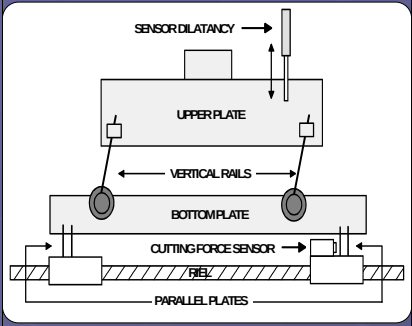
MECHANICAL PROPERTIES OF A 2D SHEARED GRANULAR SYSTEM

N. Sepúlveda*, F. Vivanco and F. Melo.

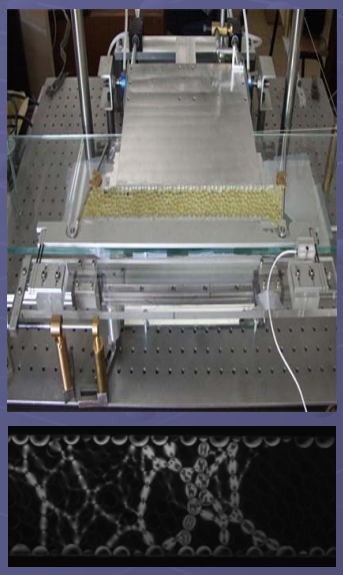
Departamento de Física, Universidad de Santiago de Chile, Avenida Ecuador 3493, Santiago-Chile, Chile

Abstract. A two dimensional granular system based on photoelastic cylinders is subjected to a constant shear rate and compressed in the direction perpendicular to the shear. It is observed that the average shear force is practically independent of the shear rate. It is also found that the average shear force is proportional to the compressive stress giving a constant dynamic friction coefficient ~0.291±0.004. In addition, for slower speeds the stick-slip phenomenon is observed.

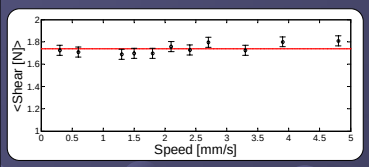
Experimental Setup



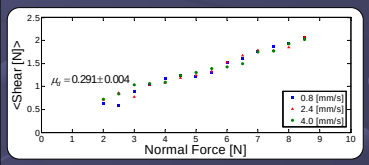
A set of around 250 cylinders with diameters of 7 and 8 [mm] have been used. The shear rate was generated by a constant speed moving wall with a velocity range from 0.1 [mm/s] to 4.8 [mm/s]. The compressive stress was generated by a normal force, 2.0 - 8.5 [N].



Average Shear Force

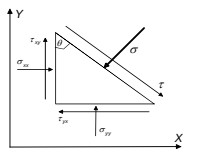


The average shear force remains constant within the range of speed employed.

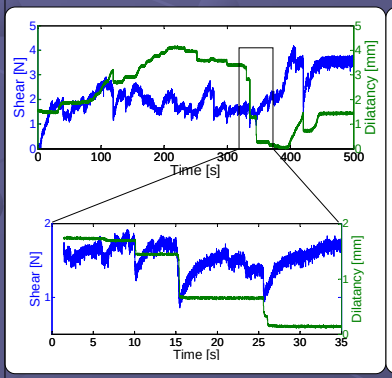


A linear behavior between average shear force and compressive stress is observed. The granular material obeys the Coulomb friction law with a dynamic friction coefficient ~0.291±0.004.

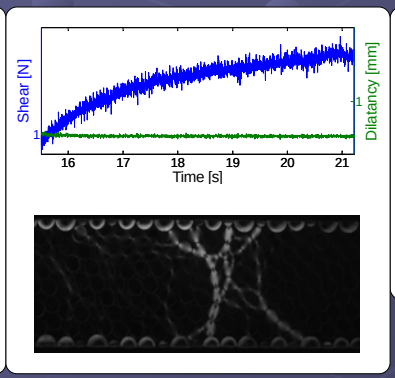
Coulomb's law $\tau_{yx} = \sigma_{yy}\mu + C$



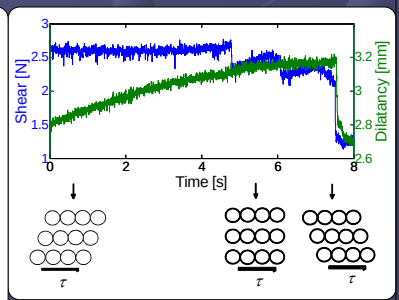
Shear Force and Dilatancy



Typical curves for shear force and dilatancy. It is observed fluctuations on shear force while the dilatancy remains practically unchanged. However, sudden changes in the shear force are accompanied by reductions in the dilatancy suggesting that these quantities are correlated in principle.



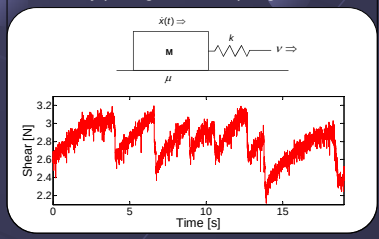
Progressive increases in the shear force are not necessarily reflected in the dilatancy. It might be due to the presence of a few force chains that keep the volume of the system unchanged.



A gradual increment of the dilatancy is observed while the shear force remains constant. A possible explanation is based on the local rearrangement of the grains that requires a change in volume.

Stick - Slip

At slower speed ~0.1 [mm/s] the shear force shows the typical pattern of stick – slip phenomena, gradual increments followed by sudden reductions is observed. Stick – slip phenomena can be modeled by a mass-spring system moving on a non smooth surface by pulling from the spring.



Conclusions

A solid-like behavior can be observed in the granular system within the range of deformation speed employed in our experiment, that is confirmed by the average shear force and compressive stress relationship and the independence of the average shear force on the speed of deformation. It is also found that the dilatancy and the shear force are connected in a complex way resembling the internal structure of the system. This is reflected in the observed behavior of dilatancy and shear force; constant dilatancy when shear force increases or fluctuates, gradually increase of dilatancy when shear force remains constant and decresing in dilatancy when shear force changes suddendly.

Future Work

-Study of the effects introduced by the number of grain layers.

-Study of the effects introduced by the mixture of grains of different sizes on the dilatancy and shear force.

-Study of the efects of the grain shape on the shear force and dilatancy.

-Study of the connection between internal structure of the granular material and the macroscopic behavior of the dilatancy and the shear force

International Workshop: Frontiers in Materials Research IV – Viña del Mar, Chile – May 21 – 24, 2008