cent of tetrasodium pyrophosphate and subjected to controlled laboratory freezing tests. The results of the tests showed that the phosphate reduced the rate of frost heave for all 11 gravels. The minimum reduction was to half of the untreated value, the maximum to essentially zero, and the average reduction was to 0.2 of the untreated value.

The material on frost additives presented at Moscow and Kiev came from a paper, "Modification of Frost-Heaving of Soils with Additives," by the writer published in Bulletin No. 135 of the Highway Research Board.

Research on the use of chemical additives to reduce the effectiveness of portland cement as a soil stabilizer was described. In general, the tests showed that, with virtually all soils studied, cement stabilization can be substantially improved (two to 10 fold) by the incorporation of relatively small quantities of sodium compounds which form insoluble compounds with calcium. The most beneficial additives were caustic soda, soda ash, sodium sulphite, sodium sulphate, sodium metasilicate and sodium aluminate. Optimum additive concentration was found to correspond very nearly to a sodium ion concentration in the molding water of 1.0 normal, i.e., between 0.5 and 2.5 per cent of the soil dry weight, depending upon soil and additive.

The soil cement work described in the Soviet Union came from two papers by the author (and associates) presented before the Highway Research Board Annual Meetings of 1957 and 1959.

SOIL STRUCTURE

In answer to requests by the Soviet soil engineers, the writer gave extemporary talks on soil structure at Kiev and at Leningrad. The nature of electrical and externally applied forces transmitted between adjacent soil particles was discussed. The variation of these forces with environmental conditions was next considered. Shear strength as dependent upon environmental factors and applied pressures was finally discussed.

Much of the material came from the writer's two papers on soil structure published in the May 1958 Journal of the Soil Mechanics and Foundation Engineering Division of the American Society of Civil Engineers.

Analysis and Design of Concrete Slabs on Ground

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Conventional methods of analysis (utilizing Winkler's assumption, or an elastic half-space) were reviewed briefly. Reference was made to observations that for lightly loaded slabs (homes), or where the loads are temporary (pavements, industrial slabs on ground), warping caused by moisture and temperature gradients was sufficient to leave a portion of the slab entirely unsupported.

A new theory *(Ref. 1)* was outlined for calculating stresses and deflections in partly supported slabs of finite size. The significance of this theory in the analysis of concrete pavements was treated *(Ref. 2)*. Finally, the results of full-scale measurements *(Ref. 3)* for both upward and downward warping that confirms the validity of the new theory were presented.

REFERENCES

1. Leonards, G. A. and Harr, M. E. (1959). "Analysis of Concrete Slabs on Ground." Journal, Soil Mechanics and Foundations Division, ASCE, Vol. 85, No. SM3, p. 35.
2. Harr, M. E. and Leonards, G. A. (1959). "Warping Stresses and Deflections in Concrete Pavements." Highway Research Board Proceedings, Vol. 38, p. 286.
3. Wiseman, J. F., Harr, M. E. and Leonards, G. A. (1960). "Warping Stresses and Deflections in Concrete Pavements—Part II." Highway Research Board Proceedings, Vol. 39.