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Tensile Shear Creep Test of Steel-Balsa-Steel Sandwich Panel as Floor Deck (II)*1

Development of Simple Shear Creep Test Machine

Maria Teresa R. REZENDE*2, Hikaru SASAKI*3,
Yoshio SHIRAKI*4 and Yasunori TANAKA*4

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Abstract——A simple shear creep test machine was proposed and creep test was made with ASTM standard shape specimens. Also comparative measuring method of shear deformation was discussed. The results obtained were as follows: 1) The test machine made as a prototype for tensile shear creep test was capable to transmit more than 1,300 kgf to the specimens so it would be suitable for test about 69% of shear strength (P_{max}=1,896 kgf), 2) The measuring method of shear deformation, which had the measurement points mounted on brass tips placed on loading plates edge, can be considered practical. Although the glue-line deformation between specimen and loading plates tested have been neglected. Prototype with accuracy and lower costs was achieved. Therefore, it is possible to extend the creep test period or to make simultaneous tests on many specimens when constructing several test machine.

1. Introduction

Knowing that one very important characteristic of lumber is duration of load in shear, and very little data exists on this characteristic as testing is expensive and time consuming[1], a simple handy test apparatus is necessary.

In previous paper[2] stress distributions of five different shapes of steel-balsa-steel sandwich panel specimens were calculated by finite element method and the shape effect was discussed. In that investigation it was found the correct shape of sandwich specimen submitted to tensile shear test, which had ASTM standard relation length/thickness≧12[2].

In the present paper a simple shear creep test machine is proposed, as a

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*2 National Institute of Metrology, Standardization and Industrial Quality-SAS Qd. 2 lote 2/5 9 undar-70.070-Brasilia, DF-Brazil, as research fellow at Wood Research Institute, Kyoto University, Uji, Kyoto 611 Japan.

*3 Wood Research Institute, Kyoto University, Uji, Kyoto 611 Japan.

*4 Koshii & Co. Ltd., 2-10-60 Hirabayashi-Minami, Suminoe, Osaka 559 Japan.

prototype and creep test was mae with ASTM standard shape specimens. The results of the test and measuring method of shear deformation, type of apparatus and its applicability are discussed.

2. Material and Method

The test machine proposed for creep test was made as a prototype. The main objective of this apparatus is to extend the creep test period from few months to years maintaing the accuracy of test without risks. Combination between the equipment capacity of 1.5 ton and lower costs were aimed at.

A scheme of the prototype is shown in Fig. 1. The magnification ratio of 10 times for horizontal lever and 10 times for vertical lever in relation to the weight applied was designed. The magnification of horizontal lever was obtained by the use of sproket and roller chain. However, its precision can be improved by the use of disc plate and steel belt. A common hexagon bolt was used to hinge each lever. The connection between the vertical lever and specimen was made through the joint plate as well as specimen and loading screw (at left inferior side) through a shackle and an eye nut.

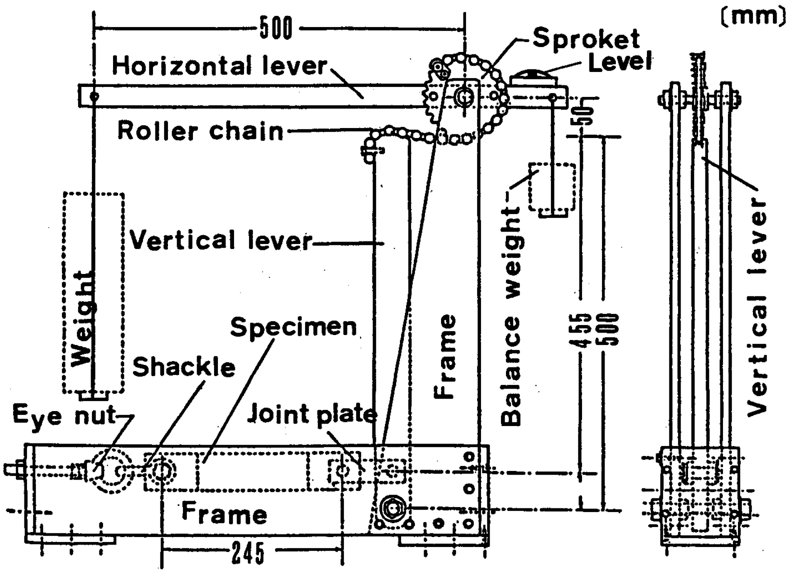


Fig. 1. Schematic view of test machine.

A load proving ring was placed at the specimen position and the weights were set on horizontal lever to obtain the calibration of load. The calibration curve obtained is shown in Fig. 2 and a linear relation was obtained. No hysteresis of the relation was observed on repetition of loading. Turning the screw at the left inferior side of the machine, the horizontal lever can be adjusted and the correct load to be applied on the specimen is produced. Two stop bars were utilized to

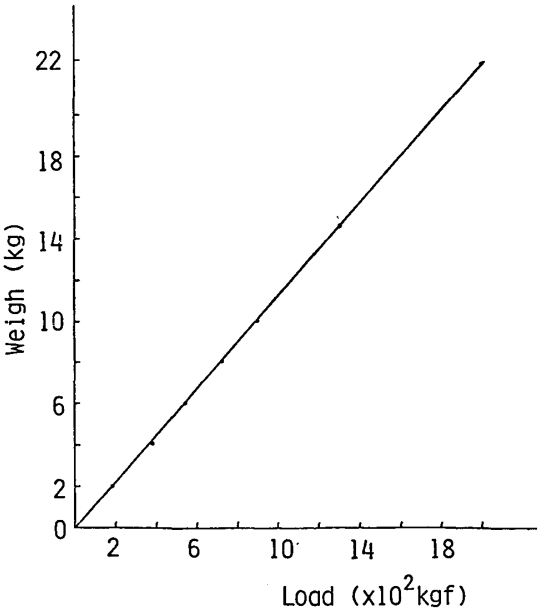


Fig. 2. Loading condition of test machine.

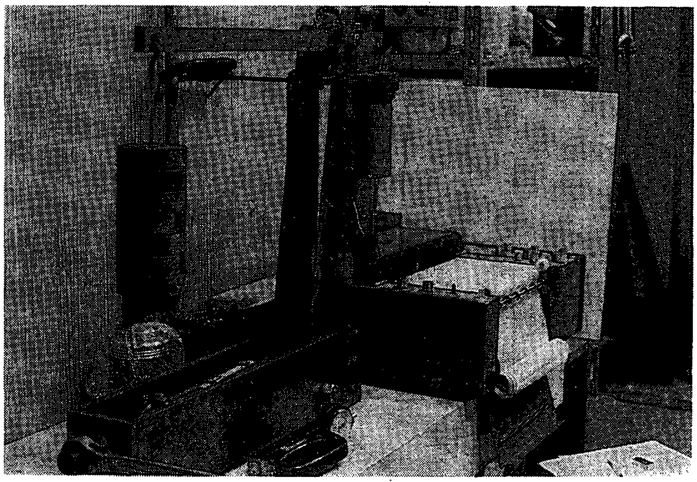
avoid the rotation of the eye nut consequently twisting at the specimen. Some comparative tests are necessary to investigate the applicability of the prototype. The general arrangement of the test setup is shown in Fig. 3.

The raw material of core utilized was balsa (*Ochroma* sp.) with a density of 0.18 g/cm^3 which was determined in accordance with ASTM-C-271-61 (1970)[4]. The dimensions of balsa wood pieces were 150×50×11.7 mm having the end-grain on the larger surfaces which were prepared using 80 mesh sand-paper. Stainless steel plates already back-primed with 150×50×0.4 mm in size were used as face of the sandwich construction. Epoxy resin adhesive (Kanebo NSC: KBR-26 as resin and KBK-13 as hardner) amounting 400 g/m^2 was spreaded on balsa core surfaces and pressure of 7 kgf/cm^2 during 20 hours was applied at room temperature.

A loading steel plates with 250×50×10 mm in size were bonded to the faces of sandwich construction with SGA adhesive (second generation acrylic adhesive, Diabond SG-11 formulated by Nogawa Chemical Co. Ltd.). Preliminary test had shown that this method of attachment would develop sufficient strength to cause fracture in the sandwich away from the connection.

Besides the trial test method (see Appendix) special measurements were made on the shear deformation of specimens. The measurement points mounted on the brass tips were placed on the loading plates' edge (see Fig. 4). The shear deformation taken by micron dial strain gauge, contact type, was obtained by measuring the displacement of one loading plate with respect of the other. In

(A)



(B)

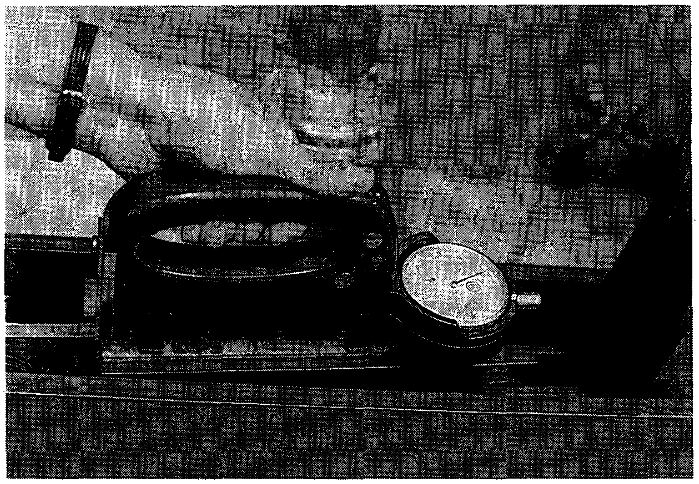


Fig. 3. General arrangement of test apparatus. (A) View of test setup. (B) Top view of conventional method for measuring shear deformation.

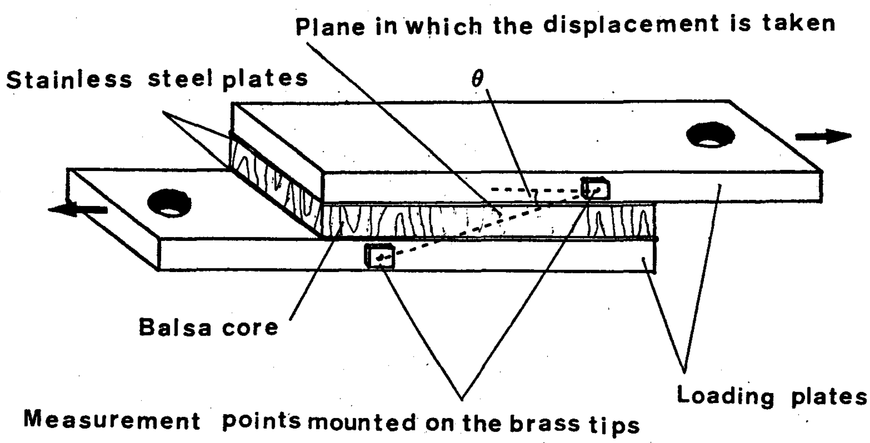


Fig. 4. Detail of specimen and method for measuring shear deformation.

order to obtain the real deformation of the sandwich a cos θ was taken as shown in Fig. 4. On the other hand, it was assumed that the shear deformation (slip) in the glue-layers between the loading plates and stainless steel faces of the sandwich are negligible.

Eight levels of loading varying from 34% to 69% of averages tatic shear strength previously investigated were selected for the tests, as shown in Table 1.

Table 1. Loading conditions used in the experiment

Weight (kg)	Equivalent load (kgf)	Percentage of static shear strength* (%)
14.6	1,300	68.6
12.4	1,105	58.3
11.6	1,040	54.9
10.9	975	51.4
10.2	910	48.0
9.5	845	44.6
8.7	780	41.1
7.3	650	34.3

* $P_{max}=1,896$ kgf.

Each specimen was submitted to constant load until failed or until the period of two weeks was completed without failure. The displacements were measured to the nearest 0.01 mm at sufficient time intervals to define a creep curve.

The level of the horizontal lever load was checked periodically during each test to insure that the specimen was been subjected to the correct load. Also the temperature during testing was recorded.

3. Results and Discussions

Fig. 5 shows the relation of displacements to the duration of load-carrying. The displacement was plotted on an arithmetic scale and the loading time was plotted on a logarithmic scale. Each curve of this figure represents a single specimen. All specimens were loaded to certain percentage of maximum shear force previously investigated, as can be seen in the appended table of Fig. 5.

When a constant shear stress is applied to core materials, a certain amount of creep takes place[5]. As creep is a function of stress, time and temperature an increase in any one of this will increase the creep[6]. Table 2 gives the time to failure the specimens subjected to constant loading condition.

From the results it can be seen that the time to failure is quite variable even for specimens subjected to the same loadeng condition. However, as a whole, in specimens under high load-carrying a great displacement and short-time to failue

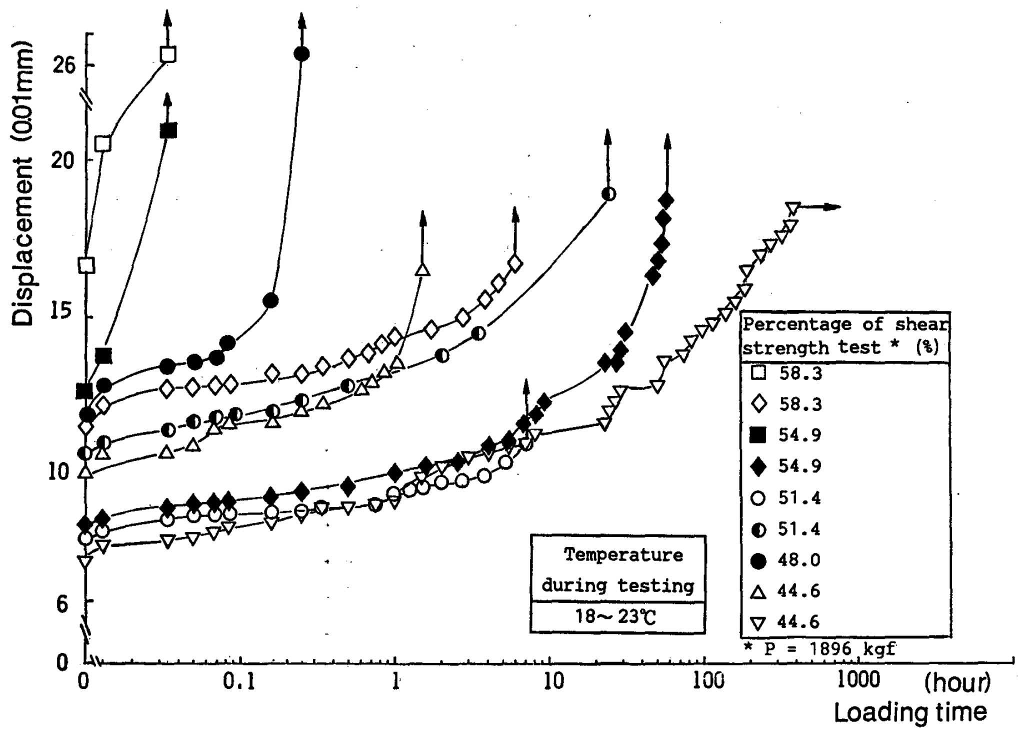


Fig. 5. Tensile shear creep test results for different rates of loading.

were observed. The tests were conducted at normal temperature, therefore any influence of this parameter was observed in the results. The ability of a material to resist fracture due to duration of load is called the endurance limit[6]. It can be determined from Fig. 6, where the testing of each specimen provides data for one point on the curve and the endurance limit is therefore the ordinate of the horizontal portion of the curve.

The glue-layers between the facings and the loading plates were aso sulbjected to shear stresses. However, this method of measurement did not consider the displacements of the boundary separately. Comparing this method of measurement with the method explained in the Appendix, one can consider the former better, so far, than the latter, although the glue-line deformation between specimen and loading plates have been neglected in the present method. Further investigations are necessary to verify the influence of the glue-line deformation in relation to the deformation of the specimen.

The test machine developed is capable of transmitting more than 1,300 kgf to the specimen, so it would be suitable for tensile shear creep testing about 69% of the average static shear strength (P_{max}=1,896 kgf).

Conclusions

The test machine proposed for tensile shear creep test was capable to transmit

Table 2. Time required for failure of specimens subjected to loading

Percentage of static shear strength* (%)	Time to failure
68.6	6 seconds
58.3	2 minutes
58.3	7 hours
54.9	2 minutes
54.9	61 hours
54.9	186 hours
51.4	16 hours
51.4	40 hours
48.0	15 minutes
48.0	18 hours
48.0	170 hours**
48.0	20 minutes
44.6	27 hours
44.6	***
41.1	***
41.1	***
34.3	72 hours
34.3	***
34.3	148 hours**
34.3	***

* P_{max}=1,896 kgf. ** No failure. *** The period of two weeks was completed without failure.

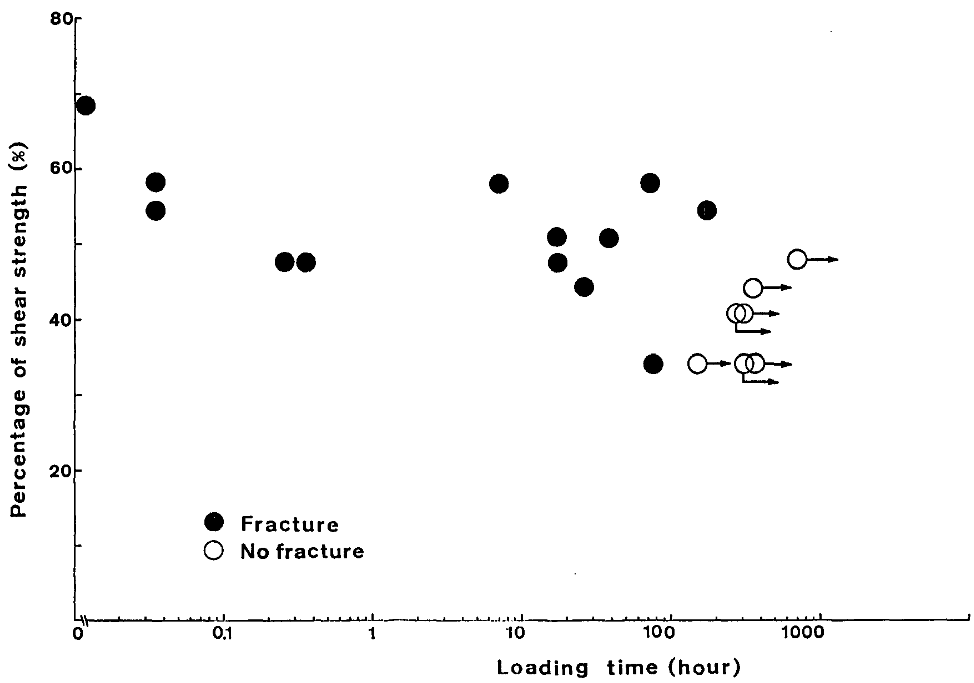


Fig. 6. Endurance curve.

moe than 1,300 kgf to the specimens so it would be suitable for test about 69% of shear force (P_{max}=1,896 kgf). Its lever system provided a linear relation between the weights and loading to be transmitted to the specimens.

Based on the results of experiment, the measuring method of shear deformation can be considered practical, although the glue-line deformation between specimen and loading plates tested have been neglected.

Finally, combination of lowr costs of the prototype with its reliability was achieved. Then, it is possible to extend the creep test period or to make simultaneous tests on many specimens when constructing several test machines.

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Appendix

Considering the influence of glue-layers between the sandwih construction and loading plates, measurements as shown in Fig. 7 were taken. In this case, the measurement points mounted on the brass tips were fixed on the angle steel plates were placed between the balsa-stainless steel interface.

The static deformation of specimens were taken directly by use of micron dial strain gauge, contact type.

The specimens condition and loading conditions were the same as those utilized in the test previously explained.

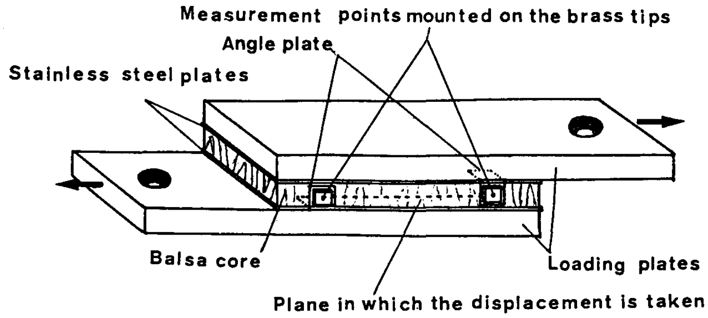

Fig. 7. Detail of specimen and trial method for measuring shear deformation.

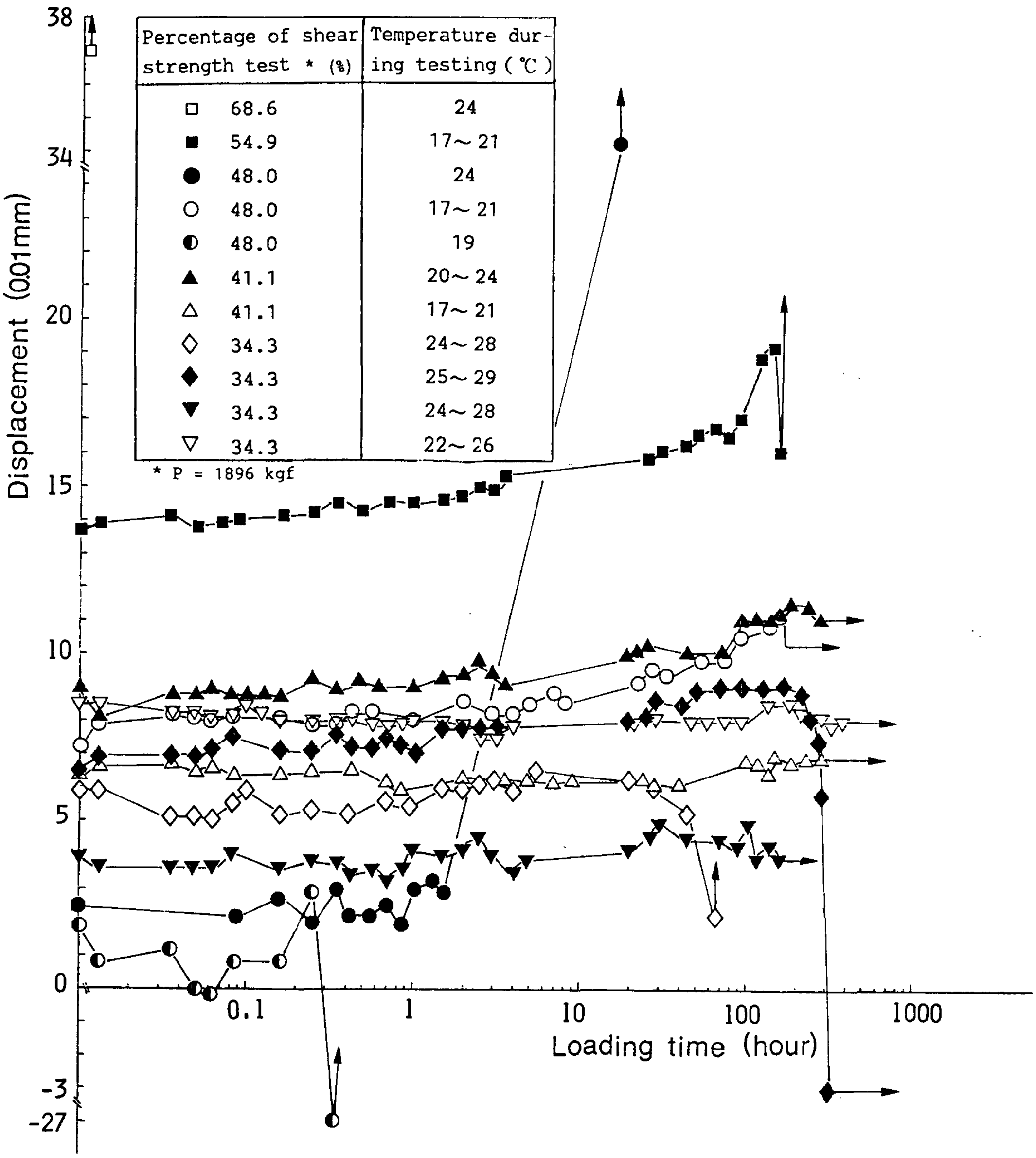

Fig. 8. Tensile shear creep test results for different rates of loading-conventional measurement method.

Fig. 8 shows the relation of displacements to loading time, and the appended table gives loading applied on the specimens as well as the temperature during testing.

As can be seen through the results the time to failure is variable. Another point of interest is the occurence of decreasing displacements and sudden failure with the increase of loading time. It can be attributed to the rotation of the angle steel plate utilized to set the measurement points.

An adequate system to measure the displacement must be used to assure the accuracy of the data. Otherwise, many specimens may not attain their correct deformation in duration of loading testing.