AN ESTIMATION ON AXIAL STRENGTH OF JOINT MADE OF FE-28MN-6SI-5CR SHAPE MEMORY ALLOY AT VARIOUS DEFORMATION RATE

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1. Introduction

Fe-based shape memory alloy (Fe-SMA) is attempted to be applied to large structural members such as the dampers to reduce vibration for the high-rise building structure [1] as well as the joint for the curved pipes in the underground. When applying this alloy to a smaller-scale member, it is difficult to fasten it sufficiently because its maximum recoverable strain so far is only about 4%. In addition, it can be realized that the pipe joint is loaded at various deformation rate such as earthquake or strong wind. Therefore, it is important to examine axial strength of the joint at various deformation rate especially at much higher deformation rate.

In the previous study, the joint strength is basically estimated by pull-out test based on the tensile test and the strength is defined as maximum force [2]. However, it is difficult to use this kind of the specimen to the impact testing machine because it has a quite complicated structure. On the other hand, a compression-shear test by pushing out only the joint has a simple method in comparison with the pull-out test. Therefore, it will be possible to expand the range of deformation rate for the test.

Fujita et al. [3] performed the three-point bending test of the joint at various deformation rate and estimated its rate sensitivity of bending strength. They define the strength at the fracture of the joint as force when the circumferential strain on the surface of the joint starts decreasing. As a result, it is revealed that the strength decreases with an increase in deformation rate. Following this viewpoint, Yamamoto et al. [4] also attempted to evaluate the axial deformation behavior by performing compression-shear test at various deformation rate by using two different testing apparatuses such as a conventional material testing machine under quasi-static condition and drop-weight testing machine under impact condition.

In the present research work, the axial deformation behavior of the joint is examined by the compression-shear test. Following the previous studies [3, 4], a specimen which consists of the expanded joint made of Fe-28Mn-6Si-5Cr alloy and bar made of SUS304 is heated to tighten. Next, the axial deformation behavior is estimated by performing the compression-shear test at various deformation rate. As a result, it is attempted that the rate sensitivity of maximum force and axial strength is discussed.

2. Experimental procedure

After machining joint and bar, they are heat-treated as same as the previous research works presented [3, 4]. On the other hand, diameter of the previously-mentioned joint is expanded by a tapered bar made of die steel. After inserting the bar made of SUS304, it is tightened by the joint because of its recovery behavior through the heat treatment. Two rosette gauges are glued at two positions on the surface of the joint. More details of the diameter expansion and fastening processes of joints can be also seen in Ref. [3, 4].

In the quasi-static test, the compression-shear test is performed by using a material testing machine (Shimadzu AG-250kNX). For the impact test, the compression-shear tests are performed by using a drop-weight test machine. The details of the compression-shear test conducted by using the material testing machine and drop-weight test are provided in the previous research work presented [4]. In order to investigate the axial strength of joint at various deformation rate including much higher deformation rate, compression-shear tests at room temperature are also carried out by using split Hopkinson pressure bar (SHPB) technique.

3. Results and discussions

Figure 1 shows the force and circumferential strain vs displacement obtained by the quasi-static test at 0.083mm/s. From this figure, both force and the circumferential strain become almost constant after reaching the maximum value. Before circumferential strain at upper side indicates its maximum value, a sudden change in a slope of the curve can be seen. Here, the axial strength of the joint can be defined as force when the slope of the curve on the circumferential strain changes as similar to the previous research works [3, 4].

On the other hand, for higher deformation rate, Fig. 2 shows the input, output and average force and circumferential strain vs displacement obtained by the SHPB technique at 3884mm/s. As shown in this figure, the circumferential strain at the upper and lower sides of the joint is consistent in the beginning of deformation. However, it can be seen that the difference begins to occur at the displacement of 0.1mm. Here, it is different from the above-mentioned mechanism of fracture, the axial strength at higher deformation rate can be defined as force at the point where the circumferential strain at the upper and lower sides of the joint start being different. In addition, compared with the maximum force and axial strength at lower deformation rate for the quasi-static test, it is possible to observe the value of both the maximum force and axial strength at higher deformation rate become higher.

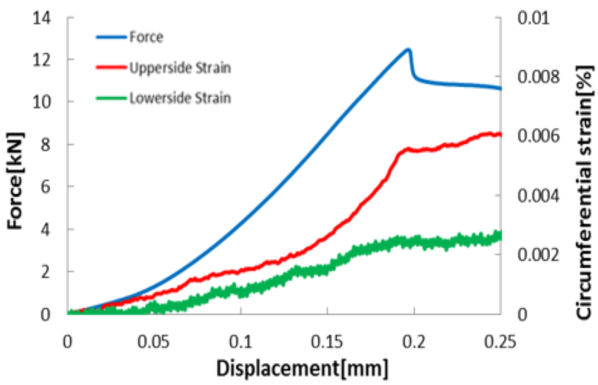

Fig. 1. Force and circumferential strain vs displacement obtained by the quasi-static test

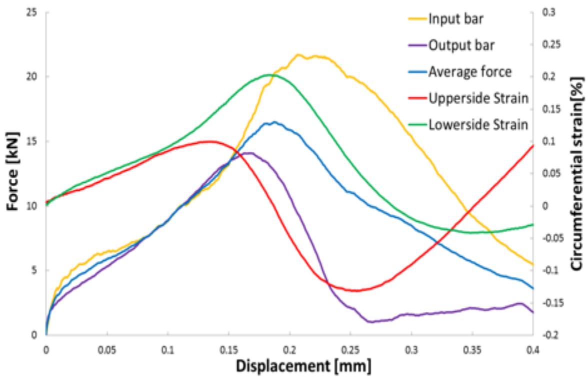

Fig. 2. Force and circumferential strain vs displacement obtained by the SHPB technique

4. Summary

For the bar made of Fe-SMA, the compression-shear test was carried out at various deformation rate. At the same time, the behavior of circumferential strain of the joint was measured. Other details will be discussed at the conference.

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