Mechanical properties of synthetic methane hydrate-bearing sand

Thi Xiu Le[1], Anh Minh Tang[1 *], Patrick Aimedieu[1], Michel Bornert[1], Baptiste Chabot[1], Stéphane Rodts[1]

[1] Laboratoire Navier (UMR8205 IFSTTAR-ENPC-CNRS), Université Paris Est, Marne-la-vallée, France
* anhminh.tang@enpc.fr

Methane hydrates, form naturally at high pressures and low temperatures. Nowadays, with growing energy demands, natural gas hydrates (almost methane hydrates) are considered as an alternative energy source (T. S. Collett et al., 2009). However, methane hydrates dissociation during boreholes drilling and production process (with heat or depressurization methods) may reduce the strength of the hydrate-bearing sediment and cause failure. In addition, slope instability and wide-scale gas venting are the two most important geo-hazards associated with methane hydrate dissociation problems on the sea floor (T. Collett et al., 2015). For these purposes, various studies have been performed to investigate the mechanical behavior of methane hydrate-bearing sediments.

In this study, methane hydrate-bearing sand (MHBS) was created in laboratory with two methods in order to have two types of gas hydrate distribution at the grain scale. This later was assessed by the measurement of compressional wave velocities combining with a model predicting the elastic-wave velocities of sediments containing gas hydrate. Mechanical properties of MHBS were investigated by triaxial compression tests. The soil used is Fontainebleau silica sand (NE34). Four tests performed with the procedure A (A1 to A4), four tests with the procedure B (B1 to B4) and one reference test were conducted.

Figure 1 shows the results of measured compressional wave velocities versus hydrate saturation compared to that calculated after Helgerud's model. After saturating methane gas saturated samples (created by partial water saturation method) by water, methane hydrate is converted from grain contacts to the pore spaces. Addition of a temperature cycle after water saturation completes this conversion process..

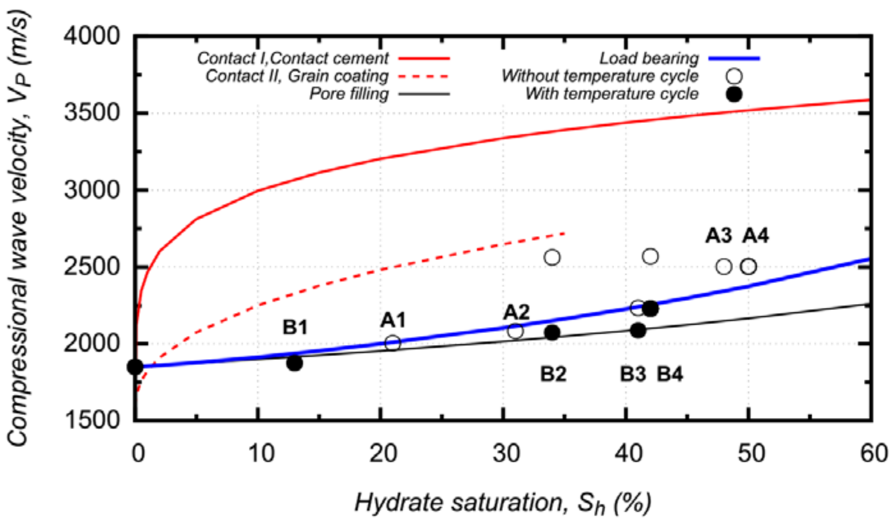

Fig. 1: Comparison between experiments and Helgerud's model of compressional wave velocity dependence on methane hydrate saturation in water saturated media

Figure 2 shows the syntheses of results obtained with the triaxial compression tests. Higher shear strength, secant Young modulus, and dilation angle are found at higher hydrate saturation. But in contrast to difference of wave velocities measures (at low deformation level), we could not distinguish drained shear strength (at high deformation level) of load-bearing and pore-filling habits.

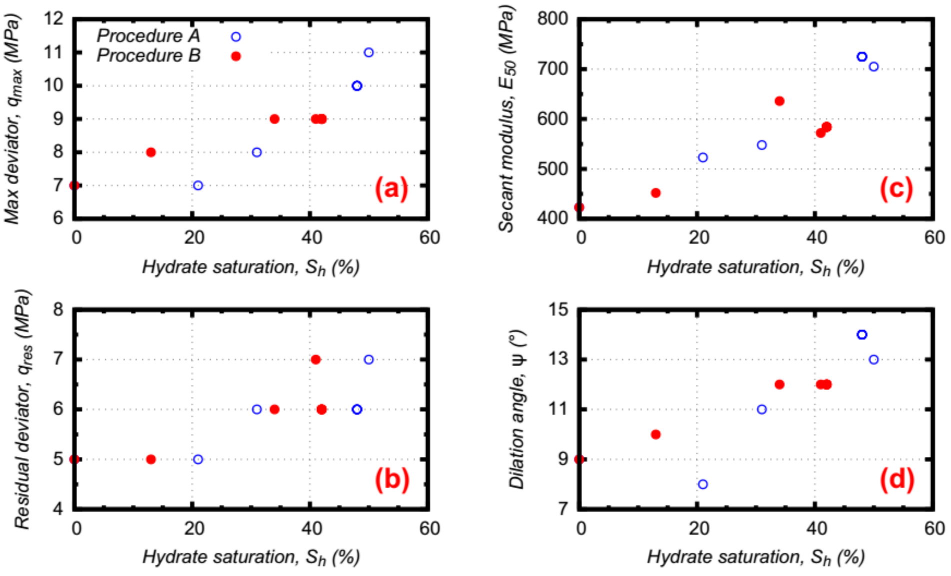

Fig. 2: Sand's mechanical properties dependence on methane hydrate saturation for all tests

In conclusion, subsequent water saturation converts (and/or redistributes) gas hydrate from grain contacts to pore spaces and decreases, as a result, V_p. This process may take several days, depending on the hydrate saturation and cannot be completed for high hydrate saturation. Heating/cooling cycle allows completing the conversion (and/or redistribution) of gas hydrate from grain contacts to the pore spaces. The effect of grain scale gas hydrate distribution can be detected in the case where the conversion (and/or redistribution) of gas hydrate from grain contacts to pore spaces was not completed.

References

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