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ORIGINAL ELECTRIC STAND AND APPROACH ON THE INTUMESCENT PAINT'S EXPERIMENTAL INVESTIGATION

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Abstract: The thermal protection of the steel structural elements represents a very important goal of the civil engineers. One of the modalities consists of applying an uniform layer of the so-called intumescent paint, which during the fire, becomes a very thick cover (growing up to several cms), presenting a high-efficiency thermal insulating behavior. The authors conceived and realized an original electric oven and tested a well-accepted steel joint [3; 4; 5; 7; 9; 10]. This joint was foreseen both with a uniform paint layer and with a non-uniform one, based on the Shape-factor (Massivity) calculus [1; 2]. The joints were loaded with a nominal force in a tensile-compression testing machine. Based on the obtained preliminary results, the authors intend to continue these investigations in an international co-operation.

Key words: electric oven, intumescent paint, paint's thickness optimization

1. INTRODUCTION

Nowadays the most important civil engineering establishments present their structural elements made from steel members. Their fire protection represents a great challenge of the civil engineers, based on the well-known fact that a non-protected steel member will reduce its load-bearing capacity significantly after its subjection to the fire (over 500°C for more than 15 ... 30 minutes).

In this case, of the steel members, the most widely used thermal protection consists of in applying a uniform intumescent paint layer. Taking into the consideration the so-called *Shape-factor (Massivity)* calculus [1; 2], the authors investigated in their previous works [4; 8; 11; 16; 17; 18; 19] a widely used steel joint [3; 9; 14] (see figure 1). This joint was foreseen with uniform paint layer (consisting of three layers), respectively with non-uniform ones (with two layers for the column and three layers for the horizontal members), based on the Shape-factor calculus [4; 8].

Previously of applying the paint, the joints (beam-to-column connection) were foreseen with thermo-resistors: #1 - in column; #3 - in

adjacent (here: horizontal) member, respectively in #2 - the connection zone, presented in the same Figure 1. One other one: #0 - was positioned in the electric furnace near the steel specimen.

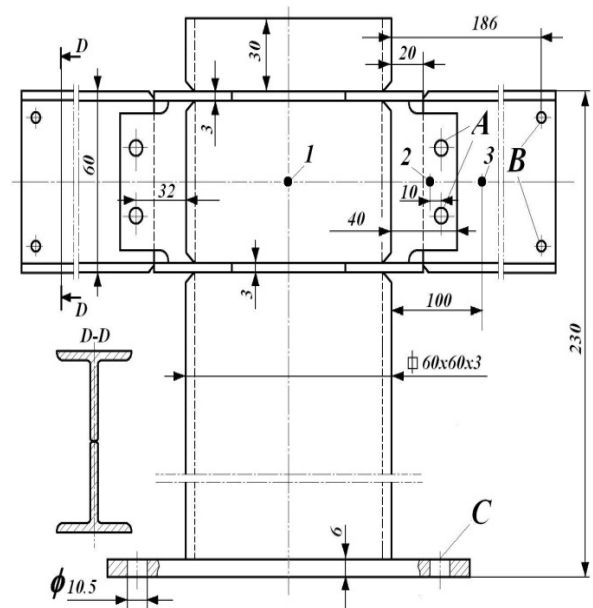


Fig. 1. The analyzed beam-to-column connection; **A** - the screw-connections; **B** - the holes for external mechanical loading; **C** - the holes for external connection [4; 8]

2. THE ORIGINAL ELECTRIC OVEN

The authors conceived an original electric oven [6], presented in figure 2.

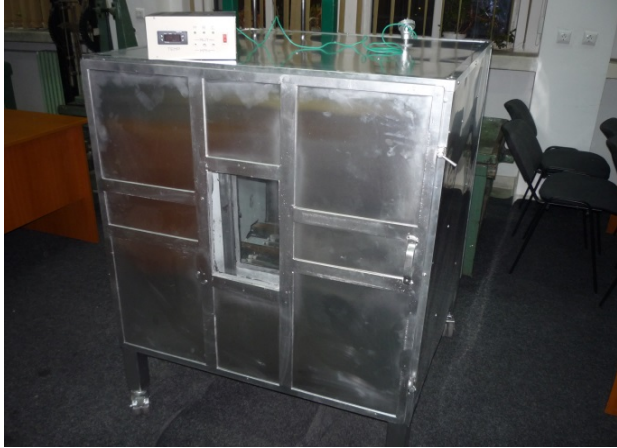


Fig.2. The oven's photo

The oven is foreseen with double door, four legs with wheels, having also in two opposite sides monitoring windows. On the upper part of the oven one can observe the electronic control system, respectively the thermo-couple which monitors the oven's temperature. The oven's structure assures also to apply mechanical loading beside the thermal ones.

Also, one has to mention the fact that the used/applied heat insulation assure up to $1100^{\circ}C$ a very efficient working of the oven.

Between its main advantages one can mention:

- it is easily to transport (it is foreseen with four wheels);
- it requires low energy consumption of maximum (12 ... 16) kW;
- it presents a high-efficiency utilization of the electric energy, both due to its good thermo-insulation and its original electronic control system, too;
- it allows the thermal and mechanical testing of some relatively large structural elements, together with their thermal and displacements' monitoring, too;
- it assures a very good thermal stability in the oven (with $0.5^{\circ}C$ accuracy over $50^{\circ}C$);
- it assure also to simulate the ISO-thermal curves (the so-called "standard fire-curve", defined in ISO 834), required by international standards;
- its performances can be also improved by placing a greater number of thermo-couples inside of the oven.

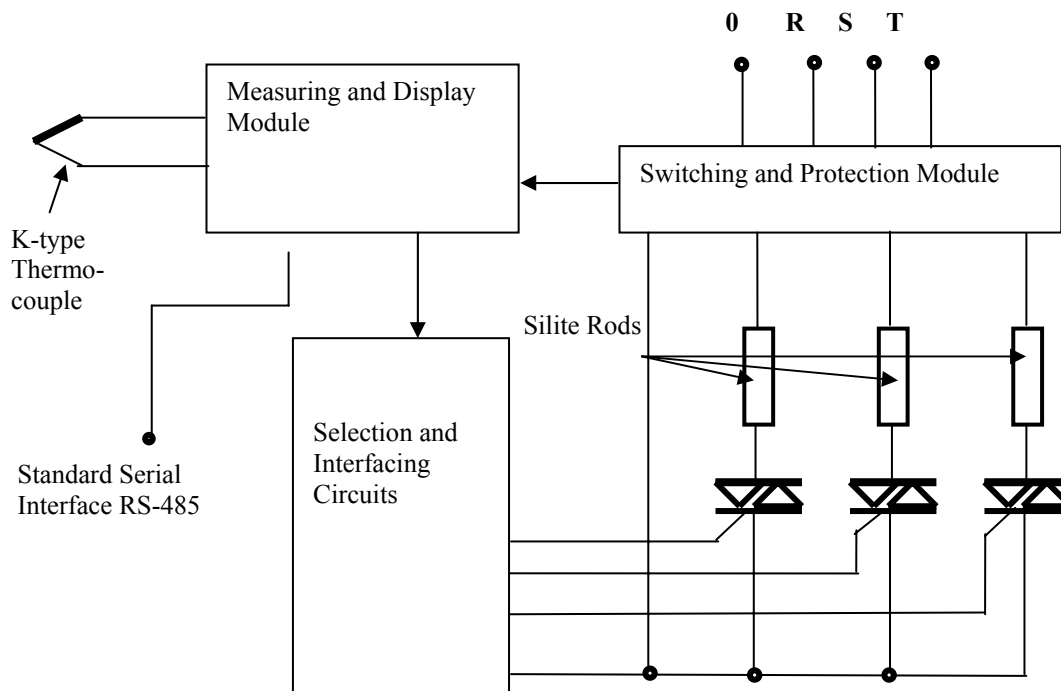


Fig. 3. The schema of the electronic circuits.

3. THE HEATING AND THERMAL CONTROL ELECTRONIC SYSTEM

The authors' original electric oven is foreseen with a high-efficient electronic system, which assure both the heating control and the thermal stability control, too. The heating is assured by 12 Silite rods, arranged in four groups (each with three elements), commanded by a close loop-type electronic control system. This control system is foreseen with both automatic and manual acting modes.

The 3-phases (common 380 V) electric power supply, assures the necessary energy, and the oven presents a maximal consumption of (12 ... 16) kW only, during the heating process of approximately 0.8 m³ up to 700^o C.

In figure 3 is presented the original electronic circuit's schema, which assures a good thermal control and thermal stability (with +/- 0.5^o C only after 20 ... 25 s).

The Silite rods' groups can be connected in such manner to assure an efficient and smooth heating control, with (1 ... 3)^o C accuracy. The RS-485 interface assures a computer connection and easy data acquisition.

4. PRELIMINARY RESULTS

In figures 4 and 5 are presented two of the unpublished measuring results, regarding on the temperature variation at points #1 and #2 of the above-mentioned steel joint.

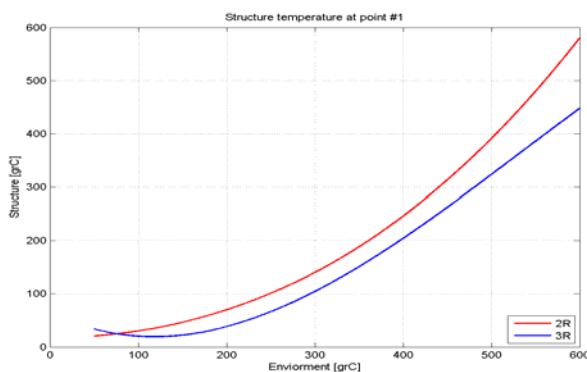


Fig.4. Comparative temperature of the structure at point #1

One can observe the influence of the layers' number (2R and 3R) on the heat protection effect.

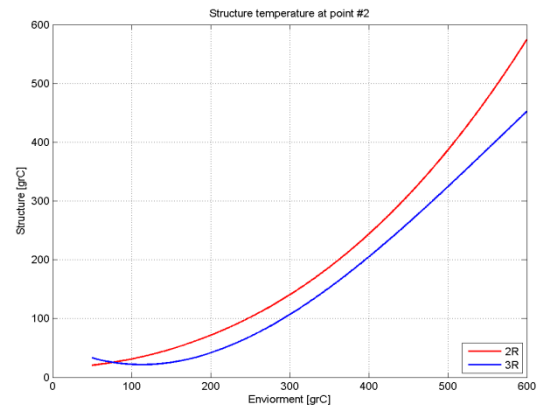


Fig. 5. Comparative temperature of the structure at point #2

Figure 6 presents the theoretical displacement in point B, considering the Young's modulus variation with temperature, respectively the connection points' infinite stiffness (of the column with the horizontal members).

A well-known relationship from literature, applicable for temperatures in range of $T \in [0, 600]^{\circ}C$, is :

$$E(T)[GPa] = e_0 + e_1T + e_2T^2 + e_3T^3, \quad (1)$$

where:

$$e_0 = 206.0; \quad e_1 = -0.044326; \quad e_2 = -3.502 \cdot 10^{-5};$$

$$e_3 = -6.592 \cdot 10^{-8}$$

The total theoretical considered load, at the level of points B was $F = 13.7 \text{ kN}$.

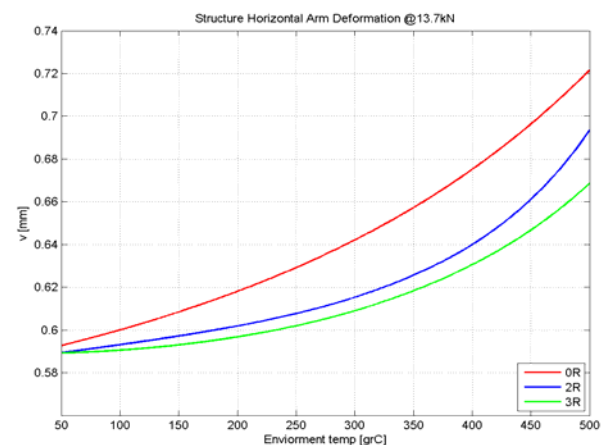


Fig. 6. Comparative theoretical vertical displacement at point B of the horizontal arm, corresponding to a total vertical load 13.7 kN, for uncovered (0R), with two (2R), respectively three (3R) uniform layers of intumescent paint, based on the Young's modulus variation with the temperature; was considered only the cantilever beam deformation

5. CONCLUSION

The authors conceived, realized and tested an original electric oven, which presents several facilities in the experimental investigations of the structural steel members' fire-protection testing.

The described oven is very suitable for the intumescent paint behaviours' testing and its impartial evaluation.

Supplementary is very useful in combined mechanical and thermal testing of the steel members, allowing also the displacements' monitoring of the tested specimens.

By mean of such experimental investigations became possible providing for engineers useful information regarding on the elastic behaviours of the steel structural members, taking into the consideration their fire protection quality, too.

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STAND ELECTRIC ORIGINAL ȘI ABORDAREA ANALIZEI EXPERIMENTALE A VOPSELELOR TERMOSPUMANTE

Rezumat: Termoprotecția elementelor structurale metalice reprezintă o problemă majoră a inginerilor constructori. Una dintre aceste modalități de termoprotecție constă în aplicarea unui strat uniform subțire de așa-numita vopsea intumescentă, care în timpul incendiului devine un strat gros (de ordinul a câtorva *cm*), cu proprietăți pronunțate de termoprotecție. Autorii au conceput și realizat un cuptor electric original, care a fost utilizat în testarea unei joncțiuni preferate de inginerii constructori din punctul de vedere a eficienței în caz de cutremur [3; 4; 5; 7; 9; 10]. Aceasta joncțiune a fost încercată, atât cu un strat uniform, cât și neuniform de vopsea intumescentă; numărul straturilor pe diferitele elemente componente ale joncțiunii fiind stabilit pe baza calculului al coeficientului de formă [1; 2]. Fiecare joncțiune a fost încărcată cu o sarcină nominală dezvoltată de către o mașină universală de tracțiune-compresiune. Pe baza acestor rezultate preliminare autorii intenționează să continue cercetările în cadrul unei cooperări internaționale.

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