Third International Conference on
BEARING CAPACITY OF ROADS
AND AIRFIELDS
3–5 July 1990
TRONDHEIM, NORWAY

THE DEVELOPMENT OF PAVEMENT DATA ACQUISITION SYSTEM AND REHABILITATION STRATEGY FOR HEAVY ROADS IN TOKYO

Yorimasa Abe — Nihon University — Japan
Tadayuki Abe — Tokyo Metropolitan Government — Japan
Yasunobu Matsui — Nihon University — Japan

ABSTRACT

This papaer describes the use of data for rutting depth measured by automatic high speed devices. In Japan these data have been used for making rough estimate of pavement condition, but they have not been used for numerical analysis because of their poor accuracy.

This paper proposes a statistical treatment of analysis for making better use of the data.

1. INTRODUCTION

The number of vehicles in Japan is going to reach 60 millions including about 30 % of commercial ones. On the other hand, pavement length is still less than 250,000 km. Accordingly, traffic jam is seen everywhere and sometimes its length exceeds 50 km on a mortor way.

The Ring Road 7 is one of the most heaviest roads in Tokyo with 4,500 commercial vehicles per 12 hours at which traffic jam occurs all day. We chose a 15 km test section from it and made three years' measurements of rutting depth using an automatic high speed (0 ~ 80km/h) device.

This kind of devices was developed in 1985 by five different firms and was admitted by the Ministry of Construction for the use of pavement condition survey. Since then more than 30,000 km of pavements have been measured by these devices every year.

Measured values, however, have not been used for numerical analysis, because they have not shown reasonable behaviour of pavement owing to errors occured in the measurement.

These errors are as follows:

(1) errors come from inaccurate distance measurement

(2) admitted errors of ± 3mm included in the device

(3) deviation according to devices and firms

(4) adjustment errors

Even though the device may include many errors stated above, it is yet to measure certain surface configuration of pavement.
This is a trial approach to the use of rutting depth data.

2. MEASURING AND DATA

Figure 1 shows a part of the Ring Road 7 which is the test section for the analysis. Rutting was measured at every 10m.
The measurement was conducted three times (1986, 1987, 1988) keeping the condition to be equal as much as possible.

The data and average rutting depth for each lane are tabulated in Table 1. Figure 2 shows an example of average values.

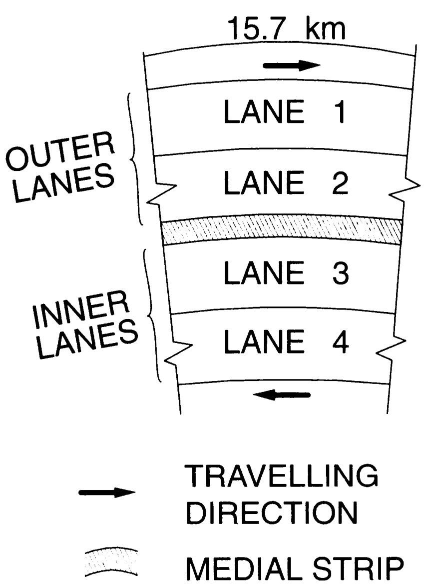

Fig.1 Plane View of Test Section

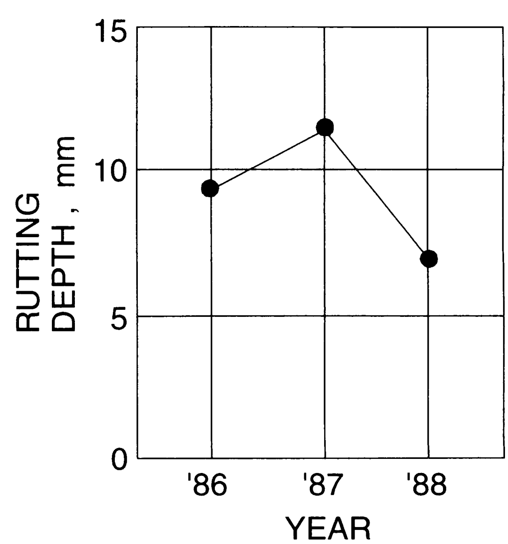

Fig.2 An Example of Average Value (Lane 4)

Comparing the average values, the rutting depth increased from 1986 to 1987, but it decreased from 1987 to 1988 led to a lower level than 1986. Generally speaking, rutting should increase year by year if rehabilitation is not conducted. These data are analyzed precisely at each position in the following.

Table 1 Average Value and Standard Deviation

	Year	Number of data	Average value	Standard deviation
Lane 1	1986	1,571	9.33 mm	5.14 mm
	1987	1,470	10.99 mm	5.41 mm
	1988	1,529	5.84 mm	3.65 mm

	Year	Number of data	Average value	Standard deviation
Lane 2	1986	1,570	11.42 mm	6.32 mm
	1987	1,418	14.12 mm	6.88 mm
	1988	1,561	10.65 mm	6.65 mm

	Year	Number of data	Average value	Standard deviation
Lane 3	1986	1,571	10.74 mm	5.27 mm
	1987	1,392	13.67 mm	6.26 mm
	1988	1,530	10.05 mm	5.75 mm

	Year	Number of data	Average value	Standard deviation
Lane 4	1986	1,571	8.99 mm	4.76 mm
	1987	1,465	10.66 mm	5.06 mm
	1988	1,530	6.67 mm	3.51 mm

The data were divided into two groups as follows;

Group A: reasonable data which show increased rutting depth compared to those of the former year at each measuring position.

Group B: others (decreased data)

Table 2 shows every percentage of reasonable data. Group A occupies about 80% from 1986 to 1987, but goes down to less than 50% from 1987 to 1988. This means that one can not find a tendency increased reasonably even if measuring is continued every year at the same position as far as these data are used without any idea.

Further investigations are needed for rational anaysis.

Table 2 Percentage of Group A with Reasonable Data

	year	Number of data*	Group A (%)
Lane 1	1986~1987	1,140	78.7
	1987~1988	1,057	9.7
Lane 2	1986~1987	1,116	83.4
	1987~1988	984	44.4
Lane 3	1986~1987	1,040	83.9
	1987~1988	940	44.3
Lane 4	1986~1987	1,161	79.9
	1987~1988	1,132	23.9

* Data of those constructed at the year are ommitted

3. STATISTICAL ANALYSIS

Two examples of measured values are compared in Figure 3. As seen clearly in the figure, the shape of surface deformation is nearly the same neglecting the absolute values of rutting depth.

So it seems that the device can measure reciprocal differences though it may have a deviation time to time at measuring absolute values.

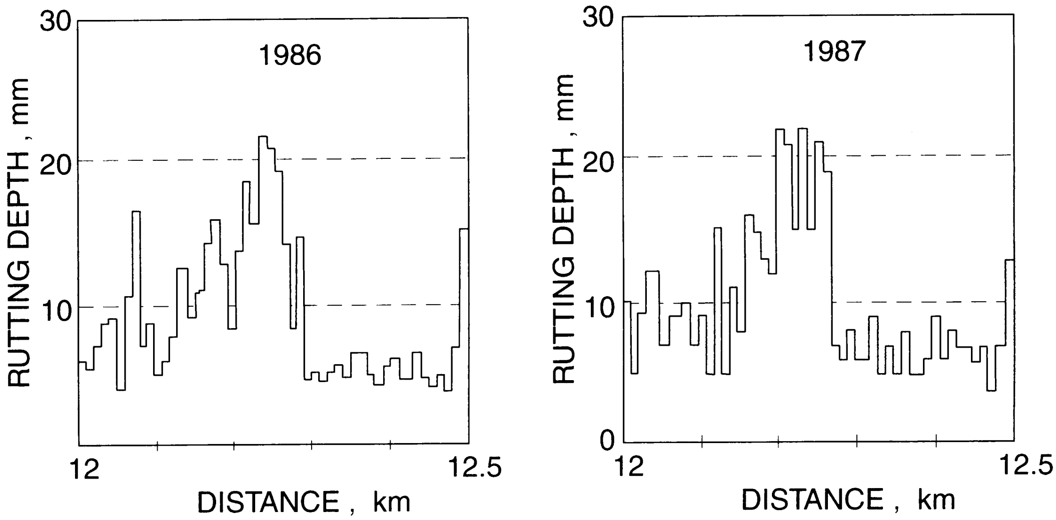

Fig.3 Comparison of Surface Deformation

Figure 4 is an example of the frequency distribution of all data including those of after rehabilitation for 1988. Figure 5 on probability paper shows that these data are expressed by a logarithmic normal distribution. Using this result, normalized deviation value at each position for every year was calculated as follows:

$$Y = 10 * (\log X - m) / \sigma + 50 \quad \cdots \quad (1)$$

where

Y : normalized deviation value

X : rutting depth at each position

m : mean value of all logX of a year

σ : standard deviation

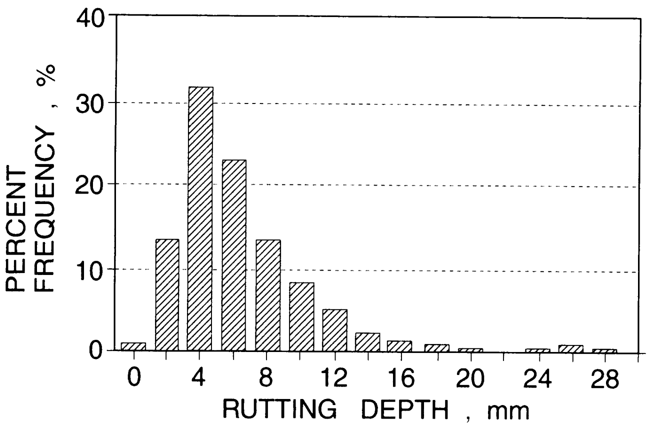

Fig.4 Frequency Distribution (1988)

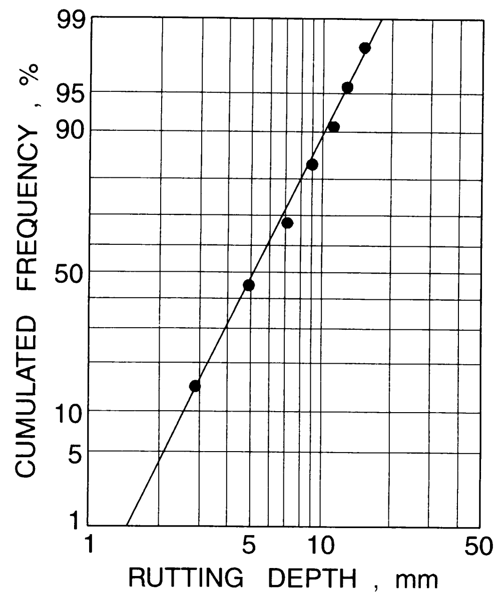

Fig.5 Cumulated Frequency on Probability Paper (1988)

Percentages of Group A are shown in Table 3 in which values of Y are used instead of measured ones. About 70% of all data are in Group A and irregularities among the year are avoided. This means that the device can give us useful informations.

Table 3 Percentage of Group A with Reasonable Data

	year	Number of data*	Group A (%)
Lane 1	1986~1987	1,140	63.1
	1987~1988	1,057	69.8
Lane 2	1986~1987	1,116	65.9
	1987~1988	984	78.3
Lane 3	1986~1987	1,040	67.9
	1987~1988	940	77.4
Lane 4	1986~1987	1,161	68.0
	1987~1988	1,132	64.7

* Data of those constructed at the year are ommitted

4. STATISTICAL DISTRIBUTION OF RUTTING

Fatigue life of steel is known to be represented by logarithmic normal distribution. Frequency distributions of rutting have also the similar tendency as shown in Figure 6,7,8,9. In Japan the main cause of rutting is attributed to plastic deformation of asphalt mixtures especially at heavy traffic roads.

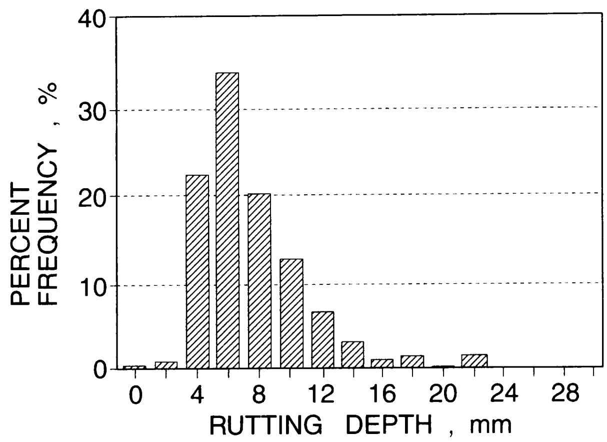

Fig.6 Percent Frequency of Rutting Depth (1 Year After Rehabilitation)

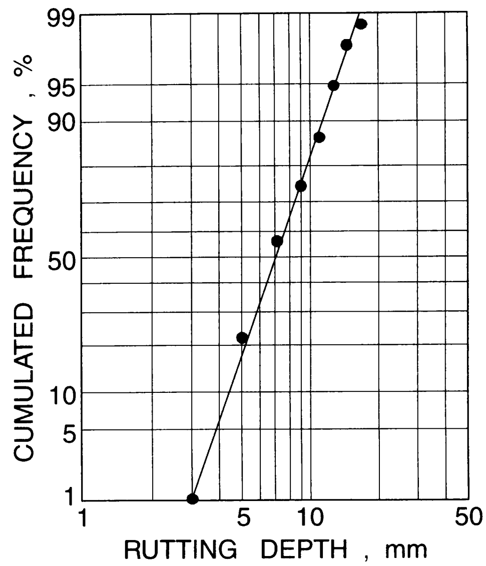

Fig.7 Cumulated Frequency (1 Year after Rehabilitation)

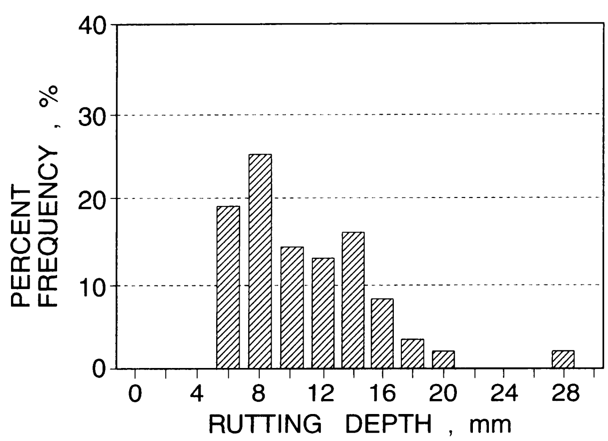

Fig.8 Percent Frequency of Rutting Depth (3 Years After Rehabilitation)

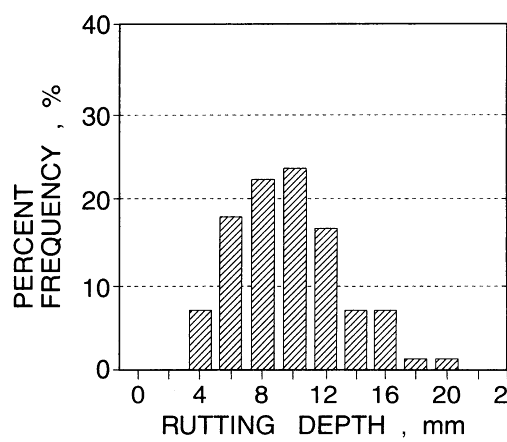

Fig.9 Percent Frequency of Rutting Depth (5 Years After Rehabilitation)

After measured values are transformed into Y as stated previously, the average values of Y were calculated for each years passed after rehabilitation. Then real values corresponding to those of Y were calculated and plotted as shown in Figure 10. The curves indicate the rutting depth most likely to occur statistically according to years passed and their behaviours explain the special circumstances of the Ring Road 7 where commercial vehicles are advised to use center side lanes (Lane 2,3) in order to minimize vibration and noise for surrounding inhabitants.

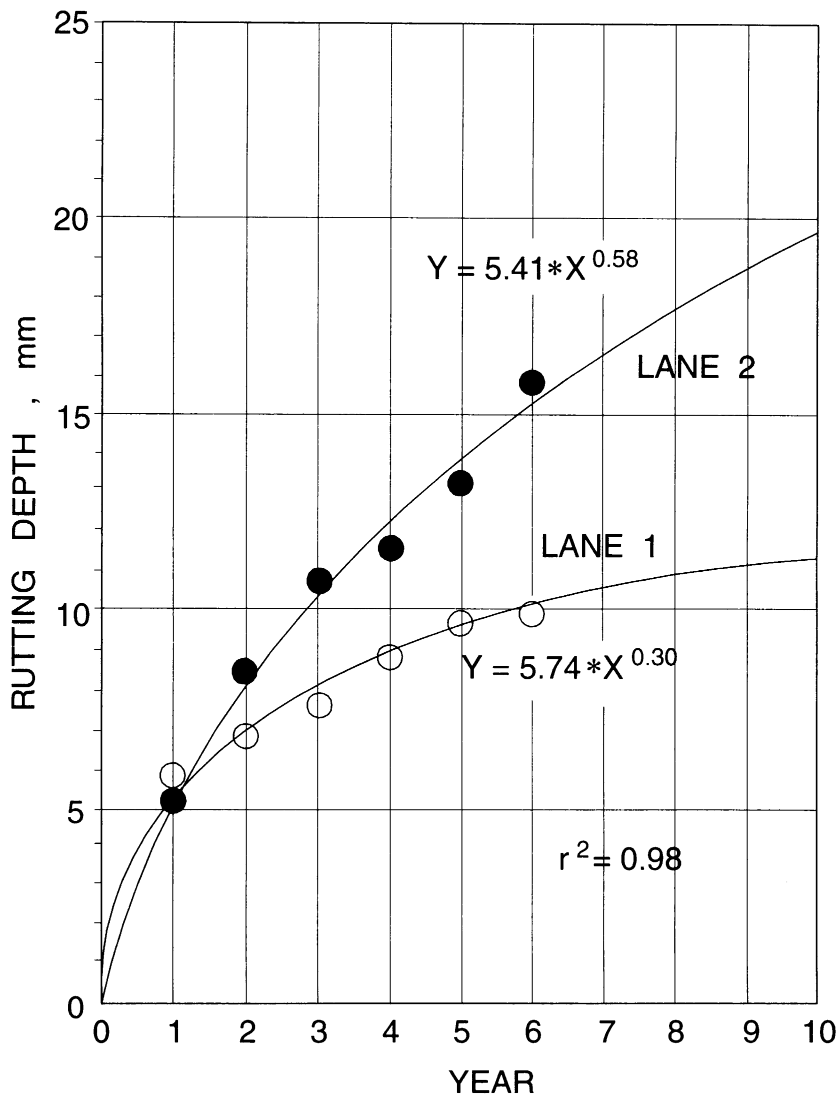

Fig.10 Increase of Rutting Depth by Traffic Loading (Outer Lanes)

5. REHABILITATION STRATEGY

Tokyo Metropolitan Government has been forced to cope with the increasing pavement deteriorations. On the other hand, users and inhabitations complain of rehabilitation constructions because they induce further traffic jam and noise. The Government has to change rehabiritation strategy from economical design to high quality one which reduces rehabiritation and traffic jam, Both the pavement evaluations stated above and the investigations of traffic loads have become significantly important.

6. CONCLUSIONS

(1) Rutting caused by plastic deformation of asphalt mixtures shows a logarithmic normal distribution.

(2) Though the automatic measuring device is not absolutely perfect, it is useful for pavement analysis.

(3) Rutting depth of a pavement in near future can be roughly estimated by using data measured by an automatic measuring device.