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Technical Note Report

ENVIRONMENTAL LOAD REDUCTION AND ENVIRONMENTAL IMPACT ASSESSMENT OF RAILWAY CONSTRUCTION PROJECTS

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Abstract

Environmental impact assessment is an important means of environmental conservation, however, there is no environmental impact statement (EIS) on railway construction projects presented from the viewpoint of environmental load reduction. This paper discusses environmental load reduction, environmental consideration and the contents of EIS for railway projects. In conclusion, it is found that (1) existing EIS fail to refer to environmental load reduction; (2) design, production and systems with eco-materials that consider the environment and are useful for building up environmentally sustainable transport are adopted more effectively and extensively than ever; (3) environmental load reduction is described in the EIS.

KEYWORDS: *environmental consideration, environmental impact assessment, environmental load, environmentally sustainable transport, railway*

1. Introduction

The railway system is considered to be a transportation method that entails low energy consumption per unit transport volume and low environmental load in terms of CO_2 and air pollutants; however, there is still room for its enhancement as a more environment-friendly and sustainable mode of transport. Environmental impact assessment (EIA) is an important means of environmental conservation. The environmental impact statements (EIS) on railway construction projects published in Japan and abroad stress the importance of the natural environment such as ecosystems and the physical environment comprising noise and vibration, although there are no EIS prepared from the viewpoint of environmentally sustainable transport (EST).

The primary objective of this study is to show the environmental considerations necessary for EST in railway construction projects, and to verify that the railway can be further enhanced as an EST. The second objective of this study is to identify the requirements of EIA related to environmentally sustainable railways.

First, case studies are carried out on EIA related to railway construction projects as well as on environmental considerations in various individual projects such as energy-saving railcars. Second,

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environmental considerations related to material recycling, water recycling and environmental load reduction that are applicable to railway systems are extracted. Finally, it is elucidated that the adoption of these environmental considerations into EIA can help build up EST.

2. Methodology

2.1 Case studies on EIA

In the first stage, existing reports are collected to comprehend the contents and level of environmental considerations useful for building up EST that appears in existing EIS related to railway construction projects. These reports comprise EIS and initial environmental examination (IEE), both the full text of EIS and summaries. The contents of the projects include both new line construction and improvement works. A total of 15 cases are classified into four railway systems: inter-city railways of 100km length or more, urban railway systems, monorail systems, and automated guideway transit (AGT). The 15 projects have been implemented in 5 countries: Japan, China, the Philippines, India and Bangladesh.

In the second stage, from among the 15 cases, the full text of EIS related to inter-city railways (2 cases) and the IEE in the feasibility study of AGT (1 case) are selected, and their contents are analyzed. It is for this reason that selected EIS on inter-city railways are in the full text, and AGT is a transport system for the purpose of the modal shift from automobiles to railways.

2.2 Case studies on environmental considerations

Practical environmental considerations useful for the enhancement of infrastructures of EST, including those at the study and trial stage are studied. The cases applicable to the railway service are introduced, while those applicable only during the construction period are excluded.

3. Result of case studies

3.1 Result of case studies on EIA

(1) EIA related to inter-city railway

This railway is constructed as part of the nationwide railway network development plan, with a view to enhance transport capacity as well as to promote economic development and eliminate poverty in the area along the line, which is located inland. The planned line is a single-track electrified railway with a length of 628 km that starts at a metropolis and terminates at a local city. Approximately sixty stations and one depot are constructed. Except for the cities at both ends, the line mostly runs through mountainous area, hence many tunnels (35%) and bridges (10%). According to the long term operation plan, 34 passenger trains composed of 18 cars and 22 freight trains, i.e., total 56 trains, are planned for operation in one direction. The train speed is 120km/h for passenger trains and 40km/h for freight trains. The metropolis at the starting point is located in the basin of a large river with heavy and chemical industries. The area between the two cities has many rivers, both large and small, and mining industries of coal, iron ore, lead, tin and natural gas as well as

agricultural production of grain and fruit.

In this country, prevention acts against air pollution, water pollution and noise, ordinances on solid waste disposal, and environmental impact assessment system for construction projects are laid down under the Environmental Protection Law, which is the fundamental law. Environmental quality standards, emission standards and environment-related industrial standards are also defined. The country, therefore, has a well-established environmental law system.

In the EIS, flora and fauna, noise, water pollution, air pollution, electromagnetic wave interference and solid wastes are selected as environmental elements that affect the natural and physical environments during construction and after the initiation of the railway service. Current status survey, forecast and evaluation are carried out on these elements, and environmental conservation measures are planned. As for social environment, current status survey and future forecast are carried out on economic development and resource development, population problems, civil life, public facilities, scenery and tourism, and secondary development after the initiation of the railway service.

Special attention is paid to soil erosion, and precious flora and fauna designated by the country are protected, as the railway runs mostly through a mountainous region. Since railway noise exceeds environmental quality standards at many points, the noise problem is solved by implementing one of the following measures: installation of soundproof walls, installation of soundproof windows and air-conditioning systems, and removal of buildings. Water pollution by the depot can be prevented as the volume of water discharge is small and the water is discharged after treatment. Air pollution due to shunting diesel locomotive engines is only local and the amount of exhausts is limited, and electromagnetic waves cause little interference; therefore, both problems can be solved with appropriate measures. The disposal of non-industrial wastes from trains and stations and low quantities of industrial waste from the depot are intensively controlled by the railway company or consigned to the local government. In the statement, the volume of energy consumption is presented as an item related to environment load reduction, but there is no mention of the amount of CO_2 emission.

(2) EIA related to inter-city railway

This line is a double track electrified railway with a length of 362 km, and is a standard gauge super high-speed railway. Main structures consist of cuttings, embankments, viaducts and tunnels. The standard railway structures are reinforced concrete rigid-frame viaducts. Tunnels are bored by NATM (New Austrian Tunneling Method). The whole track is constructed in 10 years; the major processes include 3 years of survey and land purchase, 6 years of roadbed construction, 2 years of electric works and 1 year of test operation.

In this country, Air Pollution Prevention Law, Water Pollution Prevention Law, Noise Control Law, Vibration Control Law, ordinances related to waste disposal, and Environmental Impact Assessment Law are laid down under the Basic Environment Law. Environmental quality standards, emission standards and environment-related industrial standards are also defined. The country, therefore, has a well-established environmental law system.

In the EIS, current status survey, forecast, evaluation and environmental conservation measures are presented with regard to air pollution, noise, vibration, low frequency air vibration, water

pollution, topography, geology, ground subsidence, soil contamination, obstruction to sunshine, electromagnetic wave interference and cultural properties. As to the railway noise, which is the biggest impact, there still remain some uncertainties, as the zoning has not been designated yet. Still, the noise level can be reduced with appropriate measures at points where the noise may exceed the environmental quality standards.

(a) Biodiversity and natural environment: In the EIS, current status survey, forecast, evaluation and environmental conservation measures are presented with regard to flora and fauna and ecosystem. Migration routes are secured and other environmental considerations are given to animals in the area. As 33 important plant species are to be affected in the course of construction, environmental considerations are given to minimize the influence.

(b) Interaction between people and nature: In the EIS, current status survey, forecast, evaluation and environmental conservation measures are presented on scenery and major locations where people come in touch with nature. Forecast on major tourism resources and scenery by photomontage showed that there would be little influence.

(c) Environmental load: In the EIS, forecast, evaluation and environmental conservation measures are presented on construction sludge, concrete blocks and surplus soil waste from construction as the byproducts of the construction works. There is no mention of the amount of CO_2 emission.

(3) IEE related to AGT

This AGT was planned as a transport for access to an international airport. The airport is located 10 km away from the center of the metropolis, and 5km from the business district. The planned line connects the new planned railway station, the airport terminal and the reclaimed land, with a total length of 7.4 km. The construction of the planned line is divided into two stages: the first stage of 5.3 km and the second stage of 2.1 km. In the feasibility study, feasibility of the first stage construction of 5.3 km between the airport terminal and the reclaimed land was studied, and it was reported that this project is feasible. The first 5.3 km is an L-shaped line; the full line except the terminal station and its access area is a viaduct structure. The depot is constructed on the ground near the place where the line makes a right angle. The carriage has six fixed cars with rubber tires; its total length is 54 m.

In this country, projects that require EIA and environmentally vulnerable areas are defined. An EIS for the former projects and an IEE report for the latter have to be submitted as a general rule, though submission of an EIS for projects in environmentally vulnerable areas is admitted. Based on the EIS or the IEE report, a certificate is issued for the projects whose environmental measures are approved as appropriate. Environmental quality standards are also defined. The country, therefore, has a well-established environmental law system on the whole.

This project requires an EIA. However, an IEE was carried out at this feasibility study stage. The result suggests the influence of boring works and land surveys before construction. During construction, influences on vegetation, convenience of roads, noise, vibration, air quality, traffic jams, wastes and water quality are considered, and conservation measures are planned for each. After the initiation of the railway service, effects on noise, vibration, wastes, air quality, scenery, dwellings, commercial infrastructures, transit of citizens, economy and employment are expected, and conservation measures are also planned. Among these factors, positive effect is expected regarding air quality, dwelling and commercial infrastructures and transit of citizens, economy and employment.

With regard to environmental load reduction, CO_2 reduction volume in 2005 is forecast in conjunction with reduced car traffic volume after the initiation of the AGT service.

3.2 Result of case studies on environmental considerations

Results obtained about practical environmental considerations useful for the building of EST are as follows:

(a) Auto-response dimmer glass: Polymeric material solution is encapsulated between two plates of glass. It is normally transparent, but becomes clouded according to set temperature, screens solar radiation and dims light.

(b) Ballast mat: This is a rubber plate that is placed under the ballast track in order to prevent granulation of ballast and to reduce vibration and noise. It is produced from reclaimed rubber of car tires.

(c) Biogas plant: Cattle excreta is processed into manure, and the methane produced in the process is used for electricity and hot water supply. Processing of kitchen refuse is also possible.

(d) Disused tunnels: Tunnels of discontinued railway lines can be reused as storehouses for brewing companies.

(e) Eco-cement: This is manufactured with a mixture of incinerated ashes of municipal waste, sludge and natural filler materials. It is reused as concrete products for civil engineering and construction or as a coagulating agent for ground improvement.

(f) Energy-saving railcars: The amount of energy consumed during train running is reduced by making the railcar lighter, reducing running resistance, adopting regenerative brakes and installing VVVF (variable voltage and variable frequency) inverters.

(g) Environmental management system: This manages the discharge into the air and water systems, wastes, land contamination, use of raw materials and natural resources. Many railway companies have obtained ISO 14001 approval for their inspection, repair and maintenance and production sections.

(h) Highly recyclable railcars: Teito Rapid Transit Authority, for example, reported that it broke up and studied scrapped railcars, and produced highly recyclable railcars based on the study results.

(i) Iron sleepers: Currently a large number of prestressed concrete sleepers are generally used, but it is not clear in what ways they will be disposed when their service life ends. In contrast to them, iron sleepers are easy to recycle.

(j) Kilometer posts: Light and durable plastic wire coating materials are reused for kilometer posts.

(k) Pedestrian crossings: Plastic wire coating materials are melted and molded into railway pedestrian crossings.

(l) Pruned branches and leaves: Pruned branches and leaves of trees planted for slope protection or disaster prevention are used for various purposes: mulching by making them into chips, soil improvement by composting or carbonization, and utilization as fuel by pelletizing. Currently, many trees on the roadside and in parks are processed in this way.

(m) Recycled tiles: Tiles produced from incinerated ashes of used bottles are used to cover station floors.

(n) Regenerative brakes: This is a type of electric brake that uses the main motor as a dynamo and sends back the regeneration electricity to the power line to be used by other railcars. It is one of the

functions of an energy-saving railcar.

(o) Segregated waste disposal: This is applied to both municipal waste from stations and trains and industrial waste generated from the depot repair shops. Here, non-industrial wastes are mainly expected to be reused as paper, metal, glass and thermal resources.

(p) Slab-mat: This is a rubber plate that it placed under a slab track to reduce vibration and noise. It is produced from reclaimed rubber of car tires.

(q) Solar power generation: Solar panels are installed on platform roofs or station building roofs, and the power generated is used for illumination and automatic ticket gates.

(r) Sound absorbing material: Glass wool and rigid-body open-cell glass material are manufactured from recycled materials of flat glass or glass bottles. Styrene foam and magnetic tape are used as recycled sound absorbing materials.

(s) Sound absorbing material on railway track: This is a sound absorbing material that is placed on a slab track. From the incineration ash of domestic waste, melting ashes of residues of high temperature processed nonflammable materials are extracted and granulated for reuse.

(t) Spring water in tunnels: This can be used for agricultural water and drinking water.

(u) Trolley wires: Trolley wires are replaced in a couple of years as they wear out. Displaced copper alloy trolley wires are melted and recycled.

(v) Used commuter tickets: Magnetic commuter tickets and cards are used as a reducing agent in a blast furnace at steelworks.

(w) Used tickets: They are recycled as toilet paper.

4. Discussion

4.1 Case studies on EIA

The results of surveys, as shown in above 3.1(1) to 3.1(3), on natural environment, physical environment and environmental load reduction in the EIA related to railway construction, are summarized in Table 1.

Table 1 shows that (a) impact on the natural and physical environments is regarded as important, (b) with regard to environmental load reduction, there are only some short descriptions on energy consumption and greenhouse gas, and (c) there is no description on material recycling (effective use of resources) and water recycling. The reason for the small number of descriptions is that the railway construction has already been determined at a higher level at the stage of EIS preparation and that the railway is generally recognized as a mass transport system with less environmental load.

Lastly, I would like to briefly mention the current situation of EIA on cases other than those shown in Table 1. I have confirmed that the EIA related to railway constructions in Japan generally lack in descriptions on environmental considerations useful for building up an EST. In Japan, however, the Environmental Impact Assessment Act stipulates greenhouse gases and other environmental factors. Environmental factors related to global environment are thus being selected, and we are making positive progress toward the implementation of meaningful environmental considerations.

Table 1 Summary of the results of case studies on EIA (in service).

Environmental element		Rail-1	Rail-2	AGT	Environmental impact, environmental consideration, etc.
Natural and physical environments	Ecosystem, Flora and fauna	○	○	○	Rail-1 : soil erosion, forest damage, conservation of flora and fauna Rail-2 : migration routes, transplantation AGT : street tree damage, park tree damage
	Railway noise	○	○	○	Rail-1 : noise barrier, air conditioner, removes of building Rail-2 : noise barrier AGT : track maintenance
	Railway vibration	×	○	○	Rail-1 : no description Rail-2 : include low-frequency vibration of air AGT : track maintenance
	Water pollution	○	○	×	Rail-1 : domestic sewage of station, factory sewage of depot, sewage treatment plant Rail-2 : domestic sewage of station, factory sewage of depot, sewage treatment plant AGT : no description
	Air pollution	○	○	○	Rail-1 : shunting diesel locomotive on depot Rail-2 : boiler on depot AGT : reduction of traffic volume such as bus and others, plus factor
	Electromagnetic wave	○	○	×	Rail-1 : pantograph, equipment of workshop, transforming station Rail-2 : railway structure, running train AGT : no description
	Solid waste	○	×	○	Rail-1 : municipal waste from station and train, industrial waste from depot, sludge from sewage treatment plant Rail-2 : only construction waste AGT : municipal waste from station and train, industrial waste from depot
	Landscape	×	○	○	Rail-1 : no description Rail-2 : change of view caused by railway structure AGT : obstruction of view caused by railway structure
Environmental load reduction	Transport system	○	×	○	Rail-1 : electric railway(steel wheel), plus factor Rail-2 : no description AGT : electric railway(rubber-tired wheel), plus factor
	Energy consumption	○	×	×	Rail-1 : power consumption(electric locomotive), oil consumption(diesel locomotive) Rail-2 : no description AGT : no description
	Greenhouse gases	×	×	○	Rail-1 : no description Rail-2 : no description AGT : CO_2 emissions

Note: ○: selected environmental element, ×: no select, Rail-1 and Rail-2: Inter-city railway, AGT: Automated guideway transit

Table 2 Environmental considerations effective for environmental load reduction (in service).

	Material		Water	Energy	Notes
	Recycling product	Recyclable material			
System	—	—	—	Electric railway	Transport system
	—	—	—	EMS	Management system, ISO 14001
	Trolley wire	Trolley wire	—	—	Electric power system
Track structure	Ballast mat	—	—	—	Rubber
	Slab mat	—	—	—	Rubber
	Sound absorbing material	—	—	—	Glass, slab track
	Pedestrian crossing	—	—	—	Plastic board
	—	Iron sleeper	—	—	
Civil structure	Sound absorbing material	—	—	—	Noise barrier
	Eco-cement	—	—	—	Secondary structure
	Kilometer post	—	—	—	Plastic
Earth works section	—	Pruned branches	—	—	Include disaster protection forest
Tunnel section	—	—	Spring water	—	Drinking and agricultural water
Station	Recycling tile	—	—	—	Floor tile
	—	Municipal waste	—	—	Segregated disposal, recycling
	—	Used tickets	—	—	Recycling
	—	—	Sewage plant	—	Wastewater reuse, sludge use
	—	—	—	Solar power generator	
	—	—	—	Auto-response dimmer glass	Energy-saving building
Depot	—	Municipal waste	—	—	Segregated disposal, recycling
	—	Industrial waste	—	—	Segregated disposal, recycling
	—	—	Sewage plant	—	Wastewater reuse
Train and railcar	Recycling railcar	Recyclable railcar	—	—	Design and production
	—	Municipal waste	—	—	Segregated disposal, recycling
	—	—	Train lavatory storage tank	—	Wastewater reuse, sludge use
	—	—	—	Energy-saving railcar	Design and production

4.2 Case studies on environmental considerations

Based on the results of study shown in 3.2, environmental considerations useful for environmental load reduction in railway construction projects are classified in Table 2. This table classifies and sorts out the products and systems already adopted generally, those tentatively adopted and those expected to be adopted in future, according to the factors (material, water, energy) that constitute EST and railway structures (system, track structure, civil structure, earth works section, tunnel section, station, depot, train and railcar).

In future railway construction projects, an EST can be built up by incorporating the environmental considerations listed in Table 2 into project plans and faithfully implementing them.

4.3 Environmental load reduction and EIA

Implementation of environmental policies and specific measures are required for building up an EST. This section discusses the railway construction project, which is one such specific measure. Under the condition that conversion from automotive to railway transport is an established policy based on the environmental load reduction scenario, we assume that the EIA is an important tool for environmental load reduction, and review the railway construction project, especially technical issues in new line construction.

(a) Railway facilities: In the fields of electricity, track, civil engineering and construction, recycled products of rubbers, plastics and incinerated residues are frequently used mainly for sound-proof and vibration-proof materials. Recyclable metal and paper wastes are also used effectively by many railway companies.

(b) Railcars: Energy is saved by the adoption of lightweight railcars, reduced running resistance design, regeneration brakes and VVVF, and metallic materials are recycled, but there are few cases of car production taking recyclable product life cycle into consideration from the design stage.

(c) Management and operation: Railway companies endeavor to reduce electric power consumption by improvement of train driving skills, introduction of energy-saving railcars and by maintenance and inspection of the railway track. Environmental management in accordance with ISO 14001 is mainly adopted by factories in depots.

(d) EIA: Environmental load reduction measures as explained in (a) to (c) are implemented, but our survey result shows that there has been no mention of these items in the project outlines or in the environmental conservation measures of EIS so far. Many railway companies in Japan publish "environment reports" to report on the actual results of energy saving, recycling and environment management after the railway service is initiated. Accordingly, incorporating forecasts and action plans on environmental load reduction such as material recycling, water recycling and energy consumption into the EIS will help develop an environment-friendly sustainable system.

5. Conclusions

Main results obtained in this study are summarized as follows:

(a) It is verified that the EIS related to existing railway construction include only a few descriptions on items related to EST, especially on survey, forecast, evaluation and environmental considerations for environmental load reduction (Table 1).

(b) Environmental considerations useful for constructing EST are classified into material recycling, water recycling, energy consumption, etc., and designs, products and systems based on eco-materials are presented (Table 2).

(c) It is proposed that EIS mention environmental load reduction measures, that is to say that EIA is more substantial than ever.

(d) This paper presents applicable environmental considerations in a general and qualitative manner. In order to implement environmental considerations in respective lines that fit the characteristics of the project and the region, some sort of judgment criteria are needed. We plan to investigate such criteria in future.

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