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**The calculated and observed effects of dead loads and dynamic crane loads
on the framework of a workshops building†**

by

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Discussion

Mr James C. Simmons (Atomic Power Division, The English Electric Company Limited) observed that in the Appendix to the Paper the Authors treated the roof sheeting as a membrane in shear and reiterated an appropriate part of the theory of diagonal tension. It should be noted that their results were limited, therefore, to the case of a fully developed diagonal tension field, i.e. where the applied shear load P was a large multiple of the shear load which would first have caused buckling of the sheeting. For loads less than, say, twenty times the buckling load, the shear deflexion would be appreciably less than as given in § 58. This variation of shear stiffness with applied load, as well as other similar effects, was indicated in the 02.03 series of Structures Data Sheets published by the Royal Aeronautical Society. The longitudinal and lateral rigidity of the edge members of the panel had also been shown⁵ to influence the shear stiffness of the panel, although it might well be that those effects were small for the configuration under consideration.

60. The angle of diagonal tension α deserved further attention since it was stated in the Paper that this could be determined only experimentally. An experimental approach for specimens fully representative of the roof sheeting and its attachments might prove to be difficult, especially if conformity with the theoretical treatment was required and the shear load was greatly to exceed the buckling load. That was, however, not the only way and it was more usual to determine α theoretically by applying the principle of minimum strain energy and assuming that the value of α was such that the total strain energy of the panel was a minimum. In this way a relatively simple expression was obtained, and α was found to depend both on the degree of development of the diagonal tension field and on the longitudinal and lateral rigidities of the edge members of the panel. If the tension field in the panel was fully developed, and if the strain energy of the edge members was neglected—both of those assumptions have been made by the Authors—then it was found that $\alpha = 45^\circ$, thus simplifying their result.

61. Further information on the angle of diagonal tension, together with appropriate experimental verification of the theory, was given by Kuhn⁶, who had presented probably the most complete published treatment of diagonal tension.

The Authors, in reply, thanked Mr Simmons for drawing attention to the fact that the theory referred to when considering the stiffening effect of roof sheeting applied only to

† Proc. Instn civ. Engrs, vol. 13, p. 197 (June 1959).

ultimate strength conditions. It had to be remembered that the sheeting used for cladding sheds was almost always corrugated and while there would appear to be some analogy between the behaviour of a panel of corrugated sheeting and that of a flat membrane, it was extremely doubtful if the purely theoretical approach leading to a value for α of 45° was applicable to corrugated sheeting. Indeed, Timoshenko referred to experiments with corrugated sheets which indicated a much higher value⁷. Further investigation would certainly be necessary before designers could take advantage of the stiffening effect of roof sheeting, and the Authors considered that those investigations should include experimental work, preferably both on small panels and on actual sheds.

REFERENCES

5. J. C. Simmons, "Shear moduli for flat panels and the effect of flange flexibility". J. roy. Aero. Soc., vol. 61 (1957), p. 696.
6. P. Kuhn, "Stresses in aircraft and shell structures". McGraw-Hill, N.Y., 1956. *See also* National Advisory Committee for Aeronautics, Technical Note 2661 and 2662 (1951).
7. S. Timoshenko, "Theory of elastic stability". McGraw-Hill, N.Y., 1936, p. 404.