

Small and full scale testing of container production for ships and airplanes, a review

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ABSTRACT: In this research, some of the tests that are needed in the process of manufacturing and developing the container industry are listed according to international standards. With a review of the results of some researchers of samples made of different composite materials in terms of savings weight perform in fuel savings, determine whether the cost of the idea is feasible, abrasion of the container during handling, high point loads by roller floors, check for damage tolerance after point loads and to compare the stiffness of the composite with aluminium.

1 SMALL SCALE APPROACH

1.1 *Resistance of Wear and Abrasion*

The underside of the containers floor is prone to wear and abrasion result of forklifts which are used to move the containers in ways they are not actually designed. The test of abrasion gives a good indication which the materials are suitable for these application. The device Taber Abraser uses for this test. This device is utilized as a way to found the sandability of materials and does this test by rotating a 10 cm by 10 cm specimen underneath two abrasive rollers with weights of 1 kg attached to them as shown in the figure 1. The speed of rotational is one rotation per second to creates a circular abrading pattern on the specimen, where the resistance of abrasion can be quantified by loss the weight of samples materials. The standard of ASTM D4060 is used for Abrasion test, where the wheels of CS-0 rubber are lined P60 grit sanding paper for each specimen. The test is run for 1000 cycles and cleaning the paper of sanding after 500 cycles. The Suction is present to remove any debris from the sanding surface caused by the sanding action. (Taber Industries 2018).

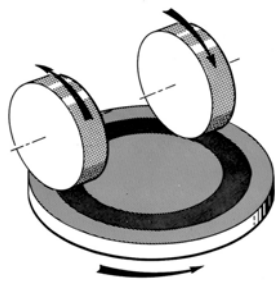


Figure 1. Schematic of the Taber Abraser test according to ASTM D4060.2001a.

1.2 Point load resistance

The durability for the container floor is suffer from the risks because of the roller floors in aircraft and on container transport vehicles. The local damage and delamination in the container floor, because of high point loads of these rollers. So, the test is performed where a roller shaped steel puncher loads with a force of 3000N/cycle for 500 cycles on the composite repeatedly. The long and diameter of roller is 50.8mm 25.4mm respectively which is a common size for rollers utilized in the industry as shown in the figure 2 (Bode 2016).

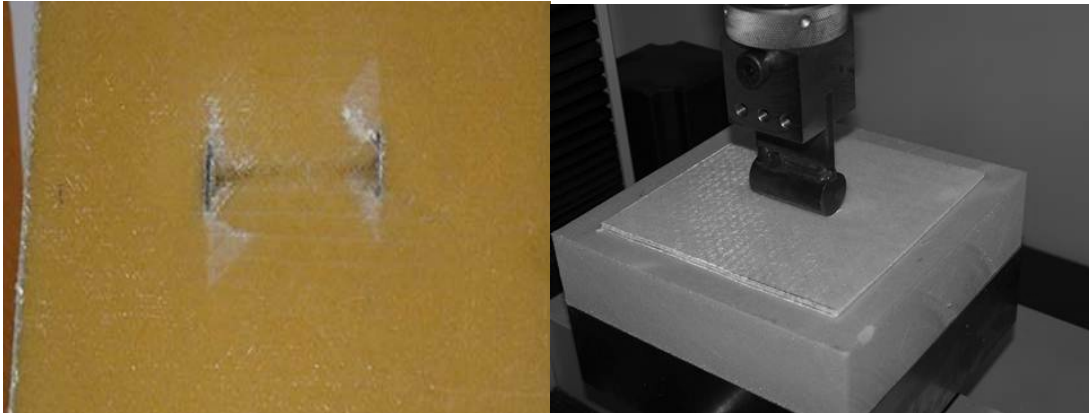


Figure 2. Test set-up of the point load test with a roller and damage glass fibre foam sandwich sample. Bode 2016

1.3 Residual Compressive Strength

The quantitative of damage caused by the test of point load resistance is hard to measure, where the specimen are inspected visually. To calculate this, the test of compression is performed on the damaged specimen and undamaged also. This gives a quantitative measure in the damage tolerance of the different concepts after being subjected to a heavy point load. The standard of ASTM 6641 (2001b) can be utilized for this test with samples dimension 140 mm by 12 mm as shown in figure 3.

1.4 Flexural properties

The flexural tests are performed to assess the mechanical properties of the concepts. The specimen are cut and tested according to ISO 14125 (three point bending, see figure 4). The shape of specimen are rectangular with dimension 150mm in length and 15mm in width. In the figure 4 , the distance L is 120 mm, R_1 is 5mm and R_2 is 2mm.. An abrasion resistant layer in specimens are tested in the side of compression as this matches the expected load case when the material is suspended between two rollers (Bode 2016).

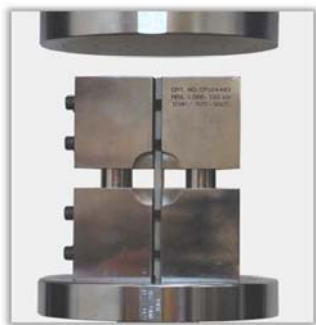


Figure 3. ASTM6641 test fixture. (Instron 2014).

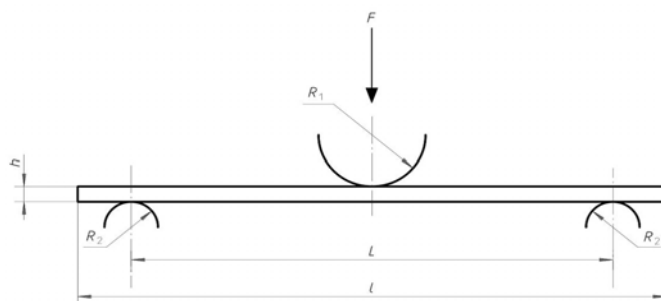


Figure 4. Schematic of three point bending (ISO 14125. 1998).

2 FULL SCALE APPROACH

2.1 Base strength test

The test of base strength is important to prove the ability of the container base during handling and transportation to withstand the maximum operational loads that may be experienced. The container floor must be loaded to three times maximum payload of the container.

2.2 Cyclic Test

This test must be performed to demonstrate that the container base can withstand the maximum operating load that may occur during handling. The test container must be loaded uniformly to a maximum gross weight and cycled 100 times over the loading system or its equivalent. The actual rig can be seen in figure 5 with an air cargo container put on the rollers and figure 6 showed visible wear lines on the aluminium plate (Bode 2016).



Figure 5. Dynamic testing of actual air cargo container on the rig. (Bode 2016).



Figure 6. Visible wear lines on the aluminium plate, where the rollers and structure made contact (Bode 2016).

2.3 Bridging and Cresting test

This test shall be performed to demonstrate the container's ability to pass from one element of ground or aircraft handling equipment to another when the surface level of the carrier is not at the same level. At the container's equilibrium point at the end of the top surface, the load is fully supported by one row of rollers.

2.4 Base deflection test

This test should be performed to demonstrate that when a fully loaded unit is crossing through ground handling equipment that meets the AHM 911 requirements, there will be no part of the bottom of the container base that relates to the supporting structure, pathways, ground equipment.

3. RESULTS, DISCUSSION AND CONCLUSION

The review summary of the results are given in table 1 as discussed below. The specimen of aluminium is the best in all tests because of the aluminium concept weight is twice that of the composite concepts. The mechanical performance will be decrease in case saving weight but as long as it is sufficient for the application, this is not problem. The performance of full aramid concept is the best compare with the other composites but it has cost price is high about €251 . The full aramid concept is light and has good wear and point load resistance. The wear resistance is 60% of the aluminum that meets the requirements, and has a residual compression strength of 92% after damage to the point load, which means that there is no adverse effect on mechanical performance. Provides high stiffness and moderate strength. The aramid/felt/glass and aramid/felt/carbon concepts contain enough point load resistance and residual compression

strength of 71% and 78% respectively. Their wear layers are identical to the Aramid concept so, the wear is similar. The stiffness of full aramid is upper than the both concepts stiffness but lower strengths. The concept of glass provides the best strength while offering the concept of better carbon stiffness. The concept of glass is the cheapest concept in the €122 while the carbon is significantly more expensive in the €164. The concepts of aramid/felt/aramid and aramid/felt/basalt do not offer advantages over the aforementioned concepts where, Their price is higher than the aramid/felt/glass concept without increases in performance. In general the Dyneema / melt / glass concept is unable to match the resistance of wear and loading point for the Aramid concepts . And its wear resistance does not exceed 25% of the aluminum and delamination is visible after the point load test. The flexural stiffness is weak compared with other composites. The concepts of cork did not present anything new or interesting to the table. Their performance is weak on a whole set of tests.

Table 1. Results of small scale testing (Bode 2016).

Sample	Weight	Point load	Residual compressive strength	Flexural properties		Abrasion resistance	Price
	[kg]	scale [1-10]	[%]	stiffness [GPa]	strength [MPa]	Weight loss after 1000 cycles [g]	[€]
AL7021-T6	14.1	10	–	75.9	575	0.33	65
Dyneema/felt/glass	7.4	5	–	13.1	255	1.28	140
aramid/felt/glass	7.0	7	71	17.5	330	0.51	122
aramid/felt/carbon	6.9	8	78	22.9	279	0.44	164
aramid/felt/aramid	6.9	6	–	20.7	207	–	149
aramid/cork/glass	6.7	5	–	13.5	107	–	122
aramid/cork/aramid	6.7	7	–	14.0	113	–	149
aramid	5.9	9	92	26.1	251	0.55	251
aramid/felt/basalt	7.6	6	–	19.7	220	–	145

4. RECOMMENDATIONS

Several topics have been needed to studied may have an influence on the container design. They are identified as:

1. More detailed research on the actual load case of the containers.
2. Study the properties of water absorption for composites materials, where it used as an outer layer for wear protection.
3. Creep resistance of the composite materials in situations with a constant loading.
4. Fire resistance of composites materials in container applications.
5. More Studies on the adhesive bonding of the composite materials to the aluminium core such as honeycomb and foam structures.

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