The influence of the rod length on the results of light dynamic probing

The results of light dynamic probing with a free rod above the ground surface from construction sites showed, that there must be an influence of the rod length on the number of blows and that the correlations between the number of blows N_{10} and the density of soil D given in DIN 4094 and Eurocode 7 cannot be used. Therefore this research project was brought into being. The experimental part in laboratory includes tests of light dynamic probing (DPL) in a container which is filled with a fine sand of known density. The free rod length of the DPL is varied. Strain gauges are fixed on the rod to examine the dynamic forces and to calculate the induced energy. Simplifying the boundary conditions to fit the analytic solution the dynamic probing is also executed on rigid ground (concrete floor of the laboratory). The results of DPL in sand show that with increasing total rod length the number of blows decreases.
The force progressions in the rod can be explained with an analytic solution of TIMOSHENKO and GOODIER. This solution calculates the forces at the top of a rod which is fixed at its bottom and which is charged by a mass falling on its top. Because of its inertia the mass keeps laying on the top of the rod even when the incident pressure wave reflected at the bottom moves up again. The mass acts as a rigid bearing and produces a superposition of the moving pressure forces in the rod. Hence the strain gauges in the test are not fixed exactly at the top; the solution of TIMOSHENKO is adapted, so that the forces produced by superposition of pressure waves at every point of the rod can be calculated. With the help of the solution of TIMOSHENKO the measured force progressions can be explained. One result is that the forces travelling along short rods are reflected more often and become zero later, when the results are plotted against the time standardised by the rod length. From the force progressions the energy applied to the rod is calculated. Hence theory gives thirty times higher values than the measured results, the results can only be compared in a standardised form. Calculating energy from the superposed forces in theory it decreases with increasing rod length. Comparing the analytic solution of TIMOSHENKO to the results of DPL it can be seen, that the superposition of forces is completely damped by the soil, because the energy of the incident wave is used for plastic work of penetrating the soil. After the initial pressure wave reaches the bottom, the rod only oscillates and no further penetration takes place. Furthermore the boundary condition at the bottom is changed to a free end and the sum of incident pressure wave and reflected tension wave becomes zero.
Energy is calculated from the initial pressure wave in the rod. It can be seen that only the total rod length is responsible for the magnitude of energy. The free rod length influences the magnitude of damping. An exponential regression curve is laid through the measured results. It fits well to the analytic solution of YOKEL who calculated the energy in the rod based on the solution of TIMOSHENKO. The solution of YOKEL is modified concerning the time end point of energy transfer. The modified solution calculates the energy until the moment the incident wave reaches the tip of the rod. From the modified solution of YOKEL the correction factors for the total rod length are formulated for low and high dynamic probing.

L_{ges} [m]	2	3	4	5	6	7	8	9	10
Yokel DPL	0,7	0,8	0,9	0,95	1,0	1,0	1,0	1,0	1,0
Measurement	0,45	0,7	0,83	1,0	1,0	-	-	-	-
Yokel DPH	0,4	0,5	0,6	0,7	0,8	0,8	0,9	1,0	1,0
Construction site DPH	0,57	0,42	0,6	0,7	0,81	1,0	(1,15)*	-	-

Table 1: Correction factors λ for DPL und DPH compared with measured results, (*: limit of rod length is reached)