Environmental problems related to railways in Japan
(Special Reference to the Shinkansen)

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INTRODUCTION

Japan is an island country consisting of Honshu, Hokkaido, Shikoku and Kyushu. Of its total surface of 370,000 square kilometers, 70 percent is mountainous with the result that most of the population, exceeding 100 million, is confined to a few small plains. Nonetheless, in 1976, business activities resulted in a Gross National Product of US $ 550 billion. With this situation, environmental problems have developed into a major national issue.

Severe public criticism arose over the pollution of the atmosphere, the rivers and the seas that has accompanied the development of heavy and chemical industries, and lately increasing attention is being paid to pollution problems created by transport systems. Among these are exhaust gas emissions, noise, and vibration caused by automobile traffic, problems Japan shares with numerous other countries. In Japan, however, railway traffic is also often cited as a cause for the deterioration of the environment. This has created yet another difficult problem for the railway industry which is already saddled with heavy deficits.

I therefore propose to examine the environmental problems facing Japanese National Railways and the measures being taken to cope with them, with particular reference to noise and virbration problems of the Shinkansen super-express trains, which have been the subject of particularly severe criticism.

OVERVIEW OF ENVIRONMENT PROBLEMS IN JAPAN

First I wish to touch upon environmental problems in general in our country. The development of these problems is analyzed chronologically in the following manner in a White Paper issued by the Environment Agency. In the first 10 years following the widespread destruction caused by the Second World War, pollution problems were few. However, in the 10 subsequent years up to 1965, not only were production levels and living standards restored to their pre-war heights, but Japan achieved a startling economic growth, bringing with it water pollution, atmospheric contamination, ground subsidence, etc. With the aggravation of the situation, the first administrative measures were taken.

In the five-year period from 1965, pollution worsened and spread. Vigorous countermeasures, coupled with legislative steps, were undertaken to create a systematized administrative framework to deal with pollution. In 1967, the Basic Law for Countermeasures Against Pollution was enacted, establishing statutory curbs on each type of pollution.

In the five years after 1970, the pollution problem became a major social and political issue. In particular, severe criticism was directed at pollution caused by public undertakings such as the operation of airports, highways, railways and land reclamation and refuse disposal projects. The conservation of nature was given unusually heavy emphasis, with the pollution problem being discussed not in isolation but as part of this broader issue.

While industry and commerce developed as the result of an exceptionally high economic growth rate over a long period, the stresses caused by this rapid pace gave rise to numerous pollution problems. With increased material affluence in their daily lives, the people's sense of priorities underwent a change so that beginning in 1970 their criticism of pollution, including that caused by the railways, reached new heights.

THE SITUATION OF THE RAILWAYS IN JAPAN AND THE CONSTRUCTION OF THE SHINKANSEN

Because of geographical conditions such as the scarcity of land that can be effectively utilized, railways play an important role in land transportation in our country. This is particularly so in passenger transportation, where dependence on railways is high because they meet the requirements for mass transportation of a dense population with a highly concentrated mobility. In this respect, Japan, where railways have more than 30 percent share in the total volume of domestic transportation in terms of man-kilometers, is markedly different from other countries.

This railway transportation is mostly provided by Japanese National Railways, with the exception of private railway services available in a number of urban centers. With a history of more than a century, JNR now operates 1.9 million passenger and freight train-kilometers daily over the 21,000 kilometer traditional network of 1,067 mm narrow-gauge tracks to transport a daily average of 19 million passengers and 400,000 tons of freight.

While this railway transport system is encountering competition from road and air transport, measures to meet future needs are being taken through quantitative increases in its transport capacity and qualitative improvement of its services, in addition to promoting modernization policies.

The construction of the Shinkansen was undertaken as a part of this program for the strengthening and improvement of the railways. It constitutes the most important largescale step taken for this purpose.

This line was built as a solution to the problem various studies had forecast, that the transport capacity of the original Tokaido main line- the most important rail link

in the JNR connecting Japan's two major cities, Tokyo and Osaka- would soon reach its limit.

This project was the result of considerable research. It would increase transportation capacity for both passengers and freight to the maximum by using a standard-gauge, highspeed line in addition to the traditional lines, allowing transfers between them at important stations. Construction of the new line could thus adopt the latest technology and the sytem could be simplified without being constrained by existing lines. The plan was adopted because it embodied these advantages, far superior to any other method.

Work on the 515.4-kilometer-long Shinkansen was started in April 1959 and the line went into operation in October 1964. In 1972 it was extended westward to Okayama and further extended to Hakata in March 1975. Today, it operates over 1,070 kilometers.

The number of passengers using this line has increased dramatically year by year, reaching a total of over of 1,000 million by May 1976 in the twelve years since it started operating, and it has now won high praise as a public transportation system.

THE PROBLEMS OF NOISE AND VIBRATION OF THE SHINKANSEN

In the planning stage of the Shinkansen, before its construction was started in 1959, technical studies were made on a wide variety of subjects such as safety, riding comfort and maintenance, required for the creation of what was to become the fastest railway line in the world. The problems of noise and vibration that could create external nuisances were also borne in mind.

With the set objective of keeping noise and vibration down to the level of existing lines, various steps were adopted. These included the use of long rails, double elastic fastenings and movable nose rail frogs for track material, and the structural lightening of carriages, which were equipped with air springs. These measures were principally aimed at achieving good riding comfort and reducing track maintenance manpower requirements, but since they also proved to serve in reducing noise and vibration they were incorporated into construction standards. Running tests carried out 18 months before operation showed that these objectives had been attained on the basis of external noise and vibration measurements.

When the Shinkansen began operating between Tokyo and Osaka in October 1964, however, complaints came from some areas. Although noise of about a 90-phon level created by the use of ballastless steel girders was admittedly a problem, it became a source of complaint in built-up urban zones that the Shinkansen entered even though it was of approximately the same level as the noise and vibration caused by the old lines.

Thus public dissatisfaction can be attributed to the fact that pollution problems were no longer measured simply in terms of physical quantity but were influenced by the psychological impact they made on the inhabitants living alongside the railway tracks. Furthermore, it shows a condition in which the background of the public attitude towards pollution cannot be ignored.

Representative examples of noise values after the Shinkansen began operating are shown in Table 1.

Table 1 - Shinkansen Noise Levels

Structure	Roadbed	Sidewalls	Noise Level - dB (A) 70 80 90 100
embankment	with ballast	none	
		1.9 m	
viaduct	with ballast	none	
		1.9 m	
steel girder bridge	with ballast	none	
		1.9 m	
	without ballast	none	
		with sound insulation	

Notes:
1. Measurements were taken outdoors 25 m from the center of the track at a height of 1.2 m from the ground.
2. Actual measurements were made of trains with speeds over 160 km/h and adjusted to represent the levels at 200 km/h.
3. —— represents 90% of the range of measured noise levels.
   —●— represents the mean of this 90%.
   – – – represents the total range of measured noise levels (used where the total number of measurements was low).

In the construction of the 164.4-kilometer-long extension from Osaka to Okayama, a reduction in noise and vibration was sought by a drastic improvement in structural design, taking into account experience gained in the Tokyo-Osaka section. For this, the steel girders without ballast were eliminated and replaced by reinforced concrete or prestressed concrete girders with ballast. The sectional dimension of reinforced-concrete viaduct structural members was enlarged to the extent that it did not result in uneconomical design, and the existing sidewalls were heightened to the extent where they served to dampen noise. As a result, the noise level was reduced to about 80 phons at a distance of 25 meters, except under exceptional conditions.

However, in view of complaints that arose after this section went into operation in 1972, sound barrier walls

with an overhang were adopted in the 397.9 kilometer extension between Okayama and Hakata as an additional countermeasure, while the route itself was located so as to avoid urban areas by the use of tunnels.

The ratio of tunnel length to the total length of the Shinkansen line is 13 percent between Tokyo and Osaka, but has grown to 35 percent in the Shin-Osaka to Okayama section, and to 56 percent between Okayama and Hakata.

Obtaining approval from inhabitants for construction work became increasingly difficult each year as popular consciousness of pollution grew to an excessively high level during the period when the line was being built.

Moreover, the delay in responding quickly to complaints on sections that had begun operating because of technical and administrative difficulties had the effect of fanning the fires of criticism.

THE ENACTMENT OF LEGAL CONTROLS ON NOISE AND VIBRATION OF THE SHINKANSEN

The Environment Agency in Japan formulates the basic policies concerning pollution in accordance with the Basic Law for Countermeasures Against Pollution, and environmental standards are promulgated and legislation enacted on the recommendations of the Central Consultative Council on Pollution.

As the noise and vibration caused by the Shinkansen tended to become a social issue, the Environment Agency recommended temporary guidelines to the Minister of Transportation in 1972 by which it should endeavor to contain the noise to 80 phons. In the event that the noise level exceeded 85 phons, noise-proofing and other noise-abatement measures for affected housing should be utilized. Japanese National Railways took steps along these lines but was unable to achieve adequate results at an early date.

In July 1975, the Environment Agency promulgated the "Environmental Standards For Noise Levels of the Shinkansen", shown in Tables 2 and 3. These environmental standards are based on Art. 9 of the Basic Law on Pollution which specifies "objectives for administrative efforts laid down by the government as being desirable for the protection of health and the preservation of the environment". Their standard values consequently differ somewhat from, for instance, the regulatory levels established concerning poisons harmful to health. Moreover, they contain an element of ambiguity in what they refer to as "desirable objectives". Thus reaction to these standards ranges from the opinion that they ought to be taken as the ideal but are difficult to attain to the view that they should be taken as a realistic and practical target.

Table 2 - Environmental Standards For Noise Levels of the Shinkansen

Area type	Noise standard
I	under 70 phons
II	under 75 phons

Notes: I represents residential districts; II commercial and industrial districts and others not covered by I where the normal quality of life needs to be protected.

In any case, when looked at from the inhabitants' position, the railways are clearly defined targets for action in that their responsible owners and operators are much easier to determine than in cases involving highways and automobiles.

The base for the values laid down in these environmental standards was established through two surveys of reactions carried out among those living alongside the Shinkansen. The base line was drawn at the level where 30 percent of the respondents said it was noisy.

The Environment Agency in March 1976 also adopted a provisional policy regarding vibration on the grounds that it was desirable to enact the noise countermeasures comprehensively with aid for those living alongside the tracks who suffered from the vibration. This policy calls for "efforts to control the vibration level to 70 dB and to take countermeasures, combined with those against noise, in cases where this level is exceeded".

NOISE AND VIBRATION COUNTERMEASURES FOR THE SHINKANSEN

In view of these strengthened administrative measures taken for the protection of the environment, Japanese National Railways carried out research into pollution countermeasures and has put them into effect.

These steps can be roughly divided into countermeasures against the sources of vibration and noise, and countermeasures relating to nuisance prevention for houses along the right-of-way.

The former deal with improvements and additions to railway structures near the source of noise and vibration, and the latter concern the measures for noise-abatement and anti-vibration on houses adjacent to the tracks where former measures have proven to be insufficient. On occasion, the affected residents are moved to another location.

Table 3 Shinkansen Noise-Prevention Targets

Shinkansen wayside regions		Target achievement periods: Period of existing Shinkansen lines	Period for Shinkansen lines under construction	Period for new Shinkansen lines
a Region of 80 phons or higher		Within 3 years	At time of opening	At time of opening
b Region of 75 to under 80 phons	i	Within 7 years	Within 3 years from opening	
	ii	Within 10 years		
c Region of 70 to under 75 phons		Within 10 years	Within 5 years from opening	

Among the measures taken against sources of noise are the strengthening of sound-barrier walls in viaduct and embankment sections. From Shin-Osaka westward, vertical reinforced-concrete walls 10 to 15 centimeters thick and 1.9 to 2.4 meters high were constructed, together with other types of sound-barrier walls. Between Tokyo and Osaka, the strength of the existing constructions proved insufficient to support such walls, so framworks of H-shaped steel pillars and beams were erected and covered both inside and out with cement-asbestos panels. Sound-barrier walls have the effect of reducing noise by 7 to 10 phons.

Another method is covering the steel girders without ballast. This consists of affixing noise-insulating plates suspended with cushions under and on the sides of the main plate girders and truss girders, reducing by 15 to 20 phons noise that had reached a near-100-phon level. Noise abatement studies related to the track and wheels are also being made. The results of these measures are shown in Table 1.

The first step in nuisance prevention for houses situated along the right-of-way is to subsidize and execute the installation of noise-abatement devices for homeowners. Because of Japan's humid temperate climate, most houses are of wooden construction and of a traditional open design that makes it difficult to soundproof them or make them resistant to vibration. These conditions call for the replacement of walls and ceilings with soundproofing materials and the fitting of double-pane, glass windows in aluminum sashes. These steps result in hermetically sealed houses, which in turn require the installation of air-conditioning equipment. While the normal insulation capacity of a traditional Japanese house against noise is about 10 to 20 phons, such improvements can generally heighten this capacity to about 30 phons. When such changes cannot be expected to reduce the in-house noise level to less than 60 phons or when vibration is very strong, the owners are urged to move, with JNR buying their property.

JNR estimates that the number of households where the noise level exceeds 80 phons and which require these measures to be completed within the next three years is 18,000. If the 70-to-75 phon standard must be met, this number reaches some 130,000.

THE EFFECTS AND PROBLEMS OF ENVIRONMENTAL PRESERVATION ALONG THE SHINKANSEN

Inasmuch as the preservation of the environment is a most reasonable aspiration, JNR does not begrudge its efforts in this direction. But it cannot be denied that the imposition of too hasty measures for this purpose leads, in effect, to unnecessary confusion.

Those who dwell alongside a railway line like the Shinkansen, which is not utilized daily like commuter lines and whose stations are 30 kilometers apart, do not develop a sense of familiarity with such a facility. The imposition of various control measures based on changeable, emotional factors such as complaints from residents with only a few surveys as a guide is therefore open to question.

Even conceding that, as a matter of principle, it is the polluter who should pay, the resulting burdens are beyond the capacity of the railways to bear in the light of their present financial condition as well as in consideration of the colossal amount of work required to carry out countermeasures designed to meet the large number of demands. Many are concerned by the manner in which controls have taken priority over administrative capacity without a sufficient prior investigation of this capacity being carried out. Moreover, such policies cannot be effective unless they are adopted in an integrated manner together with other policies such as those related to land utilization, building regulations and the construction of suitable private and public buildings and facilities alongside the tracks. While proposals have been made to this effect, they are far from being implemented.

Consequently, further studies must be carried out before the remaining problems of environmental preservation along the Shinkansen can be solved.

OTHER PROBLEMS

Cited above are the major environmental problems concerning the Shinkansen - namely noise and vibration. Some other existing problems concern interference with television reception, the creation of shaded areas that prevent the penetration of sunlight, and the noise from pressure waves in tunnels.

The TV interference problem is being solved by the erection of common transmission antennas connected to affected homes by cable.

As to the sunlight problem, we have established a set of rules for compensation to homeowners in keeping with similar measures adopted by other public bodies.

Pressure waves radiating from tunnel exits are created when a train enters a tunnel, where slabs tracks are used, traveling at a high rate of speed. These waves travel at sonic speed and emerge from the opposite end of the tunnel. The consequent minor variation in atmospheric pressure has a boom effect like that of a cannon being fired that is heard in neighboring houses. We have succeeded in eliminating this nuisance by installing experimental damping hoods at the entrance to the tunnels to absorb the variation in atmospheric pressure. We intend to apply this process to other tunnels where such effects have been reported.