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Characteristics of the Changes in the Compressive and Tensile Stress of the Construction Sealant under Cyclic Movement

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1 Introduction

The degradation of sealing joints in buildings is influenced by joint movement as well as complex weathering conditions such as heat, ultraviolet rays, and moisture. In order to quantitatively measure the effect of complex degradation of sealing materials and the load change in sealing materials during dynamic fatigue, a compact fatigue testing machine for sealants has been developed. By using it, the effect of movement on compression and tensile stress of sealants was examined.

2 Overview of the Fatigue Test

The fatigue testing machine unit (overview in Figure 1 and table 1) has dimensions of 100 (W) × 135 (L) × 110 (H) mm and can be installed outdoors or in a chamber, so that it can perform variety of complex accelerated degradation tests.

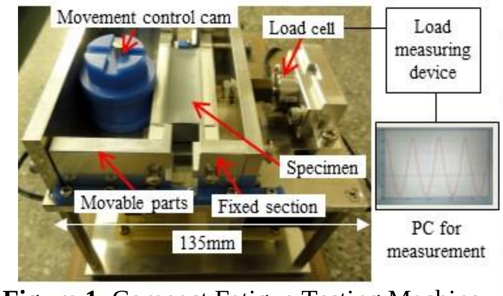

Figure 1. Compact Fatigue Testing Machine (Variable cycle type).

Table 1. Compact Fatigue Testing Machine Specification.

Testing machine type	Fixed Cycle type	Once per day: Decelerator-attached motor control
	Variable Cycle type	Once per day to 5 times/minute: Stepping motor + electric control
Load method	Drive method	Motor + worm gear
	Displacement mechanism	Displacement control by cam eccentric motion
	Displacement mode	Compressed tensile displacement: ±1.2, 2.4, 3.6mm
	Cycle	Once per day, 5 times/minute (sine wave)
Load	Load resistance	Maximum 100N
	Load measurement	Tensile compression load cell (Max.200N)
Environment used	Temperature	-10 to +50°C (depends on motor spec)
	Power	AC100V, DC12V battery (for low load)
Others	Dimensions/weight	Width 100 × length 135 × height 110mm, 1.3kg

3 Investigations Utilizing the Compact Fatigue Testing Machine

The developed compact fatigue testing machine was used to evaluate the changes in the compression and tensile stress when repetitive deformation was applied to the sealant using 1-component type (MS-1) and 2-component type (MS-2) silyl-terminated polyether (STPE) sealants. The results are as follows.

3.1 Effect of Repetitive Deformation (Movement) on Sealant in Curing

(1) Our compact dynamic fatigue testing machine could apply the movement on the sealant in curing and hence was able to measure the process of the changes in the stress continuously.

(2) MS-1 was more greatly affected by the movement in curing, compared to MS-2. For MS-1, the tension and compression stress were significantly reduced by the movement in curing, and it was greatly deformed.

3.2 Effect of Repetitive Deformation (Movement) on Cured Sealant

(1) For both MS-1 and MS-2, the relaxation tensile and compression stress were reduced each time the deformation was repeated. Additionally, the reduction rate of the compression stress was greater than that of the tensile stress. This was particularly significant for MS-1.

(2) When the repetitive deformation was applied once, the phase differences for both displacement and stress for both MS-1 and MS-2 were large, particularly larger in MS-1. This was probably because of the differences in viscoelasticity between MS-1 and MS-2.

(3) It was confirmed that the reduction rate of tensile stress for MS-2 was not dependent on the cycle of the applied repetitive deformation. On the other hand, in the case of the tensile stress of MS-1, the longer the cycle of the applied repetitive deformation was, the lesser the tensile stress became. This is due to the dominant effect of fatigue stress time over the stress reduction characteristics for MS-1. Therefore, it is necessary to take the impact of the fatigue cycle into consideration when executing the fatigue test on MS-1.

3.3 Impact of Displacement, Temperature Conditions, and the Number of Repetitive Expansion/Contraction Deformation to cured MS-2

(1) The greater the displacement was, the more significant the reduction in the compression and tensile stress accompanied by the applied repetitive deformation.

(2) At 23°C, the displacement and the phase difference of the load were small up to a fatigue count of 8,000, whereas the phase difference became large at or above the fatigue count of 20,000. Meanwhile, at 5°C, the phase difference was large even at the fatigue count of 8,000.

4 Conclusions

This fatigue testing machine was developed to evaluate the durability of sealants against degradation under various outdoor environment. Various methods of utilization can be sought such as combining the movement of the sealants reproduced by this machine with outdoor exposure or in an accelerated deterioration test device. Hence a variety of complex degradation tests can be developed and performed including for future sealing technology.

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