EAN 2017
55th conference on experimental stress analysis

Analysis of tensile strength in bending of plasterboard with use of optical correlation

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Keywords: plasterboard, tensile strength in bending, optical correlation.

Abstract. One of the basic observed parameters for plasterboards is the tensile strength in bending and sag. Therefore, tensile strength and sag is regularly verified in the development of new boards and subsequent certification. This paper shows a classic destructive standardized test extended by optical correlation of stress.

Introduction

Plasterboards are formed by combining pressed gypsum and two paper cartons and are used for dry construction. They have application in renovations and for new buildings for the production of walls, floors, ceilings and roofs and their advantage is easy and fast usage and protection against noise, moisture and fire [1]. The standard ČSN EN 520 + A1 (2010) prescribes marking, defining the properties and test methods of plasterboard and additionally unifies the requirements and designations with others countries in Europe. Declared tensile strength in bending and sag of are among the fundamental requirements [2-5]. Another definition testing of tensile strength in bending is described in standard ASTM C 473 from USA [6]. Measurement of tensile strength in bending can be carried out as a three-point bending [7] or four-point bending as described in this paper. Mechanical tests were supplemented optical correlation of digital image (DIC).

Methodology and evaluation of measurement

Specimens. Test of tensile strength in bending was carried out. Two specimens with dimensions 600×300×12,5 mm were cut of each plate faceup, one in the transversal and second in the longitudinally direction according to standard. Altogether for test were available 4 samples of one type of board. Designation of specimens and their geometry are shown in Table 1.

Table 1 Designation of specimens and their geometry.

Designation	Cut	Length [mm]	Width [mm]	Thickness [mm]	Basis weight [kg/m^2]
D1-h	transverse	600	301	12.5	13.5
D1-v	longitudinal	600	302	12.5	13.5
D2-h	transverse	602	302	12.5	13.5
D2-v	longitudinal	603	300	12.5	13.5

Four-point bending. All specimens were loaded with increment deformation constant speed of 2 mm/min until the collapse. The static scheme of the test shows Fig. 1 and photo of measuring assembly is on Fig. 2.

Tensile strength in bending (four-point) is given by the following relationship:

$$f_{cf} = \frac{F.l}{d_1 . d_2^2}, \qquad (1)$$

where f_{cf} is tensile strength in bending [MPa], F is maximal load [N], l is distance between supports [mm], d_1 a d_2 are dimensions transverse cut of specimen [mm]. Sensors for monitoring the deflection were placed at specified points.

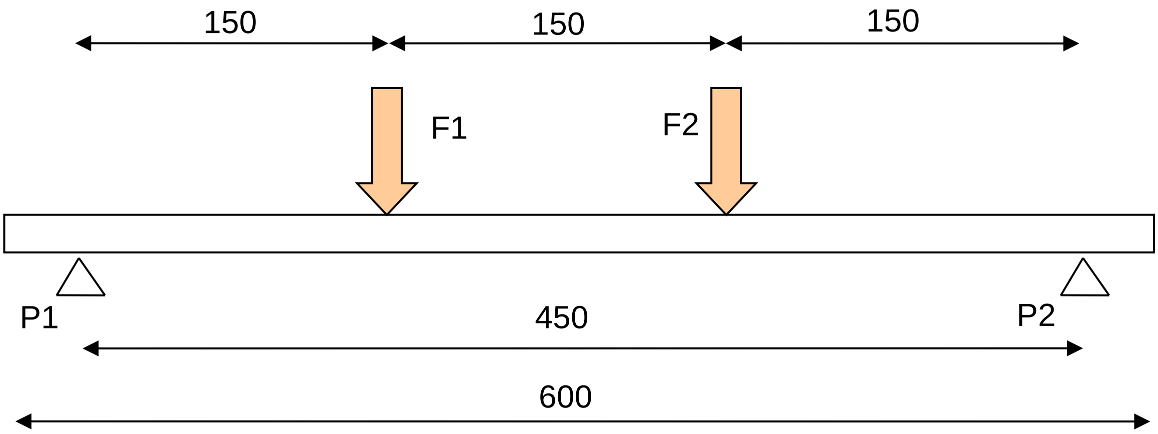

Fig. 1: Static scheme of testing.

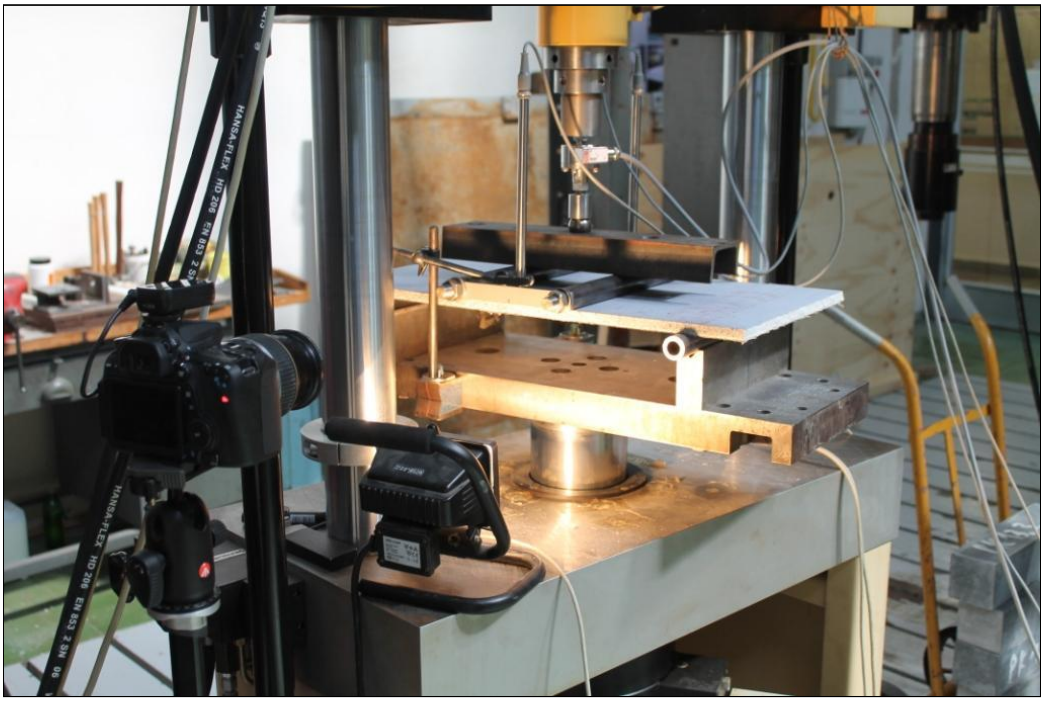

Fig. 2: The ready measuring assembly for a four-point flexural test.

Evaluation of tensile strength in bending and sag. The values of tensile strength of individual specimens and the average values are given in Table 2. A symbol of sample orientation relative to the plate is always stated in designation of specimen (h - horizontal, longitudinal, v - vertical, transverse). Typical working diagrams of loading tests show Fig. 3 and 4.

Table 2: Measured and calculated values of strength for each sample and their average.

Designation	m [kg]	F [kN]	f_{ct} [MPa]	Sag [mm]
D1-h	2.4	0.3	2.9	2.9
D2-h	2.5	0.3	2.9	6.9
average	**2.5**	**0.3**	**2.9**	**4.9**
D1-v	2.4	0.8	7.6	14.6
D2-v	2.4	0.8	7.7	15.0
average	**2.4**	**0.8**	**7.7**	**14.8**

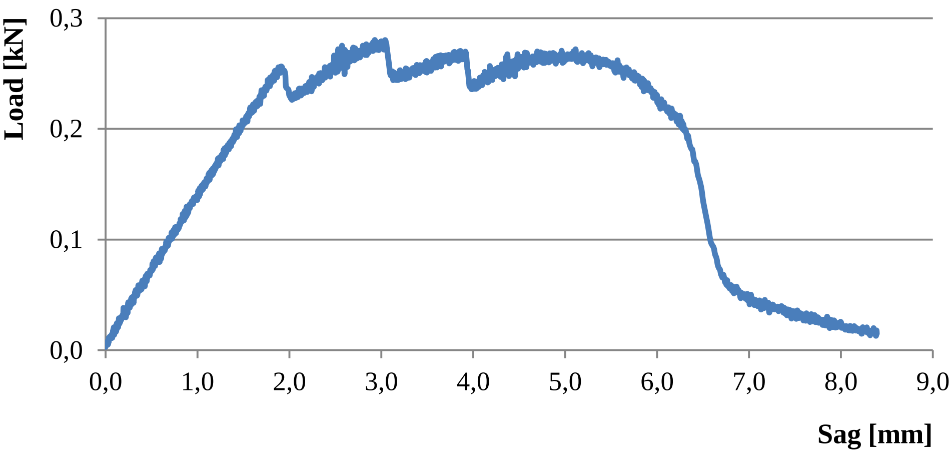

Fig. 3: Working diagram of specimen D1-h from the tensile test in bending at speed of load of 2 mm/min, F_{max} = 0.3 kN u_{Fmax} = 2.9 mm.

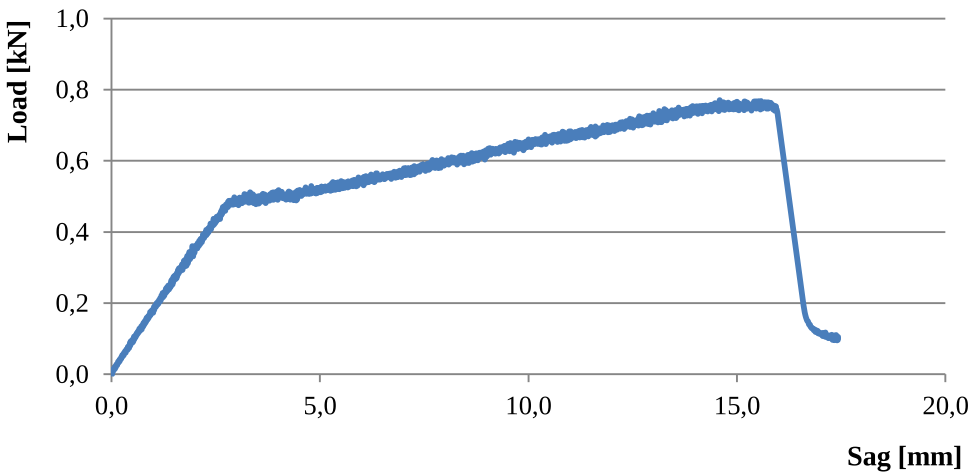

Fig. 4: Working diagram of specimen D1-v from the tensile test in bending at speed of load of 2 mm/min, F_{max} = 0.8 kN u_{Fmax} = 14.6 mm.

Optical correlation. The method of optical digital image correlation (DIC) can be successfully used for measurement of displacements, relative deformation, the changes in shape, material properties, stress and modal harmonic analysis and motion analysis. The universality of this method also lies in its independence from the scale, ie. it can be used from micromechanics, through mechanics and testing samples of standard sizes according to the CSN and the EU to analyze the whole structure (eg. lattice girders). The principle of this method is to acquire a reference image the examined surface on which is applied a contrasting pattern and in a sequence of images during the destructive testing. These digital images were then evaluated using a special software which is able to compare how between images transformed contrasting pattern and consequently to calculate therefrom the relative deformation at those locations [8]. Canon 90D DSLR camera with a remote trigger and evaluation software Ncorr was used for testing. The main deformation is shown in Fig. 5. Photos on Fig. 6 and 7 show the state of measured boards at the beginning and end of the test.

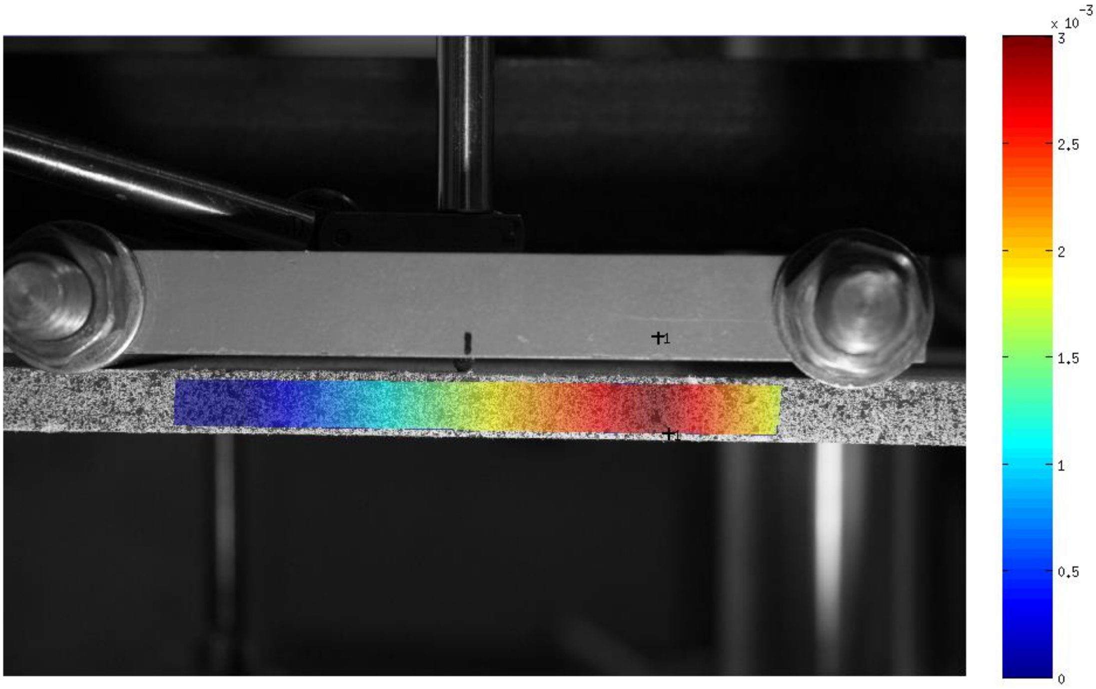

Fig. 5: Optical correlation - the main strain.

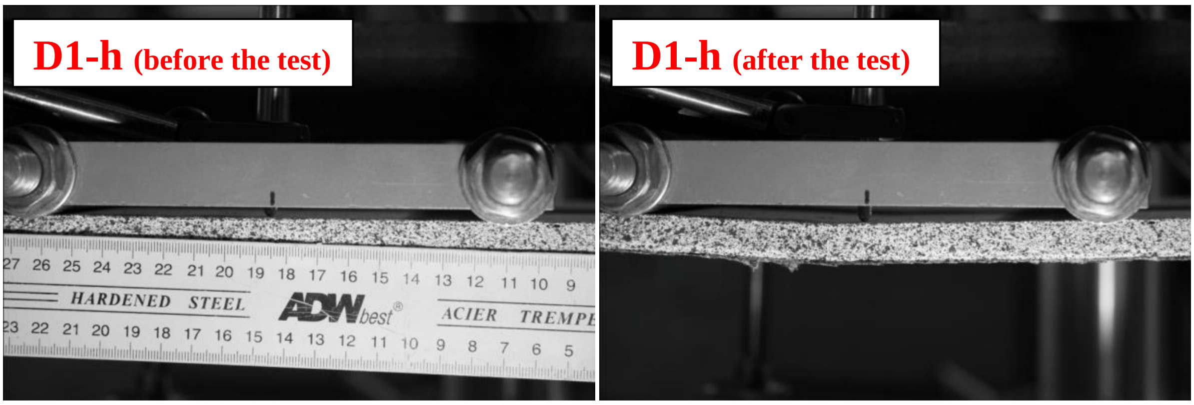

Fig. 6: State of measured boards at the beginning and end of the test.

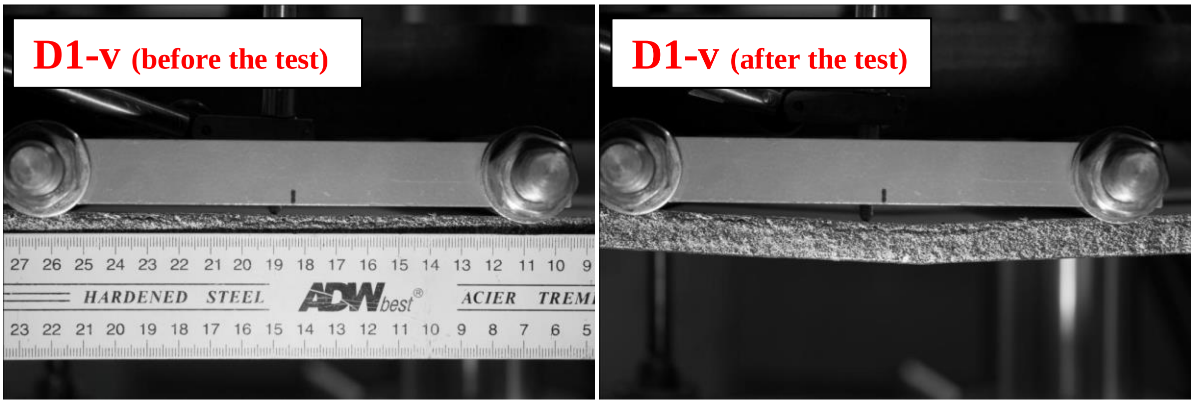

Fig. 7: State of measured boards at the beginning and end of the test.

Conclusions

Tensile strength in bending was obtained by four-point bending test. This is a classic method of measurement. A supplementary optical digital image correlation (DIC) gives except comparison to specific values detailed information about the behavior of the material during loading, which can be used to better analyze the properties and measurement of deflection.

Acknowledgement

This paper has been supported by the Faculty of Civil Engineering, Czech Technical University in Prague (SGS project No. SGS16/201/OHK1/3T/11) and by the Ministry of Education, Youth and Sports within National Sustainability Programme I, project No. LO1605.

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