Ⅱ－91

Study on fracture of PVC pipe by gradual increasing water pressure

Tohoku-Gakuin University, Dept. of Civil Eng. Student M, Kiyohiko Sato
Member , Yukio kono

1. Introduction

The fracture of pipes is occasionally caused by high static pressure and the high pressure(waterhammer) occurence by sudden valve closure in pipeline systems. In this study the static zone and the quasi-dynamic zone are divided experimentally concerning with breaking patterns of PVC test pipe. The experimental results are compared with the result of static stress analysis by finite element method.

2. Experimental approach

The PVC test pipe is 58 mm in diameter and 1.0 mm in thickness. Figure 1 is the experimental apparatus. The test pipe is fixed by four steel plates not to expand longitudinally nor to be loaded by eccentric force. The pressure which acts on the test pipe is picked up by two transducers and amplified by the strain meters and memorized by the digital memory equipment. The pressure waves are checked by the oscilloscope and written down by the pen-recorder.

3. Results of experiment

The breakage patterns of test pipes are shown as fuigure 2.

(a)When the pressure is acted on the test pipe slowly the pipe swells and white line appear to longitudinal direction. Finaly the small hole is made on the white line and water leaks out from this hole .

(b)When the pressure is acted on the test pipe faster than (a) the same pattern as (a) occurs at first then the breakage pattern shows that test pipe swells and breaks x pattern.

(c) When the pressure is acted on the test pipe quickly the pipe breaks suddenly with x pattern but it is without swollen this time.

The result of the maximum pressure versus loading time is shown as figure 3& 4. Figure 3 is the average of the maximum pressure exceeding 100 seconds loading time. The result of average pressure is 15.35 kgf/cm^2 and the standard deviation is 0.96 kgf/cm^2. This area is classified as the static pressure loading zone approximately. Otherwise, figure 4 shows the results in the less than about 10 seconds loading time. The linear equation of least square is calculated as $p = -0.23\,t + 19.8$ from the data. This area is classified as the quasi-dynamic loading zone.

4. Static stress analysis

The static stress analysis by finite element method is applied to calculate the stress at each element and the analysis is applied to find when the pressure acting to internal wall of test pipe reaches to the ultimate strength by calculating the stress at each stages. A right half circle of the test pipe section area is used as a model of this analysis. The diameter is 58.0 mm and the thickness is 1.0 mm. The top node of cutting part of the pipe is fixed to both directions of x and y axes and other nodes of cutting part are fixed only to x direction as boundary conditions.

As a result, The breaking pressure of pipe is found to be 12.7 kgf/cm^2 with the assumption of the ultimate strengh 420 kgf/cm^2 shown as figure 3.

5. Conclusions

The result of experiment shows that the average of breaking pressure is 15.35 kgf/cm^2 and the standard deviation is 0.96 kgf/cm^2 in the static zone. The breaking pressure is found to be 12.7 kgf/cm^2 according to

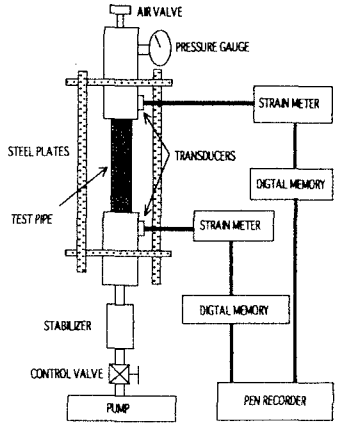

Fig. 1 Experimental apparatus

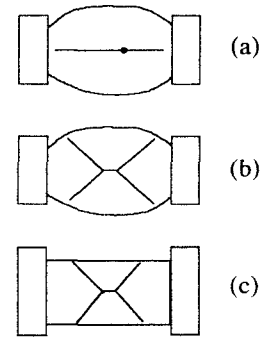

Fig. 2 Three breakage patterns

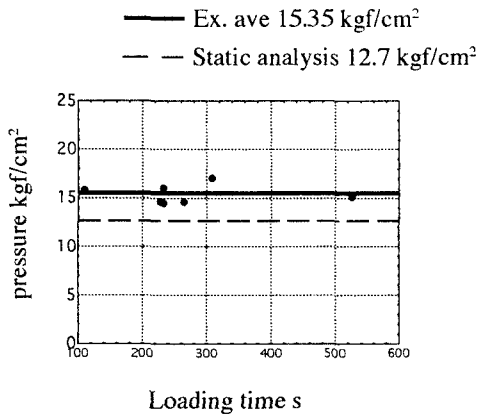

Fig. 3 Result of Experiment in static zone

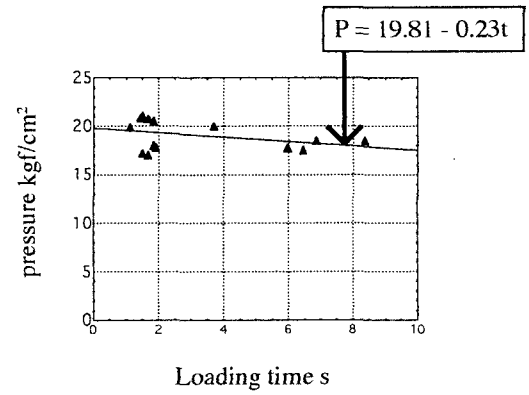

Fig. 4 Result of Experiment in quasi-dynamic zone

the static stress analysis with the assumption of the ultimate strength 420 kgf/cm^2.The ultimate strength of the PVC test pipe is found to be 520 kgf/cm^2 by the static stress analysis.

In the quasi-dynamic zone, breaking pressure is calculated as P=-0.23t+19.8 in the less than 10 seconds loading time. To connect this equation and static breaking pressure ,the loading time of the quasi-dynamic zone is less than 19.3 seconds. The ultimate strenghs at each loading time are culculated reversely by this equation and static results. As the loading time become less, the ultimate strenghs becomes higher.

7. Refrences

1) Kono, Y., Sugano, T. and Watanabe, M. : Experimental study on dynamic fracture of pipes by water hammer and quasi-static fracture by water pressure, JSCE, No. 509/II-30, 55 - 65, 1995.2.

2) Narisawa, I. : The strength study of high polymer materials. Ohomu Co., 1982.

3) Tobe, T., Sato, Y. et al : One consideration on high speed tensional deformation of circular pipes, Plastic and process, No. 25 - 283, 1984.8.