Study on Mechanism of Naturally Generated Sinkhole

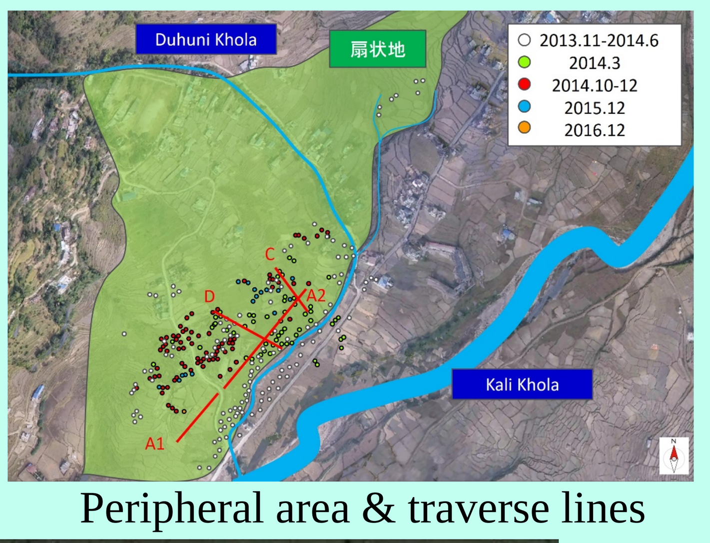
自然生成型地盤陥没の発生メカニズムの研究

Sinkhole can be naturally generated due to underground soil erosion by waterflow. Here proposed is water path detection by measurement of the sound of underground waterflow. Its effectiveness was considered with field survey and model test, and sound pressure and frequency spectrum can show where water is flowing and in some cases it may have potential to show the grain size distribution of the soil at the place.
To avoid effects of friction between grains and walls in two-dimensional cavity formation tests, cavity formation test was conducted using three-dimensional soil tank. The result implied that the process of cavity formation can be divided into two part, the first part influenced by ground water level and the latter part affected by soil property.

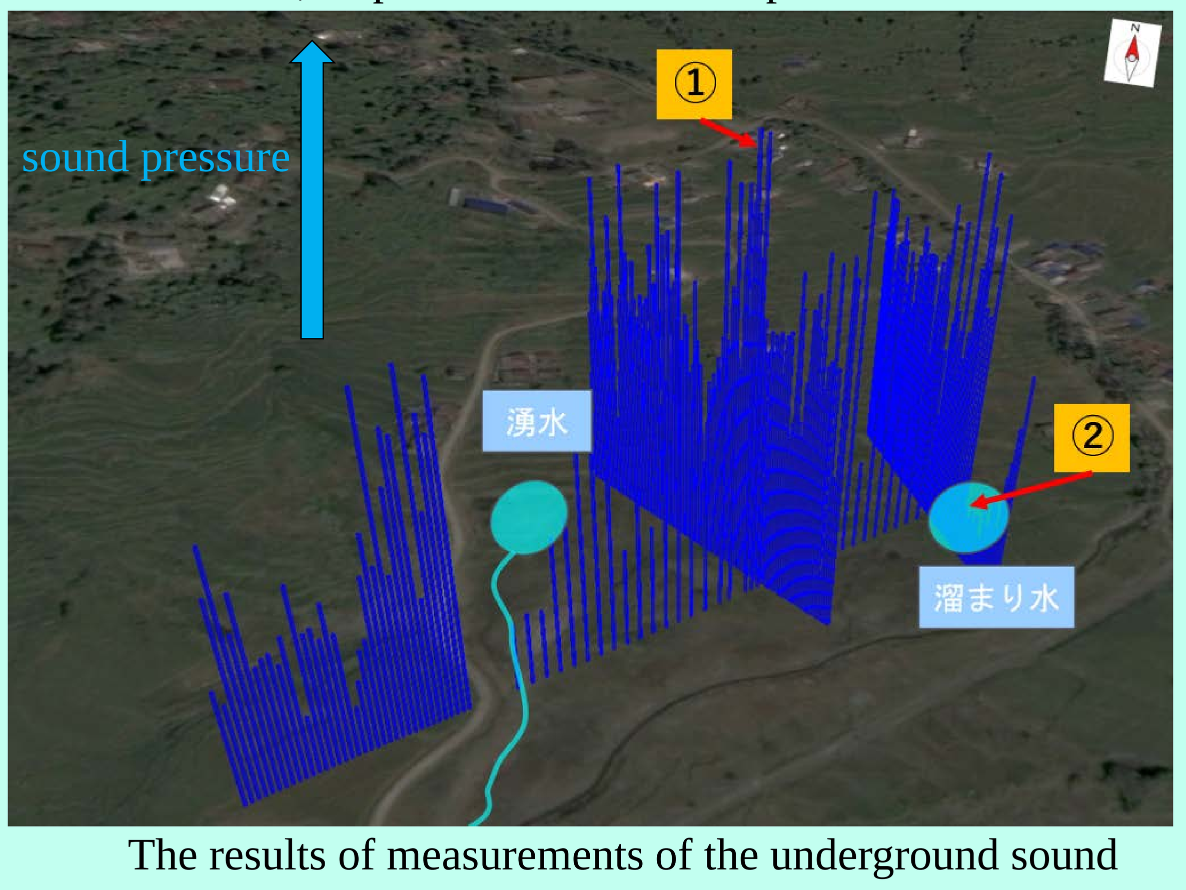
自然環境の中で発生する地盤陥没は、地下の水みち沿いに土砂が流出し空洞が形成されることで主に発生します。空洞調査として、ボーリング調査は点でのデータしか得られず、表面波探査は地下の空洞を有効に検出できないため、新しい調査手法のひとつとして地下流水音測定による水みち探索を提案し、フィールド調査と模型試験によって有効性を検討しました。音圧と周波数スペクトルの解析によって、水みちの径路のほか土の粒径の推測ができる可能性が得られました。また、既存の二次元土槽による空洞生成模型試験には壁面との摩擦の影響がある可能性を考慮して、三次元土槽において空洞生成模型試験を行った結果、空洞の生成過程が、地下水位の影響を受ける前半の過程と砂の性質の影響を受ける後半の過程に分けられることが確認されました。

流水音測定による水みち調査
Water path detection by the sound of underground waterflow

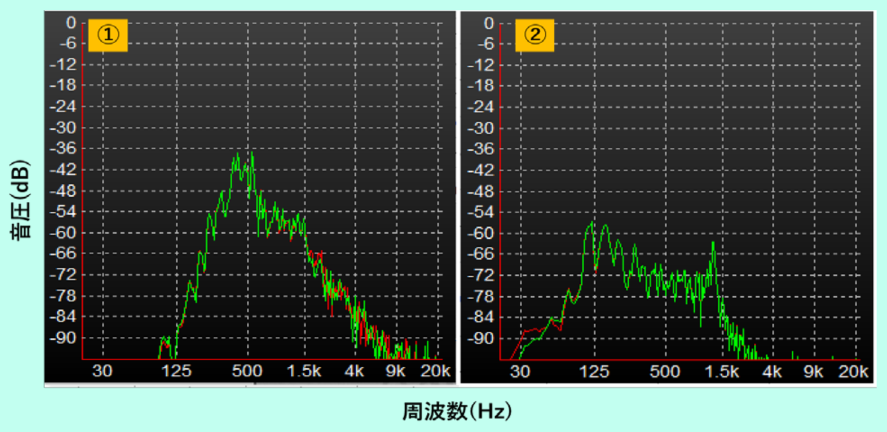

Sinkholes in Pokhara, Nepal



Peripheral area & traverse lines



The results of measurements of the underground sound



Frequency spectra at point ①, where the sound pressure was high and waterflow seems to be intense, and point ②, where the pressure was low and waterflow is supposed to be stagnant. There is a peak around 500Hz at point ①.

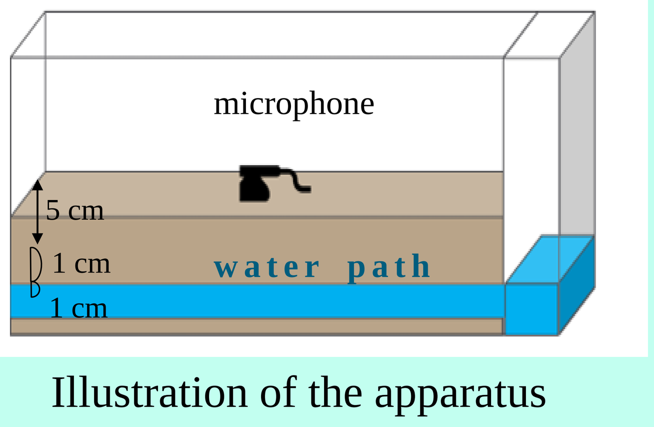
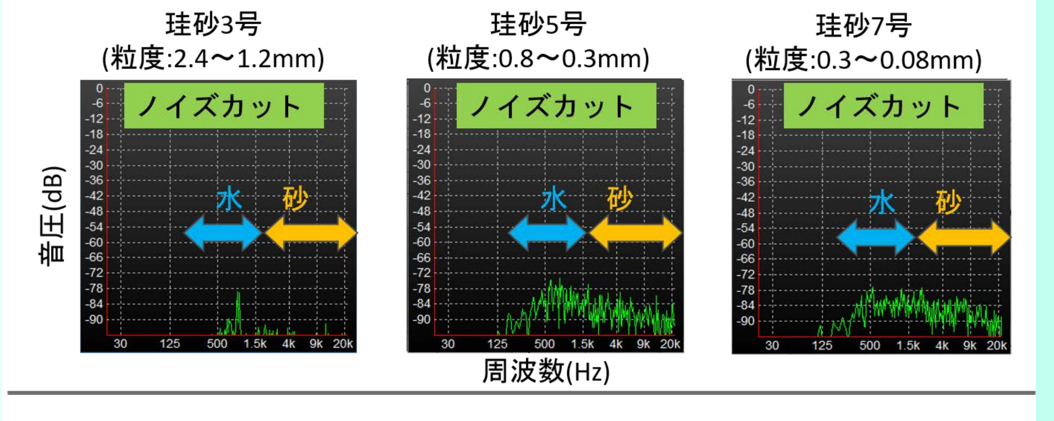
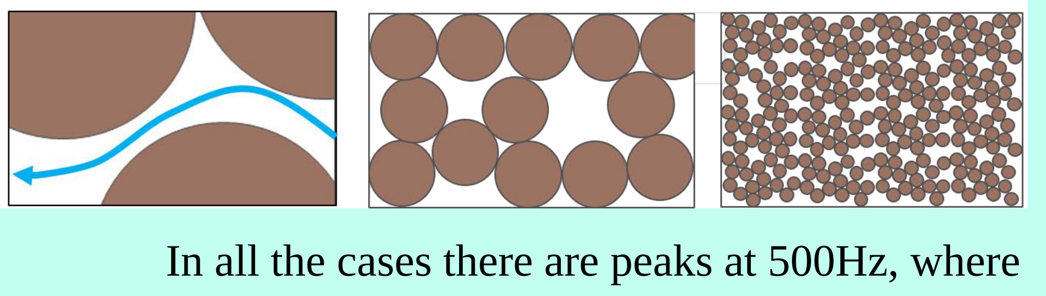


Illustration of the apparatus



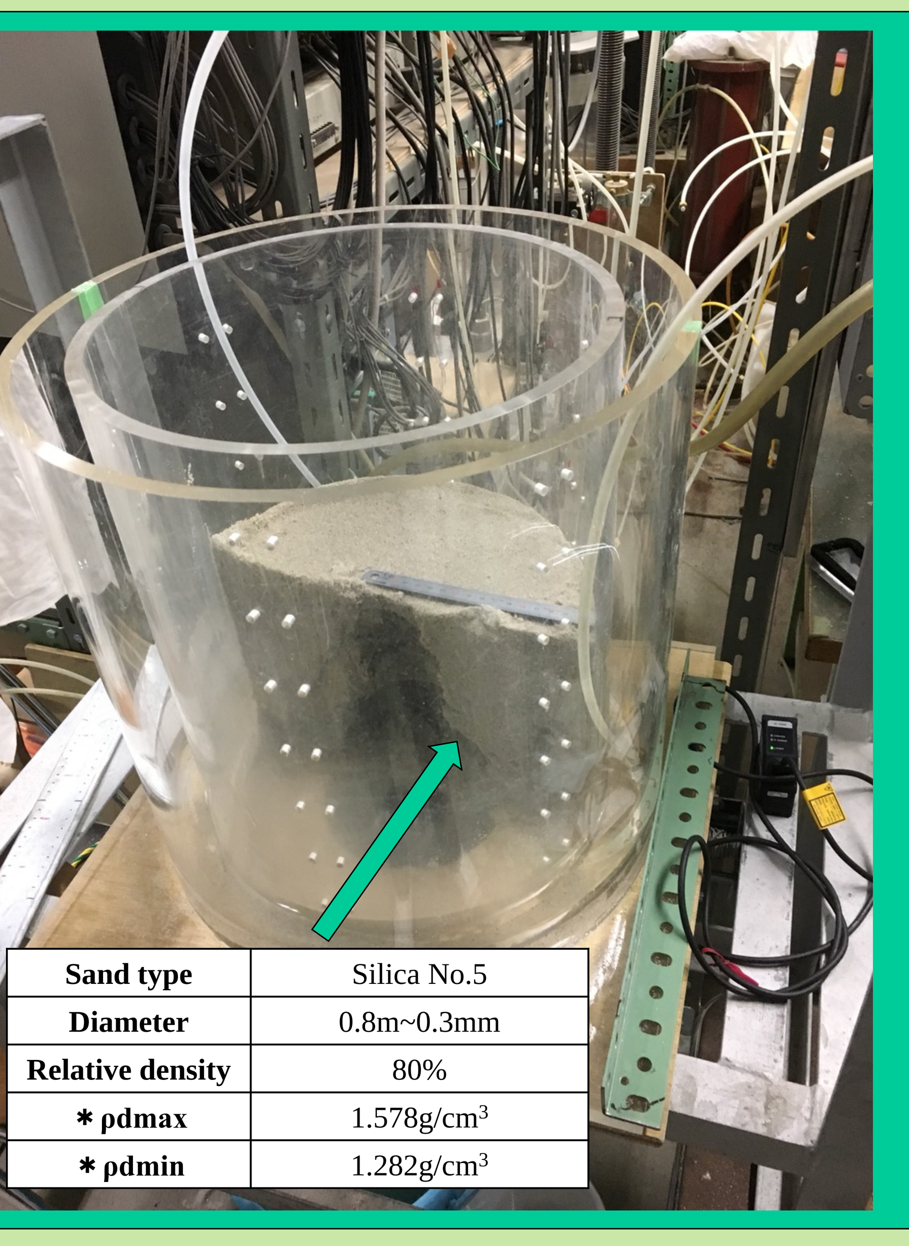


Model ground conditions

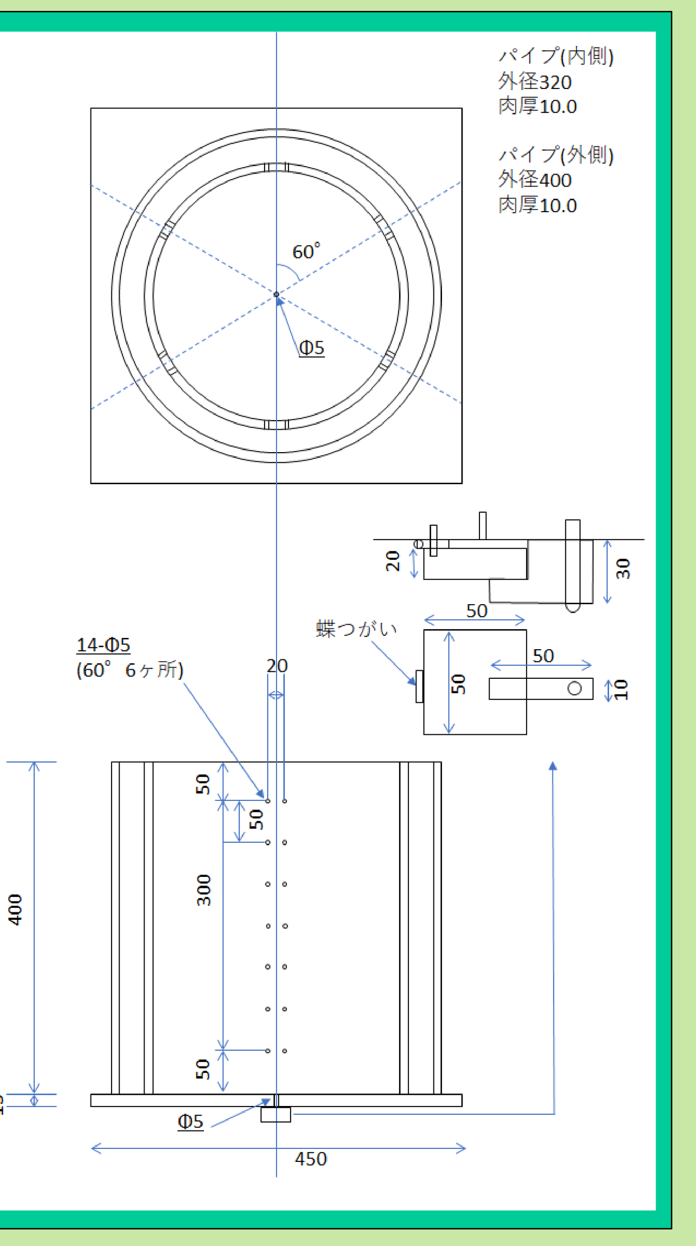
Dry density: 1.50g/cm3
Water content: ≈20%
Material: silica sand No.3 (1.2〜2.4 mm)
silica sand No.5 (0.3〜0.8 mm)
silica sand No.7 (0.08〜0.3 mm)

In all the cases there are peaks at 500Hz, where it’s supposed to represent sounds of waterflow. In the cases of silica No.5 and No.7, sounds are recorded at higher frequency, where it’s supposed to represent sounds of sand. With smaller size of grains, waterflow can move sand particles and make those sounds.

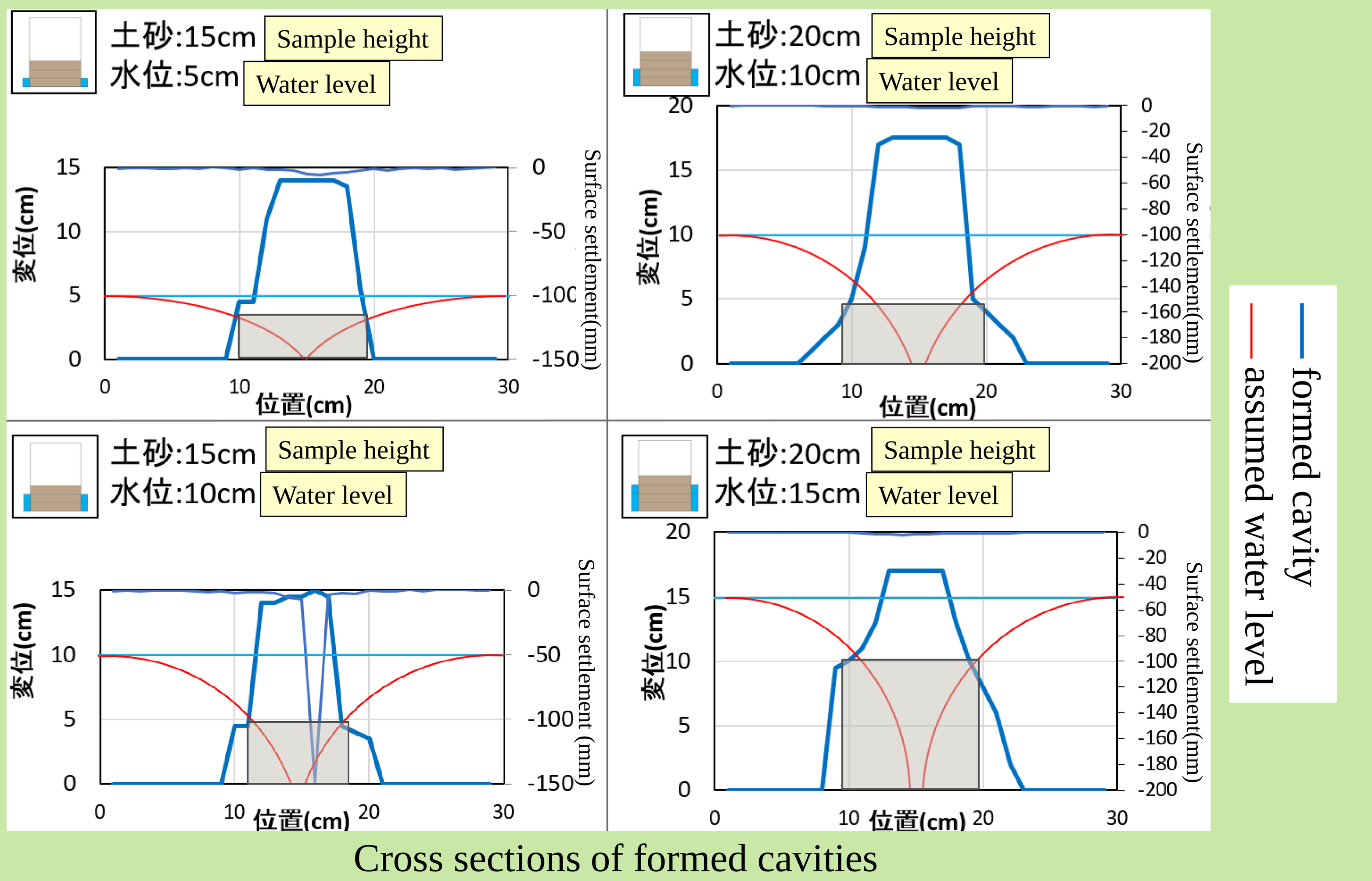
三次元的土槽を導入した空洞生成実験
Cavity formation test using columned soil tank



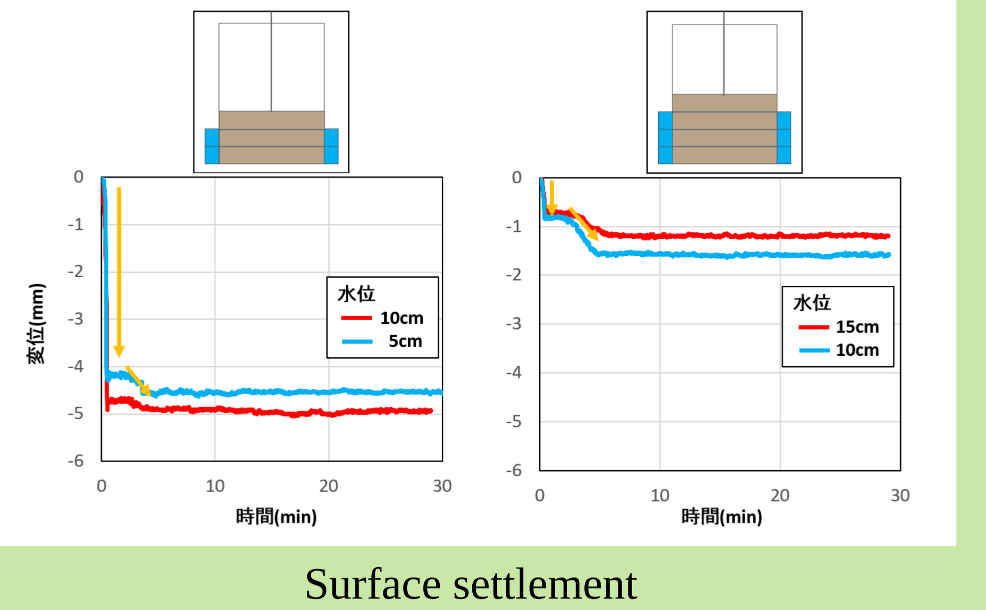
Sand type	Silica No.5
Diameter	0.8m~0.3mm
Relative density	80%
＊ρdmax	1.578g/cm³
＊ρdmin	1.282g/cm³



The soil tank



Cross sections of formed cavities



Surface settlement

The settlement of surface has two stages, which coincides with the shapes of formed cavities. It is supposed that at first the grey square part falls according to ground water level and later the upper part falls off according to the adhesiveness of the soil.

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