W.E. HODGE

From: "James K Mitchell" <jkm@vt.edu>
To: <wehodge@telus.net>
Sent: May 21, 2002 6:26 PM
Subject: Archimedes et al

Hi Bill -

Delighted to receive your note (and to learn your correct address - tried to send you a card following the fine dinner in Vancouver last December, but it bounced).

The experiment that Yogi Vaid describes sounds most intriguing, but I'm not sure I fully understand what's going on. If the cylinder, the water, the horizontal bar and the steel ball are all supported by the load cell, how can the load go down when the string is cut? i.,e., why does the load cell care whether the ball is supported by the string and bar or (partly) by the water? I can understand the water pressure going up in the short term owing to the dynamic loading, but shouldn't the pressure increase in the water be detected by the load cell? What I am missing here is undoubtedly the key point of your hypothesis for pore pressure increase.

I expect that at some time in the past you told me about your kitchen sink experiment, but between my poor memory and senior moments, I'm unable to recall the details.

I seek enlightenment!

Best regards,
Jim

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W.E. HODGE

From: "James K. Mitchell" <jkm@vt.edu>
To: "W.E. HODGE" <wehodge@telus.net>
Sent: May 22, 2002 5:25 AM
Subject: Re: Falling balls

Bill -

Wow! What an eye opener, what a dummy I am, and why didn't I read your monograph more carefully when you sent it to me in October 1998? I've just pulled it off the shelf in my campus office (didn't have it at hand at home when I emailed you last night) for careful study.

Before I get off into a ramble about the implications (which are very great) of your interpretations relative to liquefaction of gravels and well graded soils, I want now to read and ponder your ideas more carefully. It is nonetheless reassuring that F still equals Ma.

I hope that you enjoyed the wine.

Cheers,
Jim

At 07:27 PM 5/21/2002 -0700, you wrote:

Hello Jim,

It's good to be in contact, but now I've got your E-mail address you may never hear the end of me.

The test is designed so that everything in the system is kept on the load cell. The cell is tared once the steel ball is submerged, and while it is still kept suspended on a cross bar which is bearing on the walls of the water cylinder. So before the string is cut everything is stationary and accounted for. When the string is cut the ball is no longer supported by the cross bar and starts to accelerate under gravity, and at the very first instant, while it is at maximum acceleration it is at the same time at zero velocity. In this "zero" state it has no motion to generate drag force. And it is at the same time accelerating at full gravity, therefore it has no weight relative to the system. The load cell responds with an instantaneous drop in load equal to the buoyant (effective) weight of the ball. But as soon as the ball speeds under the influence of gravity it starts to build up drag resistance, and this can be seen on the oscilloscope trace reading the load cell. Once the speed of fall of the ball is sufficient to create drag forces equivalent to its effective weight, of course it is balance, and at terminal velocity. It is not accelerating any more so it is in steady state motion with the force equation reinstated. At this point the full weight is recorded on the load cell again. The interesting thing is that what is necessary to sustain the drag forces is a hydraulic pressure differential from front to back of the ball. Since the back (top side) of the ball is close to a hydrostatic condition, the front (lower side) of the ball has water in front of it which is at a pressure higher than hydrostatic. This is what we call, within the more complicate two phase system, pore water pressure. So it would seem pore water can be accounted for by the relative motion between the soil particle and the water in the pores. So now we may be able to calculate it.

The test is obviously a highly idealized situation. The reason for using a large heavy ball is that there is time to measure what happens, and to get a reading on a gauge. A sand particle would reach terminal velocity too quickly to measure. Where it takes the large ball (gravel) a fall distance of about 10 to 20 times its diameter to reach terminal velocity, and transfer its effective weight into the water, it only take a fine sand size particle a small fraction of its diameter to reach the same state. That accounts, I believe, for why a sand particle in falling the distance from a loose state of packing to a dense state of packing can reach terminal velocity and full pore pressure. And it is why gravel can't liquefy - there is not enough room to fall within the two phase structure. The lack of room to fall also accounts for the stability of well graded materials, the small particles get in the way of the bigger particles, and apart from that the general pore water pressure will only be in proportion to the relative weight of particles small enough to reach steady state.

Before daring to publish the monograph, I ran these tests in my kitchen using different thing I could find: a new potatoe, a hard boiled egg, a brass knob from a drawer. Try it at home, it's suprisingly convincing.

I don't know if I succeeded in making the point but I'm out of steam and have a bottle of wine cooling in the fridge. Great pity you are not close enough to share it.

With my best regards, Bill

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