THE CURRENT PAVEMENT ON STEEL DECKS IN JAPAN

Procédés actuels de revêtements de tabliers en acier au Japon

Der gegenwärtige Stand der Straßenbeläge auf Stahldecken in Japan

EIICHI MURAKAMI
Counselor
Japan Highway Public Corporation

SHINKO KIKEGAWA
Managing Director
Nippon Hodo Co., Ltd.

SABURO MATSUNO
Chief of Pavement Section
Public Works Research Institute
Construction Ministry

It is in 1955 that steel decks were for the first time applied to bridge construction in Japan. After that, scores of bridges with steel decks were constructed in various places up to date. However, the performance of the pavement on the steel decks are not necessarily good and there are still a many problems to be solved.
Public Works Research Institute of Construction Ministry made survey and observation of the bridge pavement in 1962 and 1968 for the purpose of revealing the best type of pavement on steel decks.
This report describes the results of the survey made in 1968.

(1) DESCRIPTION OF SURVEY

The bridge surveyed are 21 bridges with asphalt pavement of 5cm or more in thickness shown in Table-1, which are located on the streets or trunk road under comparatively heavy traffic. The structure and the composition of the asphalt pavement of the bridges differ in each one. But the typical cross section of the pavement and the composition of mixtures are shown in the Fig.-1 and Table-2.
The traffic volume shown in Table-1 indicates the number of traffic of all lanes in 12 hours. In Japan, the percentage of heavy vehicles in the traffic is 10 - 30% and 20% in average.

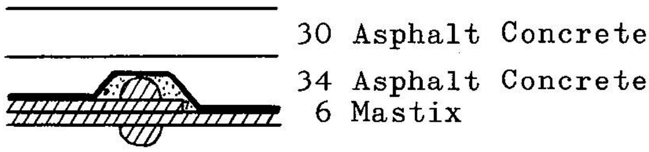
No.	Bridge	Date in Service	Volume of Traffic: Date Measured	Volume of Traffic: No./12hrs. all lanes	Structural Details: Length	Structural Details: Deck Plate Thickness	Pavement Details: Pavement Thickness	Surface Course	Leveling Course	Insulation Layer	Prime Coat	Cracking Index	Waving Index	Rutting Index	Serviceability Index
1	**Shiraga Br.**	Feb.'59	Nov. '67	21,300	37.0^{m}	12^{mm}	66^{mm}	60 As.Con.		6 Mastix	Tar Rubber Emulsion	25.8%	0%	0%	2
2	**Gasu Br.**	Nov.'59	Jul. '68	11,282	174.9	12	80	45 Warbit	28 Guss-asphalt	7 Mastix	Tar Rubber Emulsion	21.3	100	100	2
3	**Jogashima Br.**	Apr.'60	Jul. '68	10,102	235.0	12-16	84	45 Warbit	29 Guss-asphalt	6 Mastix 6 Foils		0	16	100	2
4	**Taisho Br.**	'61	Nov. '67	38,400	92.0	9	60	30 Guss-asphalt	30 Guss-asphalt		Tar Rubber Emulsion	10.4	0	80	2
5	**Nishiarai Br.**	Mar.'61	Oct. '65	10,173	181.2	12	70	30 As.Con.	34 As.Con.	6 Foils		3.1	0	0	4
6	**Hinode Br.**	Sep.'62	Oct. '65	26,073	54.3	10-14	60	30 As.Con.	30 Guss-asphalt		Tar Rubber Emulsion	3.5	3.4	5.7	3
7	**Takamatsu Br.**	Dec.'62	Jun. '68	13,514	19.3	12	50	25 Guss-asphalt	25 Guss-asphalt		Tar Rubber Emulsion	26.3	0	0	2
8	**Ajigawa Br.**	Apr.'63	Mar. '68	34,322	206.5	12	92	35 Guss-asphalt	27 Gussasphalt 30 Gussasphalt		Tar Rubber Emulsion	36.0	3.9	100	2
							92	35 As.Con.	27 Gussasphalt 30 Gussasphalt		Tar Rubber Emulsion	6.1	3.1	30	3
9	**Shinjuku Br.**	May '64	Oct. '65	43,339	100.7	12	80	50 As.Con.	25 As.Con.	5 Foils		1.2	0	0	4
10	**Nishi Br.**	May '64	Nov. '67	53,300	30.6	14-16	62	35 As.Con.	25 Guss-asphalt		Tar Rubber Emulsion	0	23	0	2
11	**Minato Br.**	Aug.'64	Jun. '68	31,960	250.0	12	97	40 As.Con.	57 Guss-asphalt		Tar Rubber Emulsion	11.1	3.4	0	2
12	**Yodogawa Br.**	Sep.'64	Nov. '67	28,000	230.0	12	65	35 Guss-asphalt	30 Guss-asphalt		Tar Rubber Emulsion	0	0	0	4
13	**Biwako Br.**	Sep.'64	Jun. '68	1,820	330.0	12	80	40 As.Con.	40 Guss-asphalt		Rubberized Asphalt	0	1.4	0	4
14	**Ukita Br.**	Nov.'64	Oct. '65	18,755	36.5	10	80	40 As.Con.	40 Guss-asphalt			9.0	0	56	3
15	**Hanshin S-Br.**	Nov.'64			192.0	12	74	10 Silica Sand As.	25 As.Con. 39 Gussasphalt		Tar Rubber Emulsion	0.7	0.2	0	4
16	**Hozumi Br.**	Jul.'65			440.0	12	80	40 As.Con.	40 Guss-asphalt		Rubberized Asphalt	0.3	0.5	0	4
17	**Shinroku Br.**	Jul.'66	Oct. '66	17,000	25.5	10-12	70	30 As.Con.	34 As.Con.	6 Foils		4.5	0	0	4
18	**Watanabe Br.**	Sep.'66	Nov. '67	49,100	58.9	12	80	40 Guss-asphalt	40 Guss-asphalt		Tar Rubber Emulsion	0	1.7	0	4
19	**Higo Br.**	Sep.'66	Nov. '67	49,100	29.1	12	80	40 Guss-asphalt	40 Guss-asphalt		Tar Rubber Emulsion	0	4.1	0	4
20	**Shinjuso Br.**	Oct.'66	Nov. '67	46,800	790.0	12	80	30 Guss-asphalt	30 Guss-asphalt		Tar Rubber Emulsion	0	0.3	0.3	4
21	**Akigase Br.**	Mar.'68	Jun. '68	12,495	80.0	12	60	30 Guss-asphalt	30 Guss-asphalt		Tar Rubber Emulsion	1.1	0	0	4

The single axle load of most heavy vehicles is 10 - 16t, but some are recorded to weigh as heavy as 20t. This is extraordinary severe condition comparing with those in U. S. or Europe.

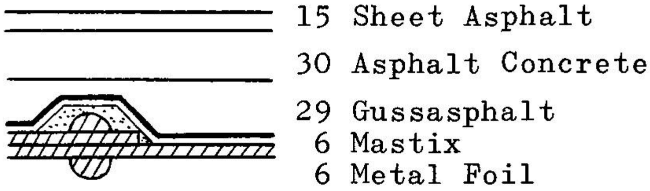
The performance of the pavement is, as shown in Table-1, estimated by Cracking Index, Waving Index, Rutting Index and Serviceability Index.

The Cracking Index, Waving Index and Rutting Index are expressed by the formula in next page.

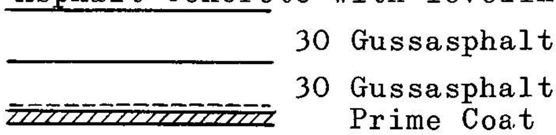
Serviceability Index is the marking by a particular individual on observation of every pavement with marks from 1 to 5 like AASHO Road Test.



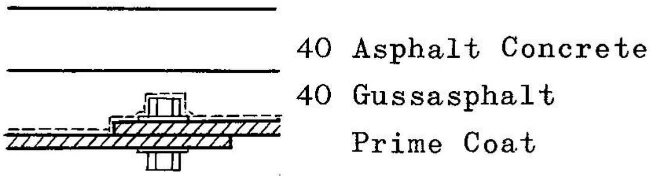
Type-I
Asphalt Concrete in 2 layers



Type-II
Combination of Sheet Asphalt and Asphalt Concrete with leveling



Type-III
Gussasphalt in 2 layers



Type-IV
Combination of Asphalt Concrete and Gussasphalt

Fig.-1 Typical Cross Section of Pavement (mm)

Materials	Type of Mixtures				
	Asphalt Concrete for Surface	Asphalt Concrete for Leveling	Guss-asphalt	Sheet-Asphalt	Mastix
Asphalt Cement	7.5%	6.0%	8.5%	14.0%	35.0%
Crushed Stone (13-5mm)	24.5	61.0	25.0		
Crushed Stone (5-2.5mm)	15.0		17.0		
Sand	45.0	24.0	21.5	68.0	
Mineral Filler	8.0	9.0	28.0	18.0	55.0
Asbestos					10.0

Table-2 Composition of Mixtures (by wt.)

$$\text{Cracking Index} = \frac{\text{total of cracked area}}{\text{whole area of pavement}} \times 100\%$$

$$\text{Waving Index} = \frac{\text{total of waving area}}{\text{whole area of pavement}} \times 100\%$$

$$\text{Rutting Index} = \frac{\text{total length of rutting}}{\text{total length of traffic lanes}} \times 100\%$$

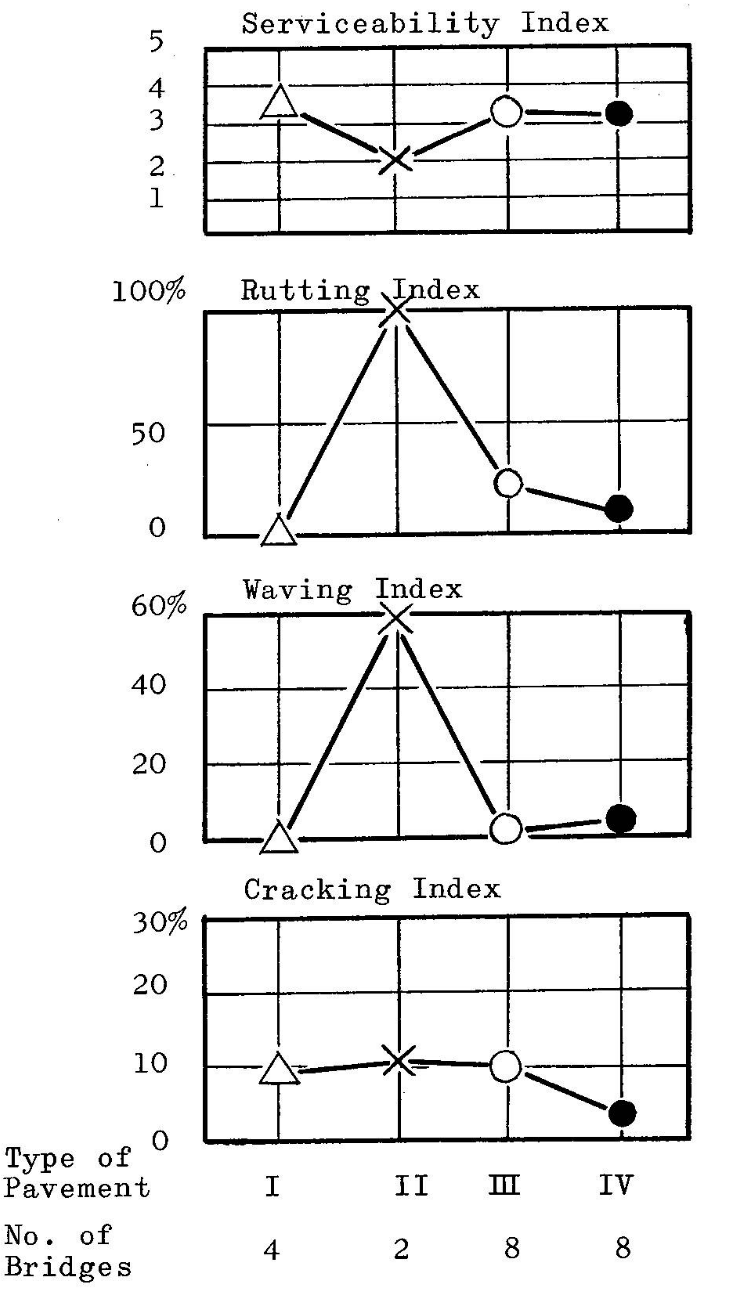


Fig.-2 Performance by Type of Pavement

Serviceability Index 4 denotes comparatively good and needing little repair. 3 denotes needing a little repair and 2 denotes needing considerable repair.

(2) STUDY OF THE RESULTS

As to the factors influencing on the performance of the pavement, period in service, volume of traffic, thickness of steel decks, interval of ribs, type of joint of plates, thickness of pavement, presence of insulation layer, are presumed, and relations between performance and those factors were seeked. The factors which are most related to the performance are period in service, type of the pavement and the volume of traffic. Fig.-2 indicates the relation of the performance and the type of pavement.

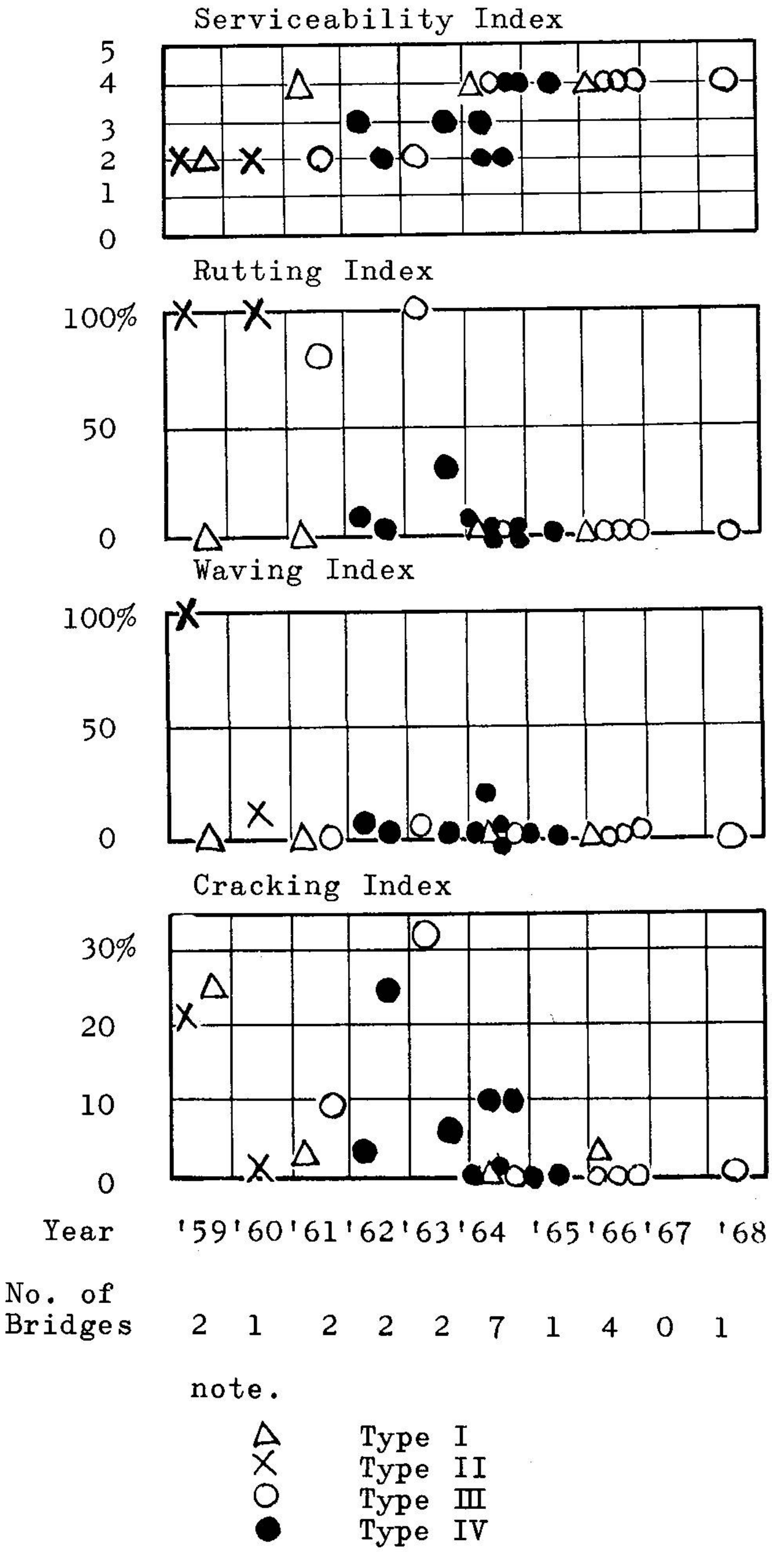


Fig.-3 Performance by Year of Construction and Type of Pavement

The pavement that resulted best in performance was Type I pavement consisting of asphalt concrete mixtures placed in 2 layers and Type III pavement consisting of new type gussasphalt mixture placed in 2 layers.

The worst was Type II pavement consisting of sheet asphalt and asphalt concrete mixtures.

Type IV pavement consisting of gussasphalt and asphalt concrete mixtures appears to cause less cracks than other 3 types.

Fig.-3 indicates the relation of the performance and the period in service in each type of pavement.

Many of the pavements constructed before 1963 are found faulty.

The pavements with asphalt concrete in 2 layers (Type I) are keeping very good condition without relation to the period in service.

The sole gussasphalt (Type III) constructed after 1964 also keeps good condition. This is supposed due to the fact that some improvement of pavement fitting to Japanese climate were made such as adopting gussasphalt with low penetration asphalt (20 - 40) and the fact that the quality control has been strictly executed since 1964.

Type IV pavement consisting of asphalt concrete and gussasphalt mixtures recorded good tendency from the trial pavement, and those constructed in recent years show a good performance.

This type of pavement may be recommended as the one of less fault.

Fig.-4 indicates the relation of the performance and the total traffic (number of vehicles) of a lane since opening for traffic up to date, showing a considerable correlation in waving, rutting and serviceability index, but correlation with the type of the pavement was not so conspicuous as that with the period in service.

The correlation of the performance and the other factors are as follows:

i) There is no correlation between the performance and thickness of the steel deck nor between performance

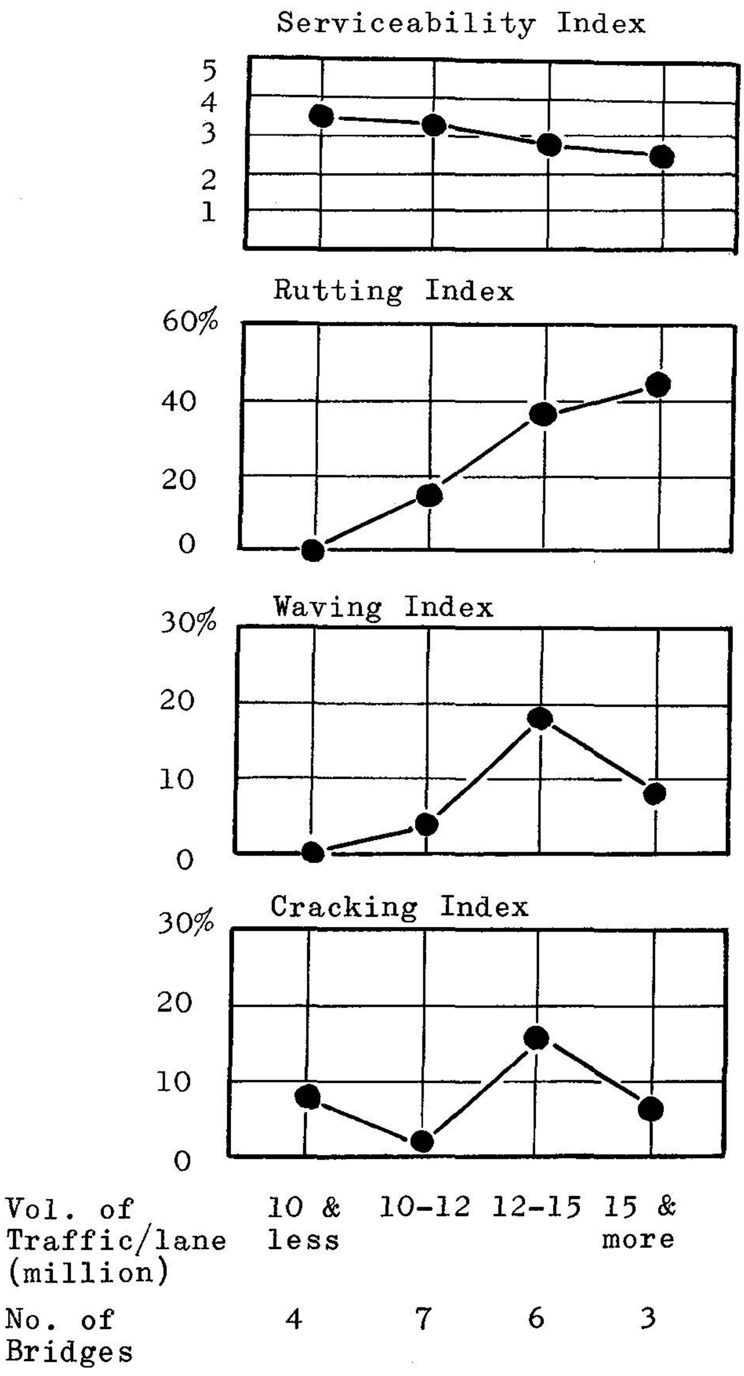


Fig.-4 Performance and Total Traffic/Lane and rib intervals.

ii) The pavement on the all welded steel deck showed good performance than that on the steel decks with riveted joints. This may be due to the fact that the all welded steel decks were comparatively new and it was easy to pave on them.

iii) Thicker pavement has a tendency to cause easily waving or rutting.

iv) In the insulation layer, those with asphalt mastic are not good because it easily causes flow. However, waterproofing is well attained as the crack of the pavement does not reach to the mastic layer.
The insulation layer with the metal foils under Type I pavement show a very good results as well as the pavement upon it.

Besides above, the following points were obtained by the observation.
i) In many cases, there were cracks near expansion joints. Also, in many cases, cracks were found at the construction joints of asphalt concrete.

ii) The bonding of steel decks and the pavement is passably attained with rubberized asphalt or tar rubber emulsion. But these materials are not so good as resinous bonding materials.
In the cracked parts, water infiltrates between steel deck plate and the pavements. However, as far as observed, there was no rust upon the steel deck plate.

iii) Generally, the pavement of which design and composition was not good, or the quality control was not well executed, cause many faults.
The pavements constructed in the past 3 - 4 years find very less faulty.

(3) CONCLUSION

At present, the final conclusion can not be set forth, as the above report is the results of surveys of only 21 bridges, besides, many of them need continuation of observation after this, however, summing up these surveys, the following may be remarked.

i) The combination of insulation layer with metal foils and asphalt concrete is the best type of pavement, and the well designed and well controled gussasphalt is recommended as well.

ii) Bonding of pavement and the steel deck is well attained with rubberized asphalt or tar rubber emulsion, however, it is advisable to develop a more suitable bonding materials.

iii) The steel deck should be all welded deck as the irregularity by splice plates or rivet heads are not good for the pavement.
The thickness of the pavement is possible to be reduced to approximately 5cm by the use of all welded steel decks, and the thinner pavement is thought to be better than the thicker ones.
It may be necessary to fix the expansion joint firmly, and to reinforce the part of steel deck near joint. Pavement near expansion joint should be finished smooth in particular.

SUMMARY

Selecting typical 21 bridges with steel decks, performance of the pavement on the steel deck were surveyed.

The following were revealed by the results of the survey:

i) Asphalt concrete pavement with insulation layer pasted metal foils with blown asphalt and mastic asphalt pavement of which quality is well controled proved good types of pavement for the steel decks.

ii) The bonding of pavement and the steel decks are passably well kept by means of rubberized asphalt and tar rubber emulsion.

However, for the final conclusion, the continuous survey and further study are necessary on this problem.

RESUME

L'observation de 21 ponts typiques à tablier en acier, concernant leur revêtement, a donné les résultats suivants:

1) Deux types de revêtement ont fait leur preuve: le béton asphaltique avec feuilles métalliques collées contre une couche d'isolation et avec asphalte soufflé, et l'asphalte coulé à qualité strictement contrôlée.

2) L'adhésion du revêtement sur la tôle est bien garantie par de l'asphalte caoutchouté et par des émulsions goudron-caoutchouc.

Cependant, une surveillance continue ainsi que des études complémentaires sur ce problème sont requises pour permettre une conclusion définitive.

ZUSAMMENFASSUNG

An 21 repräsentativen Brücken mit Stahlfahrbahn wurde das Verhalten des Belages auf der Stahldecke erforscht.

Die Forschungsergebnisse offenbaren folgendes:

i) Asphaltbetonbelag mit Isolationsschicht verklebt mit Metallfolie mit geblasenem Asphalt sowie Gußasphalt, dessen Qualität geprüft ist, sind geeignet für Stahldecken.

ii) Die Haftung zwischen Belag und Stahlunterlage vermittels Gummiasphaltes und Teer-Gummi-Emulsion ist verhältnismäßig gut. Wie auch immer, es zeigt sich, daß künftig vermehrt Forschung nötig sein wird, um dieses Problem zu lösen.