CHAPTER 5

DISCUSSION

The boundary potential setting of the experiments are shown in table 1-5. The comparison between the fitting equation and the analytical equation of the boundary potential of specimens are shown in table 6. It indicates that the boundary potential settings are closed to the theoretical values. The curve of the fitting equation is the average curve of which the actual values deviate on both sides of the curve are equal. The cause of this error is due to the boundary potential being supplied by a number of points instead of being supplied continuously.

Fig.13-17 are the equipotential lines on each specimen obtained directly from the experiment, and the shear stress lines constructed by the method shown in appendix A.

5.1 Establishment of reliability

Square and rectangular specimens are selected to verify the reliability of the equipment. They are discussed seperately as followed:-

5.1.1 Square specimen

Table 7,8 and 9 are the potential on x,y axes and diagonal line of fig.13 respectively. These values are used for calculating the shear stress component by means of the method of least square as shown in appendix A. The potentials and also the shearing stress functions on the co-ordinate axes[1,2] and the diagonal lines are plotted to compare with the analytical values in fig.18. The comparison of the shear stresses on co-ordinate axes and the diagonal lines are shown in fig.19.

Consider fig.18, curve (a) is the potential (which is also the conjugate function) on co-ordinate axis. The deviation is increased as it is closer to the origin. The same effect can be seen on the diagonal axis (curve b), nevertheless the error is small and the result shows good agreement. The same error also happens on curve (c) and (d) of the shearing stress function, but it is not so much as on curve (a) and (b).

On fig.19, the results agree with the analytical values except at the corner, the value of $\frac{\tau}{\mu\alpha}$ is nearly 2.5 while analytically it should be zero. It is considered that the increment of potential of that region is very high, just a little change of slope causes a large error to the result. So the error may be due to calculation. Since that region is near the boundary, it is also possible to be affected by the errors of the boundary potential

---

[1] The conjugate functions on co-ordinate axes are very closed to the fitting's curve obtained from the value on x and y axes, so the fitting curve is shown in stead of the observed point.

[2] The shear stress and the shearing stress function on the co-ordinate axis are the average of the values on x and y axes.

setting. So the error may be due to experiment too. This region covers about 1-2 % of the whole area of the specimen. Except this region, the remainder agrees with the analytical values.

To approximate the integral part of the torsional stiffness, the area of the square specimen was divided into several small squares as shown in fig.20 the corresponding value of the shearing stress function at the middle of the dividing squares are obtained by interpolation as shown in table18. To compare the maximum shear stress and the torsional stiffness, the co-efficient (K, K_1) of eq.(2.43) and eq.(2.44) obtained experimentally and analytically are shown in table 23.

The errbr of average maximum shear stress is 0.15 %, the greatest error obtained from W-side is less than 1 %. The torsional stiffness obtained experimentally deviated from the approximated torsional stiffness within 1 %. The results are accurate enough for engineering purpose.

5.1.2 Rectangular specimen

The reliability of the equipment is verified again by the rectangular specimens. Table 10 and 11 are the potential on x-axis of fig.14 and 15 respectively. From these values, the co-efficient K can be calculated for each specimen. The torsional stiffness of both specimens are approximated from the value in table 19 and 20. The comparison of co-efficient K and K_1 are shown in table 24.

The error of the maximum shear stress is about 2 % but the average is only 0.1 %. The error of the torsional stiffness is as high as 5 % for L-specimen while the average value is less than 2 %.

5.2 Application of I cross-section

For the I cross-section, while the maximum shear stress occurs at the middle of the web's surface, the stress concentration occurs at the reentrant corner.

The maximum shear stresses of W and L specimens are calculated from the value in table 12 and 15. The values of $\frac{\tau_{yz}}{\mu\alpha}$ at the reentrant corner are calculated from the value in table 13 and table 16, the values of $\frac{\tau_{zx}}{\mu\alpha}$ at the reentrant corner are calculated from the value in table 14 and table 17, then the values of stress concentration $\frac{\tau}{\mu\alpha}$ are calculated from $\frac{\tau_{yz}}{\mu\alpha}$ and $\frac{\tau_{zx}}{\mu\alpha}$. Torsional stiffness are calculated from the value in table 21 and table 22. The comparison between experimental results and the approximate values of eq. (2.45),(2.46) and (2.47) are shown in table 25.

It is found from the experiment that the maximum shear stress at the middle of the web is 3.77, comparing with the value approximated by the narrow-rectangle in eq. (2.46) which is 4, it is reliable. The shear stress lines in fig. 16 and 17 are almost parallel at the region near the boundary along the web. It means the shear stress along the web is almost constant and only a little bit smaller than the maximum shear stress, but on flange, the shear stress is small.

The value of $\frac{M}{\mu\alpha}$ from this experiment is 271.64 comparing with

234.67 obtained from approximate equation (2-45), it is reliable. Consider the shear stress due to stress concentration at the reentrant corner is 8.67 but theoretically it is infinity, it does not agree.

When the specimen was fixed on the wooden board, one clamp was fixed at the reentrant corner. The clamp diameter is about 1.0 cm. Consider the most favorable case, the specimen has a fillet of radius 0.5 cm. at the reentrant corner.. Recall the approximate equation of the stress concentration of an angle of constrant thickness, eq.(2.47).

$$\tau_{max} = \mu\alpha t(1+ \frac{t}{4r})$$

Since the width of flange of specimen is 10 cm. the ratio of $\frac{t}{r} = \frac{10}{0.5} = 20.$

t = thickness of flange = 2 uni

$$\frac{\tau_{max}}{\mu\alpha} = 2(1 + \frac{20}{4}) = 12$$

The stress concentration of the I cross-section obtained by numerical calculation based on the method of finite diffirence[1] is higher than the value calculated above. The experimental result is smaller than expected, it is considered unreliable.

---

[1] Timoshenko,S.P. and Goodier,J.N. Theory of Elasticity. Fig.168. P.324.