BEARING CAPACITY CHECK OF ALUMINUM PROFILES

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Abstract. Because of suspended ceiling options to be customizable they are the choice for implementation in spaces like offices buildings, schools, hospitals and commercial premises. Recent problems with suspended gypsum ceilings falling in some commercial premises led to verification by tensile test and flexural bearing capacity of 5 types of aluminum elements used to suspend the ceilings.

Key words: suspended ceilings, gypsum, tests.

1. Foreword

Suspended ceilings were designed to conceal building elements such as wiring and piping, in order to create and maintain a presentable space. Suspended ceilings have all the elements of suspension hidden from view. Because of their options to be customizable that is design, color, lighting and structure may be chosen they are the choice for implementation in spaces like offices buildings, schools, hospitals and commercial premises.

Recent problems with suspended gypsum ceilings falling in some commercial premises led to verification by tensile test and flexural bearing capacity of 5 types of aluminum elements used to suspend the ceilings.

Aluminum elements that were tested have the following nominal sizes:

- Type 1, elements with dimensions of 40×60 mm (6 samples) - Fig. 1;
- Type 2 elements with dimensions of 40×100 mm (6 samples) - Fig. 2;
- Type 3 elements with dimensions of 40×150 mm (6 samples) - Fig. 3;
- Type 4 elements with dimensions of 40×100 mm joined by two self-tapping screws with a rectangular strap dimensions 40×200 mm (6 samples) - Fig. 4;
- Type 5 elements with dimensions of 40×100 mm joined by two self-tapping screws with a piece of mullion length 200 mm and width 50 mm (6 samples) - Fig. 5.

Nominal thickness of the profiles is 4 mm.

2. Test description

The following tests were performed:

a) Tensile test to failure on the longitudinal axis of the profiles. Tensile testing was performed by applying the tension force between the fastening bolt located on the short side of the L profiles and the long side of these profiles directly (for types 1-3) or through the agency of the parts of which it is attached (for types 4 and 5).

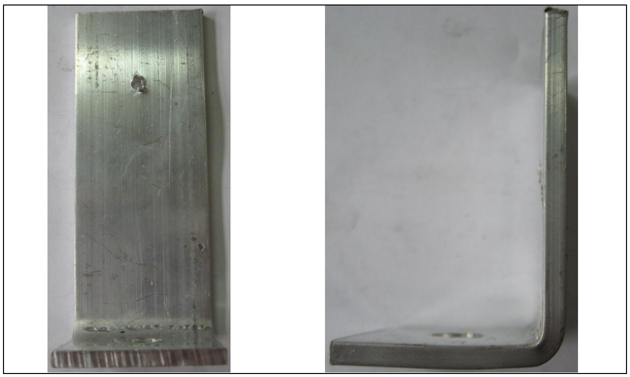

Fig. 1 – Type 1 element

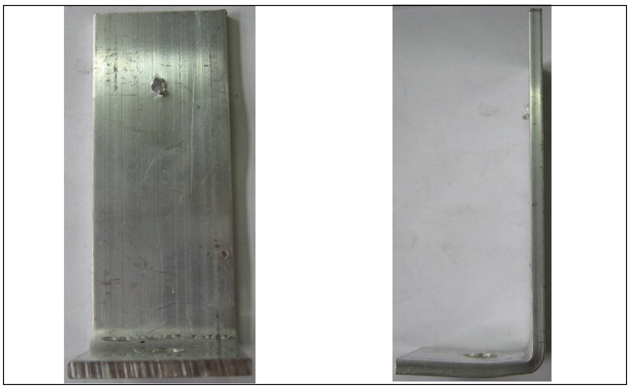

Fig. 2 – Type 2 element

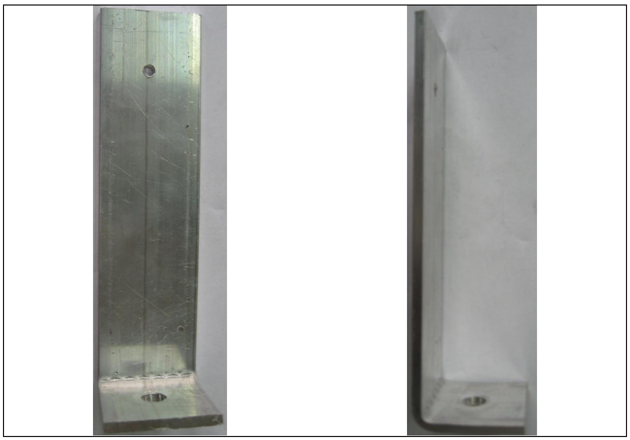

Fig. 3 – Type 3 element

Fig. 4 – Type 4 element

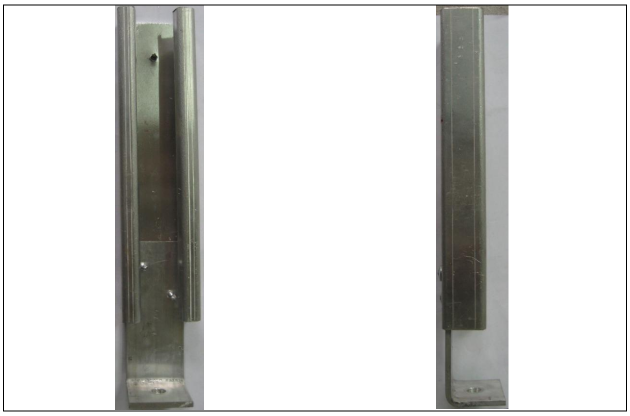

Fig. 5 – Type 5 element

Due to the elements makeup, the tension force is applied eccentrically to the plane of the long side of L profiles, the eccentricity being equal to the distance between the middle of the thickness of the side and the hole center, respectively the screw axis with which the short side of L profile is fixed.

The test was performed with a universal test machine by fixing the bolt with the fixed bottom grips and the long side of the L profiles, respectively the elements to which they are fastened to the mobile top grips.

3 elements of each type were tested; aspects of the tests are presented in Fig. 6-9.

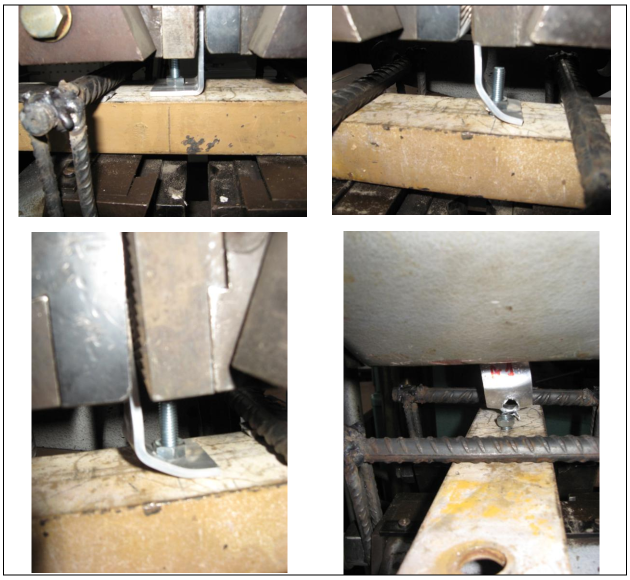

Fig. 6 – Failure mode by hole enlarging and screw nut passing through it (for type 1 element)

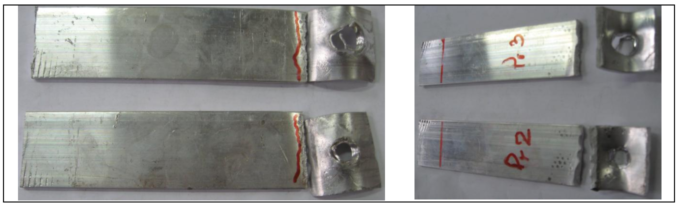

Fig. 7 – Failure mode by self-tapping screws rupture (for type 3 element)

Fig. 8 – Failure mode by hole enlarging and nut passing through it and also by self-tapping screws rupture (for type 4 element)

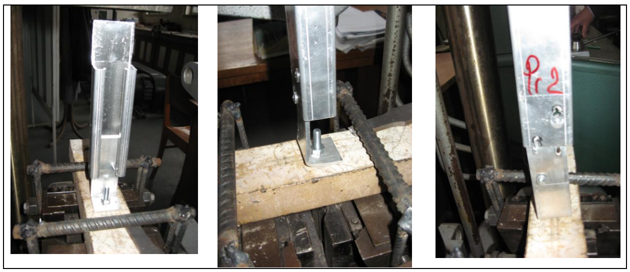

Fig. 9 – Failure mode by self-tapping screws rupture (for type 5 element)

b) Bending test for the profiles mounted in cantilever with the fastening bolt with the determination of the deflection for the 7.0 daN load at the end of the cantilever.

Bending test was performed by fastening the short side of L profiles to a vertically fixed rigid profile with screws and loading the end of the long side (directly or through parts to which they are attached) with weights suspended on a metal rod. Elements were mounted with the long side up.

The vertical movement of the cantilever was measured during the test in the section where the force was applied. The measurement was performed with a measuring device with rod 1/100 mm.

Three elements of each type were tested; aspects of the test are presented in Fig. 10 and 11.

Fig. 10 – bending of the elements (for types 1 and 2 elements)

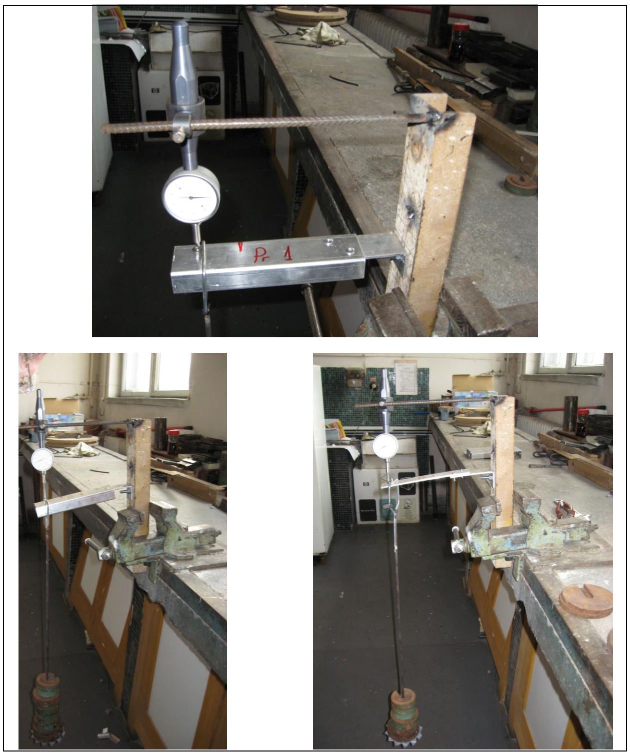

Fig. 11 – bending of the elements (for types 4 and 5 elements)

3. Test results

3.1. Results for tension testing

The results obtained in tensile testing are shown in Table 1. These types of elements are susceptible to failure in the following zones:

- L profiles - in the section of the screw hole from the short side and in the bending section;

- Elements types 4 and 5 have in addition, the L profiles connection fastened with self-tapping screws.

Most failures have been produced by enlarging the screw hole and the nut passing through the enlarged hole.

Causes leading to this effect are:
- profile unbending due to the eccentric application of the tension makes the screw - profile interface to pass from compression under nut in profile and tension in the screw shank to pressure in the hole profile and tension in the rod combined with shear in bolt;
- Pressure in the hole combined with local shear yields failure to the aluminum profile, the inferior nut edge shears the hole area.

Tension in the screw and L profile with compression under the nut becomes strong shearing in the screw from forces in the range 20.0 ... 30.0 daN.

For 2 elements of type 3 the failure occurred by tearing bending zone of the profile L.

For 2 elements of type 4 and 3 elements of type 5 the failure occurred by tearing of the self-tapping screws fixing the L profiles. With one exception (element 1 of type 4), failure forces for this failure mode were lower than those corresponding to other modes of failure.

3.2. Results for bending testing

Bending test results are presented in Table 2. The table shows, in addition to the deflection for the 7.0 daN force, the maximum applied load and reference is made to load-displacement diagrams.

The different values measured for the deflections depend on the cantilever length but for the same type (with equal cantilever lengths) they are influenced by the bending stiffness of the L profile (actual bending radius).

Table 1 – Tension test results

Item no.	Profile type	Tested element	Failure force (daN)	Failure mode
1	Type 1	1	60,0	Hole enlarging and screw nut passing through it
		2	72,5	
		3	80,0	
2	Type 2	1	87,5	Idem type 1
		2	80,0	
		3	85,0	
3	Type 3	1	80,0	Idem type 1
		2	70,0	L profile tearing in bending
		3	80,0	
4	Type 4	1	77,5	L profile self-tapping screws fasteners rupture on the flange
		2	85,0	Idem type 1
		3	45,0	L profile self-tapping screws fasteners rupture on the flange
5	Type 5	1	62,5	L profile self-tapping screws fasteners rupture on the U profile
		2	52,5	
		3	55,0	

Table 2 – Bending test results

Item no.	Profile type	Tested element	Deflection for 7,0 daN load (mm)	Maximum applied force (daN)	Reference to load-deflection diagram
1	Type 1	1	0,67	11,0	Fig. 12
		2	0,14		
		3	0,15		
2	Type 2	1	2,37	11,0	Fig. 13
		2	1,23		
		3	2,71		
3	Type 3	1	8,57	11,0	Fig. 14
		2	8,90		
		3	6,57		
4	Type 4	1	32,89	7,0	Fig. 15
		2	35,91		
		3	24,80		
5	Type 5	1	12,80	7,0	Fig. 16
		2	27,22		
		3	23,99		

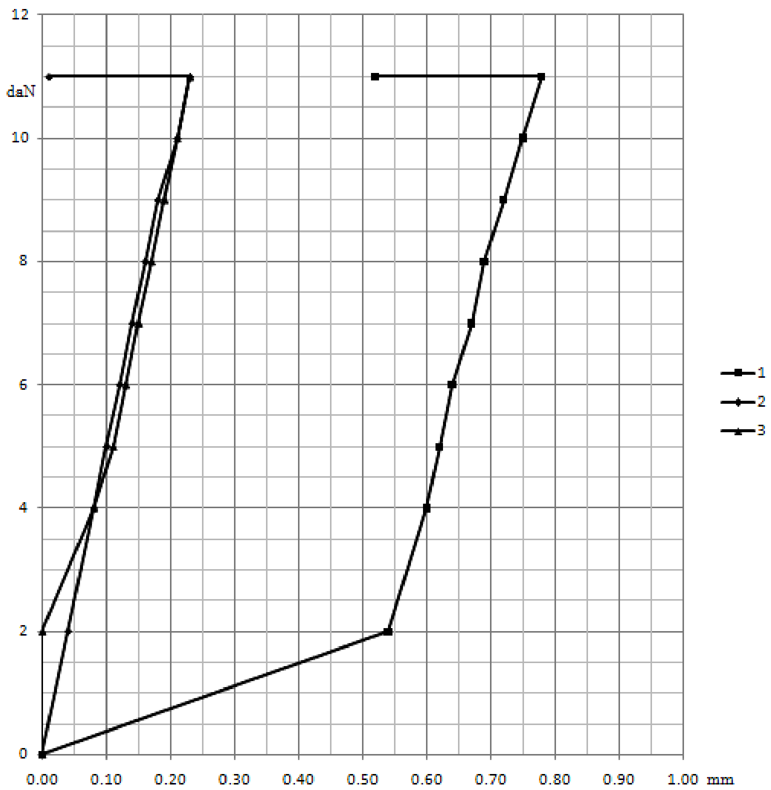

Fig. 12 – Load-deflection diagram for type 1 profiles

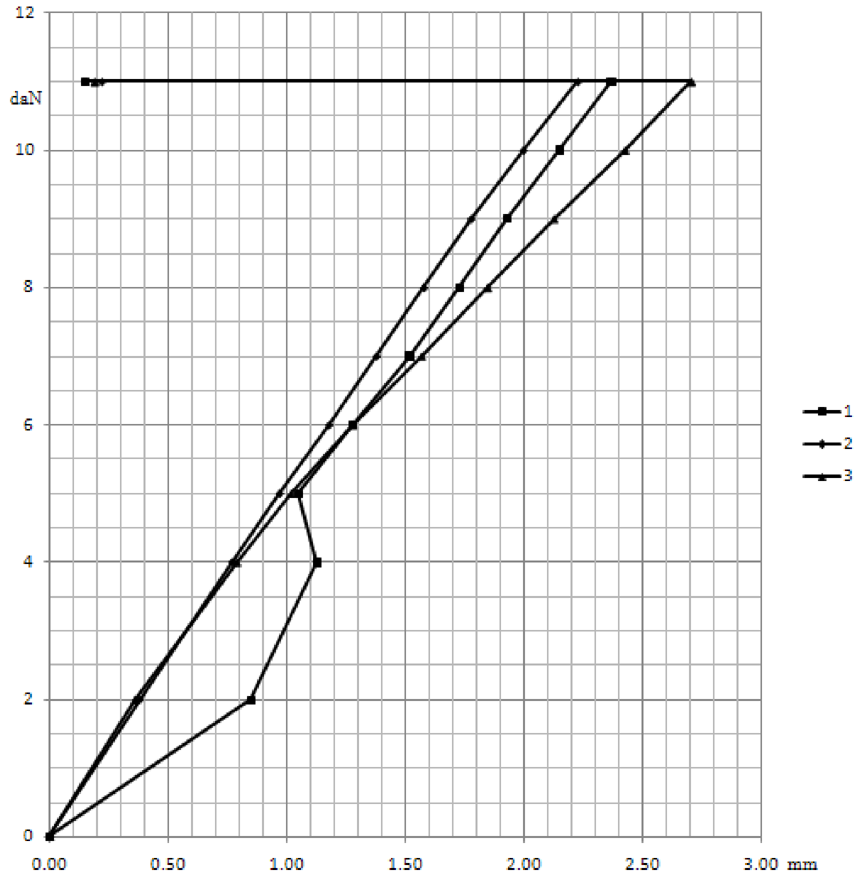

Fig. 13 – diagrama forță-deplasare pentru profilul tip 2

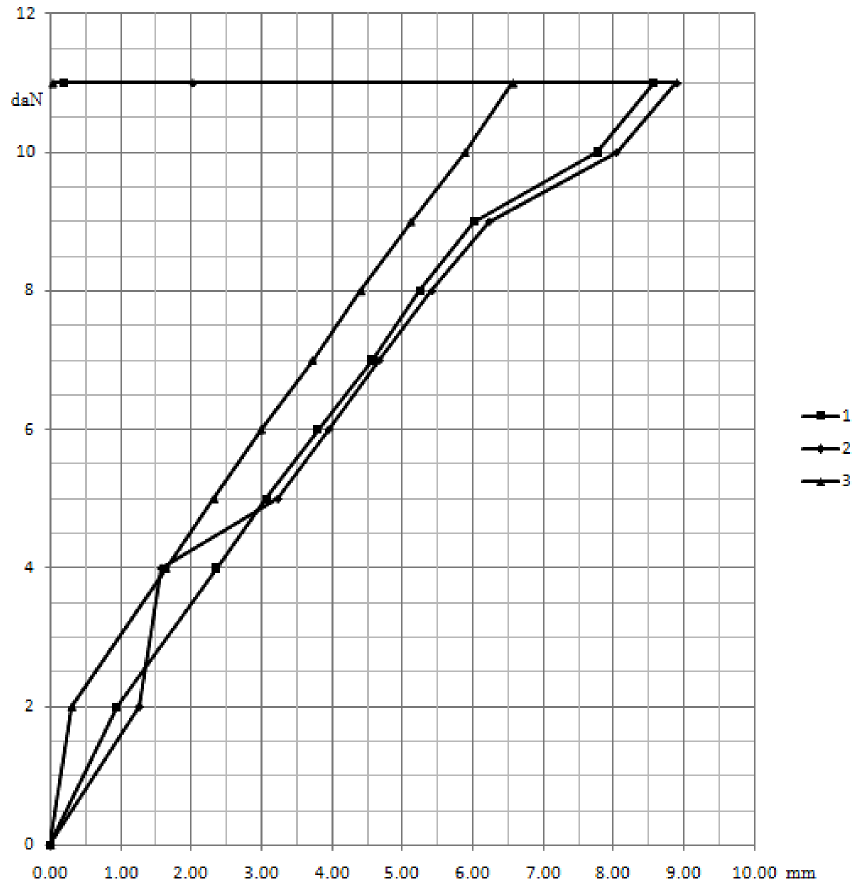

Fig. 14 – Load- deflection diagram for type 3 profiles

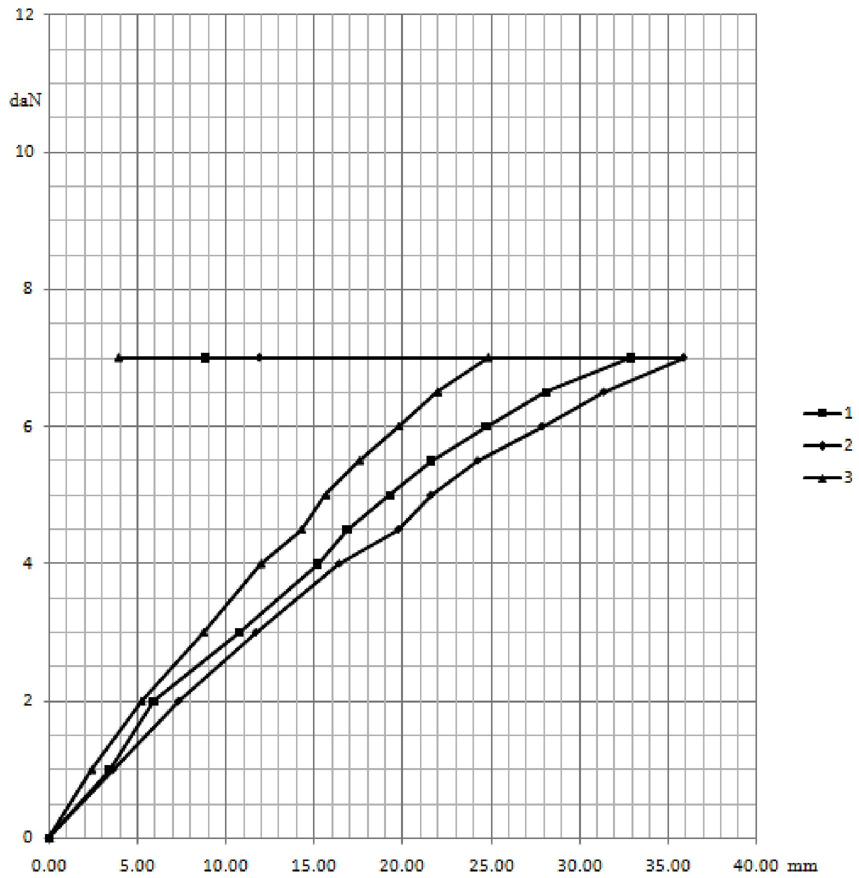

Fig. 15 – Load- deflection diagram for type 4 profiles

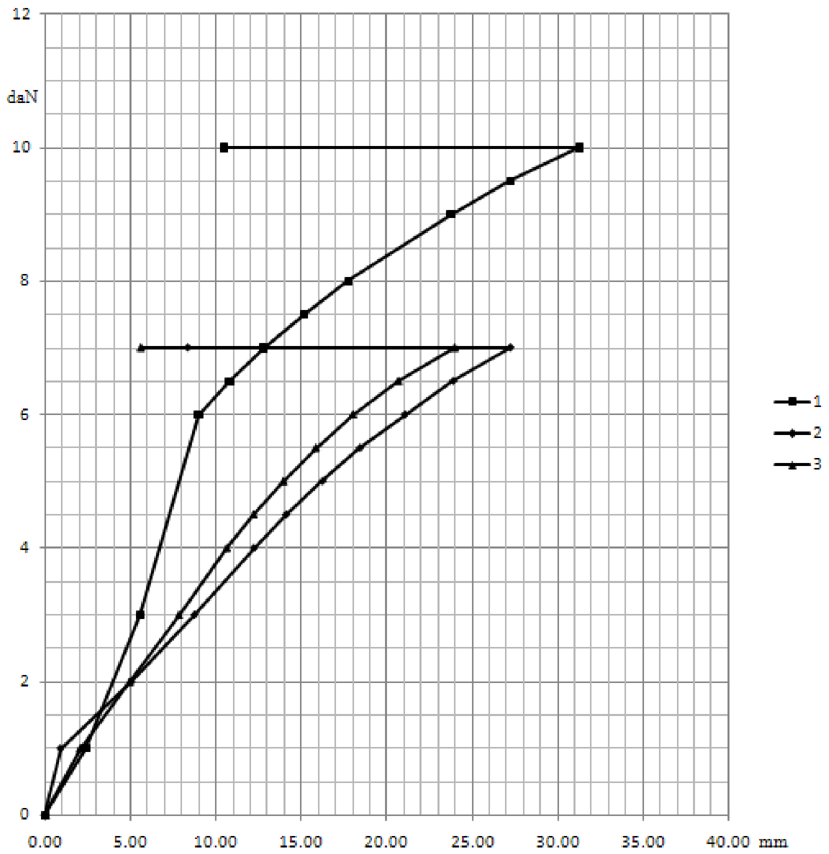

Fig. 16 – Load- deflection diagram for type 5 profiles

4. Conclusions

4.1. Conclusions regarding tension testing

The characteristic failure of these element types was by enlarging the hole of the L profile nut penetration through the hole. This failure occurred in 8 out of the 15 elements, but it must be taken into account that 4 of those that undertake failure in other modes were undersized (failure in self-tapping screws of element 3, type 4 and type 5 elements).

Failure forces were close in value, indicating homogeneity of the material, if it is taken into account that for this mode of failure a significant influence has the relative position of the nut that overtakes the shear effect in the hole zone.

The following comments are performed upon the results:

a) - the material making up the L profile is soft, ductile, so it allows such a failure mode;

b) - strength increase, if required, can be achieved by:

- the provision of wide rigid washers, under the nut;
- manufacturing ribs in the bending zone;
- use a harder material;

c) - the elements must be designed so that the three zones susceptible to failure, as previously shown, to be of equal strength, such that, besides the absence of stress concentrators when bending the L-profile the fastening with self-tapping screws have to be dimensioned accordingly;

d) - the necessary conditions for durability should be considered, in this respect for the ironworks (particularly for aluminum-steel contact zones highly susceptible to corrosion), it is recommended also to refer to the applicable provisions of the standards.

4.2. Conclusions regarding bending testing

The obtained results for each element type have a value significantly different from the other two.

Behavior of the L profile bending in cantilever largely depends on the bending zone stiffness, which is on the bending radius, which can be a cause for variability of results.

If a higher stiffness is need (that is smaller deflections), they can be obtained by the methods shown in section 4.1,b.

REFERENCES

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