MONITORING ON SKID RESISTANCE COEFFICIENT OF VARIOUS SURFACE LAYERS ON URBAN EXPRESSWAY

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ABSTRACT RÉSUMÉ

Pavement management on bridge deck is one of the most important business and technical issues of management organization of urban expressway network such as Hanshin Expressway in Osaka and Kobe urban regions in Japan. More than 80% of Hanshin Expressway consist of viaducts and suffer from heavy traffic loads.
In order to provide safe and comfortable road condition for drivers, we have tested various types of surface layers. However, the characteristics of skid resistance on such surface layers have not been clarified yet, and therefore we are monitoring Skid Resistance Coefficients of those surface layers by using a test vehicle. As the result of the monitoring, we confirmed that Skid Resistance Coefficients of each new pavement are approximately 0.5-0.7 and Skid Resistance Coefficients of permeable-resin-mortar top coating show better durability than those of permeable pavement.

1. INTRODUCTION

Urban expressways have often been constructed in the limited area, in which urban facilities, such as buildings, housings, schools and hospitals, stand close together. So most of urban expressways consist of viaducts and there are many sharp curve sections because of restriction of construction sites. In addition, a great many vehicles including many large goods and items travel on them and road surfaces suffer from very heavy traffic loads. Thus, in order to keep safe condition for high speed driving, the maintenance of pavements on bridge deck is a very important issue for expressway management organizations.

Various types of surface layers by combining aggregate-gradings and asphalt-binders are developed and introduced to Hanshin Expressway. In the last decade, permeable pavement has been employed for the purpose of providing safe and comfortable road condition in the rainy condition for drivers and reducing traffic noise caused by vehicles traveling on the expressway. Furthermore, urban expressway managing heavy traffic volume also need higher durability for pavements and modified asphalt binders have been developed. In addition, permeable-resin-mortar (PRM) top coatings are overlaid on various asphalt surfaces to improve skid resistance for the purpose of traffic accidents mitigation, especially at the sharp curve sections.

However, the characteristics of skid resistance on such surface layers have not been clarified yet. Therefore, we are monitoring Skid Resistance Coefficients (SRCs) of those surface layers by using a test vehicle. This paper presents the results of the monitoring.

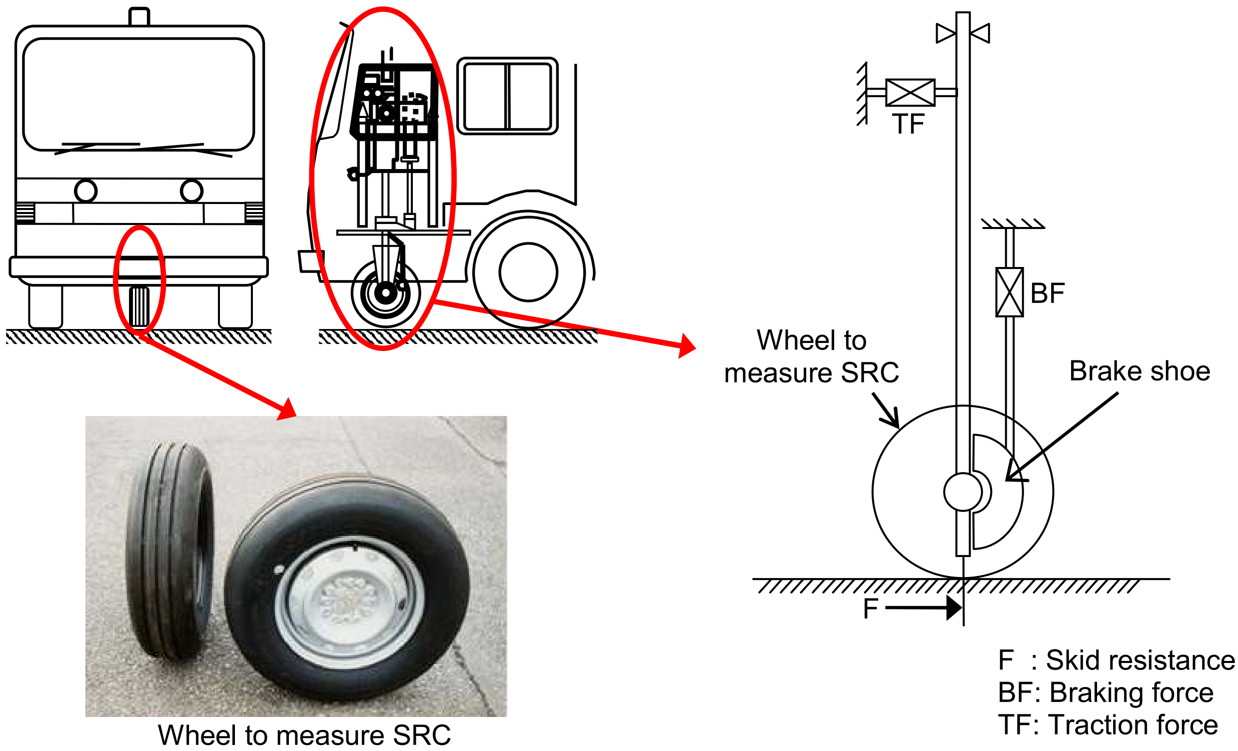

Figure 1 - Test vehicle

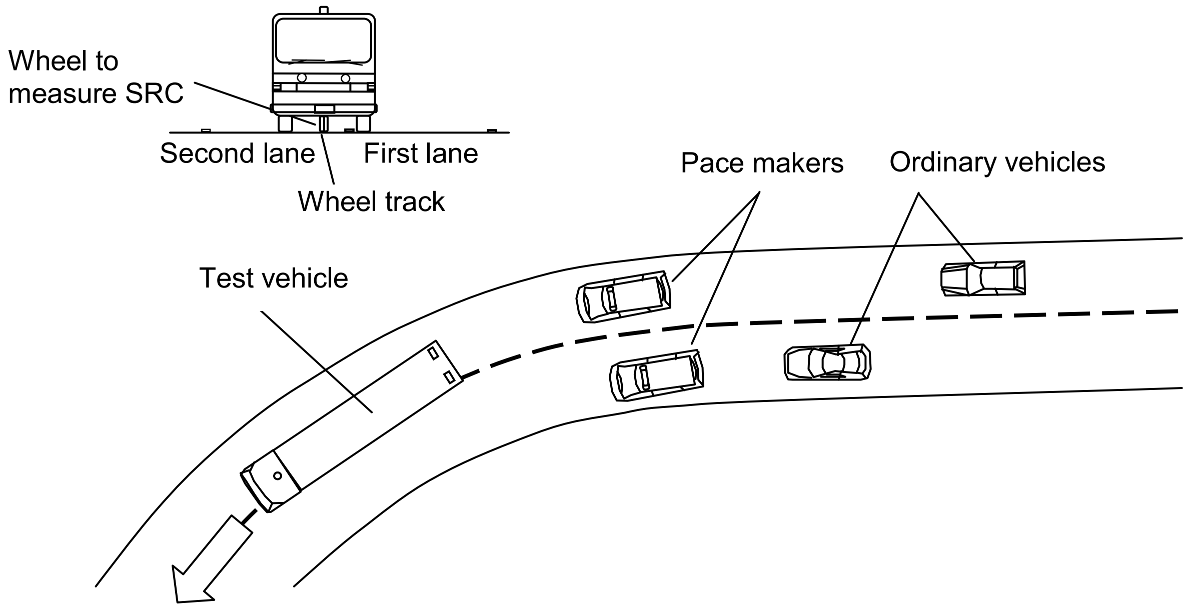

Figure 2 – Formation when SRCs are measured

2. OUTLINE OF MONITORING

2.1. Method of monitoring and calculating SRC

Figure 1 shows SRCs measured by a test vehicle with an additional wheel to measure SRC. Braking force (BF), traction force (TF) and vertical loads are measured by loadcell when only the wheel to measure SRC was braked driving the test vehicle at regulatory speed. SRC is calculated by following Equation.

$$\mu(BF) = \frac{BF}{W} \qquad \mu(TF) = \frac{TF}{W}$$

μ(BF) : SRC calculated from BF
μ(TF) : SRC calculated from TF
BF : Braking force on the wheel (kN)
TF : Traction force on the wheel (kN)
W : Vertical load on the wheel (kN)

Monitoring was carried out on the position of a wheel track, where the decline of skid resistance caused by aging or vehicle driving seems to be the largest, and pace making vehicles controlled ordinary vehicles during the measurement.

2.2. Monitored surface layers

Table 3 shows the types of surface layers which were monitored and terms from their construction. Figure 3 shows the pavement structure. Permeable pavement or PRM top coatings are installed for the purpose of providing safe driving condition, and modified

Table 3 - Monitored surface layers

Types of surface layers	Expected performance		Terms from surface layers were constructed (month)	Numbers of monitoring sections
	Skid resistance	Durability		
① Dense-graded modified asphalt Ⅱ	Normal	Normal	1	1
② Dense-graded Modified asphalt Ⅲ	Normal	High	1	5
③ Gap-graded modified asphalt Ⅱ	High	Normal	1	4
④ Gap-graded modified asphalt Ⅲ	High	High	1	15
⑤ Permeable pavement	High (rainy condition)	Normal	53	1
			61	1
			73	1
			105	2
⑥ High durable permeable pavement	High (rainy condition)	High	1	7
⑦ PRM top coating	High	—	1	5
			15	1
			25	1
			29	2
			38	1
			41	1

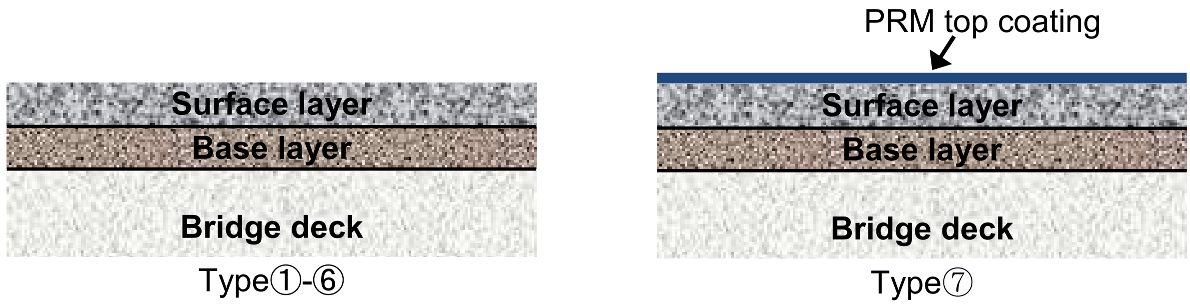

Figure 3 - Pavement structure

asphalt Ⅲ, which is expected to be more durable. In order to compare skid resistance of new surface layers, we monitored SRCs of various types of surface layers which had been constructed about one month before. Moreover, in order to study aging properties, we also carried out monitoring SRCs of permeable pavement and PRM top coatings which had been constructed from one month to 9 years before.

3. RESULTS OF THE MONITORING

3.1. Results of new surface layers

Measured SRCs of surface layers which had been constructed about a month before the measurement are shown in Figure 2. SRCs of all new surface layers are approximately 0.5-0.7, which are much larger than 0.25[1] as a target SRC for maintaining urban expressways.

3.1.1. Difference caused by asphalt-binders

Comparing dense-graded modified asphalt Ⅱ and dense-graded modified asphalt Ⅲ, gap-graded modified asphalt Ⅱ and gap-graded modified asphalt Ⅲ, SRCs of modified asphalt Ⅲ, which is expected to be more durable, were slightly smaller than those of modified asphalt Ⅱ in both cases. However, as described below, considering measured SRCs of permeable pavement constructed 4-9 years before were approximately 0.3-0.4, difference between SRCs of modified asphalt Ⅱ and modified asphalt Ⅲ is not significant if modified asphalt Ⅲ has expected durability.

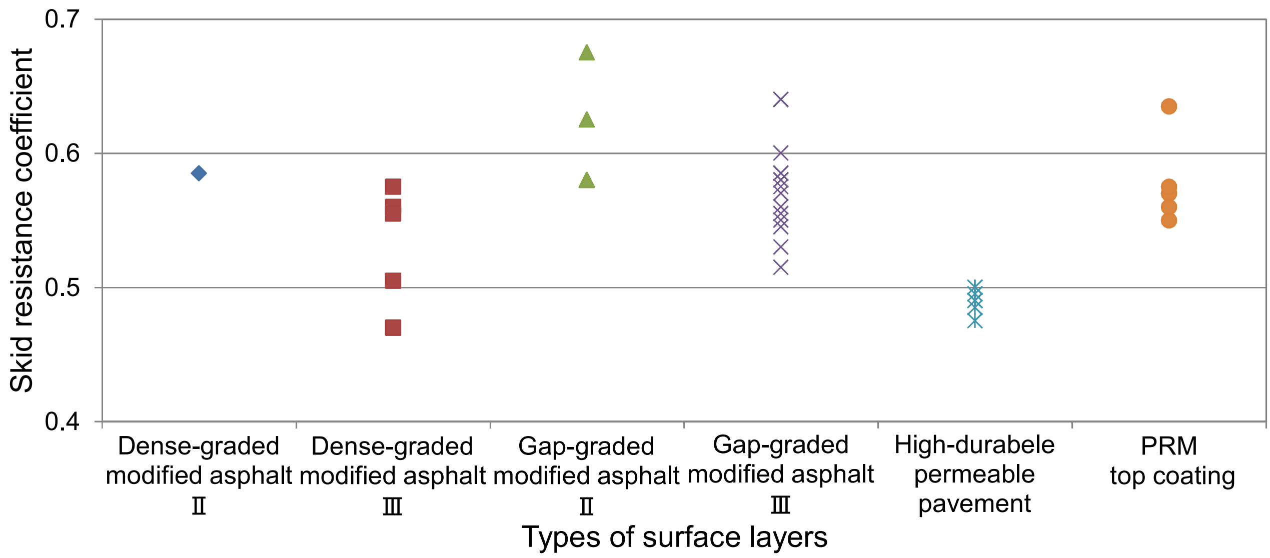

Figure 4 - Measured SRCs of new surface layers

3.1.2. Difference caused by aggregate-gradings

Comparing dense-graded modified asphalt Ⅱ and gap-graded modified asphalt Ⅱ, dense-graded modified asphalt Ⅲ and gap-graded modified asphalt Ⅲ, SRCs of gap-graded asphalt, which is expected to be more resistive to skids, are slightly larger than those of dense-graded asphalt. However, the difference is too small to assert that gap-graded asphalt is more resistive to skids.

3.2. Results of aged surface layers

As described above, the difference among new surface layers' SRCs caused by types of surface layers is not significant. Therefore, it seems to be that aging deterioration of skid resistance influences safety of traveling vehicles practically. Thus, in order to grasp tendency of deterioration of skid resistance, SRCs of permeable pavement and PRM top coatings which differ in terms and total traffic volume from construction, were measured. Figure 5 shows relations between SRCs of surface layers and terms from their construction, and Figure 6 shows those between SRCs and amounts of total traffic from their construction. Linear approximations are also shown in these graphs.

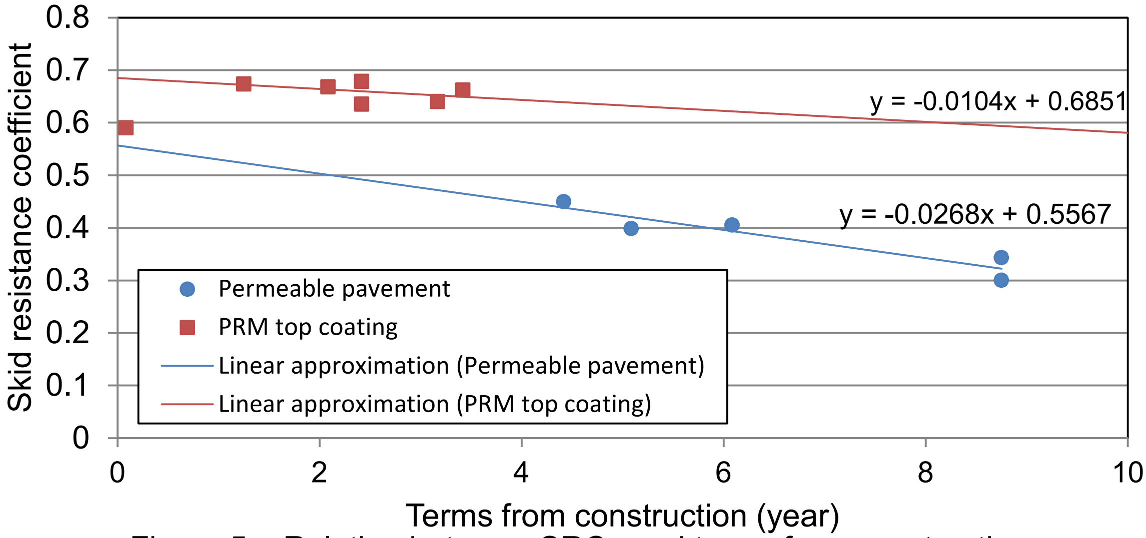

Figure 5 – Relation between SRCs and terms from construction

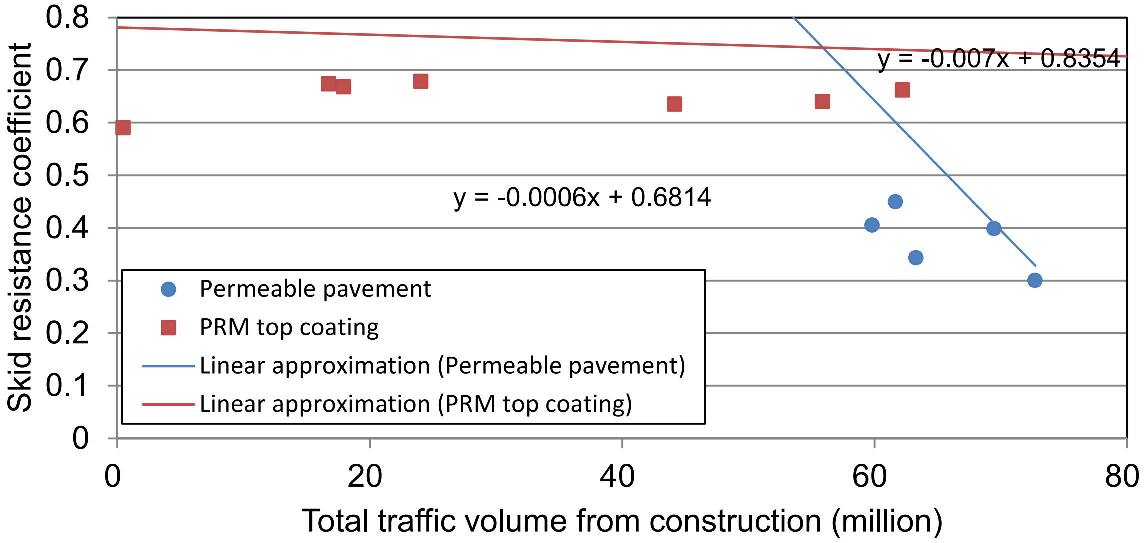

Figure 6 – Relation between SRCs and amount of total traffic from construction

According to Figure 5, though PRM is relatively new material and PRM top coatings only past 4 years from the construction, SRCs of PRM top coatings had not deteriorated as much as those of permeable pavement. In addition, SRCs of PRM top coatings which had been constructed 1-4 years before were approximately 0.65-0.7, which were larger than those of new ones and other types of new surface layers shown in Figure 4. On the other hand, SRCs of permeable pavement which had been constructed about 4-9 years before had decreased to 0.3-0.45, though these values are also larger than 0.25[1] as a target SRC for repairing.

According to the relations between SRCs and total traffic volume shown in Figure 6, skid resistance of PRM top coatings less deteriorated. Furthermore, comparing SRCs of PRM top coatings and permeable pavement which have almost same total traffic volume, SRCs of PRM top coatings were approximately 0.2-0.3 larger than permeable pavement.

Thus, skid resistance of PRM top coatings is more durable than permeable pavement, and it is effective to overlay PRM top coatings on pavement to keep safe road condition.

4. CONCLUSION

The SRC monitoring survey has been carried out on the various types of new surface layers and aged surface layers, and following results were confirmed.

- SRCs of new pavement are approximately 0.5–0.7.
- SRCs of permeable pavement which had been paved 4-9 years before decreased to approximately 0.3-0.45.
- Overlaying PRM top coating is effective in improving SRCs of aged permeable pavement, and SRCs of PRM top coating show better durability than those of permeable pavement.

REFERENCES RÉFÉRENCES

1. Japan Road Association. (1978). Manual for road maintenance and repair [in Japanese]