

## **Characteristics of Stains on Elevated Roads in Urban Area**

**Hidetoshi OMATSU\* and Yasuo HINO\*\***

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### **Synopsis**

Elevated urban roads would not serve their real purpose unless they are not designed as taking into account the prevention of excessive dirt and stains, even though they may look scenically pleasant. As a result of examining the stains and their compositions, it is clear that a close relationship exists between the stain and the rain or the structures and materials used for such urban roads. Also, on analyzing the stain adhering to the road structures, it is apparent that they are caused by exhaust gas. Thus, it is quite necessary to build elevated roads with less umbo and less use of covering materials of lower surface energy.

**KEYWORDS:** Elevated road, Stain, Landscape, road structures, Landscape measures

### **1. Introduction**

In recent years, high quality life space has become necessary for the realizing of an affluent living conditions. Especially because the roads are close and indispensable to our lives, the structures of roads should follow the land characteristics of the local area or region, as providing a familiar and friendly environment for all. Hanshin Expressway, for instance, has an influence on the urban appearance because it passes through major town areas where people gather around.

Given such background, Hanshin Expressway Public Corporation has carried out various measures to improve the landscape by painting the roads in special colors (except ordinary colors of public corporations), by painting colorful pictures and patterns, and by applying specific coverings. However, even if we incorporate such designs for their improvement of landscape-wise, there are still problems of stain and difficulties in maintaining the initial colors of road structures over a long time, which are obstacles to our efforts in landscape improvement.

Therefore, we will report on the form of stains and on the investigation results of their build-ups and composition on our urban elevated roads.

### **2. Form of Stains on Elevated Roads**

The elevated road structures have various countenances according to shapes and materials. The stain adhering to the surface of these road structures also consist of various forms for shapes and materials on the surface of road structures. Shapes and materials on the surface of structures can be classified according to types of stains.

One of the reasons to be classified has been known as the intervention of rainwater based on some references.<sup>1)</sup> Therefore, the form of stain should be investigated according to the classification into the next two patterns, that is, with-or-without intervention of rainwater. The typical form of stains under each condition may be summarized as follows.

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\* Section Chief of Engineering, Meiho Engineering Co.,Ltd

\*\* Associate Professor, Department of Civil Engineering

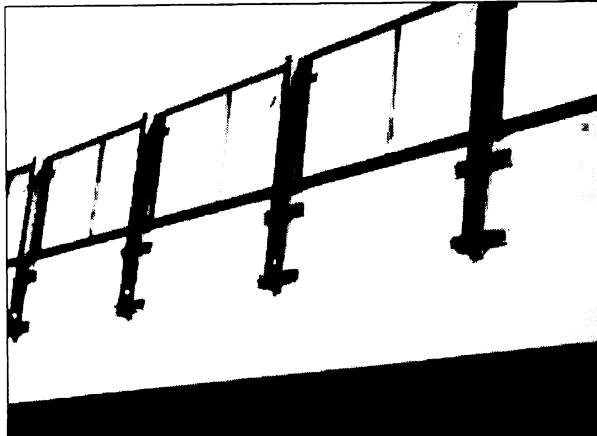
*(1) The stain with intervention of rainwater*

*1) Stains to be caused by rainwater and umbo (photo.1, 2, 3)*

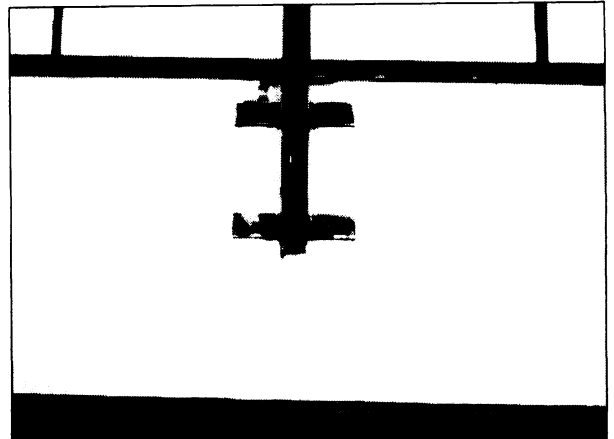
Linear stains were observed under the umbo, like the strut of the soundproof walls and the road signs.

*2) Stains caused by a water leak from the expansion joint (photo.4)*

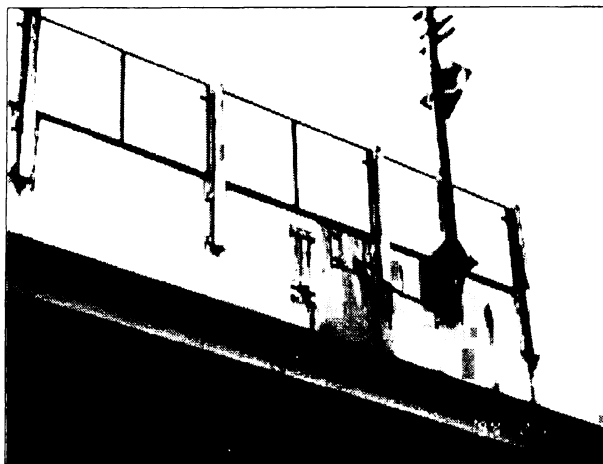
A substantial answer of stains caused by a water leak from the expansion joint was observed. These gave the worst impression of all stains found on pier.



**Photo 1** Example of linear stains observed under the strut of the soundproof walls



**Photo 2** Example of linear stains observed under the strut of the soundproof walls (enlargement of Photo 1)



**Photo 3** Example of linear stains observed under the strut of the road signs



**Photo 4** Example of stains caused by a water leak from the expansion

*3) Stains caused by rainwater on the concrete structure surface (Photo.5)*

Linear stains of white, black, brown and green were observed on the non-coated surface of concrete structures that was exposed by the rainwater.

*4) Stains caused by rainwater on the surface of metallic structures)*

In case of metallic structure, the color of linear stains on the surface that were exposed to rainwater was observed as only black, as contrasted with the case of concrete structure surface.



**Photo 5 Example of stains caused by rainwater on the concrete structure**

*(2) Stains without intervention of rainwater*

*1) Uniform stains on the pier (photo.6)*

The stains without intervention of rainwater such as the stains on the pier were almost observed as the uniform.

*2) Stains around the umbo (photo.7)*

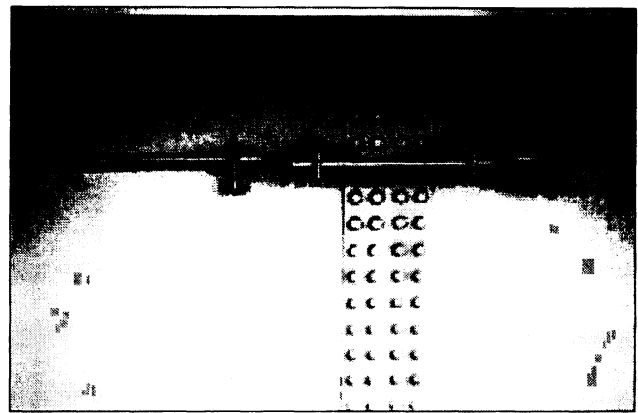
In this case, it seems that the stains tend to adhere around the umbo, although rainwater does not intervene.

*3) Stains of the drainpipe (photo.8)*

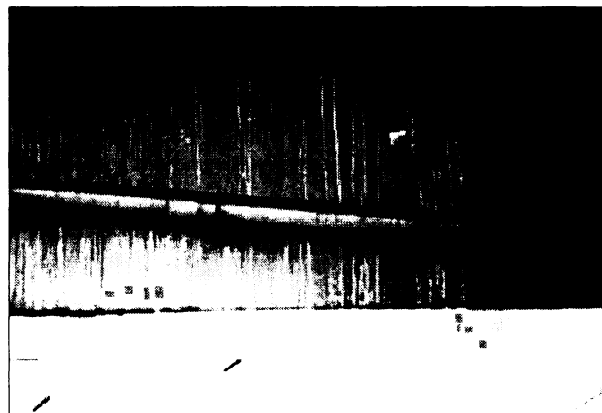
Much stains adhered on the drainpipe.



**Photo 6 Example of uniform stains on the pier**



**Photo 7 Example of stains the umbo**



**Photo 8 Example of stains of the drainpipe**

According to photo.1 to 8, the characteristics of the stain form on the road structure may be summarized in the next three points.

- a) Every stain owing to intervention of rainwater was linear, and the stain owing to non-intervention of rainwater was uniform.
- b) Stains were mainly caused by the umbo regardless of intervention or non-intervention of rainwater.
- c) Stains color on the surface of concrete structure (non-coat) differed from ones of metallic structures.

### 3. Composition of Stains on Urban Elevated Road Structures

Before we take measures to cope with stains, it is necessary to examine the characteristics of stains as mentioned above. Then, at first, the composition and the cause of the stain adhering to the road structures have been investigated in the central part of Osaka City. In order to do that, the data of stain on the surface of the metallic girder that is not exposed to rain were collected along the East Osaka Line of the Hanshin Expressway. As a reference, the data of the particles adhering to the muffler of diesel engine cars were also collected. These collected samples were analyzed by the next three methods and some results are shown in Table 1, 2 and 3.

- a) The organic element quantitative analysis of C · H · N · ash content
- b) The X-ray fluorescence analysis
- c) The gas chromatography mass analysis

Table.1 The consequences of the organic element analysis (in case of the metallic girder)

Carbon	17.0%
Hydrogen	2.0%
Nitrogen	1.0%
Ash content	65.4%

Table.2 Inorganic elements contained in the particles of the metallic girder and the exhaust gas

Detection element	The strain particles on the metal	The strain particles in exhaust gas
Silicon	+++++	+++
Sulfur	++++	++++
Calcium	+++	++
Aluminum	+++	++
Iron	+++	+
Potassium	++	
Chlorine	++	
Magnesium	++	
Sodium	++	
Titanium	++	
Phosphorus	+	
Zinc	+	

Note) + + + + + Very large amount      + + + + A large amount  
 + + + Large amount      + + A small amount  
 + Very small amount

**Table.3 The organic substance to be contained in the particles on the metallic girder and in the exhaust gas**

The stain particles on the metallic girder	The stain particles in the exhaust gas particles
Propanoic acid, 2-methyl, 1-(1,1 dimethyl ethyl)-2-methyl-1, 3-propanediyl ester	Propanoic acid, 2-methyl, 1-(1,1 dimethyl ethyl)-2-methyl-1, 3-propanediyl ester
Hexadecanoic acid	
Octadecanoic acid	
1,2-Benzendicarboxylic acid, bis(2-ethyl hexyl) 1-ester	1,2-Benzendicarboxylic acid dibthyl ester
n-C <sub>17</sub> ~C <sub>33</sub> Paraffin	n-C <sub>17</sub> ~C <sub>33</sub> Paraffin
+aromatic compound	+aromatic compound

According to Table.2, 3, major inorganic elements concerned with the stain caused by exhaust gas or particles along the elevated roads are distinguished as follows.

- a) A considerable amount of Sulfur was detected from both particles. And also, regarding the organic substance,
- b) Propanoic acid, 2-methyl, 1-(1,1dimethyl ethyl)-2-methyl-1,3-propanediyl ester was detected from both particles.
- c) Ester of very similar structure was detected.
- d) Paraffin of the same molecular weight was detected.

From these characteristics, the stain on road structures was considered as a mixture of air dust and paraffin by exhaust gas.

#### 4. Conclusion

Elevated roads in urban areas actually produce negative impressions on urban landscape because of large-scale structure. In addition, stains on road structure may make worse the situation. Therefore the effective measures for stains on the road structure should be required to improve the urban landscape. In this study, the characteristics of stains were analyzed as the essential factor to investigate the measures to remove them. As a result, the three fundamental forms of stain on road structures were obtained as follows;

- 1) Linear stain by rainwater intervention
- 2) The characteristic stain on structure material
- 3) The stain on umbo of surface, which was unrelated to rainwater intervention

It is considered that the stain on road structures in the urban surroundings was a combined substance of air dust and paraffin caused by exhaust gas of diesel engine. Now, the measures against stains on road structures in the cities will become increasingly important as new technique to improve the environment as promoting landscape measures at the same time. However, because the examination on the measures against stain has just started, it is necessary to continue examining more actively from now and onwards.

#### References

- 1) S.Katawaki, *The metal bridge painting*, Vol.21, No.4, 7 (1993)