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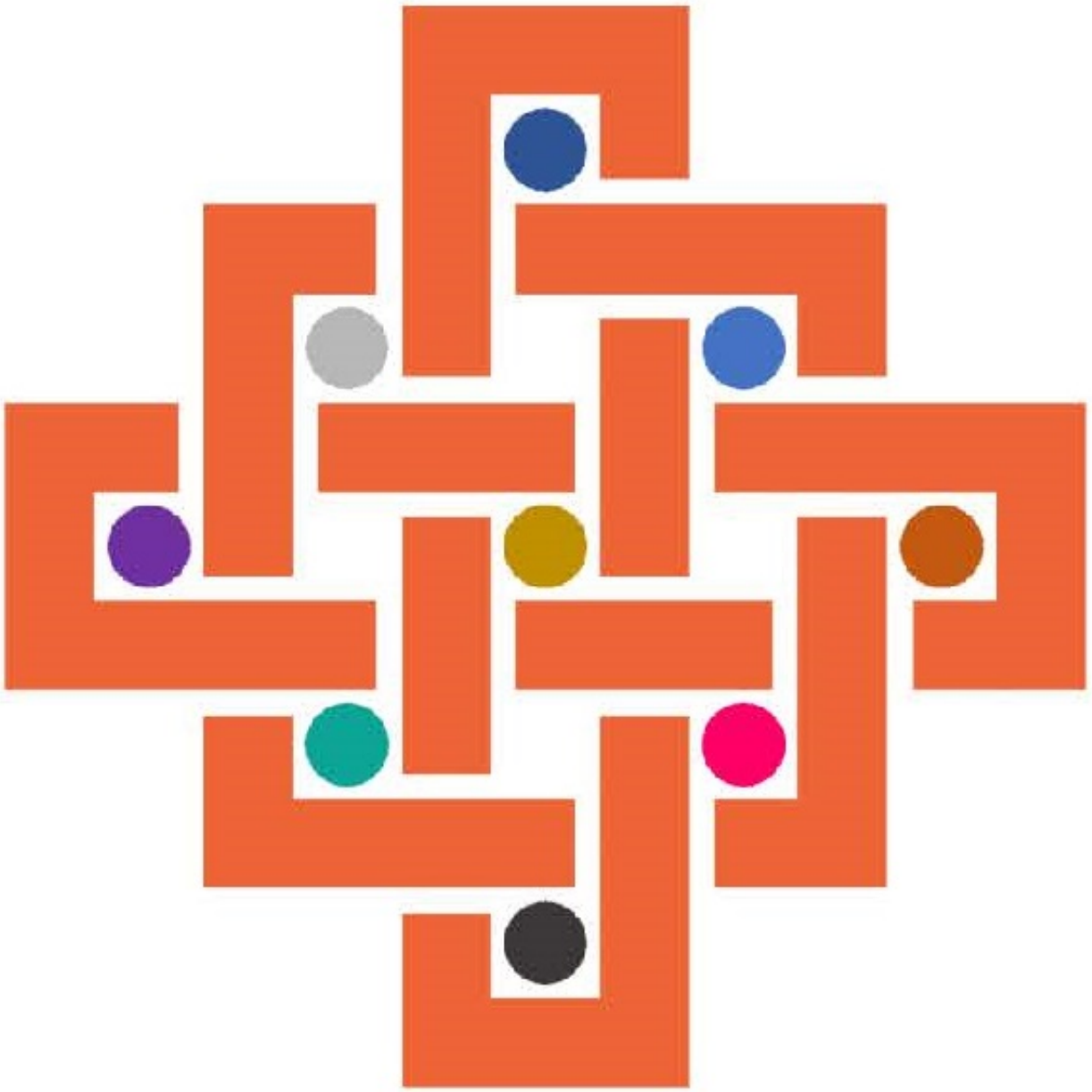

ДГКМ
ДРУШТВО НА ГРАДЕЖНИ КОНСТРУКТОРИ НА МАКЕДОНИЈА

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MACEDONIAN ASSOCIATION OF STRUCTURAL ENGINEERS

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THE COMPARATIVE ANALYSIS OF THERMAL BEHAVIOUR OF A DIFFERENT THICKNESSES WALLS MADE FROM AUTOCLAVED AERATED CONCRETE BLOCKS EXPOSED TO FIRE

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ABSTRACT

In this paper a comparative analysis of thermal behavior of six partition walls with different thicknesses were presented. The walls were dimensions 3000 mm x 3000 mm made from autoclaved aerated concrete blocks with dimensions 625 mm x 200 mm and thicknesses 50 mm, 75 mm, 100 mm, 120 mm, 150 mm and 250 mm. All walls were exposed to standard fire test according the standard SRPS EN 834-1, non- combustibility test according the standard SRPS EN 1182 and surface spread of flame test according to SRPS U.J1.060. All walls were tested to fire resistance in vertical furnace with a data acquisition system, according to standard fire test. Standard furnace for testing construction consist of four two step burners in liquid fuel type „Major P25 AB HS TL V.C.“, heating power of 296 kW manufactured by ECO FLAM. Two transmitters of differential pressure type 6321 manufactured by TESTO (Germany), with range ±100 Pa installed inside the furnace were used for pressure measurement. Inside the furnace the temperature on six places with thermocouple type K were measures. The measure ranges of thermocouple type K were -270^{0}C to 1372^{0}C. The temperatures on unexposed fire side were measured in nine places with thermocouple type T with measure ranges -270^{0}C to 400^{0}C of according the national standard SRPS U.J1.090. The obtained temperature results depending of the time of reaching the critical temperature were presented for each wall thicknesses. The five identical cylindrical samples with high 50 mm and diameter 45 mm for non-combustibility test has been used. All samples have been tested in standard furnace for non-combustibility test. The average temperature in furnace and specimens were presented. Surface spread of flame testing is carried out according to standard SRPS U.J1.060, if the coating material is based on organic or mixed materials. The samples for these test are with dimensions 900 x 230 mm.

Keywords: autoclaved aerated concrete; standard fire test; temperature measurement; thermal behavior; wall thickness, non-combustibility test, surface spread of flame test.

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1. INTRODUCTION

Autoclaved aerated concrete blocks is the load bearing building material with a low density due to its higher porosity compared to other load bearing building materials [3]. Low densities of autoclaved aerated concrete blocks reach low thermal conductivity and that is an advantage in terms of thermal insulation at ambient temperatures as well as an asset to fire resistance. The lighter weight implies the better sustainability to assuming to benefit for less material outweighs potentially higher energy costs for production, which together with non-combustibility represent additional assets of this material in building industry. Autoclaved aerated concrete blocks have a high porosity [3]. Because of these advantages autoclaved aerated concrete blocks are widely used as a wall material to minimize heating and cooling looses through the walls [4].

The currently valid Rulebook on mandatory attestation of elements of standard building structures for fire resistance and on working conditions that must be met by organizations of associated labor authorized to attest these products from 1990 requires testing of each product, or structural element, according to the domestic SRPS standards. The Rulebook prescribes that when attesting load-bearing and non-load-bearing walls, three tests must be performed: Fire resistance, surface spread of flame and non-combustibility tests. In this paper the six fire tests, one non-combustibility test and one surface spread of flame test has been presented.

2. DESCRIPTION OF EXPERIMENT AND MEASURING EQUIPMENT

In this paper the resistance to fire of six walls different thicknesses exposed to standard fire test was presented. The wall were made from the same autoclaved aerated concrete with dimensions 625 mm x 200 mm with thicknesses 50 mm, 75 mm, 100 mm, 120 mm, 150 mm and 250 mm. The walls were divided in two groups. The first group of walls consists of walls made from autoclaved aerated concrete blocks with thicknesses 250 mm, 150 mm, 120 mm and 100 mm which are used to make partition walls. The second group of walls consists of walls made from autoclaved aerated concrete blocks with thicknesses 75 mm and 50 mm which are used for protecting different elements. All walls were tested in vertical furnace with acquisition system, in according to standard fire test. The walls with dimensions 3m x 3 m and tested in Institute IMS in Laboratory for thermal technique and fire protection. Standard furnace for testing these construction consist of four two step burners on liquid fuel type „Major P25 AB HS TL V.C.“, with instaled unit heating power of 296 kW manufactured by ECO FLAM. Two transmitters of differential pressure type 6321 manufactured by TESTO (Germany) with range ±100 Pa inside the furnace were used for pressure measurement. Inside the furnace the temperature on six places with thermocouple type K were measured. The measuring range of thermocouple type K is -270^{0}C to 1372^{0}C. Acquisition system and monitoring for standard fire test in vertical furnace were made completely in laboratory for thermal technique and fire protection according to standard SRPS ISO 834-1 [1]. Standard fire development was described with logarithm curve. In equation 1 a standard fire temperature curve was given:

$$\boldsymbol{T = 20 + 345log_{10}(8t + 1)} \quad (1)$$

Where: t [min] is time and T[^{0}C] is temperature inside the furnace depending on the time t.

In Figure 1 the standard fire curve is presented.

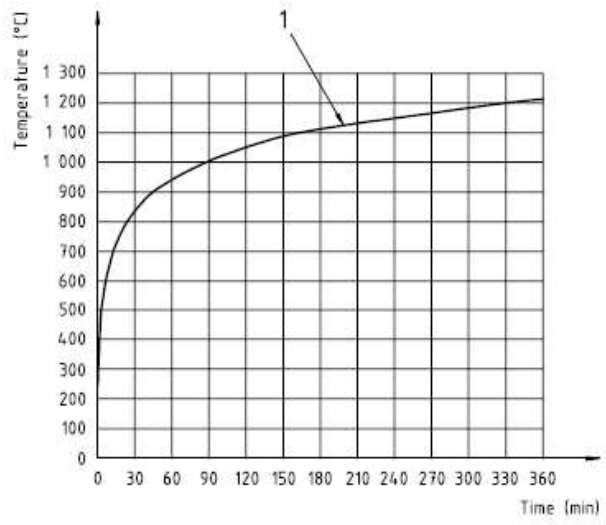

Fig. 1. Standard fire curve in accordance with SRPS ISO 834-1

On a fire unexposed side the temperatures of walls with thermocouple type T were measured in nine places according to standard SRPS U.J1.090 [2]. The criteria for fire resistance of construction are preservation of integrity, stability and insulation. The insulation properties of construction are maintained when average temperature is above the initial average temperature increase by more than 140 K on all thermocouples on unexposed fire side and increase above the initial temperature at any location (including the rowing thermocouple) by more than 180 K. The initial temperature is the average unexposed fire side temperature at the commencement test. In every 12 s, which is sample rate, the temperature of the furnace, the temperatures on a wall of unexposed fire side and the pressure were collected. The furnace pressures are measured and recorded continuously in two control point. In Figure 2 the disposition of thermocouples and standard furnace for fire test has been shown. The thermocouples are marked with numbers 1-9.

The five identical cylindrical samples with high 50 mm and diameter 45 mm for non-combustibility test has been used. All samples have been tested in standard furnace for non-combustibility test defined in standard SRPS EN 1182. The average temperature in furnace and specimens were presented. In Figure 3 the disposition of thermocouples and standard furnace for non-combustibility test has been shown. Before the test start, the furnace stabilization has been done. Three thermocouple type K has been used for for non-combustibility test. The first thermocouple is for temperature measurement inside the furnace, the second and third thermocouples are for temperature measurement on surface and center of the sample.

Surface spread of flame testing is carried out according to standard SRPS U.J1.060, if the coating material is based on organic or mixed materials. The samples for these test is with dimensions 900 x 230 mm. In Figures 4 and 5 the specimen made from autoclaved aerated concrete blocks before and after testing has been presented. The result of test is the class of a material which depends on the length of the flame spread. Because the wall were made from the same autoclaved aerated concrete blocks, only different thicknesses, the one test of non-combustibility and surface spread of flame has been done.

Fig. 2. The disposition of thermocouples in standard furnace for fire test

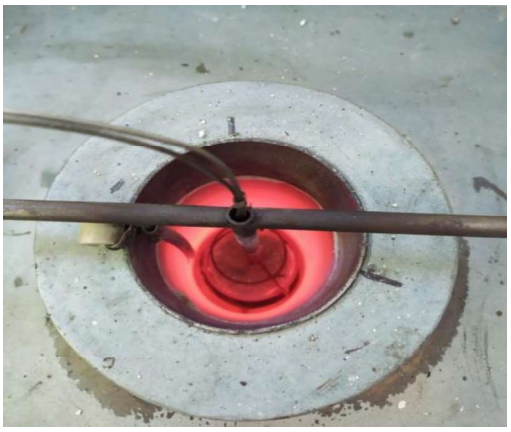

Fig. 3. The standard furnace for non-combustibility test

Fig. 4 Specimen before the surface spread of flame test

Fig. 5 Specimen after the surface spread of flame test

3. EXPERIMENTAL RESULTS AND DISCUSION

In Figure 6, the measurement temperatures in furnace of six fire test were presented. For each fire test, the average temperature of six thermocouples inside the furnace was shown. The uniform temperature conditions inside the furnace during all tests, has been in accordance with limits in standard. In unexposed fire side, on each wall, the temperature in nine places has been measured. In Figures 7-12 the temperature distribution of unexposed fire side of each wall were shown. In these figures with T1-T9 are presented the temperature of unexposed fire side of a wall, Tav is the average temperature of thermocouples T1-T9, Tav,cr is the temperature limit for average temperature Tav, and Tmax,cr is the temperature limit for each thermocouple T1-T9. The walls with thicknesses 250 mm, 150 mm and 120 mm have fire resistance of 180 min and this fire resistance were presented in Figures 7,8 and 9. The wall with thickness 100 mm has fire resistance of 120 min, and wall thickness 75 mm has fire resistance 90 mm which are presented in Figures 10 and 12. In Figure 11 is shown that the wall thickness 50 mm has been failed insulation properties in measurement point number 6 in 72 min, so this wall has fire resistance of 60 min. At the start of fire test, in each wall, the temperature of a wall has been constant. Then, due to conduction and evaporation of the moisture, the temperature through the wall was begun to increase, than temperature on unexposed fire side has been constant. Only specimen of the wall thickness 50 mm has been lost the insulation properties. In Figure 13 the average

temperature of a six tested walls has been shown. In Figures 14 and 15 the temperature during the furnace stabilization and the temperature on furnace (red curve), on surface (pink curve) and center (blue curve) of a specimen during the non-combustibility test were presented. The specimen during the surface spread of flame test did not ignite and therefore the flame path was traversed after 600 s and 900 s is 0 mm. Because of this, in according to standard SRPS U.J1.060, the specimen has been given class 1.

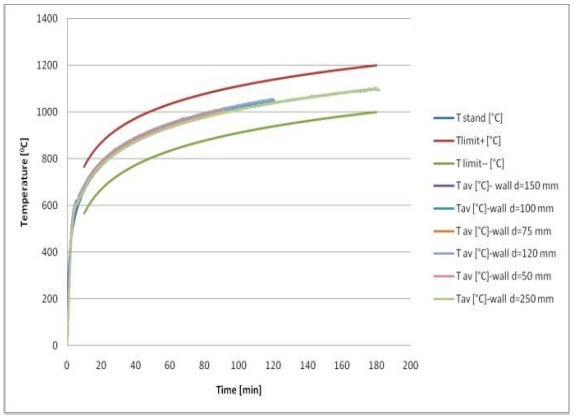

Fig. 6. The average temperature in furnance during the six fire test

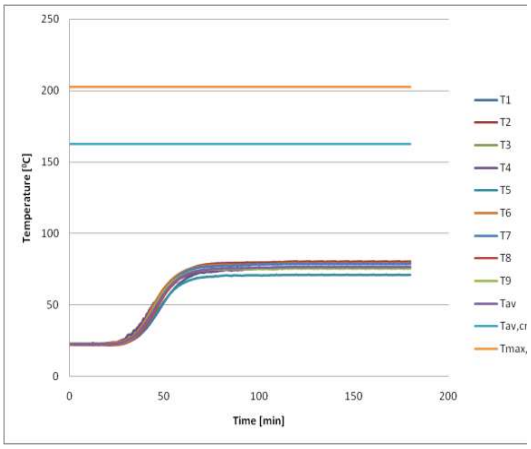

Fig. 7. Temperature on unexposed fire side of wall thickness 120 mm

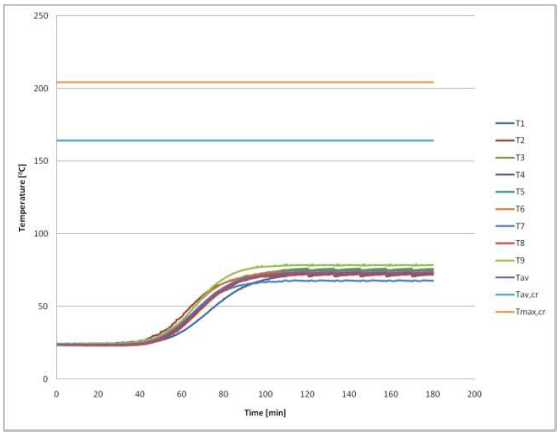

Fig. 8. Temperature on unexposed fire side of wall thickness 150 mm

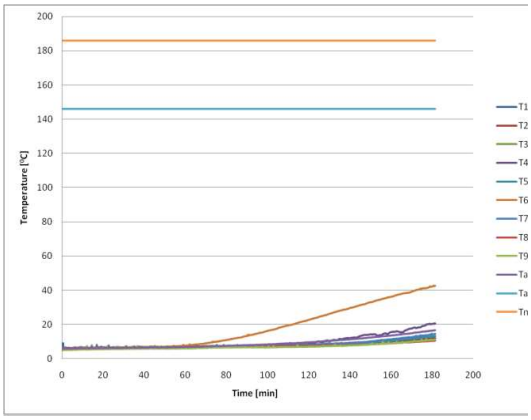

Fig. 9. Temperature on unexposed fire side of wall thickness 250 mm

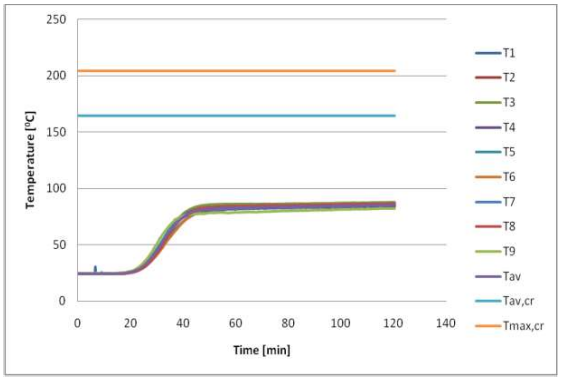

Fig. 10. Temperature on unexposed fire side of wall thickness 100 mm

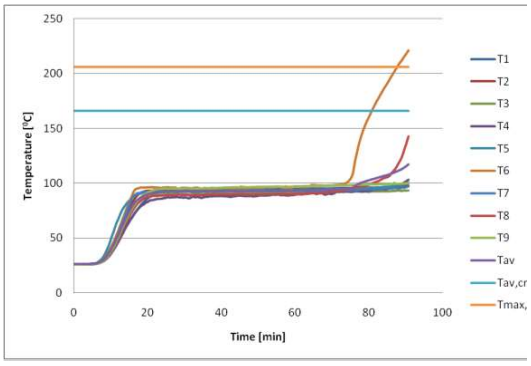

Fig. 11. Temperature on unexposed fire side of wall thickness 50 mm

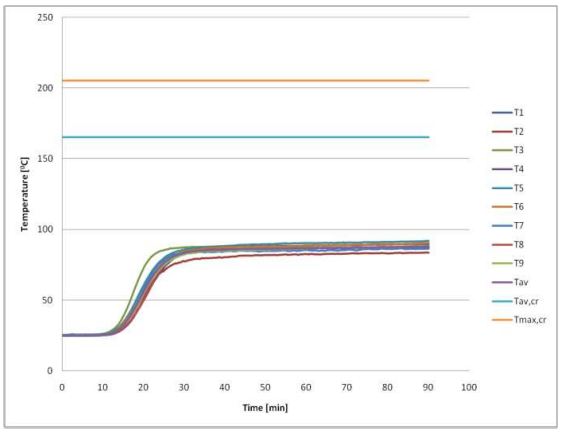

Fig. 12. Temperature on unexposed fire side of wall thickness 75 mm

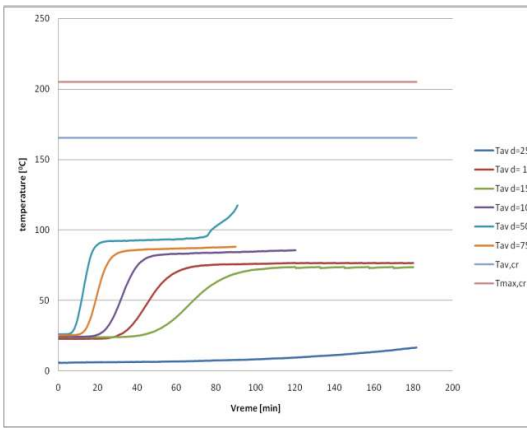

Fig. 13. Average temperature on unexposed fire side of six walls

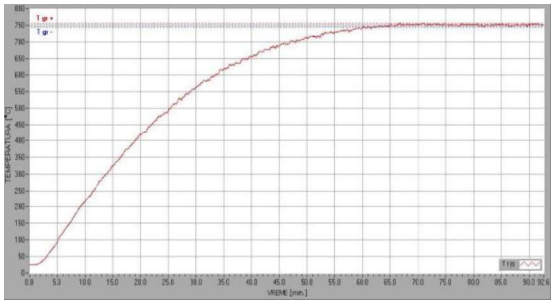

Fig. 14. Temperature inside the furnace during the stabilization test during the non-combustibility test

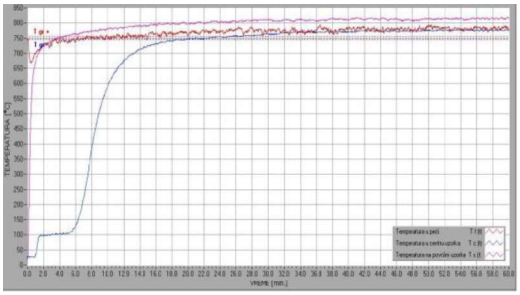

Fig. 15. Temperature inside the furnace on surface and center of a specimen during the non-combustibility test

4. CONCLUSION

In this paper, the fire resistance of six walls made from same autoclaved aerated concrete blocks but with different thicknesses was presented. The walls were divided in two groups. The first group of walls consists of walls made from autoclaved aerated concrete blocks with thicknesses 250 mm, 150 mm, 120 mm and 100 mm which are used to make partition walls. The second group of walls consists of walls made from autoclaved aerated concrete blocks with thicknesses 75 mm and 50 mm which are used for protecting other elements. All walls were exposed to standard fire test according the standard SRPS EN 834-1, non- combustibility test according the standard SRPS EN 1182 and surface spread of flame test according to SRPS U.J1.060. The temperatures on unexposed fire side in standard fire test were measured in nine places according the national standard SRPS U.J1.090. The comparative analysis of obtained results was presented. The temperature inside the furnace, on surface the specimen and in center of specimen during the non-combustibility test were shown. The specimen during the surface spread of flame test did not ignite and therefore the flame path was traversed after 600 s and 900 s is 0 mm. Because of this, in according to standard SRPS U.J1.060, the specimen has been given class 1.

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