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The calculation of membrane stresses in hyperbolic cooling towers†

by

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Discussion

Mr L. Goodwyn Wills (Director, Holst & Co., Ltd) congratulated the Authors on their valuable Paper on the design of reinforced concrete shells for hyperbolic-shaped cooling towers.

37. The Authors referred to the latest amendment to the British Standard Code of Practice i.e. the 1958 amendment to C.P.3. Chapter V, Loading, but the forces per lin. ft given in Fig. 8 of the paper were obtained using Table 3 (basic wind pressure) and Table 5 (shape factor) of the 1952 Code, and not the revised Table 6 and factor of 1.1 given in the new Clause 13b of the 1958 amendment. In support of this the Authors quoted part of the wording of Clause 13a. No doubt they were justified in this as the new Clause 13 was contradictory and the use of a factor which totals as high as 0.77, when the new factor 1.1 was included, for brick and concrete chimneys of more than 15 ft diameter, was at variance with all other data and well established practice. On the other hand, the height of cooling towers and chimneys often exceeded 200 ft, and it would be an advantage to use Table 6 of the amendment since it catered for these greater heights.

38. Coefficients referred to in the Paper and by Batch and Hopley were multiples of the dynamic pressure or unit wind force. This was not the same thing as the equivalent pressure acting on the surface projected perpendicular to the wind, for which the factors in Table 5 of the code were given. The appendix to the code (p. 26) gave a formula for dynamic pressure. If, in this formula, wind speeds were used derived from those quoted for exposures 'C' and 'D' respectively in Table 3, by allowing for the amount by which the height of the tower exceeded 40 ft, higher stresses than those shown in the Paper would be found. This would also be the case if equivalent values were taken from Table 6.

39. The Authors said that their results might be inaccurate because of the existence of bending moments caused by the ring beam, for which they had not allowed. If the shell were joined direct to a rigid base there would be local perturbation of the membrane stresses, and bending moments might have to be considered. However, the usual support of many inclined pairs of columns fixed positions at the base of the shell in two directions but not the third. This provided support and defined the shape of the structure without redundancy, in precisely the manner required in membrane theory. It provided boundary conditions whereby the differential equations for the strains could be integrated upwards, thus permitting the calculation of displacements induced at the top of the tower by the forces discussed in the Paper. These displacements should now be calculated, as their magnitude would indicate whether the geometry and the stresses assumed by the Authors to hold at the top of the tower were compatible with

† Proc. Instn civ. Engrs, vol. 19 (Aug. 1961), pp. 503-514.

the support conditions at the base. If the discrepancy was appreciable, the constraining effect of the cornice would be important, and would reduce and redistribute the reactions between the shell and the base. With a cornice of normal dimensions the readjustment would probably not amount to more than 10% or 15% modification of those stresses which were important in practice, but it would be useful if the effect could be worked out.

40. The selection of horizontal pressure distribution and suitable unit wind force was not so certain. In accordance with the papers by R. Pris,¹⁰ French engineers had concluded that the surface roughness of a cooling-tower must be taken into account in each case and that model experiments carried out at atmospheric pressure could be made use of, whereas in Britain it was held that model experiments must be made in a high-pressure tunnel because of the large influence of Reynolds number and it was not considered that surface roughness within practical limits would alter the pressure distribution seriously. Probably this conclusion would not apply if there was a proposal to build cooling-towers with ribs as might be suitable for precast construction and had been used on the Continent, but so far this type of construction had not been suggested in Britain.

41. Mr Wills hoped that further work would resolve these discordancies so that effective economies might be made from the valuable theoretical studies described in the Paper.

The Authors in reply thanked Mr Wills for his appreciation of their Paper.

43. They were grateful for his statement, in §§ 37 and 38, of the difficulties which faced them in interpreting the Code of Practice on wind loading, and they hoped that some clear instructions on this matter would now be formulated by the British Standards Institution.

44. The suggestions made in § 39 were very helpful, and the Authors were at present calculating the distribution of displacements over the specimen tower.

REFERENCE

10. R. Pris, "Tour de réfrigération hyperbolique", *Etudes aérodynamiques*, Ann. Inst. Tech. du Bât. et Tr. Pub., Feb. 1959, No. 134 (Paper EM42), pp. 147-167. Also, Nov. 1960, No. 155, pp. 1231-1246.