Reply to questions raised by Harry Yeh concerning slides 6 and 7 in the PPT file of Sekiguchi for the Hilo Workshop

Hideo Sekiguchi, Kyoto University

Questions by Harry Yeh

I have a few questions in PPT file. In p 7, I understand that the graph is to determine the value of w with the measured dz/dt and give values of C and C_sub_gf, correct? If so, why the value of dz/dt in the graph is not equal to 17.8 mm/sec for C = 38.3% (dz/dt = 17.8 mm/sec was presented in p. 6)?

It is not clear to me what the parameter tan beta is and how it is incorporated in LIQSEDFLOW.

Response to the first question

I would first like to mention that we built up experimental datasets over a period of a few years, along with developments in data processing and data interpretation. The essence of the latest outcome is reflected in the 2006 NJG paper. The PPT file was basically prepared for an oral presentation (by Shinji Sassa) of our paper for the related, 2nd International Symposium on Submarine Mass Movements and Their Consequences, which was held in Oslo, Norway during 5-7 September 2005.

For convenience of description, I subsequently put Fig. 6 of the 2006 NJG paper (which is essentially the same as slide 6 in contents). Note that the data points came from test FEB05-② with c=38.3%. Here either c or C denotes the volumetric concentration.

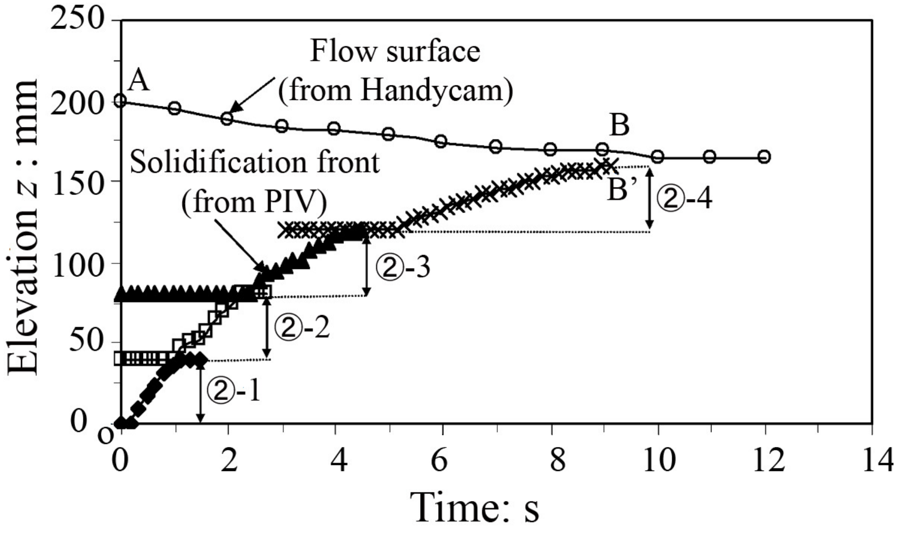

Figure 1 Evolutions of flow and solidification surfaces in **test FEB05-②** with c=38.3% (the same figure as slide Fig. 6 of the 2006 NJG paper; also, representation was essentially the same as slide 6). The initial height of the sediment column (at t=0) was: H=200mm.

As described in the NJG paper, the (overall) velocity of solidification front was evaluated from the slope of the straight line that connected the terminal point (point B’) with the origin of the diagram. This procedure gave rise to the velocity of solidification front equal to 17mm/s or so (expresses as being 17.8mm/s on slide 6) in this particular test that had c=38.3% and H=200mm. Here H denotes the height of the fluidized sediment column, H, immediately before the start of the hindered settling process.

Now, let us look at a data point for c=38.3% in slide 7. The data point actually came from an earlier series of hindered settling tests. In short, it was from test PPTCCD-1 with c=38.3% and H=143mm. The evolutions of flow and solidification surfaces in test PPTCCD-1 is presented below for clarity.

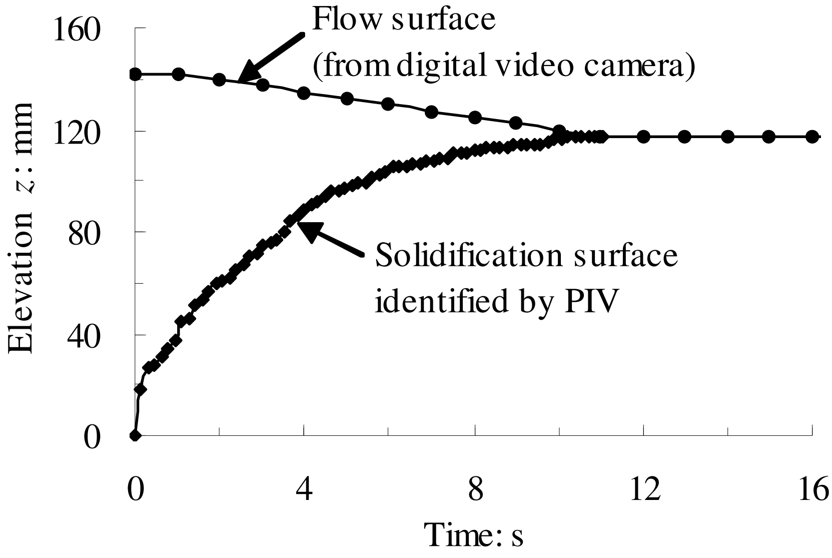

Figure 2 Evolutions of flow and solidification surfaces that occurred in **test PPTCCD-1** with c=38.3% . The initial height of the sediment column (at t=0) was: H=143mm.

From this figure above, we estimated that the (overall) velocity of solidification front was equal to about 11mm/s (as plotted in slide 7), with the time of completion of solidification being equal to 11s or so.

In conclusion, I have no ready explanation for the difference in the velocities of solidification front, dz_{SF}/dt, in the two tests while their volumetric concentrations c were essentially the same. Admittedly, there should have occured some experimental scatter in the two different test series. Also, I now have come to realize that it will be worth attempting to examine the possible effect of the height of the fluidized sediment column, H, upon the following hindered settling behavior.

Response to the second question

The second question by Harry Yeh is concerned with the definitions of two parameters β and β_{cr}. I should first like to replace slide 9 with a revised one, which is shown below for clarity. Note herein that β is an empirical parameter which represents the local slope of the interface (called the solidification surface) between the fluidized and already solidified zones.

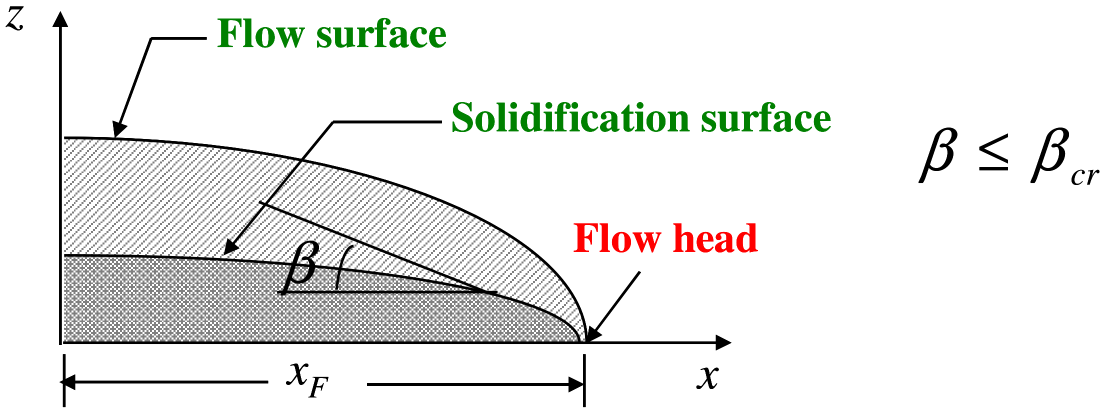

Figure 3 Representation of the parameter β which specifies the local slope of the solidification surface; A physical constraint may be imposed on the value of β so as not to exceed a critical angle βcr, in light of the frictional resistance of sediment with grain-supported framework being reestablished.

For one-dimensional conditions such as hindered settling, the solidification surface is a level surface (β =0). However, in the case of subaqueous sediment gravity flow, the development of a solidified zone may take more complex configurations. Now it comes to the matter of modelling for such a subaqueous gravity flow. In our approach with LIQSEDFLOW (Sassa, Miyamoto and Sekiguchi, 2003), we have used the VOF (volume of fluid) procedure so as to trace two moving boundaries: one is the flow surface that essentially is an interface between the ambient water and fluidized sediment; and the other is the solidification surface which is an interface between the fluidized sediment and internally formed zone of solidified soil. In the context of the VOF procedure, we have treated the solidified zone as being an obstacle (rigid body) to the flowing fluidized sediment, such that the (particle) velocities in the solidified zone become zero.

In physical terms, however, we consider that the solidified soil should have a certain frictional resistance. In fact, this reasoning has led us to introducing a critical angle βcr in such a way that the slope of the solidification surface, β, cannot exceed the critical angle anywhere. In this sense the parameter βcr may relate to the angle of frictional resistance of granular soil, which depends on the state of packing or solids concentration. For instance, a higher critical angle βcr may correspond to sediment with a higher density (along with a higher solids concentration c).