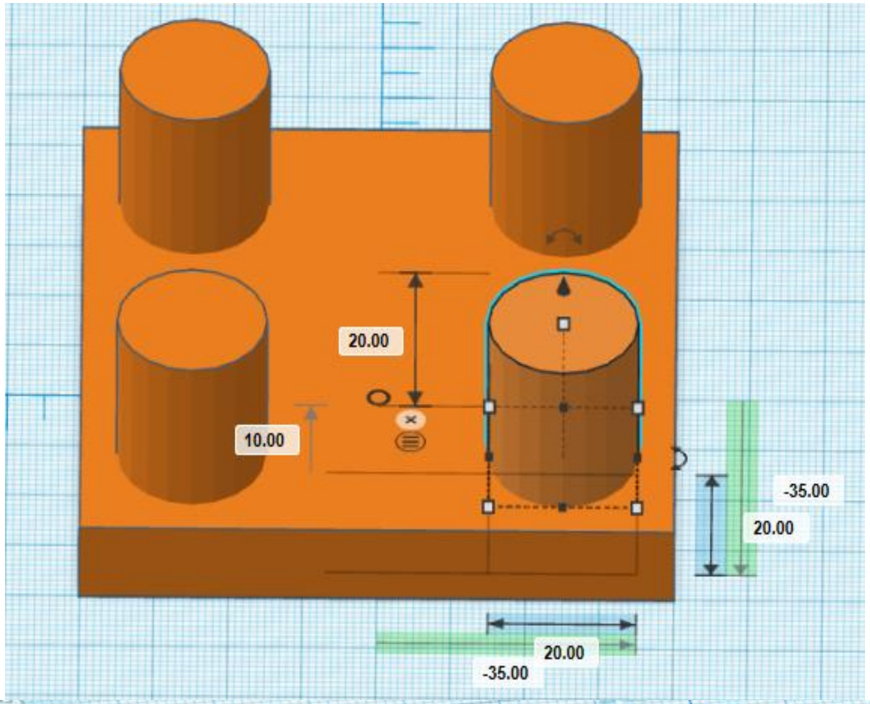
Alexander Shelenkov and Eldar Khabibulin

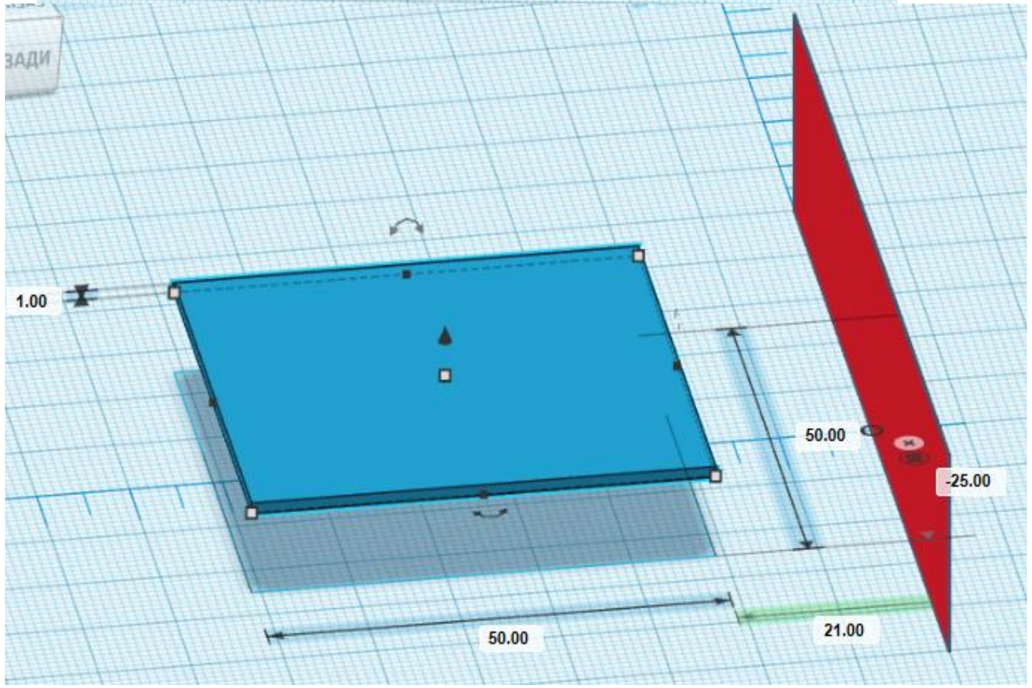
Bachelor students 6th year at Moscow State University (MSU), Faculty of Mechanics and Mathematics, department of plasticity's theory.
MSU supervisor: Professor Alexander Sakharov
UNIS supervisor: Professor Aleksey Marchenko
Purpose of staying at UNIS:

1. Practice in a Norwegian company «Kvaerner» as part of the SITRA project
2. Make experiments for our Master project at Spring time on Svalbard

Our assignment period at UNIS had started at 2 October 2017 and ended at 3 November 2017.

Kvaerner is a leader among contractors in engineering, logistics and project management, as well as the construction of oil and gas facilities, including superstructures for offshore stationary or moving platforms and onshore processing facilities.





Task's settings:

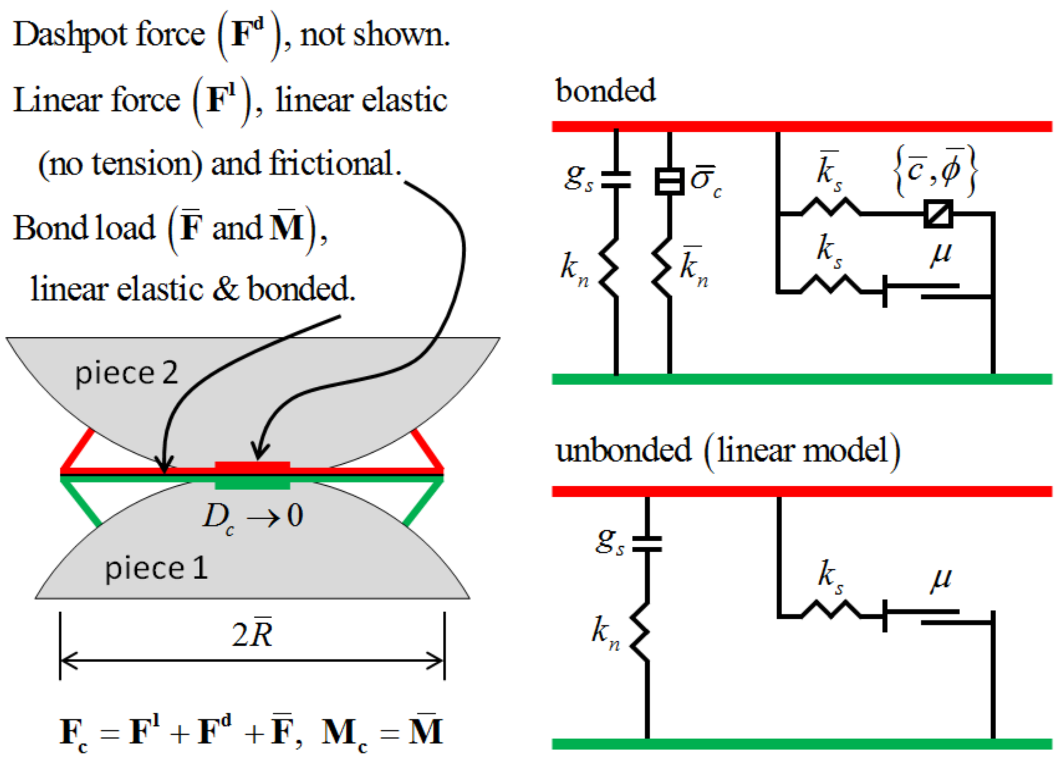
- The first task set before us is to simulate in Itasca PFC3D the trajectory of motion and the load acting on the structure of 4 cylinders standing on the platform, from pieces of ice that float on it. On picture on the left you can see the dimensions of the structure. (All dimensions in meter)

- The second task set before us was to simulate in Itasca PFC3D the influx of the ice field on the wall and determine the load acting on it. The picture shows the dimensions. (All dimensions in meter)

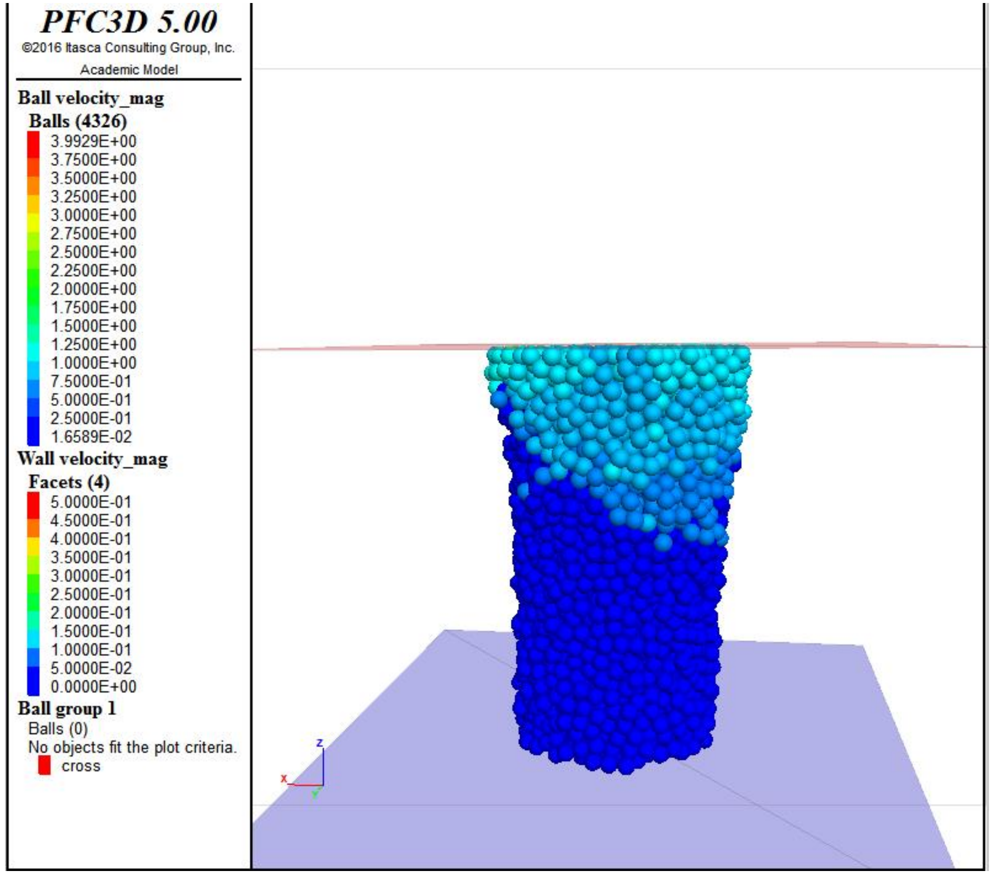
Itasca PFC is commercial, multi-physics simulation software for engineers and scientists using the Distinct Element Method (DEM).

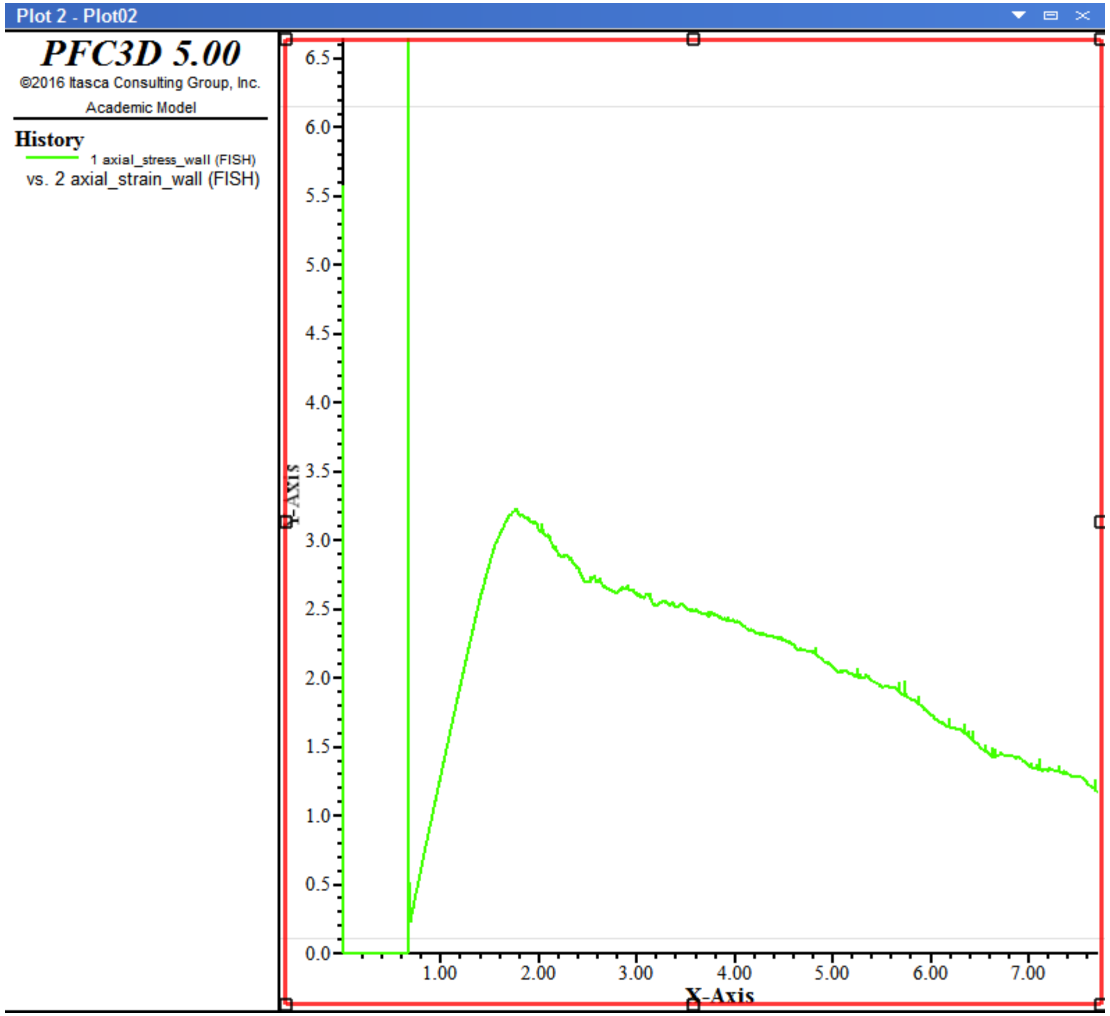
The first and probably the main problem that we have encountered is to correctly choose the model of interaction between discrete elements and parameters in this model. To do this, we simulated a series of experiments on compression and stretching with different models and parameters. But in none of the tensile tests there was a decrease in the cross sectional area. The most approximate character of the destruction of the cylinders in the tests was observed in the Linear Parallel Bond Model.

A parallel bond can be envisioned as a set of elastic springs with constant normal and shear stiffnesses, uniformly distributed over a {rectangular in 2D; circular in 3D} cross-section lying on the contact plane and centered at the contact point. These springs act in parallel with the springs of the linear component. Relative motion at the contact, occurring after the parallel bond has been created, causes a force and moment to develop within the bond material. This force and moment act on the two contacting pieces and can be related to maximum normal and shear stresses acting within the bond material at the bond periphery. If either of these maximum stresses exceeds its corresponding bond strength, the parallel bond breaks, and the bond material is removed from the model along with its accompanying force, moment, and stiffnesses.



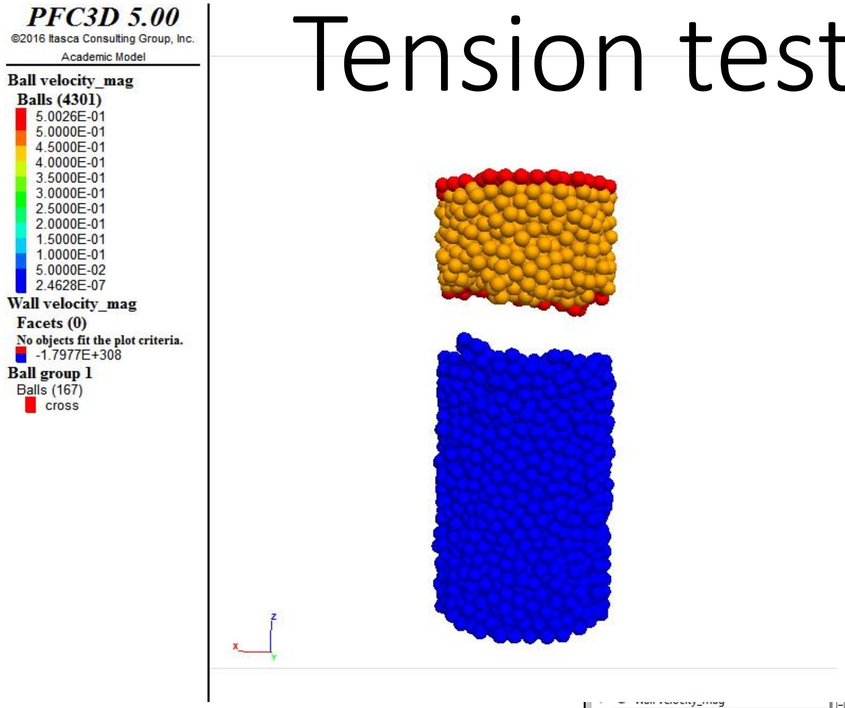
Compression test (Linear Parallel Bond Model)

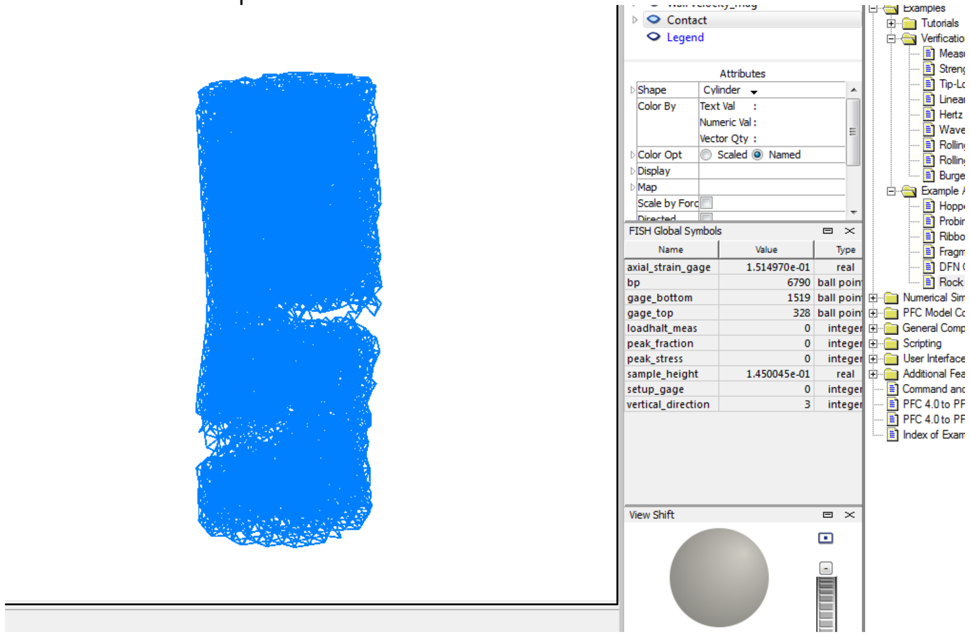


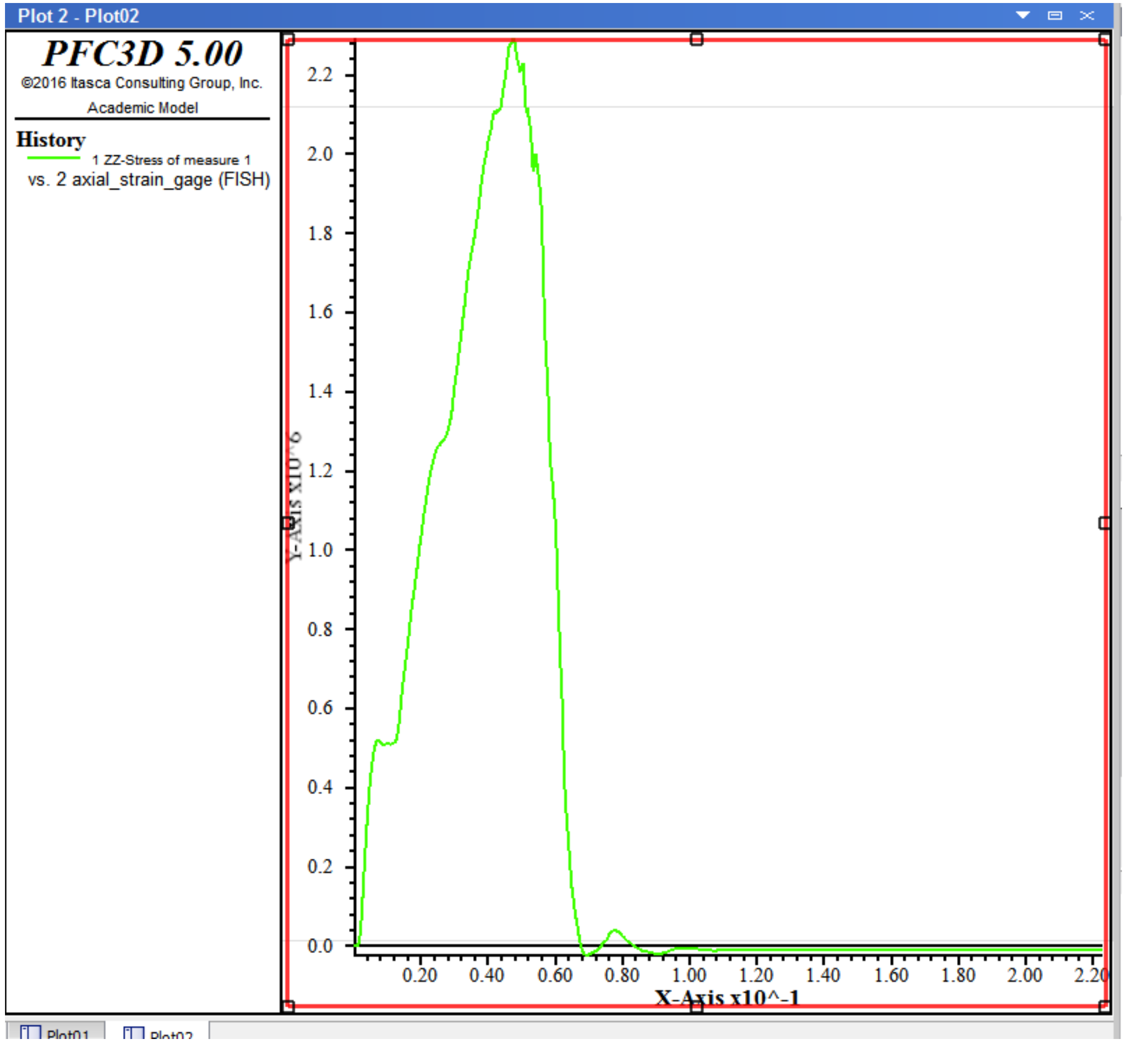


Stress [Mpa] versus Strain [%]

Tension test (Linear Parallel Bond Model)

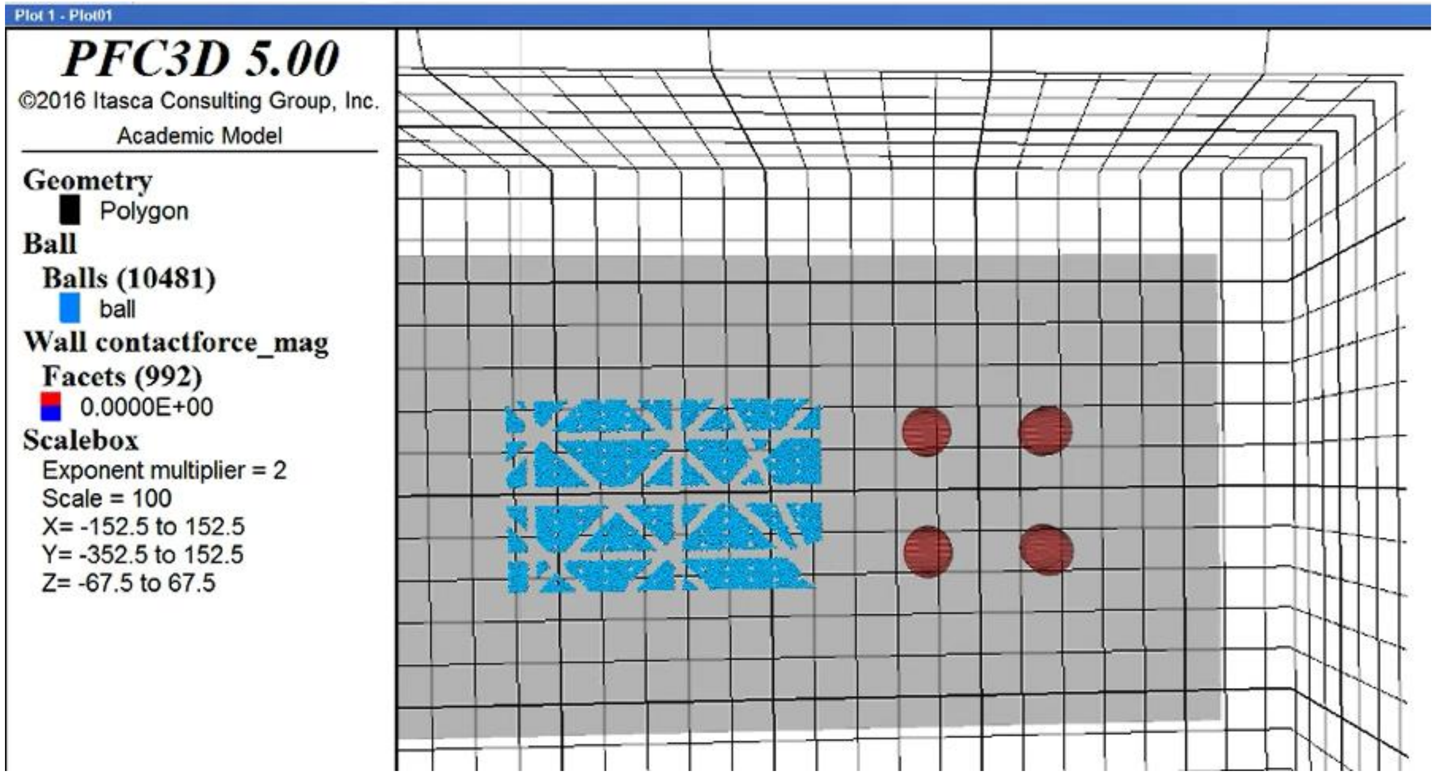


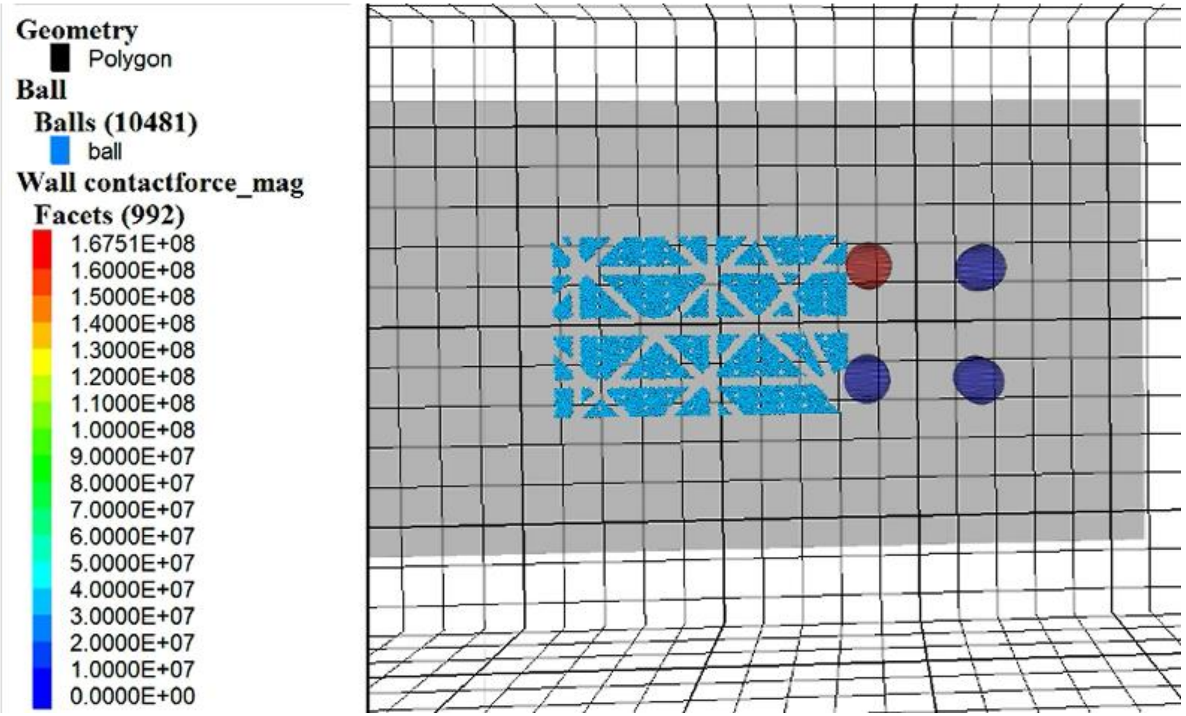




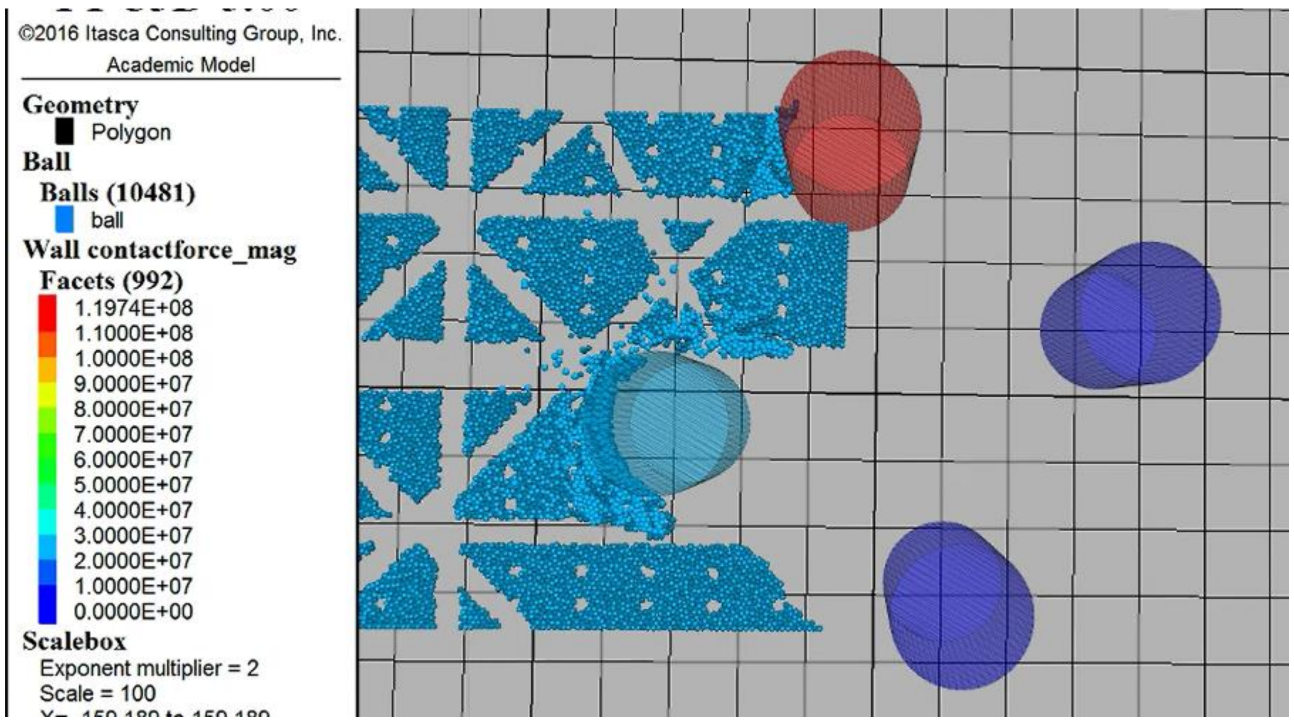
Stress [Pa] versus Strain [%]

The next problem that we encountered is that the program's expense depends on its complexity: by increasing the number of discrete elements and functions that change their position (for example, the functions that describe the Archimedes' force, the angular and linear speed of the structure, the friction of elements from water) increases its counting in geometric progression, since for the description of such functions it is required to connect the python programming language, but PFC does not allow parallelization of the account, therefore the program uses only one stream, i.e. single-threaded.
The pictures below show the results of the first task.

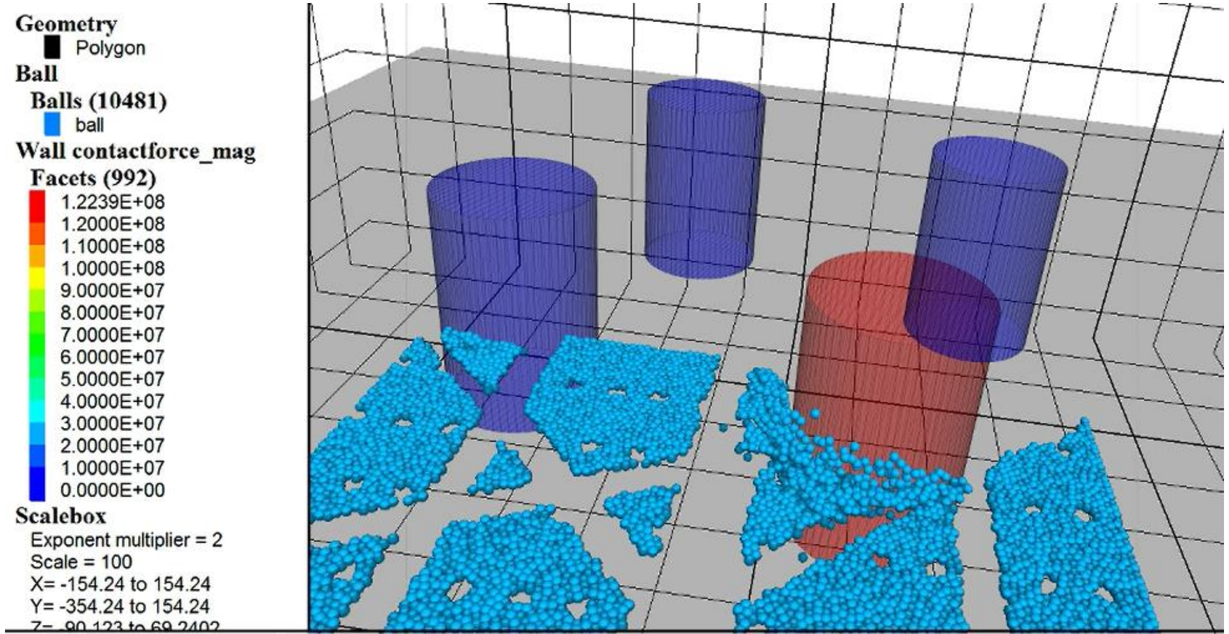




First touch of the ice field with the structure

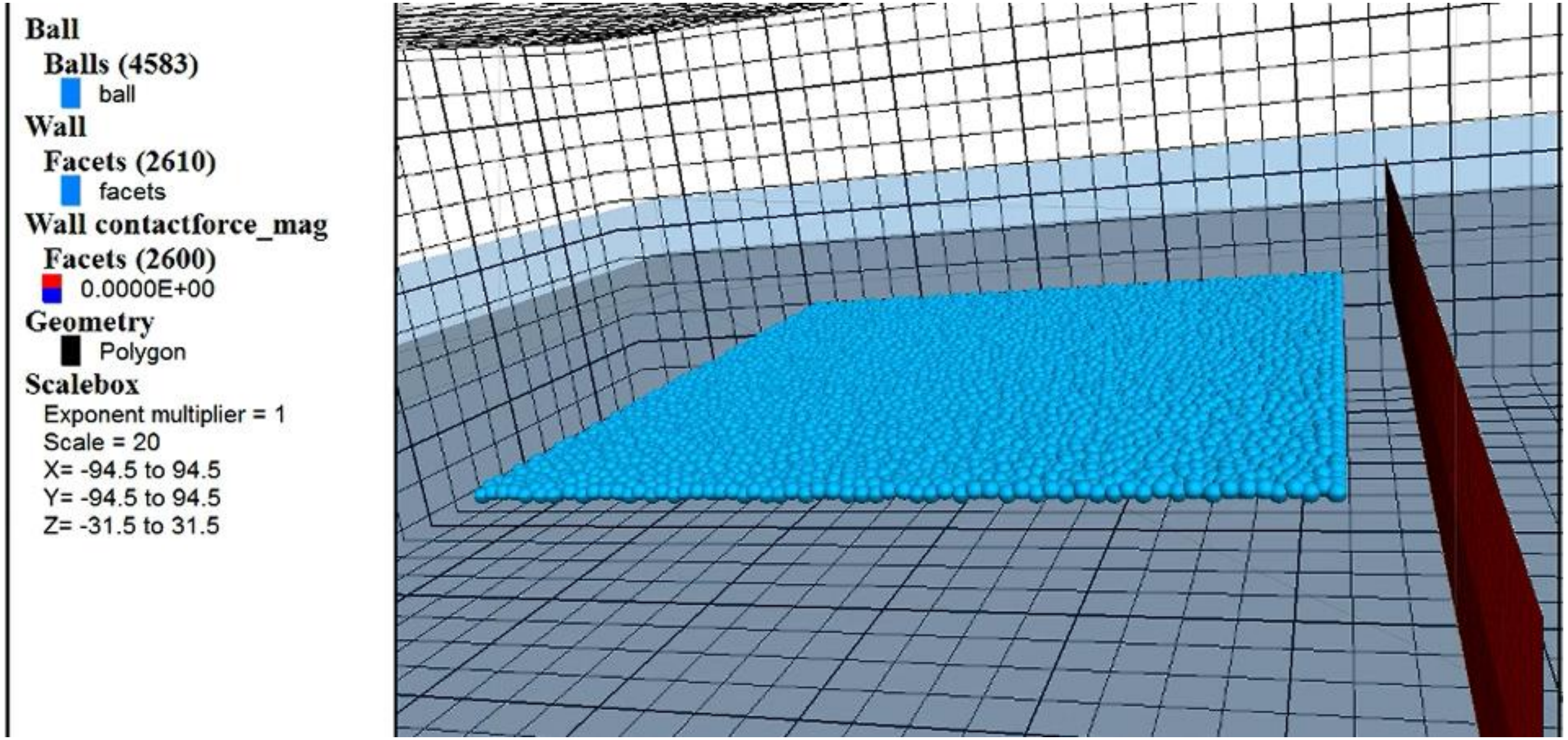


The picture shows the movement of the structure

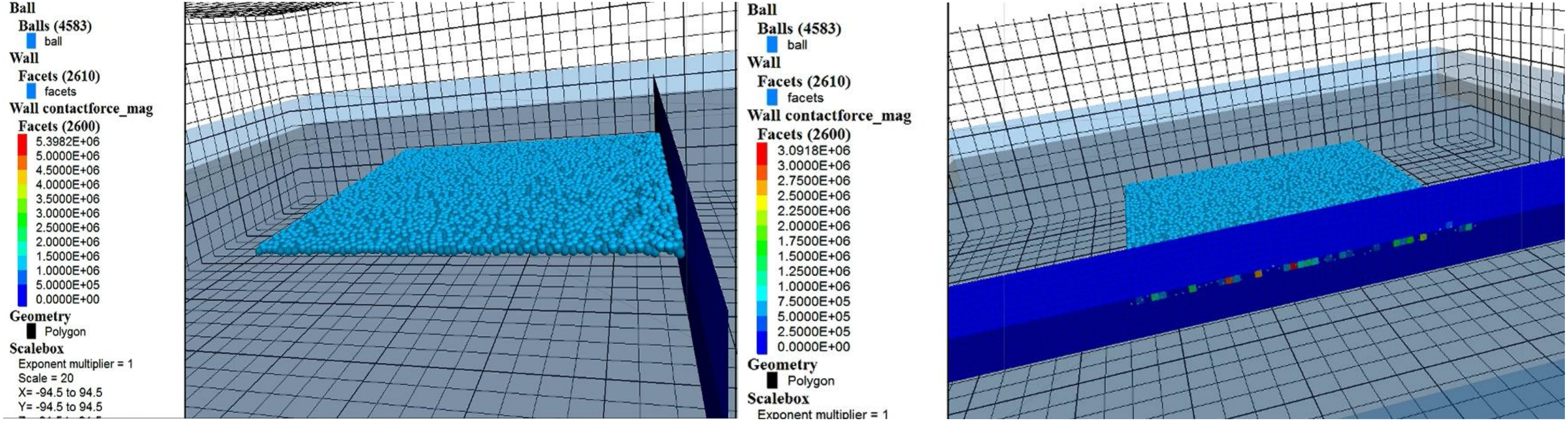


The picture shows the toros formed during the influx of ice

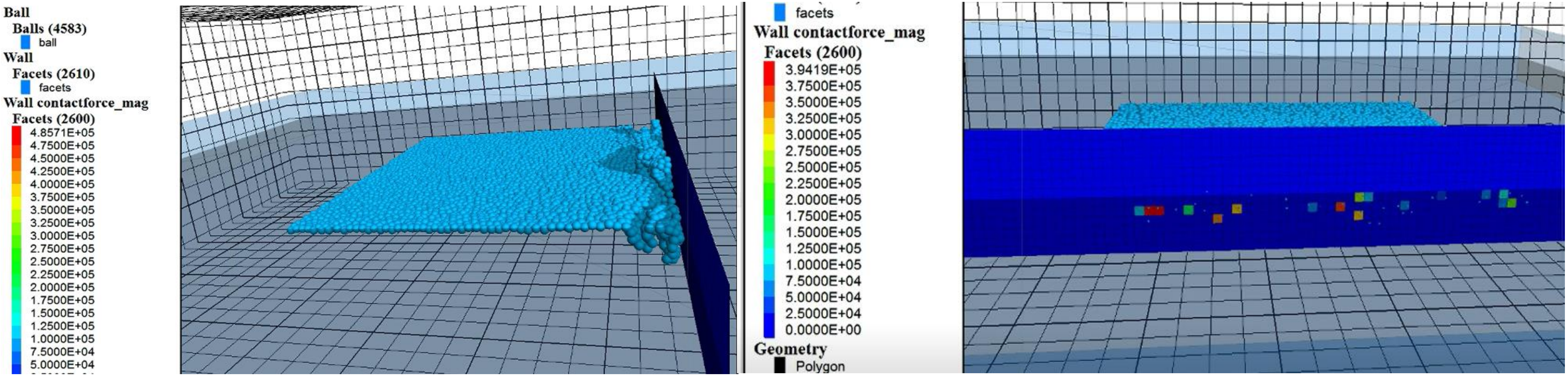
When we were modeling the second task, a problem arosed in the derivation of the force profile. To solve it, we built a wall of small squares of the same size and width in the diameter of the discrete element. When the force is applied to an element, it is painted in a certain color. It is presented in the pictures below.



Creating a field of ice and a wall



First touch of the field of ice with the wall



The picture shows the toros formed during the influx of ice