials (e.g., Hirato, et al., 2009; Spatari, et al., 2005; Johnson, et al., 2005). The method used for estimating material stocks in a society can be divided into two types: the top-down approach and the bottom-up approach. The top-down approach is a method used to calculate material stocks by using annual time series statistical data for material consumption, trade of materials and lifetime distributions of end-use products in a society. On the other hand, the bottom-up approach is used when the top-down approach cannot be used due to a lack of data. In the bottom-up approach, the number of products within a specified boundary is quantified. Then, the material use intensities of the products are multiplied by the number of products to give an estimate of material stocks (Hirato, et al., 2009).

Hatayama et al. (2010) classified the end uses of steel into 8, i.e. civil engineering, building, electrical appliances, machinery, vehicles, shipbuilding, containers and packaging and other, and estimated in-use stock of steel for each end use. However, in their study, railway vehicles



and tracks were included in machinery, and not investigated in detail. In addition, their study was mainly intended in developed countries.

Railway vehicles and tracks have long life, and many countries developed the railway in the early stages of their economic development to distribute commodities. Therefore, the flow and stock of steels for railways were of interest, especially, in developing countries. So, in this study, we estimated in-use stock and future demand of steel for railway in 58 countries of the world

## **MATERIALS AND METHODS**

In this study, we used the bottom-up approach to estimate the in-use steel stock of railways. We obtained chronological data for the use of tracks and railway vehicles, i.e. passenger carriages and freight cars, and the data about the steel use intensity for those products. The former data of 58 countries during 1980-2010 was obtained from International Union of Railways; the latter data of Japan was obtained and applied to the other 57 countries.

Passenger carriages consist of body, bogie, electrical parts, and equipment and others. It was assumed that only body and bogie contain steel. The body is made of common steel, stainless steel, or aluminum, and also the amount of steel used for the body is different. The ratio of common steel, stainless steel, and aluminum body in 2007 in Japan was obtained, and was applied to other 57 countries for the entire study range.

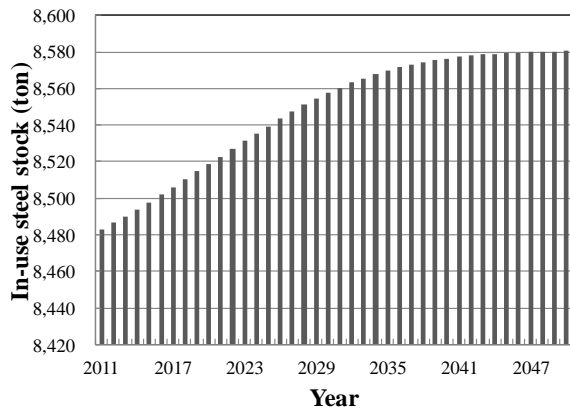
We also assumed freight cars to be entirely made of steel. The weight of a Japanese freight car was obtained, and was applied to other 57 countries.

Tracks consist of rail, crosstie, and pavement. It was assumed that only rail contains steel. In Japan, rails are standardized by the weight per unit length. So we obtained the steel use intensity for tracks in Japan, and applied the data to other 57 countries.

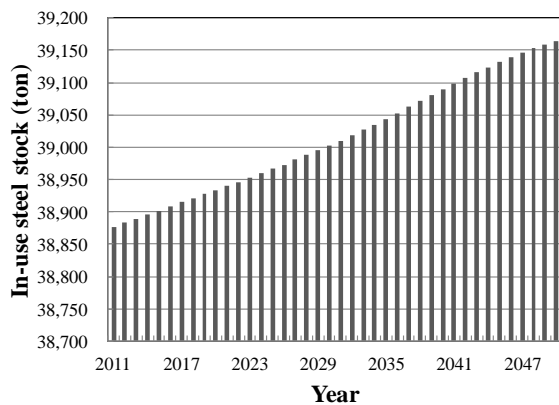
We divided 58 countries into two groups. The first group comprised of countries whose quantity of in-use steel had its maximum value in 2010; whereas, the second group was made up of countries whose quantity of in-use steel stocks did not have its maximum value in 2010. And then, we estimated the future demand of steel under the assumption that the in-use steel stocks of the first group will increase according to logistic curves respectively, and those of the second group will keep at the value of 2010.

## **RESULTS AND DISCUSSION**

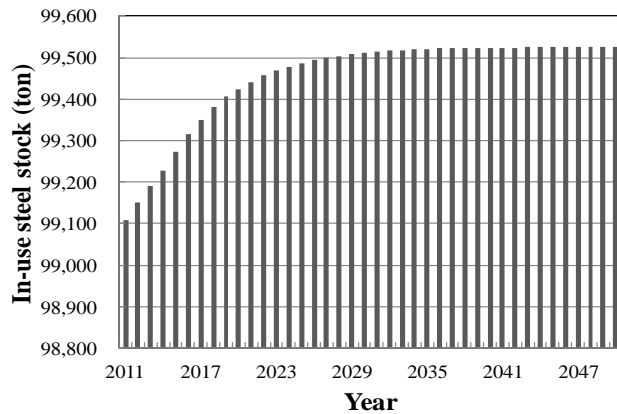
Figures 1, 2, and 3 show the in-use steel stock for railways, i.e. passenger carriages, freight cars and tracks. The in-use steel stock for passenger carriages, freight cars, and tracks in the 58 countries was estimated as 8.48, 38.9, and 99.0 million ton in 2010, and 8.58, 39.2, 99.5 million ton in 2050, respectively.



**Fig. 1** In-use steel stock for passenger carriages in the world



**Fig. 2** In-use steel stock for freight cars in the world



**Fig. 3** In-use steel stock for tracks in the world

The future demand of steel for passenger carriages, freight cars, and tracks in the 58 countries was estimated as 2.46, 2.04, and 5.30 million ton in 2050, respectively. The future demand of steel for passenger carriages is expected to reach its maximum in 2033, and then decrease. This is because most of the demand is caused by replacement of old stocks. The future demand of steel for freight cars and tracks will also reach maximum in a specific year, and then decreases for the same reason.

## CONCLUSIONS

In this study, we estimated the in-use stock and future demand of steel for world railway in 58 countries during 1980-2050. It was estimated that the in-use stock in 2010 was 146 million ton, and the future demand in 2050 was 7.26 million ton.

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