This paper explores the possibility of using high-resolution fiber-optic distributed sensing for in situ geotechnical estimation of soil shear modulus distribution with depth. It is shown that a recursive analysis of an elastic problem together with a measured vertical strain can assist in evaluating the sought stiffness values. It is suggested that high-resolution fiber-optic distributed sensing can provide the necessary strain for the proposed process. The approach was demonstrated in a field trial, entailing a stratified soil profile including a thin sand layer encapsulated between two clay layers. Results of the suggested profiling method are compared against data from a geophysical survey and against correlations with conventional in situ testing. Excellent agreement is exhibited between the different methods, indicating aptitude and viability of the idea for implementation as a geotechnical investigative tool.