

Examination of Pull-out Test Response of Sandwich Panels with Different Core Materials

Introduction:

As a part of a joint project between the Concordia Centre for Composites CONCOM and Innovative Composite Products ICP, a series of mechanical tests will be performed for process optimization and material characterizations. This report covers the results related to the complementary tests for assessment of manufactured sandwich panels and core materials. Several types of panels and core materials provided by ICP were investigated, which is presented in table 1. Pull-out tests were performed and repeated for all the presented samples. Screws provided by ICP for the pull-out tests are galvanized flanged hex head screws. The screws are partially threaded with pointed tip, total length of $1\frac{1}{2}$ inches, thread length of $1\frac{5}{16}$ inches, screw size of $\frac{5}{16}$ Inches and 8 threads per inch. All the tests were done without any pre-drilling.

Test procedures:

Even though ASTM C900 [1] is specified for standards method for the pull-out test for concrete walls, due to lack of facilities the standard details were not followed in this research. All the tests were performed using a universal tensile MTS machine. For the first set of tests, samples were clamped with two bar clamps to the moving head, while the screw was machined in order to grip to the head. Thus, only half of the screw length was embedded into the samples during the tests. To improve the test condition and perform the test under the same boundary conditions, second series of test was performed using a stainless steel circular plate with inner diameter of 3.125", outer diameter of 5.5", and thickness of 0.3" as the boundary condition. Furthermore, as shown in Figure 1, a specific setup was designed for the test to be able to screw the maximum length into the samples.



Figure 1: Pull-out test setup with the 3.125" diameter circular boundary condition.

Table 1- Comparison of pull-out test results of all the provided materials

Sample	Material	Thickness [mm]	Maximum force before the first sudden load drop [N]	Normalized to effective screw length [N/mm]	Maximum force at the linear part of the curve [N]	Normalized to effective screw length [N/mm]	Force/Displacement at the linear part of the curve [N/mm]
1	PET	10	151.3	15.1	47.0	4.7	47.0
2	PET	19	322.3	17.0	138.1	7.3	180.1
3	PET	50	516.4	24.1	433.4	20.2	388.1
4	EPS type III	50	117.3	5.5	83.3	3.9	273.3
5	EPS type II	50	38.1	1.8	37.6	1.8	82.6
6	Honeycomb	17.9	186.3	10.4	107.0	6.0	236.0
7	1 layer of Glass/PP composite with weight fraction of 60% glass	1.4	336.6	240.4	306.4	218.9	68.1
8	2 layer of Glass/PP composite with weight fraction of 60% glass	2	776.1	388.1	755.8	377.9	142.2
9	Sandwich panel with 10mm PET core, 60% glass/PP facesheets	11.4	577.8	50.7	288.3	25.3	295.1
10	Sandwich panel with 20mm PET core, 60% glass/PP facesheets	20	543.8	27.2	253.2	12.7	406.2
11	Sandwich panel with 50mm PET core, 60% glass/PP facesheets	53.1	936.3	43.7	560.5	26.1	560.5
12	Sandwich panel with 50mm PET core, 40% glass/PP facesheets	51.9	806.1	37.6	480.9	22.4	658.7
13	Sandwich panel with 50mm EPS type III core, 60% glass/PP facesheets	49.4	482.5	22.5	217.9	10.2	242.5
14	Sandwich panel with 50mm EPS type II core, 60% glass/PP facesheets	50.6	303.4	14.2	165.4	7.7	211.4
15	Sandwich panel with 50mm Honeycomb core, 60% glass/PP facesheets	50.2	503.7	23.5	345.7	16.1	323.8
16	Sandwich panel with 20mm Honeycomb core, 60% glass/PP facesheets	19.1	743.4	38.9	517.4	27.1	241.1
17	1 layer of dry wall	12.3	100.0	8.1	71.7	5.8	296.7
18	2 layers of dry wall	24.6	349.4	16.3	214.1	10.0	479.5

It should be mentioned that around 8mm of screw length was out for grip part. This includes the $\frac{3}{16}$ inches grip length as well. Except for the first set of tests which was performed with 100KN load cell, all the other tests were done using a 5KN or 1KN load cell depending on their exhibited force-displacement behavior. The pull-out tests were performed at the speed rate of 2mm/min.

Pull-out test results:

As mentioned, the first round of tests were performed without the specified boundary condition and only with clamping the sandwich panels to lower bed. It is worth mentioning that with this fixture, only half of the screw length could be screwed into the sandwich panels due to the grip limitations. Only PET core samples with 50mm thickness and sandwich panels with 50mm PET core and 60% glass/pp face sheet (sample #3, #11) were tested using this method. Figures 2, and 3 depict the pull-out test results for the mentioned samples.

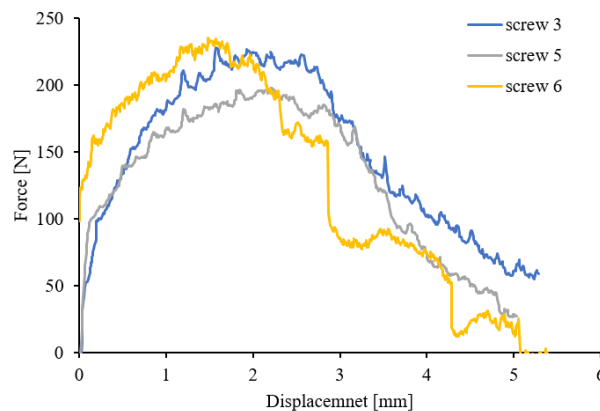


Figure 2. Pull-out test results for the 50mm thick PET foam core (sample #3) using the first testing setup.

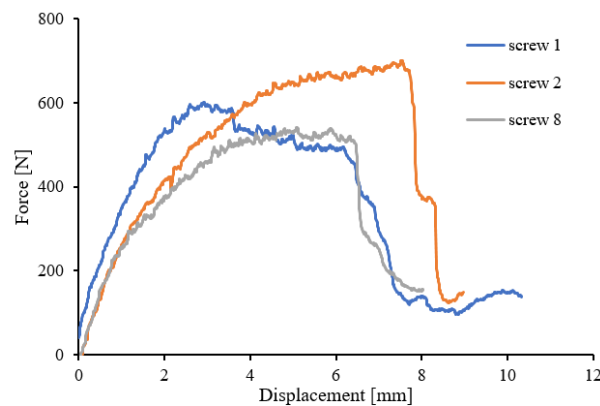


Figure 3. Pull-out test results for the 50mm thick sandwich panels with PET foam core (sample #11) using the first testing setup.

Since the repetition of the tests requires a reliable test setup, all the remaining tests were performed using the newly designed fixture with 3.125" diameter circular boundary condition. Due to minor damages, each pull-out test was done using a new screw. The following figures represent the force-displacement diagram of pull-out test for the determined core materials.

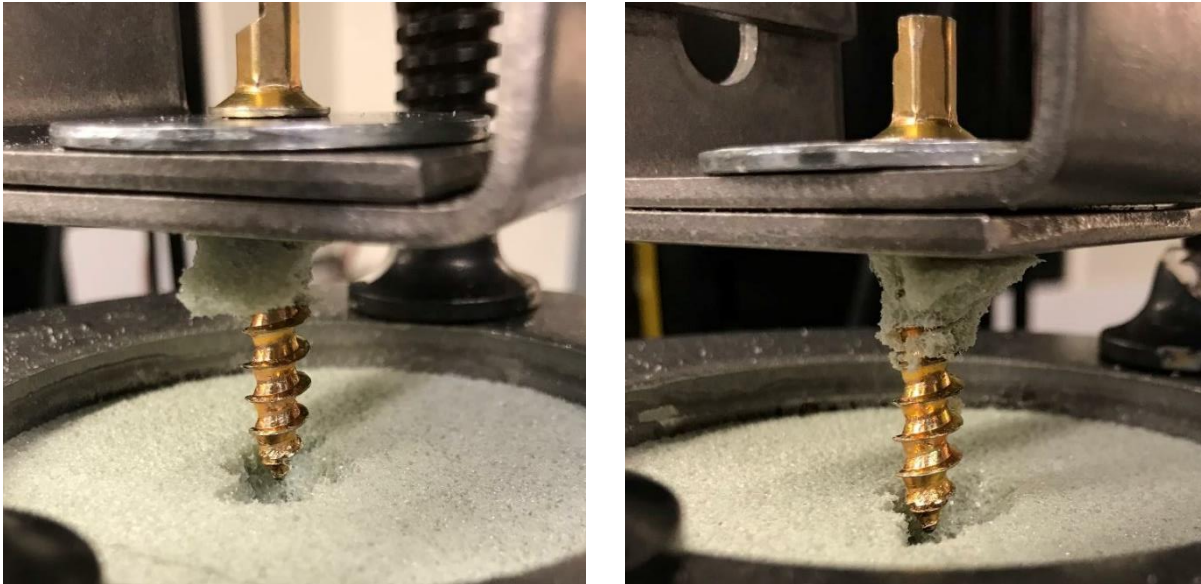
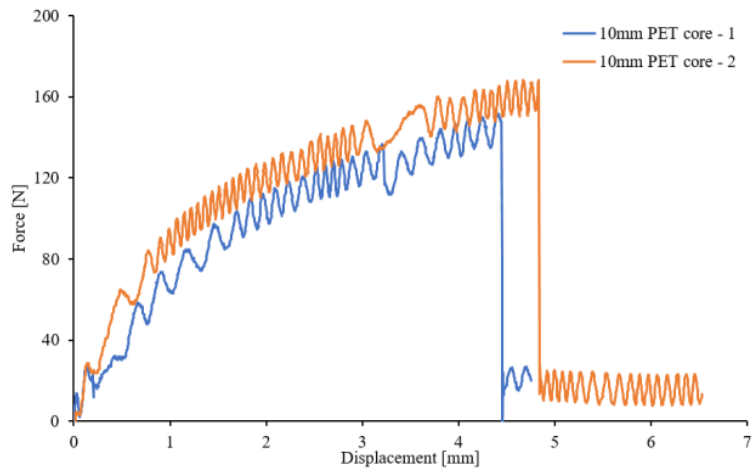


Figure 4. Pull-out test results for the 10mm thick PET foam core (sample #1) under 3.125" diameter circular boundary condition.

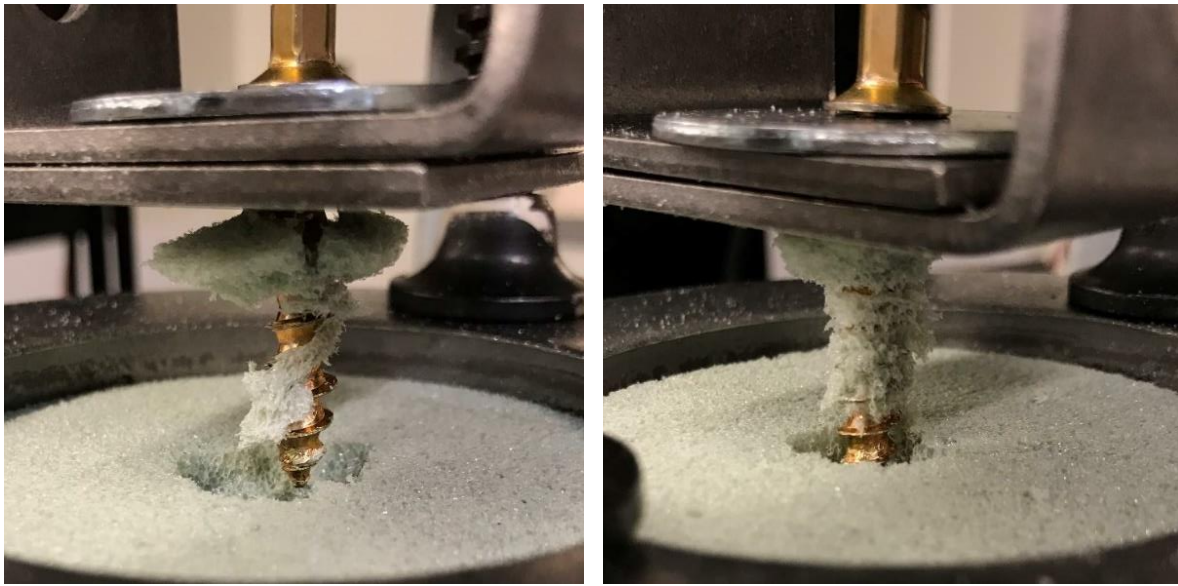
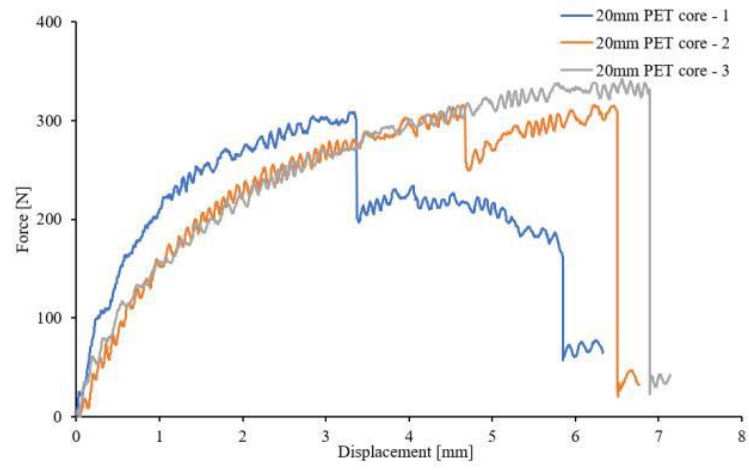


Figure 5. Pull-out test results for the 20mm thick PET foam core (sample #2) under 3.125" diameter circular boundary condition.

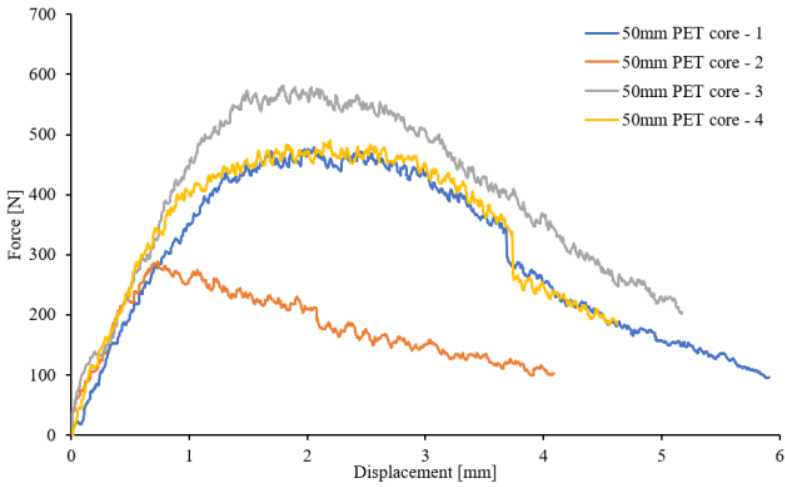


Figure 6. Pull-out test results for the 50mm thick PET foam core (sample #3) under 3.125” diameter circular boundary condition.

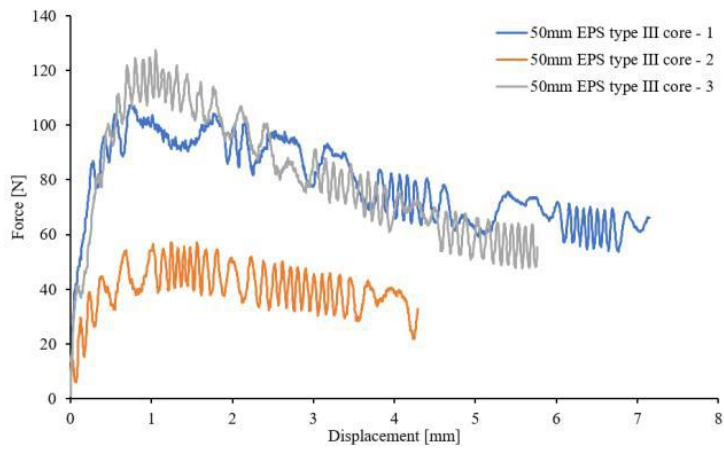


Figure 7. Pull-out test results for the 50mm thick EPS type III foam core (sample #4) under 3.125” diameter circular boundary condition.

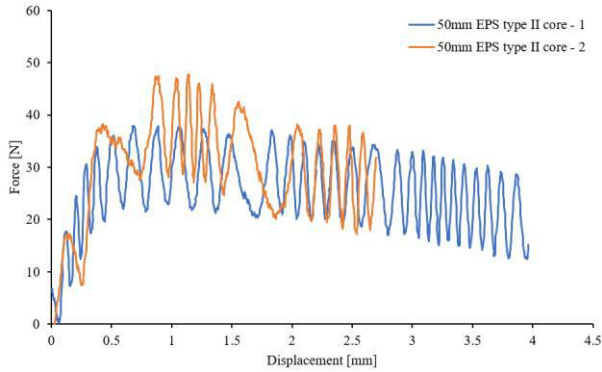


Figure 8. Pull-out test results for the 50mm thick EPS type II foam core (sample #5) under 3.125” diameter circular boundary condition.

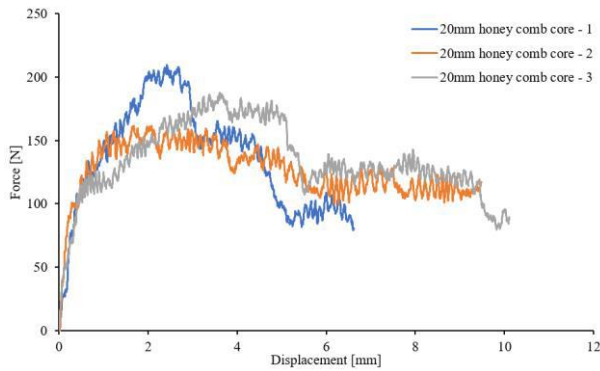


Figure 9. Pull-out test results for the 20mm thick Honeycomb core (sample #6) under 3.125” diameter circular boundary condition.

Not only neat manufacture laminates were tested, but some samples were also cut out of the separated facesheet of a sandwich panel. Since they are the same material, the results should be almost the same. As a matter of fact, the results of the separated facesheet plate and one layer of 60% glass/pp composite laminate responses similarly under pull-out tests as expected.