C-TYPE METHOD FOR LIFE-ESTIMATION UNDER SOLVENT-STRESS CONDITIONS FOR PLASTICS

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Abstract - The author has developed a new method, capable of predicting durability of plastic parts under railway service conditions. It uses newly revised C-shaped specimens, which are kept under a constant tensile and compressive stress in a crack-promoting agent, while following the stress relaxation to determine S.S.C. Index, at a specific temperature and holding time. These indices have been correlated with field test results collected over about 12 years. Actual damage rates, based on the probability of plastic parts lasting about 10 years can be now estimated by a one-hour laboratory test.

Key words plastics, polycarbonate, durability, life-estimation

Specimen[1] In this method, a circular ring-shaped specimen with a split (C-type specimen)[1], designed by the author, is used as shown in Fig. 1. A photoelastic scale for measuring non-destructively the restoring force of a specimen through polarized light and a metal plate for holding the specimen with desired deformation are attached to C-type specimen as shown in Fig. 1.

Principle[1]

$$\Delta\sigma = K_1 P \dots\dots\dots(1)$$

here, $\Delta\sigma$: the principal stress difference at the center of C-type specimen,

P : the restoring force of C-type specimen,

K_1 : the C-type specimen size constant.

$$E = \frac{K_2 P}{L_n - L_p} \dots\dots\dots(2)$$

here, E : the apparent modulus of elasticity,

K_2 : the C-type specimen size constant,

$L_n - L_p$: the relative displacement in the slit of the specimen.

$$E_t/E_0 = P_t/P_0 = N_{s,t}/N_{s,0} \dots\dots\dots(3)$$

here, N : the total fringe order caused in photoelastic scale at time t and time 0 .

Apparatus[2][3] A general view of "C-type apparatus" is shown in Fig. 4. It can be also used for testing under vibrating conditions by attaching a moving magnet type oscillator to the shaft 9. In this apparatus, the restoring force per unit thickness $P(N/mm)$ of C-type specimen is measured under constant deformation by immersing it in liquid at constant temperature. In this process, we can follow the apparent rigidity changes caused by a quality change, crazing and cracking.

Fig. 1 Standard dimensions of C-type specimen

Fig. 2 N_s change by alkali immersion

Fig. 3 N_s change by photodegradation

(1)Specimen (6)Ultraviolet irradiating lamp (8)Chamber (9)Shaft (11A)(11B)Differential transformer (12)Weight (13)Load cell (15)Polarizer with quarter-wave plate (16)Temperature control (18)Strain indicator (20)Displacement indicator (21)One-pen recorder

Fig. 4 Schematic view of C-type apparatus

Fig. 5 Principle of C-type method

a,c: Electric insulating collar in rail expansion joint
b,c: Electric insulating plate in rail expansion joint
d,g: Electric insulating plate between rail and tongue rail
e,f: Electric insulating plate for joint rod
h,i,j: Plastic anchor plate

Fig. 6 Correlation between S.S.C. Index and endurance percentage

S.S.C. Index We proposed "S.S.C. Index"[4](Solvent Stress Cracking Index) as shown in Fig. 5. This Index $P/P_0(\%)$, where P is the restoring force after 30 minutes, is effective to evaluate the durability of railway track materials under dynamic load of a train and in oily environment to prevent corrosion.

In trouble shootings, there was a good agreement between laboratory data and the damages in actual fields.

As the result of field tests continued for about twelve years, it became clear that the grades of PC expected to have a long life by C-type method show a long life in actual fields.

Fig. 6 shows the correlation between S.S.C. Index value and the endurance percentage.

Conclusion We concluded that on solvent stress cracking, PC with a higher value than 80% of S. S.C. Index is considered a grade that endures to the end of its fatigue life of about 10 years and PC lower than 10% is considered a grade that cannot endure.

C-type method is basically applicable not only to track materials, but also to the other fields under stress and active environment conditions, furthermore, not only to polycarbonate, but also to the other kinds of plastics and rigid elastomers[5][6][7]. And now, the author is studying "New C-type method" for evaluating fundamentally durability of polymeric materials.

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