Investigation for crack on base-isolated rubber bearing subjected to environmental degradation factors and external loads

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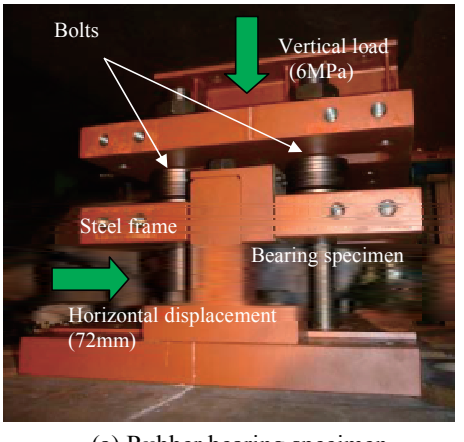
Natural rubber is widely used as a material for base-isolated bearings for bridges. The durability of base-isolated bearing is important for the long term performance of bridges. However, the mechanical properties of natural rubber are changed due to several factors such as temperature, solar radiation, and ozone. It is known that the stiffness of natural rubber bearing for bridges increases with the elapsed time.

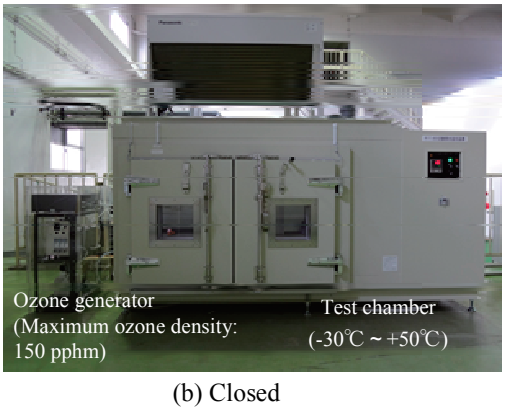
On the other hand, a lot of cracks by ozone attack are actually observed on the surface of base-isolated natural rubber bearings for bridges being used only in a few years. The cracks are observed in the natural rubber bearings for bridges not only in cold region but also normal temperature region. The feature of these cracks is the linear shape with horizontal direction and the occurrence in the tensile strain region on the surface of rubber bearing by the shear deformation.

It is important that the crack initiation and propagation behaviour is investigated for evaluating the performance of natural rubber bearing. However, the existing evaluation conditions for ozone crack of natural rubber bearing by JIS (temperature from -30 to 40 degrees Celsius, ozone density of 50 pphm and elongation of 20%) are not enough for simulating the actually generated cracks. It is unknown how the crack is initiated and propagated on the surface of natural rubber bearings.

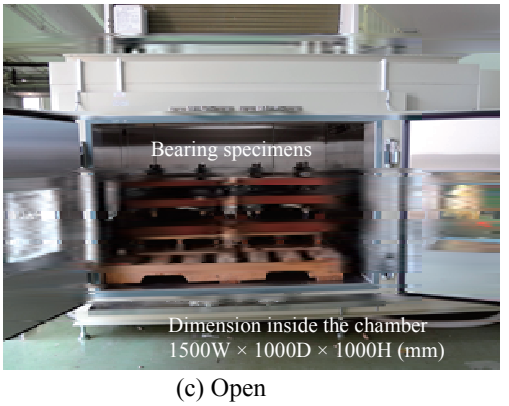
To solve this problem, the large size accelerated exposure experimental system as shown in *Fig.1* was



(a) Rubber bearing specimen



(b) Closed



(c) Open

Fig. 1: Rubber bearing specimen and accelerated exposure experimental system

newly developed for applying the environmental degradation factors (temperature and ozone) and strain on the natural rubber bearing specimens. By using this experimental system, effects of environ- mental degradation factors and strain on the occurrence of cracks on the surface of natural rubber bearings were investigated.

The experimental results on the dumbbell specimens are shown in the *Table 1*. Cracks occurred in the dumbbell specimens (*Fig.2*) with anti-aging agent under the high temperature (23 degrees Celsius) and high ozone density (100 pphm) condition. Furthermore, the larger the magnitude of pre-strain was, the earlier the cracks or breaking occurred. Cracks occurred on the surface of bearing specimen with anti-aging agent under the high temperature (40 degrees Celsius) and high ozone density (100 pphm) condition. The cracks occurred in the region which the high tensile strain was applied on (*Fig.3*). The features of cracks were almost the same as that observed in the actual rubber bearing used during 10 or more years in the general temperature sites.

As shown in *Fig.4*, the influence of cracks generated by the accelerated exposure experiments on the mechanical performances of bearing specimens was not so large because the cracks did not reach the rubber layers inside the specimens. No crack propagation could be observed by the loading experiment.

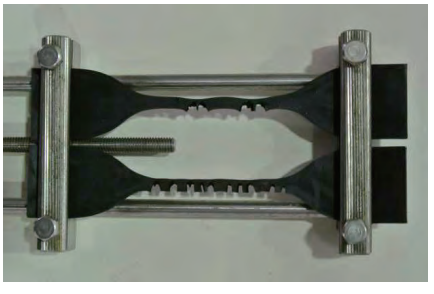


Fig. 2: Damaged dumbbell specimen (23 degrees Celsius, Ozone 100 pphm, pre-strain 80%)

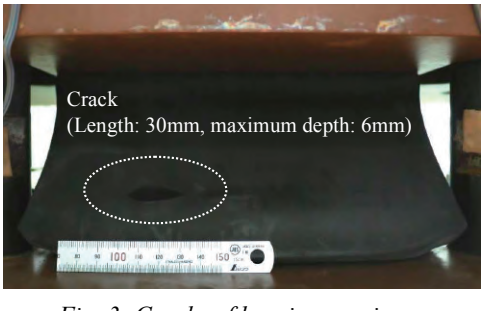


Fig. 3: Cracks of bearing specimen

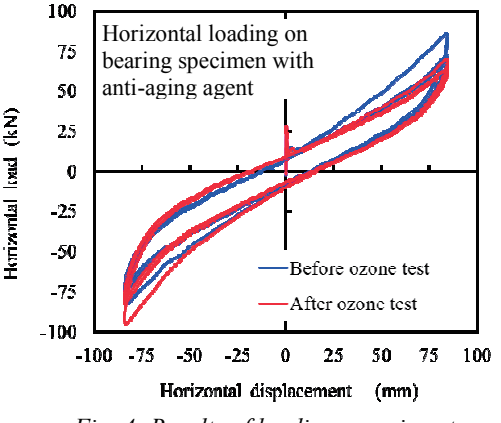


Fig. 4: Results of loading experiment

Table 1: Experimental conditions under the high temperature and their results

Condition	(1)			(2)			(3)			(4)		
Temperature (degrees Celsius)	-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
Time (hour)	96	96	96	96	96	24	192	192	192	192	144	24
Crack or break	-	-	-	-	-	X	-	-	-	-	X	X

X: Crack occurrence