THE USE OF BOARDS FROM RECYCLED LAMINATED CARTONS IN THE BUILDING ENVELOPE

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Summary

Boards made from recycled laminated cartons (e.g. Tetra Pak) can be used as an alternative to traditional materials (e.g. gypsum boards or oriented strand boards) used nowadays in the sandwich building envelope. This paper presents a methodology and results of a long-term experiment with prefab sandwich facade-panels (made of these boards) exposed to real exterior conditions. Altogether 15 facade-panel samples were used divided into 3 sets – reference set (not exposed), set 1 (exposed for 27 months), and set 2 (exposed for 43 months). The samples within the sets differed in external plastering. The samples of size 500 x 500 mm were placed in a wooden grid that was placed vertically on the roof of the Faculty of Civil Engineering Czech Technical University in Prague facing towards the south. Throughout the experiment there were monitored basic climatic data near the testing grid and concurrently the surface temperature was measured on samples. The progress of the experiment was documented using visual techniques and finally all the 3 sample sets were step by step submitted to aging material tests. The results of these tests were compared with reference samples results.

Keywords: recycled materials, recycled laminated cartons, building envelope, aging test

1 Boards from recycled laminated cartons

The boards are intended for interior and exterior panelling where final thin external rendering, tilling, etc. must be applied. Boards can be also used as underflooring or as a temporary surface protection. Furthermore, partition wall sandwich panels and facade

panels (**Fig. 1**) are produced from these boards. There is a good practice with all the interior applications in dry environment but there is a lack of experience with the applications in humid interior environment, e.g. in bathrooms and in exterior. That was the motivation for the long-term durability test in real exterior conditions. Concerning the raw material both laminated cartons from sorted municipal waste and process scrap from the production of beverage cartons are used. The cartons are shredded (cartons from municipal waste are subsequently washed and dried), spread into sheets and compressed at a temperature of about 170 °C. The polyethylene (PE) content in the material melts and acts as a binder. Besides PE content in the raw material additional waste PE is being added to the raw material to reach the proper cohesion. Usual composition of the beverage cartons is as follows: cartoon ~73 %, PE ~21 %, aluminium ~5 %, pigments ~0.5 % (by weight). This kind of laminated cartons recycling seems to be the most efficient way [1].

2 Long-term durability test

2.1 Test description

During the March 2007, a long-term durability test of the sandwich facade panels was launched. Altogether 15 panel samples with 5 different kinds of thin exterior rendering were prepared for the testing. Five samples (reference set) were stored in dry interior environment. Ten samples (exposed set 1, resp. 2 for 27, resp. 43 months) were placed in vertically fixed timber frame (**Fig. 2**), where the samples were fixed and sealed so that only plastered surface is exposed to exterior conditions. Completed assembly was placed on the roof of the Faculty of Civil Engineering at the Czech Technical University in Prague facing southwest where extreme insolation and driven rainfall can be expected. There was launched a surface temperature measurement on the panels and relative humidity measurement in the fixing frame behind the panels.

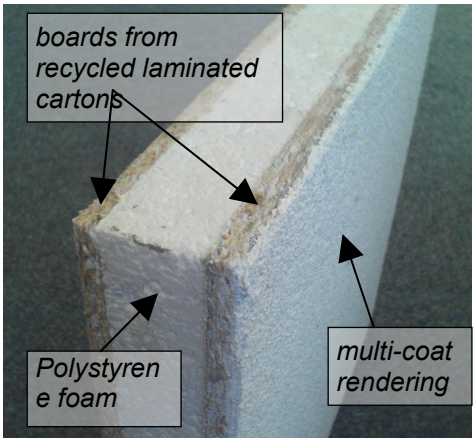

Fig. 1 *Cutting edge of sandwich facade panel test sample with exterior rendering*

Fig. 2 *Fixing frame for the durability testing of the facade panel samples*

Except this measurement there were measured and logged external climatic data by a meteorological unit placed near by the fixing frame. The degradation state was regularly documented by a series of photographs. Throughout the test there were no visible marks of degradation like cracks or swelling, except the slight colour-tone changes of different panel samples.

2.2 Methodology

The long-term durability test was focused on the behavior of surface layers of facade panel samples. That is way the test samples were not loaded by the heat and moisture flow through the structure. The evaluation of the test was focused on the bond strength between surface rendering and the recycled boards (bond strength test). To quantify the degradation process there was firstly tested the referential set and subsequently the exposed set of the test samples. The bond strength testing methodology of surface layers of facade panel samples was based on ETAG 004 guideline [2]. The used testing methodology was slightly modified and extended comparing to the guideline because of the specific composition of facade panels.

Typical composition of the facade panels is as follows (from the exterior):

- multi-coat rendering: finishing coat – decorative finish / facade paint, base coat with reinforcement, bonding primer;
- facade panel: (i) recycled board: covering carton laminated with melted PE foil, board core from shredded recycled laminated cartons, bottom covering paper; (ii) polystyrene foam board EPS 100S; (iii) recycled board see above.

2.3 Results

The most typical failure occurred during the bond strength test was a failure in recycled boards. This occurred in all 3 layers of the board, respectively on interfaces between them, separately or in a combination (**Fig. 5 to 7**):

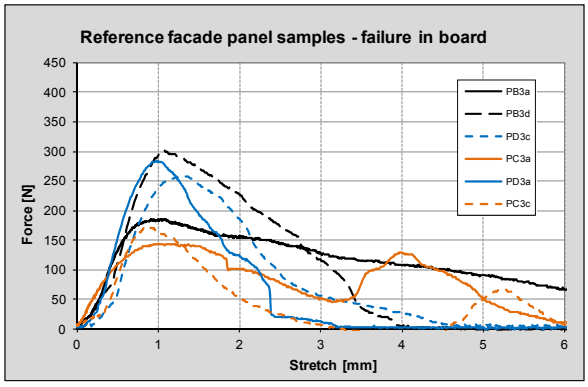

Fig. 3 *Bond strength test deformation graph _ reference set with failure in the board*

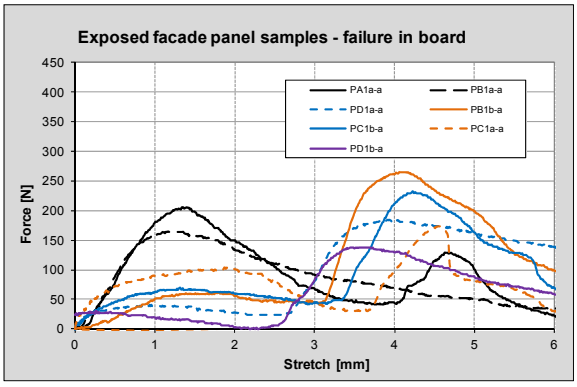

Fig. 4 *Bond strength test deformation graph _exposed set 1 with failure in the board*

The graph (**Fig. 3**) shows the deformation of reference set of samples with failure in the board. The deformation graphs are characteristic with a fast increase of the force and a slow force decrease after reaching the maximum. The other graph (**Fig. 4**) shows the typical deformation graphs of exposed set 1 of samples with failure in the board. The mean bond strength by the failure in the board decreased after 27 months (exposed set 1) from 107 kPa to 90 kPa (84 %) and after 43 months (exposed set 2) to 87 kPa (82 %) [3]. Besides it is necessary to take into account the progress of deformation during the loading where the maximum strength is often reached at hardly acceptable deformation. Also the deviation of measured strengths is high, appreciable number of strengths didn't reach even 50 kPa.

Fig. 5 *Failures in the board: in covering carton layer*

Fig. 6 *Failures in the board: in board core*

Fig. 7 *Failures in the board: in bottom covering paper.*

3 Conclusions

The different character of deformation behaviour of the exposed set is largely caused by a progressive degradation of the material. The cyclic thermal and moisture load causes a progressive loss of bond strength of the covering carton and laminated carton inside the board. This progressive loss practically results in a very slow increase of the force in deformation graph (**Fig. 4**) when the maximum is reached at an extreme deformation. All this can result in fatal consequences. There can e.g. appear cracks in the rendering especially on edges of the boards and come to flaking off the rendering (pillow effect). This leads to an increased moisture content in the board and consequently to swelling and rapid loss of bond strength. The described degradation can arise not only during exterior climatic load but to smaller extent also in wet interior environment, e.g. in bathrooms.

Acknowledgement

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