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RESEARCH ON THE TENSILE BEHAVIOR OF THE STUCCO SHEETS

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Abstract: *The paper presents the influence of impurities and alloying elements on the properties and characteristics of aluminum sheets. The researches were carried out on the Stucco aluminum sheet with dimensions of 120 x 50 x 85 mm, used to make billboards, roofs, containers, films, kitchenware, chemical equipment, vaporizers for refrigerators, etc. The sheet is made of non-alloyed aluminum, according to the EN-AW 1050 standard and belongs to the 1xxx class. The sheets have a high percentage of aluminum in their chemical composition, approximately 99.5%. The aim of the work was to subject the samples from this type of material to mechanical tensile stress and to measure their modulus of elasticity.*

Keywords: *aluminum sheets, alloying elements, tensile strength, modulus of elasticity*

1. INTRODUCTION

Aluminum alloys, which have recently gained the widest spread in all technical fields, were first developed at the beginning of our century. The expansion of the use of aluminum and its alloys, at a rate that considerably exceeds that of all other metals, is due to its characteristics, as well as important technical and economic advantages.[1-3]

The technical advantages that have led to the wider use of aluminum alloys are:
- superior mechanical characteristics - although pure aluminum is relatively soft, its alloys can have mechanical characteristics equivalent to those of low-alloy construction steels; unlike other metals, the mechanical characteristics of aluminum are kept at the same values, without showing a tendency to embrittlement, up to very low temperatures (-250 °C);
- corrosion resistance - corrosion, which annually destroys more than 20% of the amount of manufactured metals, is practically inactive in relation to aluminum, as it is covered with a fine layer of aluminum oxide, adherent and impermeable, protecting the metal from the corrosive agent (industrial atmosphere, marine or different acids);
- it is non-toxic, which is why it can be used unlimitedly in the food industry, for the construction of machines or for packaging;
- decorative aspect – the easy processability allows its use in the most different forms, as a decorative material in architecture and art (different processes can give different aspects, such as matt, satin and colored gloss in all shades);
- high thermal conductivity – transmitting heat quickly and homogeneously in all directions, does not present local overheating points and is an excellent material for cookware, pistons and engine blocks, etc.;
- high electrical conductivity – compared to that of copper, which has high electrical conductivity (aluminum's conductivity represents over 60%);
- it is non-magnetic, being appropriate to the construction of equipment that works in magnetic fields (in electrical equipment, it reduces current losses and magnetic disturbances);
- reflective power – even in its untreated state, it reflects more than 80% of the sun's rays and only lets 10% of the heat through (specially polished magnesium alloys can reflect more than 90%, and the fine oxide layer obtained by anodizing protects the mirror surface , without diminishing its luster).[3-7]

2. THEORETICAL CONSIDERATIONS

Among the elements that chemically react with aluminum, forming intermetallic phases, are iron and silicon.

The solubility of iron in solid aluminum is very low, but even at a low iron content (thousandths of a percent of iron) a $FeAl_3$ compound is formed, acicular in shape, brittle and separating at the grain boundaries, considerably reducing the plasticity, the characteristics mechanics and increasing the tendency to microcracks in castings.
Silicon is less soluble in aluminum.[11-14]
Excess silicon appears in the grain boundary aluminum structure as an acicular-shaped silicon precipitate, producing embrittlement. [5-9]
Insoluble impurities in solid aluminum can be: impurities that form easily fusible eutectics (tin, lead, bismuth) and impurities that form difficult-to-fusible chemical compounds (arsenic, stium, selenium, tellurium).

The category of partially soluble elements in aluminum includes a series of elements with multiple influences on the characteristics of aluminum, such as: copper, magnesium, manganese, zinc, nickel, chromium, molybdenum, titanium, cobalt, beryllium. Most of these metals are used as alloying elements in aluminum alloys. [5-8]

Copper is soluble in solid aluminum up to 5.6%, it improves mechanical and machining characteristics, but increases brittleness, produces hot segregation and cracking, greatly reducing corrosion resistance. [7-10]

Magnesium increases mechanical and corrosion resistance but worsens fluidity and plasticity. It is the alloying element that, together with copper, gives aluminum the property of hardening through heat treatment (aging).
Manganese increases mechanical strength and corrosion resistance, reduces the negative effect of iron, but decreases fluidity and, especially, electrical conductivity.
Zinc increases mechanical strength and machinability, but decreases fluidity, corrosion resistance at ordinary temperature and at high temperature.
Nickel increases mechanical strength, corrosion resistance and refractoriness.

Chromium and molybdenum increase mechanical strength and high temperature stability.
Titanium is added to aluminum alloys to give a fine structure with good mechanical strength. [7-14]

3. EXPERIMETAL PART

Experimental studies were carried out on unalloyed aluminum sheets according to EN-AW 1050, which belong to class 1xxx containing aluminum in proportion of 99.5%.
Table 1 shows the chemical composition of the analyzed aluminum sheets as well as that of the EN AW 1050A standard, according to EN 485-573. [10]

Table 1. The chemical composition of aluminum Stucco sheets

No.	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V	Al
1	0,085	0,33	0,005	0,014	0,004	0,003	0,008	0,003	0,004	0,001	0,017	99,55
2	0,087	0,36	0,003	0,002	0,009	0,001	0,006	0,003	0,006	0,007	0,015	99,54
3	0,1	0,33	0,006	0,026	0,02	0,005	0,009	0,004	0,005	0,006	0,019	99,50
V.m.	0,25	0,4	0,05	0,05	0,05	0,03	0,03	0,07	0,05	0,03	0,03	99,50

V.m = The maximum value According to the Standard

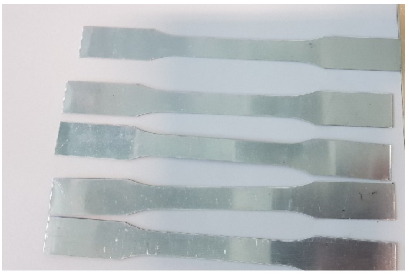
3.1 Tensile testing of Stucco sheets

The choice of material for the manufacture of a certain part is based on the so-called mechanical characteristics that the material presents.

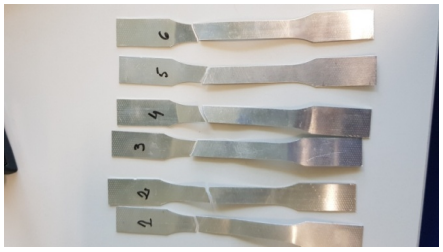
With the help of mechanical tests, qualitative data are obtained regarding the behavior of materials under the stress conditions corresponding to these tests and the values of some physical or conventional quantities, called mechanical characteristics, which can be used as quantitative parameters for expressing mechanical properties.

The basic mechanical test, which determines the most important mechanical characteristics of materials, is the tensile test.
The conditions and method of performing the tensile test and the mechanical characteristics that can be determined through this test are regulated by the SR EN ISO 6892-1:2010 standard. [10]

Figure 1 shows the Stucco aluminum sheet specimens, before and after the tensile test. From Figure 1 b, we observe the breaking mode of the analyzed specimens and note that the specimens do not break in the same place.



(a)



(b)

Figure1. The samples of Al (a) before and (b) after the tensile test

4. RESULTS AND DISCUSSION

The tensile strength was determined on a number of six samples, shown in figure 1, all having the same dimensions: L_{sample}xD x d = 120 x 50 x 85 mm, obtaining the following graphical results shown in figures 4-15.
The tensile tests were carried out at a speed of 5 mm/s.
The measurement of the mechanical properties following the traction demands were carried out in the "Prototyping and eco-design in renewable energy systems" Laboratory at the Multidisciplinary Scientific and Technological Research Institute of the VALAHIA University in Târgoviște (ICSTM-UVT), on a MTS multifunctional system Bionix (figure 2), equipped with the necessary kits for testing the three-point bending strength and testing the tensile strength.

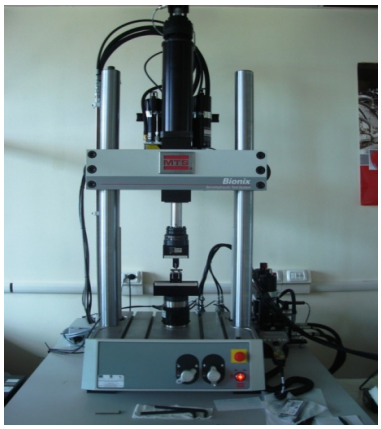


Figure 2. The tensile test machine

Determination of the bending strength [1-16] of the sample (σ) in the software of the Bionix MTS system is based on the following equations:
- the conventional curve:

$$\sigma = \frac{F}{A_0} \ [MPa] \qquad (1)$$

$$\varepsilon = \frac{\Delta L}{L_0} \ [mm] \qquad (2)$$

- real characteristic curve:

$$\sigma = \frac{F}{A_r} \ [MPa] \qquad (3)$$

$$\varepsilon = \frac{\Delta L}{L_0} \ [mm] \qquad (4)$$

where:
A_0 - the area of the initial section of the test piece;
L_0 - the initial length between the two cross-sections of the test piece;
A_r - the real section area of the specimen;
P $\rightarrow\sigma_p$- conventional proportionality limit; represents the stress for which the deviation from the current modulus of elasticity E_σ and the initial modulus of elasticity E_0 it is of 10%.
Deviation is calculated with the formula:

$$\sigma_{10} = \frac{E_0 - E_\sigma}{E_0} \ [MPa] \qquad (5)$$

E $\rightarrow\sigma_e$ – the limit of technical elasticity, for a prescribed specific residual linear deformation, is usually considered ε_r = 0,01% and it is noted $\sigma_{0,01}$.
In the case of materials that do not have an apparent yield strength, its determination is done conventionally:
- $R_{p0,2}$- conventional yield strength, for a prescribed non-proportional elongation of 0.2%;
- $R_{r0,2}$ - yield strength, for a prescribed elongation of 0,2%.
- R $\rightarrow\sigma_r(R_m)$ breaking strength, represents the ratio between the maximum force that is achieved at point R, and the area of the initial cross section of the sample:

$$\sigma_r = \frac{F_{max}}{A_0} \ [MPa] \qquad (6)$$



(a)



(b)

Figure 3. a) Dumbbell specimen clamped between the jaws of the tensile testing machine before breaking
b) Specimen after breaking

Table 2. The mechanical characteristics of Stucco sheets analyzed

Results obtained from tensile testing						
Sample of Aluminiu	**Tensile load [kN]**	**Tensile Strength [kN/mm²]**	**Strain At Break [mm/mm]**	**Modulus [MPa]**	**Offset Yield Strength (0.2%) [kN/mm²]**	**Area of the cross section [mm²]**
1	0.581	0.093	0.042	27903.610	0.085	6.2500
2	0.587	0.094	0.038	32900.130	0.083	6.2500
3	0.588	0.094	0.045	33594.247	0.083	6.2500
4	0.591	0.095	0.036	32283.194	0.082	6.2500
5	0.590	0.094	0.039	28461.478	0.085	6.2500
6	0.583	0.093	0.033	29885.286	0.080	6.2500

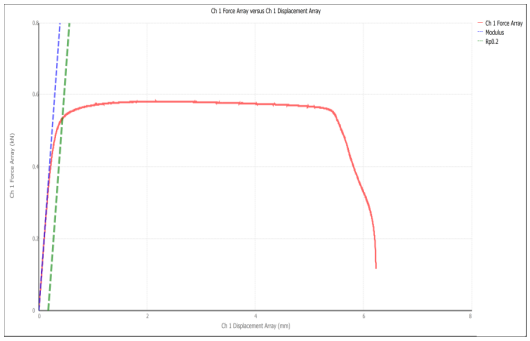


Figure 4. Applied force – elongation curve for sample no. 1

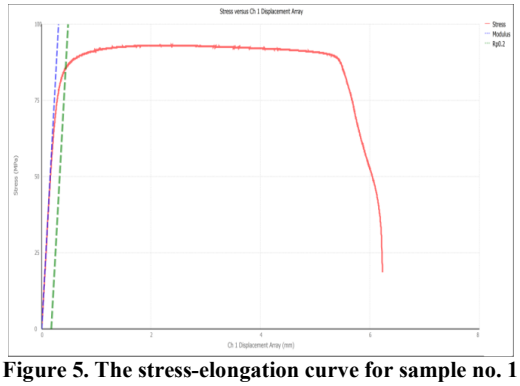


Figure 5. The stress-elongation curve for sample no. 1

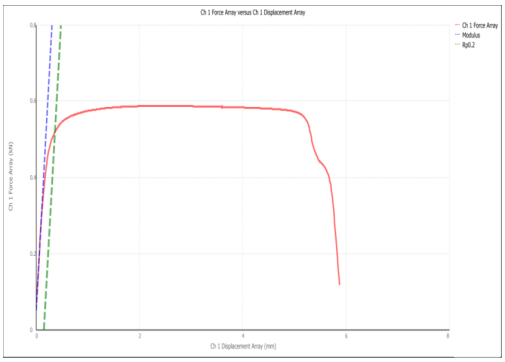


Figure 6. Applied force – elongation curve for sample no. 2

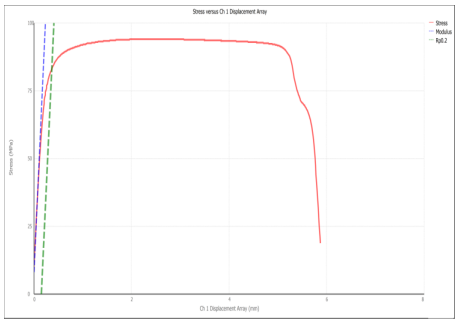


Figure 7. The stress-elongation curve for sample no. 2

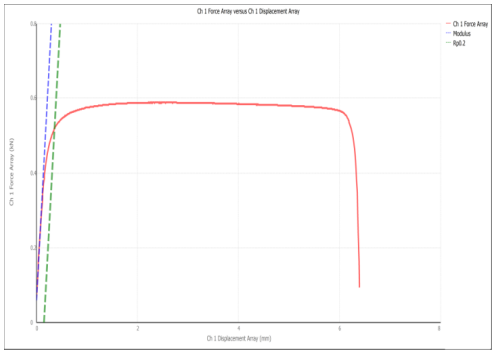


Figure 8. Applied force – elongation curve for sample no. 3

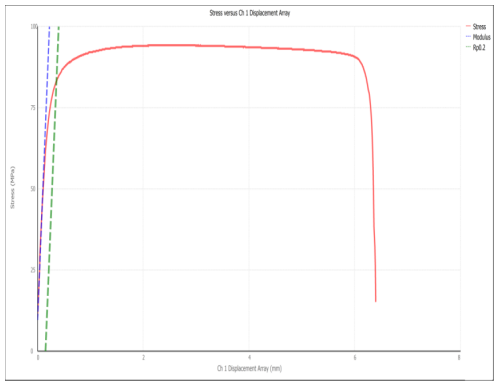


Figure 9. The stress-elongation curve for sample no. 3

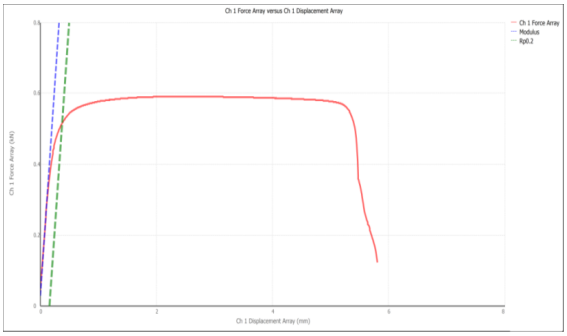


Figure 10. Applied force elongation curve for sample no. 4

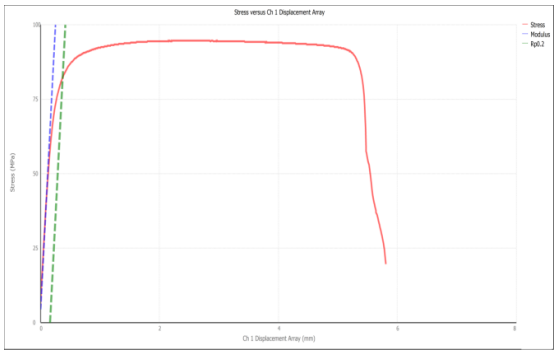


Figure 11. The stress-elongation curve for sample no. 4

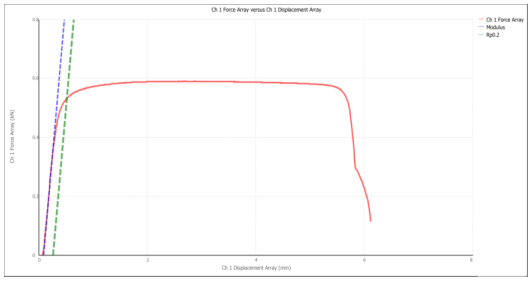


Figure 12. Applied force –elongation curve for sample no. 5

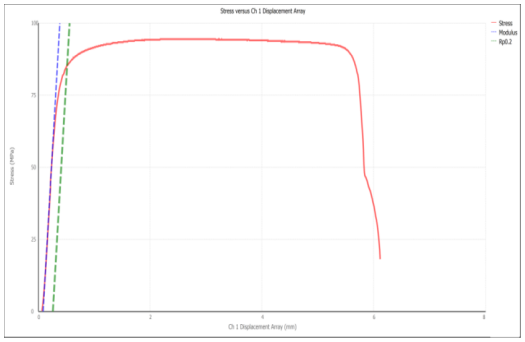


Figure 13. The stress-elongation curve for sample no. 5

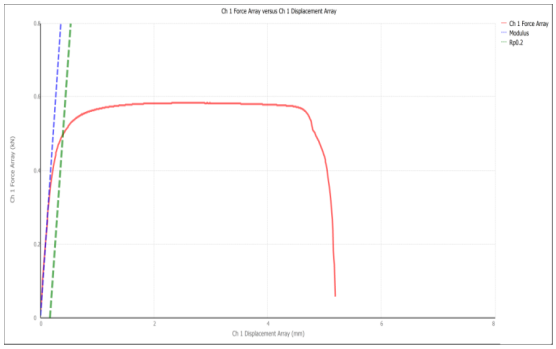


Figure 14. Applied force – elongation curve for sample no. 6

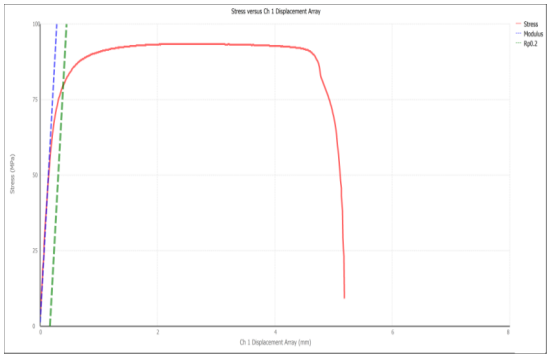


Figure 15. The stress-elongation curve for sample no. 6

Tensile tests were performed at a speed of 5 mm/s.
From table 2, we notice that the value of the modulus of elasticity, for the analyzed aluminum sheets, is between 27903.610 MPa for sample 1 and 33594.247 MPa, value obtained for sample number 3, the average value of the module being 30837.990 MPa.

4.CONCLUSIONS

The mechanical characteristics and chemical compositions are certified by the company that provided the aluminum sheet.
It is found that the bands analyzed from a chemical point of view fall within the specialty standard, both from the point of view of chemical composition and mechanical properties.
As a result of these tensile tests, it was found that for all six samples, the tensile strength does not exceed the limit given by the manufacturer.
For a certain material, the mechanical strength characteristics can acquire different values, depending on the conditions in which their experimental determination was carried out. The factors that determine the results of the test and that produce an apparent change in the values of the mechanical resistance characteristics are: the dimensions of the specimen, the speed of stress and the characteristics of the machine to be tested.
Elongation characterizes the material from a technological point of view and is not useful for strength

calculations. This refers to the behavior of the specimen material in a limited area where, after reaching the maximum load, much larger local deformations occur than elsewhere.

The results of the values obtained after the tensile test for the aluminum sheet samples fall within the standards.

The strain rate influences the tensile strength and elongation in the following way: the slower the loading, the lower the tensile strength and the greater the elongation.

In conclusion, this material can be used with confidence in constructions of various types, respectively for the creation of road protection parapets, both black and galvanized, fulfilling its technological functions.

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