Analysis of translational shell structures

A. M. ANSAH

Professor J. E. Gibson, The City University, London

The elliptical paraboloid mentioned in § 63 is an extremely large area to be covered by a single shell and it would seem that perhaps a multi-elliptical paraboloid might be of structural benefit.

71. To cover the same area by a multi-shell of three bays and to preserve the same major span (i.e. 156 m) with the same geometry demands that R_β is 156 m and β_K (the half angle) is 30° . Transversely the minor span of 100 m would consist of three arcs each of radius R_α equal to 48.7 m and half angle α of 20° as shown in Fig. 10.

72. Using a multi-bay program for shells of double curvature^{10,11} in which the basic equations were as presented in (3)–(8) with some modification and a Fourier type of solution, results were obtained for a uniformly distributed load of 390 kg/m^2 and a shell thickness of 0.125 m. Table 1 presents the values for the first order term only.

73. For a shell thickness of 0.08 m it was shown that this would be a not unreasonable design allowing for the decrease in dead weight due to the reduced thickness.

Fig. 10

Table 1

	ϕ	M_x	N_x	N_β	$wE \times 10^6$	$N_{x\beta}$
Shells 1 and 3	30°	0	0	5822.1	1.98	0
	0°	10.6	-486.4	-1681.1	-5.10	-640.4
	-30°	196.8	-764.4	-1599.6	-7.44	-339.1
Shell 2	30°	196.8	-764.5	-1562.2	-7.40	-339.1
	0°	12.3	-923.0	-1791.3	-5.30	0.0
	-30°	196.8	-764.5	-1562.2	-7.40	-339.1

74. The program was developed for feather edge types of multi-shell, no support being provided by edge beams; a simple transverse support at the ends was assumed.

75. In the main the stress resultants N_x and N_β are compressive, except that N_β at the extreme unsupported edges is in tension. The transverse bending resultant is now severe at the internal springings only.

76. It would seem that, as stated in § 67, shells of double curvature produce sensitive solutions no matter what method of analysis is attempted. An obvious requirement is for further experimental evidence on the structural behaviour of curved edge ribs and multi-doubly curved shells using physical models.

Dr Ansah

Professor Gibson's comment on the first numerical example is accepted. A shell roof of this size may be contemplated only for civic halls, stadia and so on, where aesthetic and spatial effects are important. For industrial and several commercial purposes a multi-shell roof such as the one suggested by Professor Gibson would be preferable for economy and suitability. With multi-shells of similar size and geometry it would be convenient to analyse the shells separately, assuming no lateral sway for the inner edge ribs.

References

- GIBSON J. E. A theoretical and computer investigation of multi-shells of double curvature. *Proceedings of the world conference on shell structures, San Francisco, 1962*. National Academy of Sciences, 1964.
- GIBSON J. E. *The design of shell roofs*, 3rd edn. Spon, London, 1968.