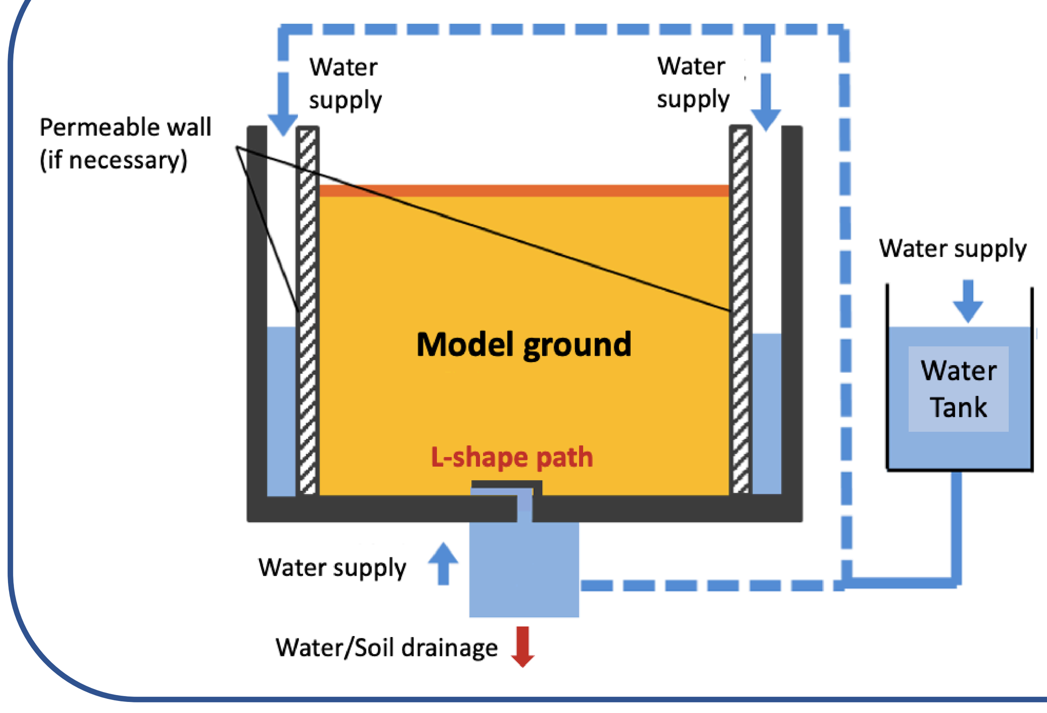
Generation and Expansion of Subsurface Cavity around a Joint of Buried Pipe

埋設管表面の止水不良箇所における地盤内空洞の生成・成長過程

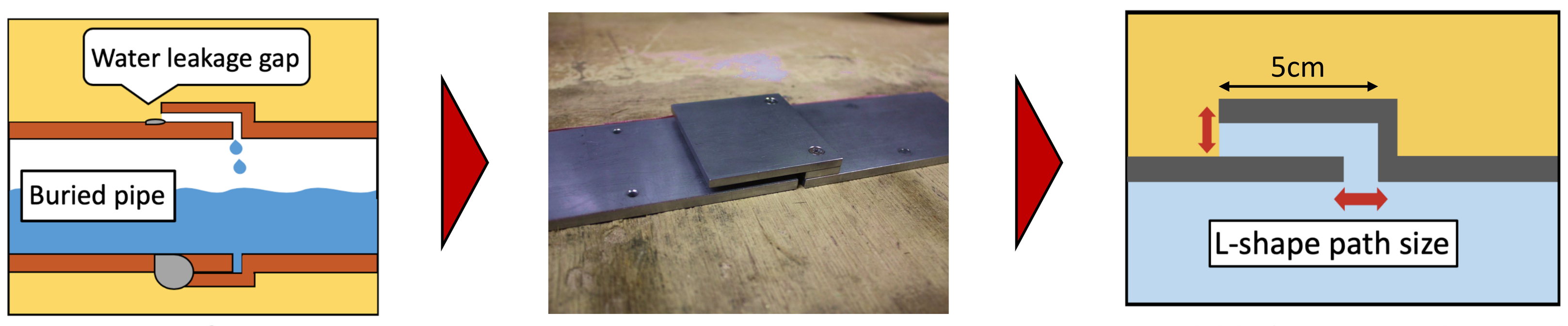
A road cave-in is becoming a serious problem in accordance with the aging of infrastructure. Recently, a field excavation survey on subsurface cavities revealed that small damage in pipe joints can be a cause of cavities. Those damages are regarded as water leakage, not regarded as a structural breakage of pipe. In this study, the process of generation and expansion of subsurface cavities around the location of water leakage in buried pipes are investigated through a series of model tests.

インフラ老朽化に伴い道路陥没現象が深刻な問題となっています。近年実施された地盤内空洞の開削調査から、一見して破損が確認できないような下水管上に空洞が発生する場合があることがわかりました。構造上の破損とは言い難い継手部の軽微な隙間、いわゆる止水不良箇所における地盤内空洞の生成・成長過程に対して、模型実験による考察を行ないました。

Model test apparatus and test procedure　実験装置と手順



① Model ground is made in a soil chamber and and a L-shape path is set on the bottom.　模型地盤を作成しL字型土砂流出口を底部に配置。
② Water is supplied into the model ground.（=the rise of the ground water level）　模型地盤内に水を供給。(=地盤内水位の上昇を再現)
③ The L-shape path is opened and soil and water drain through the path.　L字型土砂流出口を開けることで土砂と水が流出する。
④ The cycle of water supply and drainage is repeated and a cavity grows up.　②と③のサイクルを繰り返すことで空洞が生成・成長。



Reproduction of water leakage gap in a buried pipe　埋設管接合部の止水不良箇所の再現

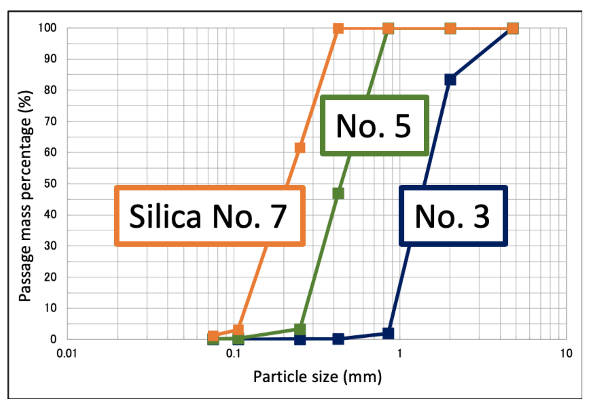
Model test with single-particle-size ground
均一粒径地盤を用いた模型実験

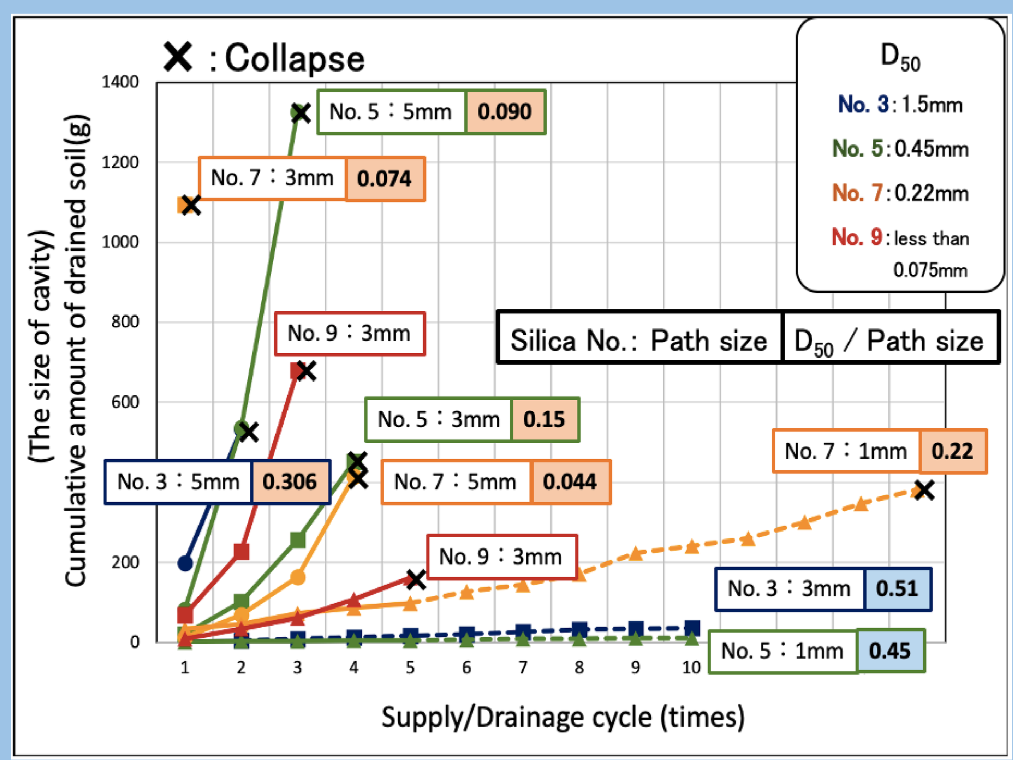
Material　地盤材料

Silica 硅砂　No. 3（D_{50}：1.5mm）
No. 5（D_{50}：0.45mm）
No. 7（D_{50}：0.22mm）
No. 9（D_{50}：Less than 0.075mm）

※ D_{50}: 50% pass particle size 通過重量百分率50%の粒径

Relative density: 50%
相対密度: 50%





✔The ratio of particle size to path size is related to the degree of soil drainage.
・土粒子の粒径と土砂流出口の幅との比が土砂流出の程度に関与。

D_{50} / Path size　D_{50} / L字型土砂流出口の幅
Less than 0.31 → Cavity growth (→Collapse)
0.31以下　空洞成長あり（→陥没）
More than 0.45 → No cavity growth
0.45以上　空洞成長なし

✔The degree of soil drainage is not necessarily in proportion to the path size.
・土砂流出の程度は土砂流出口の幅に必ずしも対応しない。

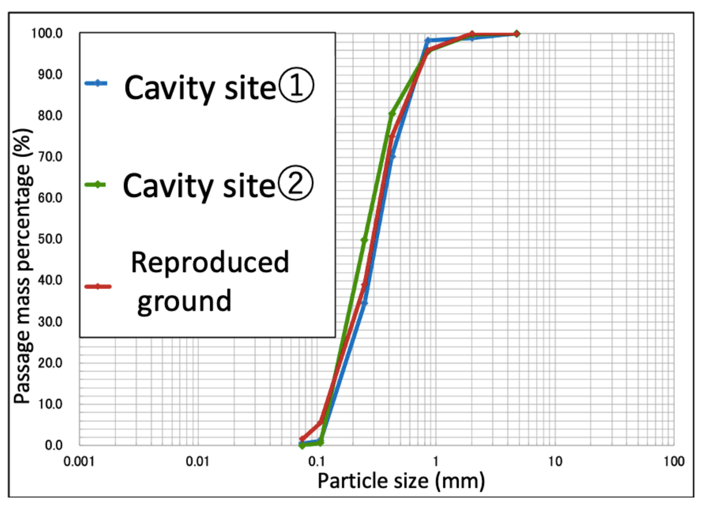
The degree of soil drainage　土砂流出の程度
Path size 土砂流出口の幅　3mm ＞ 5mm ＞ 1mm
※ In the case with Silica No. 7　硅砂7号を用いた実験

Model test with real cavity site ground
空洞発生現場の再現地盤を用いた模型実験

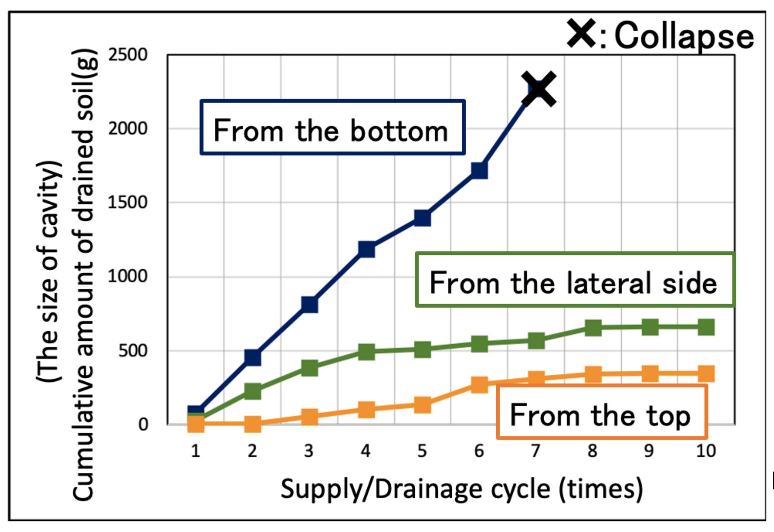
Material　地盤材料

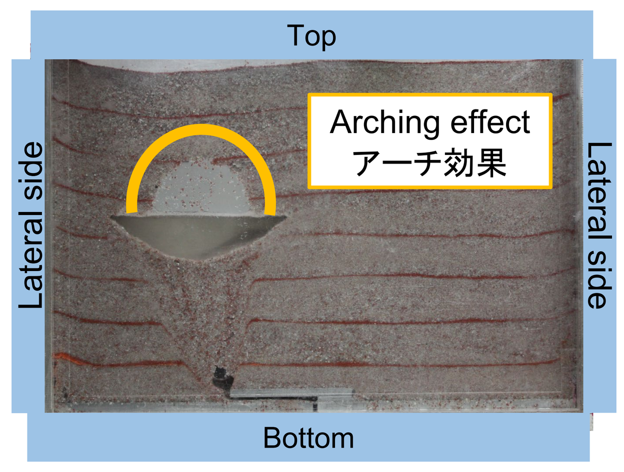
Same particle-size-distribution ground of real cavity site which is based on the data of a field survey in Fujisawa city
藤沢市にて実施された現地調査のデータをもとに、実際に空洞が生じている地盤と同一の粒度分布を持つ再現地盤を作成。

Relative density: 50%
相対密度: 50%



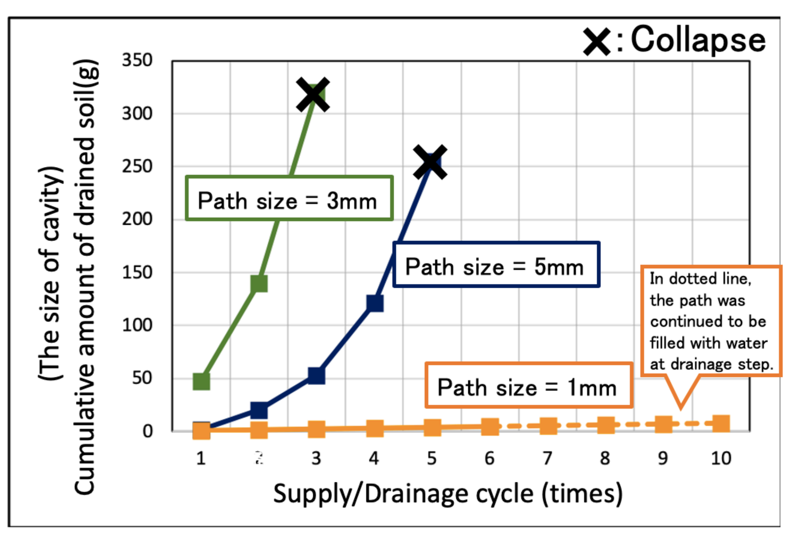
The effects of water supply method
給水方式が土砂流出に及ぼす影響





①Rise of water level 地下水位の上昇 ➡ ②Collapse of arching アーチの崩壊
➡ ③Reformation of arching アーチの再形成 ➡ ④Growth of cavity 空洞の成長

The effects of path size
土砂流出口の幅が土砂流出に及ぼす影響

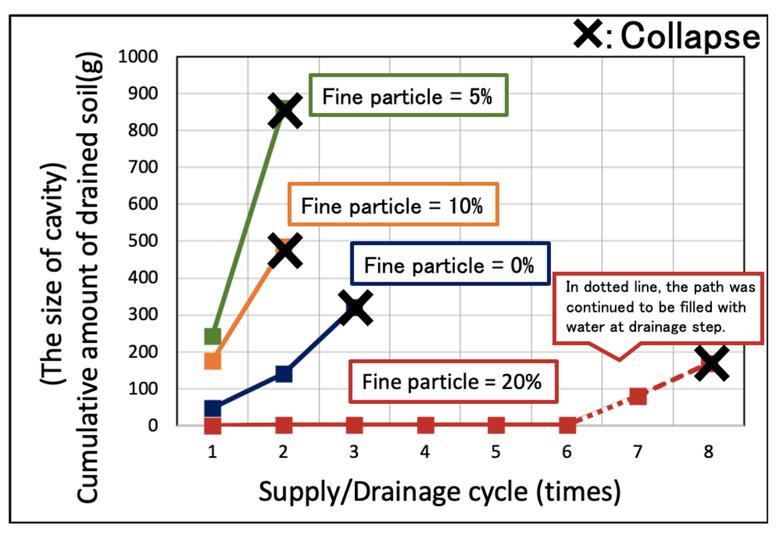


The degree of Soil drainage　土砂流出の程度
Path size 土砂流出口の幅　3mm ＞ 5mm ＞ 1mm

✔In the 3mm-path-size case, Soil and water filled the horizontal part of the path and sustainably drained together as fluid.
・流出口幅が3mmのケースでは、土砂と水が流出口の水平部を満たし、流動体として一体となって持続的に流出。

＝The Mechanism which can promote soil drainage
土砂流出を促進し得るメカニズム

The effects of fine particle
細粒分が土砂流出に及ぼす影響



In the case in which fine particle rate is 20%, the tendency of soil drainage was smaller.

The increase of fine particle rate　細粒分含有率の増加
⬇
The decrease of Permeability　透水係数の低下
⬇
The suppression of water stream　水流の抑制
⬇
The decrease of soil drainage　土砂流出の低減

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