Claims

What is claimed is:

1. A method of generating a geotechnical survey of a target area, comprising:

measuring DFOS data in an optical fiber located within a sensing distance of the target area; and

determining subterranean characteristics of the target area based on the measured DFOS data, including:

applying surface-wave analysis of the DFOS data to estimate a shear-wave velocity (Vs) profile of a subsurface;

applying body-wave analysis of the DFOS data to estimate a compressional-wave velocity (Vp) profile of the subsurface; and

calculating a Vp/Vs ratio from the Vs and Vp estimates.

2. The method according to claim 1, wherein

the measuring of the DFOS data includes measuring at least one of:

strain;

strain rate;

velocity;

displacement;

pressure;

motion; or

acceleration induced in the optical fiber.

3. The method according to any one of claims 1 or 2, wherein the measuring of the DFOS data includes:

cross-correlating neighboring channels against one channel to amplify coherent noise components and suppress incoherent noise components, and

stacking time segments of duration T1 of cross-correlations over a total duration T2, longer than T1.

4. The method according to claim 2 or 3, wherein

the strain is induced in the optical fiber by background seismic noise; and

the background seismic noise is caused by at least one of generators, vehicles, construction and excavation equipment, pumps, machinery, infrastructure, wind, and ocean waves.

5. The method according to any one of claims 2-4, wherein the determining subterranean characteristics of the target area based on the measured DFOS data includes:

measuring seismic wave velocity as a function of frequency; and

modeling subsurface geological layers under the optical fiber based on the wave velocity calculated as a function of frequency; or

modeling subsurface layers based on frequency dependence of velocity of seismic waves at multiple depths; and

inverting for 1-D models of compressional wave speed and/or shear wave speed that represent subsurface geology by applying Markov Chain Monte Carlo to search over a possible model parameter space or by applying seismic tomography.

6. The method according to any one of claims 2-4, wherein the determining subterranean characteristics of the target area based on the measured DFOS data includes:

measuring seismic wave velocity as a function of offset;

modeling subsurface layers based on measuring a travel time or an attenuation of seismic waves that penetrate the subsurface.

7. The method according to any of claims 2-6, wherein

the survey result is a two-dimensional profile of the subsurface along a path of the optical fiber or

the survey result is three-dimensional, preferably wherein the survey result is a subsurface volume with layers and isopachs across region.

8. The method according to any of claims 2-7, wherein the survey result includes:

lithological information in an upper 50 m, including rock and soil type, layer thicknesses and layer depths, or

physical parameters, including density, shear modulus, bulk modulus, Poisson's ratio, saturation, layer thicknesses and layer depths, or

Vs30 values or a different statistical representation of seismic shear wave speed information.

9. The method according to any of claims 2-8, wherein the survey result is:

hydrological information, including water table depth, recharge state, hydrological stage of health, total available water volume, water banking volume, infiltration rate, or

deep soundings at >150 m depth, or

a measurement of depth of cover of the optical fiber.

10. The method according to any of claims 2-9, wherein recorded signals used for the geotechnical survey are at least one of natural seismic energy and artificially created seismic energy.

11. A geotechnical surveying system, comprising:

a DFOS device that includes a light transmitter configured to transmit light into an optical fiber, a receiver configured to receive light from the optical fiber, and a controller configured to execute a method of generating a geotechnical survey of a target area, comprising:

measuring DFOS data in an optical fiber located within a sensing distance of the target area; and

determining subterranean characteristics of the target area based on the measured DFOS data, including:

applying surface-wave analysis of the DFOS data to estimate a shear-wave velocity (Vs) profile of a subsurface;

applying body-wave analysis of the DFOS data to estimate a compressional-wave velocity (Vp) profile of the subsurface; and

calculating a Vp/Vs ratio from the Vs and Vp estimates.

12. The geotechnical surveying system according to claim 11, further comprising:

the optical fiber, wherein the optical fiber is a part of a fiber bundle used for communication.

13. The geotechnical surveying system according to claim 11 or 12, further comprising:

at least one active seismic source configured to generate and output seismic energy into ground to generate seismic waves that are detectable by the DFOS device.

14. A DFOS device, comprising:

a light transmitter configured to transmit light into an optical fiber;

a receiver configured to receive light from the optical fiber; and

a controller configured to execute a method of generating a geotechnical survey of a target area, comprising:

measuring DFOS data in an optical fiber located within a sensing distance of the target area; and

determining subterranean characteristics of the target area based on the measured DFOS data, including:

applying surface-wave analysis of the DFOS data to estimate a shear-wave velocity (Vs) profile of a subsurface;

applying body-wave analysis of the DFOS data to estimate a compressional-wave velocity (Vp) profile of the subsurface; and

calculating a Vp/Vs ratio from the Vs and Vp estimates.

15. A system for processing earthquake data, comprising:

one or more DFOS devices as recited in claim 14; and

one or more optical fibers operatively connected to the one or more DFOS devices.