Influence of corrugated cardboard corners in shock damping: Case of a 100% cardboard packaging.

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1 / Introduction :

Goods shipped in corrugated box have generally cushioning foams issued from petroleum industry (polystyrene, polyurethane, polypropylene,é).

This study tried to characterize the damping capacity of a cardboard corner.

Two specific tests were realized to determine the corner capacity of a box to dump shocks without cushioning foam adding in this part.

2 / description of experiences :

a / Falls of entire boxes on corners :

We made a wooden box 150x200x300 mm. We cut both corners of 7 cm edge length. The box weight was 1100 g. For the purposes of the experiment, we add wooden boards to increase the mass as following: 1560 g, 1970 g, 2360 g, 2930 g, and 3500 g. Using a rapid prototyping machine (Zund M- 1600 and its associated software ArtiosCAD and Impact), we manufactured corrugated cardboard box, an American box type, in EB type, with internal dimensions 150x200x300 mm. The box was glued with hot melt glue. The wooden box without two corners has been installed inside the cardboard box, a three axis acceleration sensor screwed inside.Boxes were closed for the tests by a standard adhesive of 50 mm width. The falls were realized by using a Lansmont drop tester. To records accelerations, the Lansmont software TP3 was used. Boxes fall at four different heights: 30 cm, 40 cm, 50 cm, and 60 cm. We used for our results the records of the resultant of the three axis of the shock.

b / falls of corners only :

We manufactured corrugated cardboard corners, EB type, with the rapid prototyping machine. We simulated falls using the machine Lansmont cushion tester. We used different masses as following: 950 g, 1422 g, 1927 g, 2363 g, 2835 g, and 3340 g. These different masses were fall at four different heights: 30 cm, 40 cm, 50 cm, and 60 cm.The drop height of the cushion tester is adjusted according to the amount equivalent to a free fall impact velocity.An acceleration sensor was positioned on the plate supporting the masses, the acquisition is performed by the Lansmont software TP3.We performed two series of measurements with two different techniques to keep the cardboard corner in place: one with a wooden frame and one with a standard adhesive, 50 mm width.

c / Corrugated cardboard EB characteristics :

Resistance to Vertical Compression according to standard NFH 13-001 = 2350 N

Edge Crush Test according to standard ISO 3037 = 829, 3 N

Paper used: type and weight data following manufacturer, Smurfit Kappa, plant of Brignoles (Var, France):

Ref = EB30 K135/C090/C090/HP125/TL120

K = kraft paper

C = recycled paper

HP = High performance paper

TL = test liner paper

Numbers: weight in g/m2

3 / Results obtained :

a / Falls of entire boxes on corners cases :

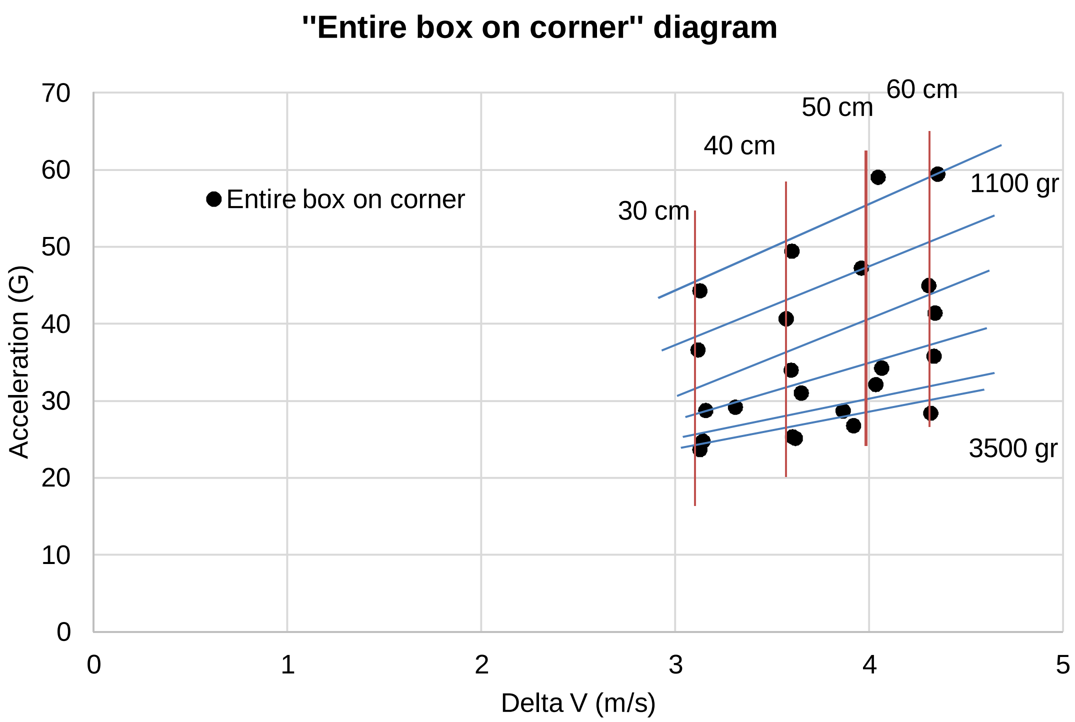

Fig 1: Free drop of ôôEntire box on cornerôô

The diagram (Fig 1) has allowed us to do these four findings :

ÅFor each fall heights, the Delta V is constant.

ÅThe variation of intensity of the acceleration during the impact is inversely proportional to the mass.

ÅFor one mass, the shock increases with increasing height.

ÅThe absorption of the impact energy by the corner is higher if the mass increases, in the limit of deformation of the corner.

b / Falls on corner only cases, maintained by a wooden frame :

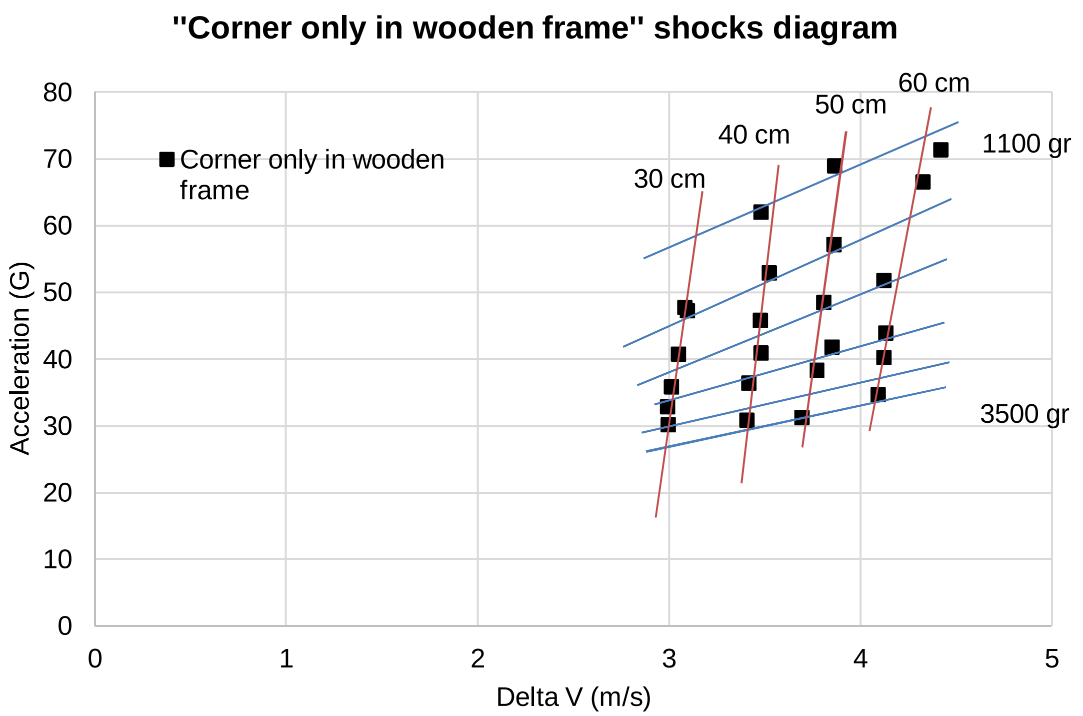

Fig 2: Free drop of mass on ôôCorner only in wooden frameôô

The diagram (Fig 2) has allowed us to do these four findings :

ÅFor each fall heights, the Delta V is slightly increasing.

ÅThe variation of intensity of the acceleration during the impact is inversely proportional to the mass.

ÅFor one mass, the shock increases with increasing height.

ÅThe absorption of the impact energy by the corner is higher if the mass increases, in the limit of deformation of the corner.

The last three findings are equivalent to the results of the falls of entire boxes on corners cases. However, the general level of energy is higher, which means the impact is overestimated in comparison to the entire box.

The following diagram (Fig 3) highlights this phenomenon:

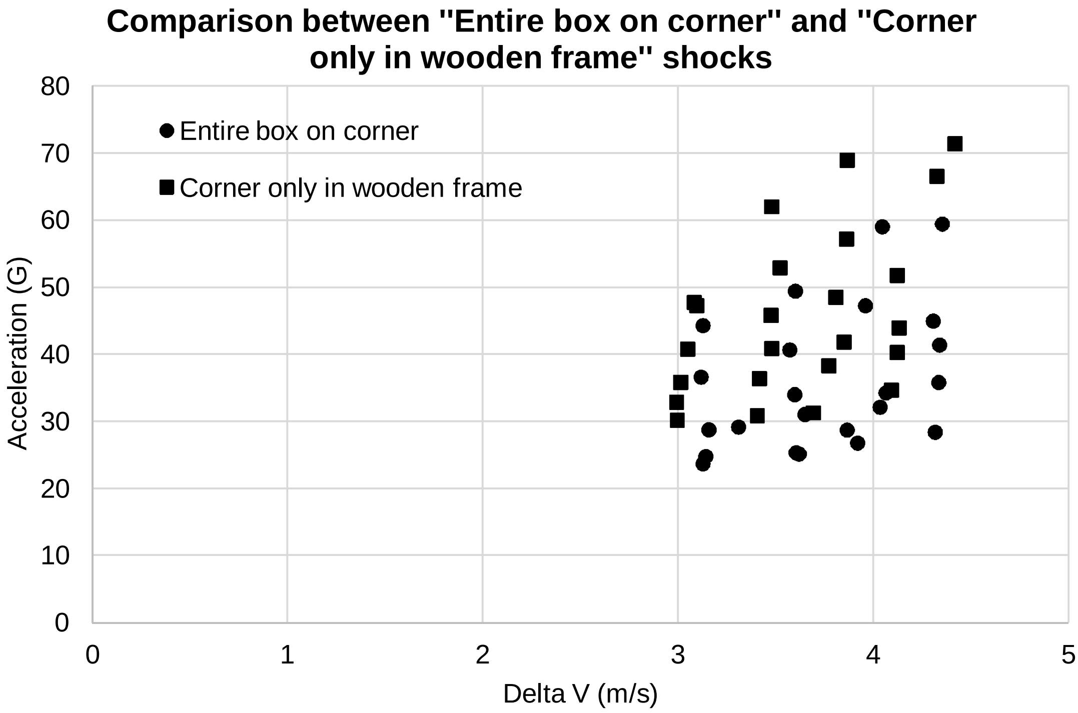

Fig 3: Comparison between “Entire box on corner” and “Corner in wooden frame”

c / Falls on corner only cases, maintained by standard adhesive :

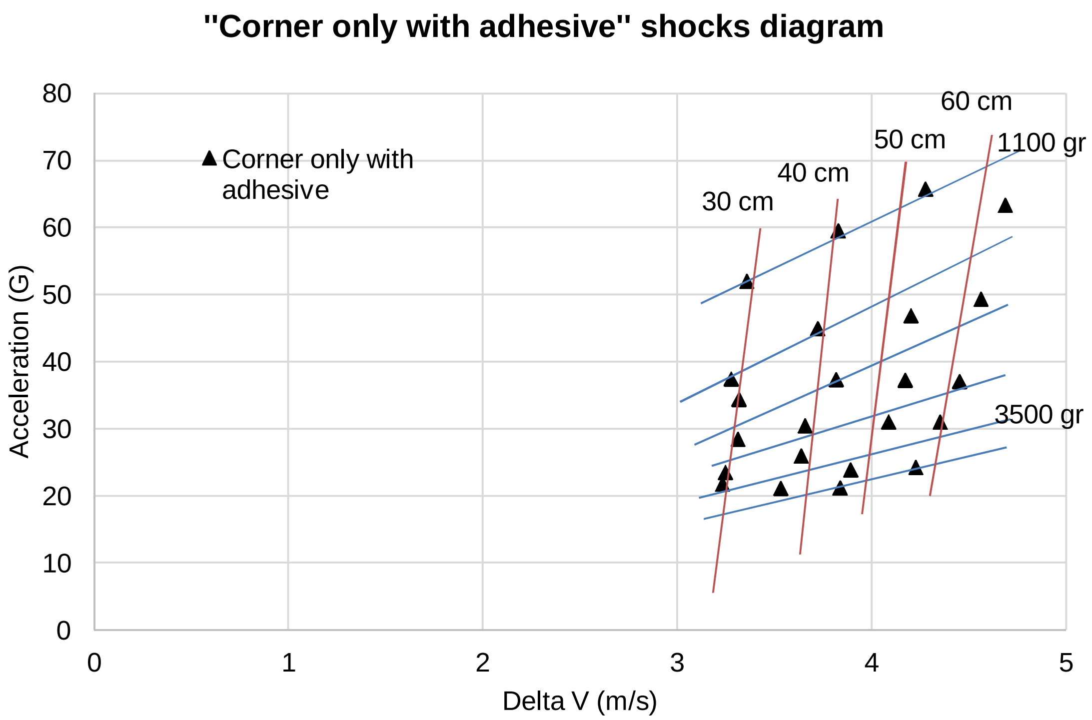

Fig 4: Free drop of mass on “Corner only with adhesive”

We findings the same that we had on the corner only in wooden frame, with a variation of the impact level energy. This case is closer than the result of entire boxes. There is a small underestimation of impact in the high masses.

The following diagram (Fig 5) shows it is almost equal :

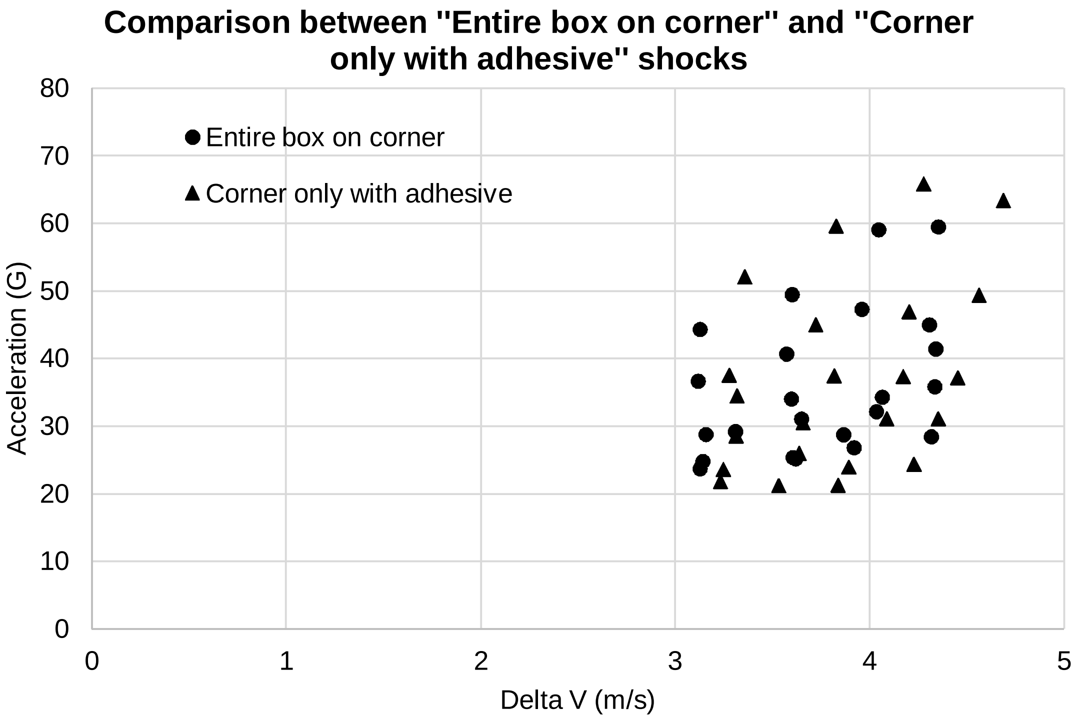

Fig 5: Comparison between ôõEntire box on cornerôõ and ôõCorner only with adhesiveôõ

<u>4 / Conclusion :</u>

It is pertinent to use both cushion tester and cardboard corner shaped, provided the corner is maintained with adhesive, to get closer to an entire box corner shock. The corrugated cardboard, flute EB, is concerned by this approach. Studies are in progress to confirm or not if the behavior of other types of cardboard or flute is equivalent as ñentire boxò or ñcorner onlyò.

Finally, this study shows that cardboard box corner is an excellent cushion and an efficient shock absorber insofar as the deformation is dimensionally smaller than the value to reach the object to be protected in the box. Furthermore, depending on the rigidity of the cardboard, the mass of the object to be protected is different : on our flute EB cardboard study, a rigid cardboard, the best protection is clearly on the higher masses, that means a lower energy shock.

Future studies will be realized to show if the rigidity of cardboard varies its shock absorbing efficiency depending of masses of objects to be protected.