This paper is part of the Journal of the Geotechnical Engineering Division, Proceedings of the American Society of Civil Engineers, ©ASCE, Vol. 107, No. GT8, August, 1981. ISSN 0093-6405/81/0008-1129/$01.00.

PERMANENT DISPLACEMENTS DUE TO CYCLIC WAVE LOADING[a]

By W. Allen Marr, Jr.,[1] M. ASCE and John T. Christian,[2] F. ASCE

INTRODUCTION

When a soil is subjected to a sequence of cyclic loads, both cyclic strains and residual or permanent strains develop. The latter are the strains that remain at the end of each cycle of load and represent a cumulative effect that must be added to the effects of previous storms. To date, most attention has been directed toward evaluating the peak cyclic displacement that occurs during a storm rather than the permanent displacement, even though the permanent displacement is an important consideration for structures that must resist many storms, such as breakwaters and some offshore platforms.

One could predict permanent displacements in two ways. First, one could develop a hysteretic stress-strain relation for the soil and use the resulting nonlinear relations with a finite element program to solve each cycle of the loading history (5). Although this procedure has several advantages, it suffers from disadvantages. No generally recognized hysteretic stress-strain relation exists for soils that includes effects of load reversal for two- or three-dimensional conditions, despite the great deal of important and useful work in progress in this area. Even with such a relation, the solution would have to proceed by small steps through each cycle of a storm that might contain several hundreds or thousands of cycles. The computer runs could be quite long, and the results would apply to one time-history of wave loading.

This paper describes a second approach that develops relations among the initial soil properties and conditions, the stress changes in a cycle, the number of cycles, and the permanent strains. Thus, the distribution of permanent strains at the end of cyclic loading can be computed. To use this information in a finite element program requires the capability to generate strains and deformations for no net change in load.