An idealized relationship between porosity and permeability for unconsolidated soil formations

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The relationship between the porosity and the permeability has been studying for many years. Kozeny-Carman equation which shows the relation between the porosity, grain size and permeability, and Timur equation which shows the relation between the porosity, irreducible water saturation and permeability are well known equation.

Kozeny-Carman equation indicates that the permeability increases with increasing the porosity, but decreases with getting smaller grain size. Timur equation indicates that the permeability increases with increasing porosity, but decreases with increasing irreducible water saturation because of the smaller grain size.

On the other hand, in unconsolidated soil formations, the permeability is estimated by different indicator such as effective grain size. In general, an increase of small particles such as clay makes the porosity large, but makes the permeability small, because effective grain size is getting smaller. The grain size in Kozeny-Carman and irreducible water saturation in Timur affect the permeability value larger than porosity does. In soil formations, therefore, we have to take more account of these two parameters, grain size and irreducible water saturation, than in rocks.

Kodai(1985) showed the difference of the relationship of the porosity and the permeability for rocks and unconsolidated formations by experimental data. In this time, we apply our data to his figure, and our data, density porosity and in-situ permeability, show same trend as for unconsolidated formations or soils. In order to explain the trend for soils, we use the bimodal grain mixture model shown in Dvorkin and Mario(2001) to represent the relation between clay content and porosity, and study the trend which shows the permeability decreases with increasing the porosity in soil formations.

In the bimodal grain mixture model, the porosity for sand and clay are defined and it shows that the porosity decrease with increasing the clay content first, and then the porosity increases gradually at larger porosity. And assuming effective porosity as a function of porosity, we can explain that the permeability decreases with increasing the porosity at larger porosity.