12 Mar 1991, 10:30 am - 12:00 pm

# The Dynamic Properties of Carbonate Sands from Seabed

Du Jian
*Tongji University, Shanghai, China*

Wu Xiaofeng
*Tongji University, Shanghai, China*

Zhu Longgen
*Tongji University, Shanghai, China*

Proceedings: Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, March 11-15, 1991, St. Louis, Missouri, Paper No. 1.29

# The Dynamic Properties of Carbonate Sands from Seabed

**Du Jian**
Professor of Geotechnical Engineering, Tongji University, Shanghai, China

**Wu Xiaofeng**
Research Engineer of Geotechnical Engineering, Tongji University, Shanghai, China

**Zhu Longgen**
Associate Professor of Geotechnical Engineering, Tongji University, Shanghai, China

SYNOPSIS: Four kind of carbonate sands from offshore seabed together with LB sand of U.K and Fujian sand of China were tested with the Resonant Column method. The results show that the stress-strain relationship in the condition of small strain can be represented with the hyperbolic model. The modulus is less than that of general sand. The cementing strength between particles of carbonate sands is weak. The breakage of particles is easy after disturbed and the density, therefore, will be increased. These properties should be further studied for engineering purpose.

## INTRODUCTION

With the frequently increasing offshore structures planed to be constructed, the seabed carbonate sands with various contents of calcium carbonate and properties were found in some offshore regions of the world. It was also found that the pile capacity in such regions is lower than those where the subsoils were not consisted of carbonate sand. So, it is necessory to know the allsided properties of these sands and the dynamic property is just one of them. Others can be seen in reference [1].

Using four kind of seabed sands from various regions, the resonant column test were carried out. The same tests were carriedout using standard cilica sand of Fujian, China and LB sand from U.K for comparing purpose.

## MATERIALS

Four offshore seabed sands collected were briefly described as follows:

Ballyconneely sand(simplified as BC) is a calcareous algal one. It was obtained from above the high water mark of beach at Ballyconneely Bay, near Clifden, Connemarra, Ireland.

Bombay Mix sand(simplified as BM) was obtained from boreholes in Bombay High and South Bassein Oilfields on the Western Continental Shelf of India. The maximum depth of water on the shelf is approximately 140M and the borehole depth varied from 8M to 145M. Samples with a calcium carbonate content over 80% were selected and mixed. This material contains high ooid and foraminifera content which is not present in large quantity in other materials.

Quiou sand(simplified as Q) was obtained from the Institute Francais du petroli in Paris. The sand was taken from a formation laid in the Miocene opech of the Tertiary period. This sand is not recent and has an age in excess of 1.6 million years.

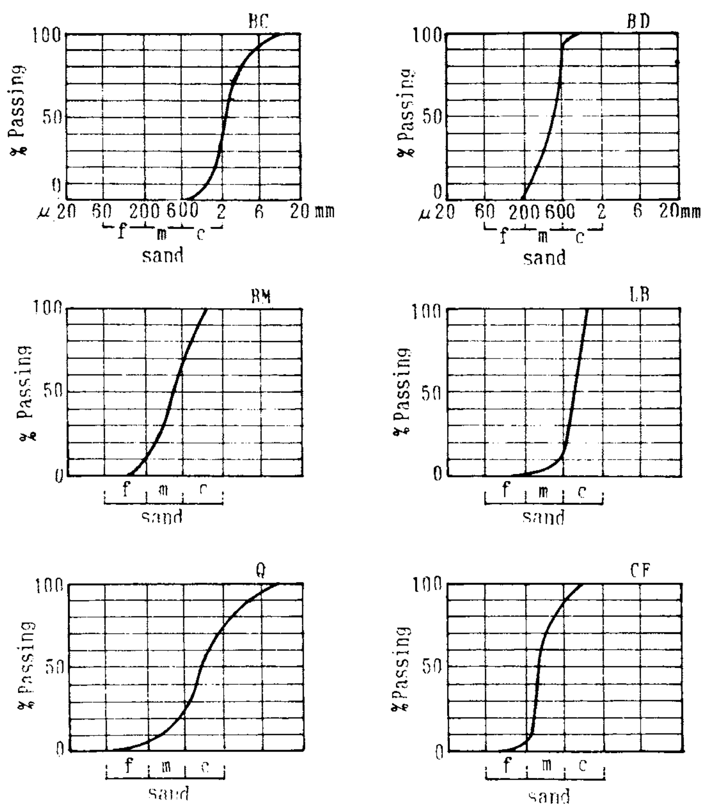


Fig. 1 Grading Curves

Dogs Bay sand(simplified as DB) was taken from above the high water mark from the beach of Dogs Bay, Roundstone, Connemarra, Ireland.

Leighton Buzzard sand(simplified as LB) has been used in a number of studies over the last 20 years, particularly in the United Kingdom. It was used as a reference material against which to measure the behavior of the four carbonate sands as above. It was obtained from quarries in Leicestershire.

The Fujian standard sand(simplified as CF) is pure siliceous one from Fujian province of China and was defined as a kind of standard sand in China.

All materials were passed through a 2mm sieve and their grading curves are shown in Figure 1. The main physical properties are listed in Table 1.

Table 1. Physical Properties of the Sands

| Name | Spec. Grav. | $D_{10}$ | $D_{50}$ | $C_u$ | $e_{min}$ | $e_{max}$ |
|---|---|---|---|---|---|---|
| BC | 2.72 | 1.00 | 1.45 | 1.11 | 1.62 | 1.98 |
| BM | 2.80 | 0.17 | 0.32 | 2.33 | 0.75 | 1.07 |
| Q | 2.72 | 0.40 | 0.80 | 2.28 | 1.15 | 1.61 |
| DB | 2.75 | 0.24 | 0.44 | 2.06 | 0.98 | 1.83 |
| LB | 2.65 | 0.60 | 0.82 | 1.48 | 0.51 | 0.84 |
| CF | 2.66 | 0.18 | 0.33 | 1.58 | 0.57 | 0.84 |

TESTING METHOD

The V.P.Drnevich Resonant Column Apparatus with a fixed end and a free one as well as a lumped mass was used. It can exert not only an axial exciting force under 0.07MPa of maximum confining pressure to determine $E_d$ and $D_L$(axial vibration damping ratio),but an torque exciting force to determine $G_d$ and $D_r$(torsional vibration damping ratio). The torsional vibration was only used for all of sand samples mentioned above in order to determine the $G_d$ and $D_r$ in this study.

The testing was only carried out on dry samples with minimum void ratio. The diameter of sample was 3.57cm. The lumped mass on the top of sample was 12.17N. The confining pressures were exerted with 0.05, 0.1, 0.2 and 0.4MPa for every kind of sample respectively, but one of the pressure may be lacked for individual kind of sand.

The shear modulus $G_d$ was calculated according to the exciting frequency exerted. The strains at the center and the edge of sample section are zero and maximum respectively when a sample was put to torsional vibration. The strain at the point of 2/3 radius was regarded as corresponding shear one. The damping ratio $D_r$ was calculated according to the 1st and 5th amplitudes on the free decrement vibration curves.

TEST RESULTS AND ANALYSES

The tests showed that the carbonate sands had less cementing strengths, especially for those having a thin and long form. The breakage of particles is easy with fingers. The sand particles were broken in different degrees after testing and the Q sand is the most obvious one. It was certified that the samples with less void ratios

than the minimum natural one were easily reprepared after testing. For example, the minimum natural void ratios of BC, BM and Q sands are 1.62, 0.75 and 1.15(see Table1) and the void ratios of reprepared sands are 1.53, 0.675 and 1.05 respectively. The granulometric composition changed because of particle breakage, and, therfore, the sands can not be used again.

The changes of the modulus $G_d$ and damping ratios $D_r$ of six kind of sands under the confining presures $\sigma_a$ with the shear strains $\gamma$ were shown in Figure 2. It was similar to the those of the general sands except the amount was different, i.e.. $G_d$ increased and $D_r$ decreased because of the increment of stiffnesses of samples when the confining presure $\sigma_a$ increased. The $G_d$ was almost a constant when $\gamma$ was small, then gradually increased after that. They showed that the four carbonate sands and the standard sand were in elastic condition when the strain was small. The irreversible deformation partly generated with the increase of strain and the samples entered into the elastic-plastic condition. Similar to the standard sand, on the whole, the boundary strain $\gamma = 10^{-5}$.

It was shown that the relationship curves $1/G - \gamma$ were linear, in other word, the stress-strain relationship was a strain softing one and it could be represented with a hyperbolic model.

It was well known that the initial shear modulus was related to the density of samples and confining presure. In this test, we did not compare the properties of the same density sands because the densities of various sands were quite different(see Table 1) and the same density of sands could not be obtained. The quantity of various sands was limited and they could not be used repeatedly. Therefore, the tests were only carried out under certain density and it was diffcult to appropriately compare the strength of different materials. But the general variation tendancy of initial shear modulus was clear if the relationship curves between $G_0$ and confining pressure $\sigma_a$ were drawed as what shown in Figure 3.

It increased with the increasing of confining pressure and their relationship was not a linear one.

From Figure 2 and 3, we can also see that the shear modulus of four carbonate sands in the condition of greatest density were approximat-

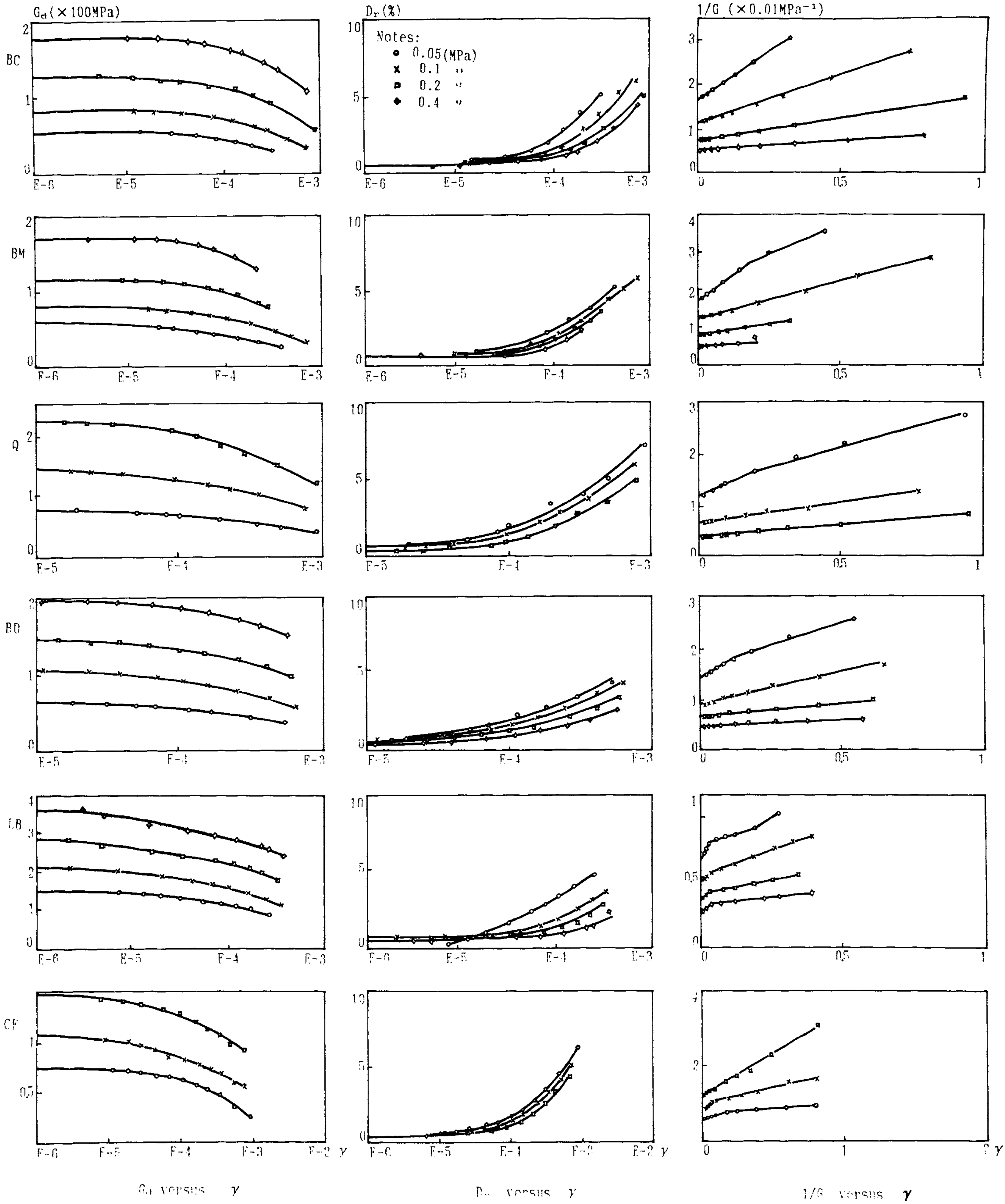


Fig. 2 $G_d$、1/G and $D_r \sim \gamma$ relationship curves

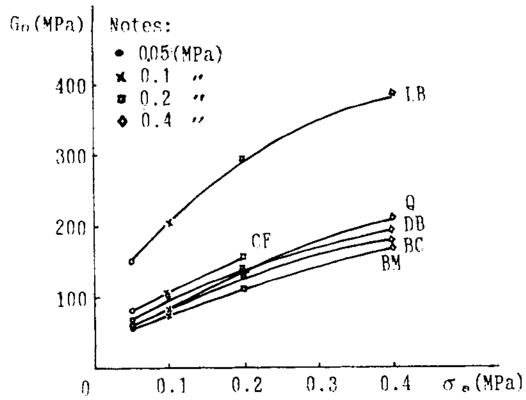


Fig. 3 $G_0 \sim \sigma_a$ relationship curves

ely the same. The modulus of Fujian standard sand of China was a bit higher and that of LB sand was much higher. In the non-compacted condition, the modulus of the four carbonate sands must be further lower. But, when disturbed, the sand particles would be broken and the density would increase. So, it is very important to know what way make the sand particles break and how great the modulus can be raised.

## CONCLUSIONS

A. Four kind of carbonate sands from offshore seabeds are of weak cementing strength of particles and can easily be broken after disturbed;
B. As standard sands, the stress-strain relationship of carbonate sand is a strain softong one and can be represented with hyperbolic model;
C. The modulus of the four kind of sands less than that of China standard sand and much less than that of LB sand of U.K.
D. According to the easy breakage behavior of carbonate sand particles, we can change the granulometric composition and increase the density of sand fo engineering purpose. And it is worth of further studies.

## REFERENCES

Golightly,G.R. (1989), "Engineering Properties of Carbonate Sands", Ph.D theme, Bradford University, U.K.

Zhu, L.G. and Wu, X.F. (1988), "A Study of Dynamic Properties of Sands under low Amplitude Strain", J. of Dam Observation and Geotechnical Tests, Vol.12, No.1, 27-33.

Zhu, L.G. and Du, J. (1990), "Comparision Tests of Resonant Column", J. of Dam Observation and Geotechnical Tests, Vol.14, No.3, 26-32.