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The Influence of Environmental Degradation Factors on Cracks of Base-isolated Rubber Bearings under Loading

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荷重下の免震ゴム支承の亀裂発生に及ぼす環境劣化因子の影響

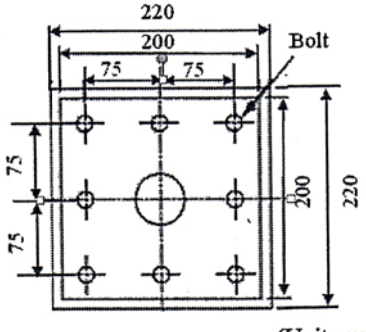
1. Introduction

Base-isolated rubber bearings are widely used in bridges to dissipate the energy due to earthquakes because of their high elastic, high damping and large elongation at failure. However, rubber bearings are exposed to the air and hence they are easily attacked by ozone, dynamic strain and other degradation factors. Although the anti-aging agents are being used to prevent the rubber from degradation, it is indispensable to investigate thoroughly the influence of environmental degradation factors on cracks of base-isolated rubber bearings. Therefore, in this study a series of environmental accelerated aging tests were conducted to investigate the aging characteristics. Two base-isolated rubber bearings and hundreds of dumbbell-like specimens were tested under several test conditions. This study is fundamental to predict the occurrence of cracks of base-isolated rubber bearings under different test conditions.

2. Base-isolated rubber bearing

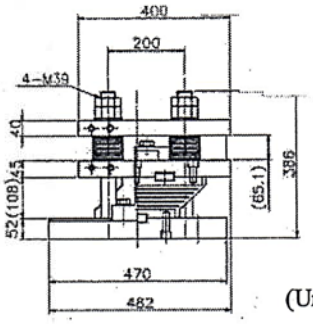
2.1 Size of rubber bearing The main body of base-isolated rubber bearing is composed of several rubber layers spaced by thin steel reinforcing shims. The size of base-isolated rubber bearing is 220×220×108 mm in this study, as shown in Fig. 1.

2.2 Apply loads to rubber bearing Vertical pressure of 6 MPa was applied on the top of rubber bearing first, and then the shear deformation of 72 mm (150% of the thickness of rubber layers) was applied, as shown in Fig. 2.



(Unit: mm)

Fig. 1 Dimension of rubber bearing



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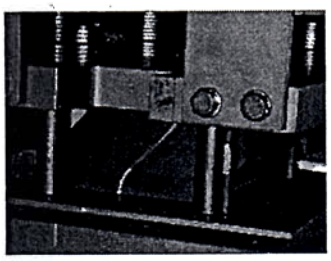

Fig. 2 Rubber bearing applied loads

3. Environmental accelerated aging test

3.1 Dumbbell-like specimen A series of environmental accelerated aging tests were conducted by using the dumbbell-like specimens which are specified in JIS K6521, as shown in Fig 3. All the dumbbell-like specimens were mixed with anti-aging agent and the pre-strain were set as 0%, 40% and 75% (80%). The test result is shown in Fig.4 and Table 1.

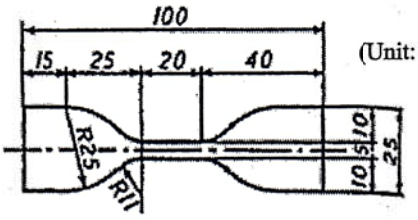

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Fig. 3 JIS K6521 No.3 Specimen

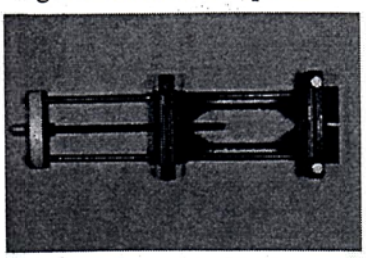

Fig. 4 Cracked dumbbell-like specimen

Table 1 Environmental accelerated aging tests by using dumbbell-like specimens

Condition	(1)			(2)			(3)			(4)		
Temperature(℃)	-15			0			23			23		
Ozone density(pphm)	150			150			50			100		
Pre-strain(%)	0	40	75	0	40	75	0	40	80	0	40	80
Test time(hour)	96	96	96	96	96	24	192	192	192	192	144	24
Crack or not	No	No	No	No	No	Yes	No	No	No	No	Yes	Yes

3.2 Environmental accelerated aging tests by using base-isolated rubber bearings Two base-isolated rubber bearings were tested in low temperature and high temperature corresponding to different ozone densities. Only one of the rubber bearings was mixed with anti-aging agent. The test result is shown in Table 2.

Table 2 Environmental accelerated aging test

Condition	(1)		(2)
Temperature( )	-30		40
Ozone density(pphm)	150		100
Vertical pressure(MPa)	6		6
Shear strain(%)	150		150
Test time (hour)	480		192
Anti-aging agent	No	Yes	Yes
Crack or not	Yes	No	Yes
Crack location	All the surfaces	----	Maximum strain area
Figure	Fig.5	----	Fig.6

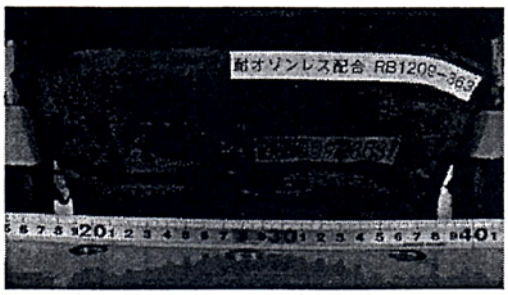

Fig. 5 Rubber bearing without anti-aging agent

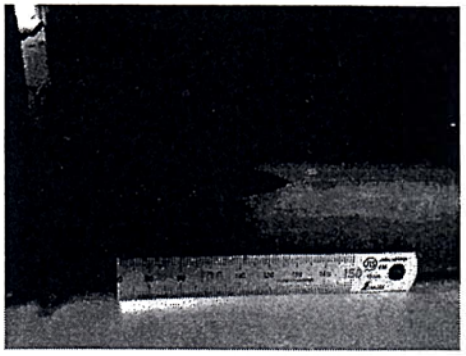

Fig. 6 Rubber bearing with anti-aging agent

4. Conclusions

The results of the tests clearly show the following:

(1) High temperature is severer to degradation of base-isolated rubber bearing in comparison with low temperature.

(2) Local tensile strain could accelerate the occurrence of cracks of base-isolated rubber bearing under the high temperature conditions.

(3) The associative effects of all the degradation factors are presented.

Reference

1) JIS: JIS handbook-Rubber, Japanese Standards Association (1999).

2) Itoh, Y.,and Gu,H. (2009) : Prediction of Aging Characteristics in Natural Rubber Bearing Used in Bridges, Journal of Bridge Engineering, ASCE,Vol.14, No.2, pp. 122-128.