Case Study of Environmental Impact Analysis for Railroad Construction Project by Using Life Cycle Assessment Method

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***Abstract*—LCA (Life Cycle Assessment) method was applied to a line of Korean High-speed Railroad construction site in this study. The portion of environment was larger with this investigated site than other sites. Detailed design specification and event breakdown system construction cost analysis program was used to assess the required amount of major construction materials and heavy equipment energy consumption. The environmental impact for 1 km was analyzed. The obtained results will be used for the prediction of environmental impact for project, the selection of environmentally-friendly construction method, and the comparison of environmental impact for major materials.**

Keywords-life cycle assessment; railroad construction; environmental impact, eco-friendly

I Introduction

The earth is facing a wide threat due to the abnormal climate change caused by the destruction of environment which was initiated by the development and economic growth. For this reason, the reduction of life-cycle environmental impact of a product from the production to waste is getting more important worldwide. Especially, the life-cycle environmental impact of a construction material is very important, and the life-cycle assessment method is widely used to evaluate the environmental load. By using this method, we can induce the promotion of environmentally-friendly construction method.

In this study, a life-cycle assessment method was applied to analyze the environmental impact of construction site with earth work, bridge construction work, and tunnel construction work. These results will be useful for the prediction of environmental load for each construction work, the selection of more environmentally-friendly work, and the comparison of environmental load for major construction materials.

II LCA Assessment

A line of Korean high-speed rail construction site was chosen as the target site to assess the environmental load for each construction works. The amount of main construction materials used and the energy consumption from heavy equipment were used as the input data. Detailed design specification, EBS, construction work cost analysis, and table of main construction material used were also needed. The amount of main construction materials used and the energy consumption from heavy equipment were calculated by the method described in Fig. 1. The boundary of the system includes the material production, material processing, material transport, and the amount of main construction materials used and the energy consumption from heavy equipment as presented in Fig. 2. The recycle and waste step was excluded from this analysis.

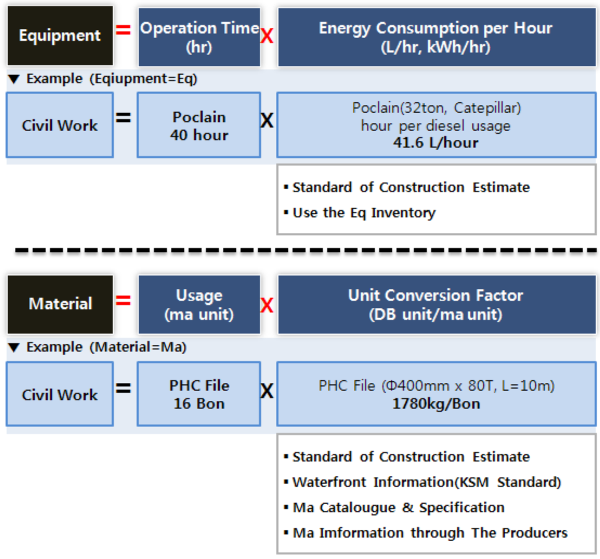

Fig.1: Calculation method of the energy consumption and the use of material

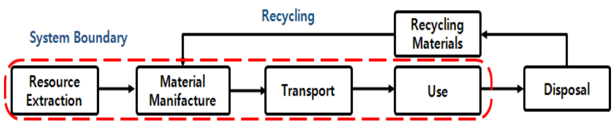

Fig.2: System boundary of Construction Process

III Results and Discussions

The environmental load for the construction of 1 km high-speed railroad was 2.30E+03. As presented in Table 1 and Fig. 3, the earth engineering work has the highest environmental load of 2.05E+03 (89%), while track work, construction work, and electric work have environmental load of 1.62E+02 (7%), 4.22E+01 (2%), and 4.32E+01 (2%), respectively. The amount of major materials needed and energy consumption per 1 km of railroad construction work was calculated, and presented in Table 2. This data can be used for the prediction of environmental impact from the construction of railroad.

TABLE 1: RESULTS OF ENVIRONMENTAL IMPACT ASSESSMENT IN CONSTRUCTION SECTOR

Impact Category	Results (Person·year/f.u)				
	Civil	Track	Architecture	Electricity	Total
Abiotic Resources Depletion (ARD)	5.08.E+02 (88%)	4.28.E+01 (7%)	1.55.E+01 (3%)	1.32.E+01 (2%)	5.79.E+02 (25%)
Acidification (AD)	3.11.E+01 (57%)	2.43.E+00 (4%)	4.67.E+00 (9%)	1.61.E+01 (30%)	5.43.E+01 (2%)
Eutrophication (EU)	1.26.E+01 (70%)	9.35.E-01 (5%)	1.07.E+00 (6%)	3.42.E+00 (19%)	1.81.E+01 (1%)
Global Warming (GW)	1.11.E+03 (92%)	7.69.E+01 (6%)	1.66.E+01 (1%)	4.73.E+00 (0.4%)	1.20.E+03 (52%)
Ozone Depletion (OD)	9.52.E+00 (91%)	8.98.E-01 (9%)	6.55.E-02 (1%)	3.27.E-02 (0.3%)	1.05.E+01 (0.5%)
Photochemical Oxidant Creation (POC)	1.53.E+02 (87%)	1.75.E+01 (10%)	2.15.E+00 (1%)	3.90.E+00 (2%)	1.77.E+02 (8%)
Human Toxicity (HT)	1.47.E+02 (90%)	1.30.E+01 (8%)	1.03.E+00 (1%)	1.37.E+00 (1%)	1.62.E+02 (7%)
Terrestrial Eco-toxicity (TET)	8.10.E+01 (90%)	7.98.E+00 (9%)	1.06.E+00 (1%)	4.17.E-01 (0.5%)	9.05.E+01 (4%)

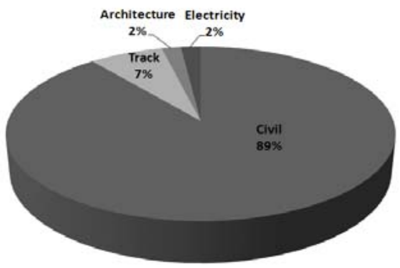

Fig.3: Contribution to environmental impact

TABLE 2: RESULTS OF MATERIAL USE PER 1 KM OF RAILROAD CONSTRUCTION IN CIVIL SECTOR

Field	Material	Amount
Earthwork	Remicon	5,383 m^3
	Steel	235,310 kg
	Steel Plates	0 ton
	Cement	1,722 ton
	Portland Cement	2,154 kg
	Diesel	673 kg
Bridge	Remicon	37,214 m^3
	Steel	5,545,650 kg
	Steel Plates	587 ton
	Cement	11,084 ton
	Portland Cement	791 kg
	Diesel	869 kg
Tunnel	Remicon	28,035 m^3
	Steel	1,387,470 kg
	Steel Plates	116 ton
	Cement	11,587 ton
	Portland Cement	564 kg
	Diesel	606 kg

TABLE 3: IMPACT ASSESSMENT OF LCA IN EACH CONSTRUCTION

Impact Category	Earthwork			Bridge			Tunnel		
	C	N	W	C	N	W	C	N	W
Abiotic Resources Depletion	1.06E+04	4.26E+02	9.83E+01	7.65E+04	3.07E+03	7.09E+02	6.03E+04	2.42E+03	5.59E+02
Acidification	6.25E+03	1.57E+02	5.65E+00	4.92E+04	1.24E+03	4.45E+01	3.65E+04	9.17E+02	3.30E+01
Eutrophication	7.90E+02	6.03E+01	2.29E+00	6.22E+03	4.75E+02	1.80E+01	4.67E+03	3.56E+02	1.35E+01
Global Warming	4.09E+06	7.40E+02	2.13E+02	2.92E+07	5.29E+03	1.52E+03	2.42E+07	4.38E+03	1.26E+03
Ozone Depletion	2.62E-01	6.45E+00	1.88E+00	1.85E+00	4.55E+01	1.33E+01	1.45E+00	3.57E+01	1.04E+01
Photochemical Oxidant Creation	4.93E+03	4.78E+02	3.11E+01	3.42E+04	3.32E+03	2.16E+02	2.57E+04	2.50E+03	1.62E+02
Human Toxicity	4.06E+05	2.74E+02	2.88E+01	2.88E+06	1.94E+03	2.04E+02	2.28E+06	1.54E+03	1.62E+02
Terrestrial Eco-toxicity	1.19E+02	7.28E+01	1.57E+01	8.66E+02	5.31E+02	1.15E+02	6.51E+02	3.99E+02	8.62E+01
Total	4.52E+06	2.21E+03	3.97E+02	3.23E+07	1.59E+04	2.84E+03	2.67E+07	1.25E+04	2.29E+03

IV CONCLUSION

The environmental loads during earth work, bridge work, and tunnel work during the 1 km of railroad construction work were analyzed in order to predict and compare the environmental impact of each work. The results showed that all works has a significant impact on global warming, the exhaustion of natural resources, and industrial or chemical oxidant. In addition, the total environmental loads were 2.84E+03, 2.29E+03, and 3.97E+02 for bridge work, tunnel work, and earth work, respectively.

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