SIEĆ BADAWCZA ŁUKASIEWICZ

Institute of Ceramics and Building Materials
Refractory Materials Division in Gliwice

Fire barrier based on expanded perlite composites

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About us…

SIEĆ BADAWCZA ŁUKASIEWICZ

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- **Ceramic and Concrete in Warsaw**
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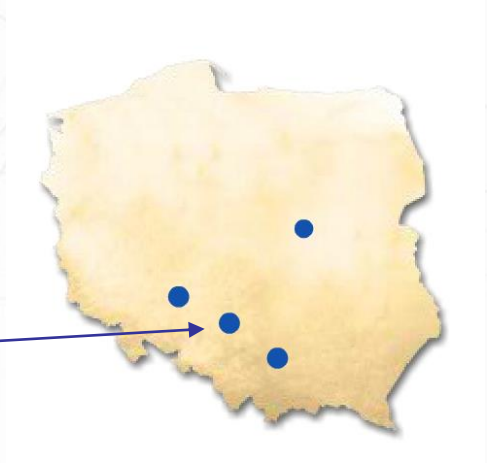
- **Glass and Building Materials Division in Cracow**



Our division….

Over 50-year experience in conducting research and development works, also expertise in the area of manufacturing and application of high temperature ceramics as well as in the area of processing ceramic raw materials and application thereof in the environment protection ambience

The main directions of activities:

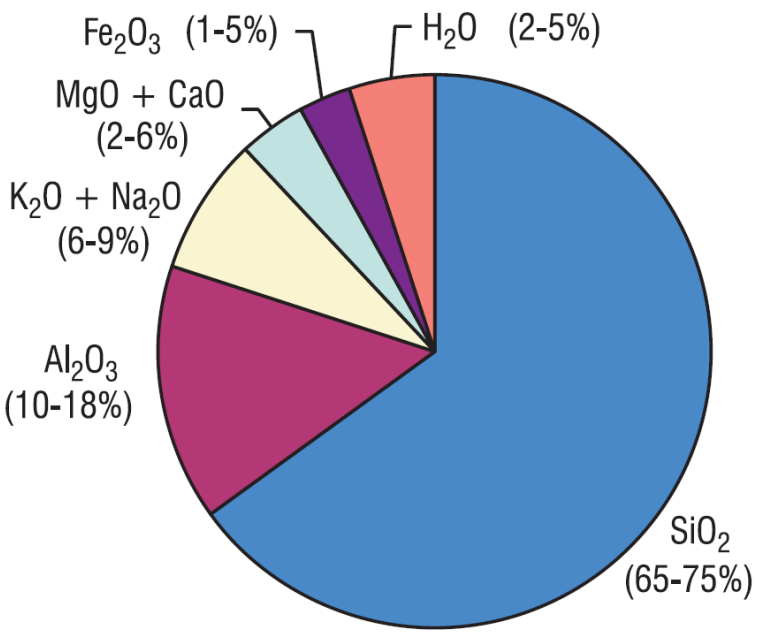
- ❑ microporous ceramic materials for applications at high temperature processes
- ❑ new ceramic materials for thermal processing and gasification processes
- ❑ unburnt fire-resisting materials for monolithic coatings
- ❑ ceramic coating and multilayered materials for high-temperature applications
- ❑ ceramic materials of controlled microstructure
- ❑ oxide-matrix and non-oxide matrix composites
- ❑ regeneration and processing of fire-resisting waste
- ❑ utilisation of industrial and municipal waste with the help of ceramic processes

Presentation plan

- Introduction
  - expanded perlite
  - fire-resistance of building materials
- Purpose and scope of research
- Overview of the results
  - properties of the expanded perlite composites
  - results of the fire resistance test
- Summary

Perlite – main informations

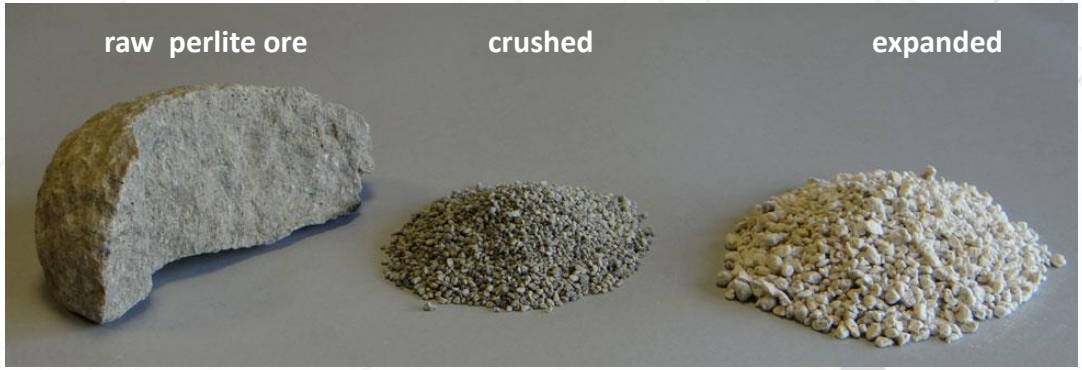
- perlite - mineral, transformed effusive magmatic rocks composed of volcanic glass
- hydrated potassium and sodium aluminosilicate
- the emitted lava quickly solidified in contact with water and enclosed its drops (2 to 5 vol%) which are responsible for the specific properties of this mineral



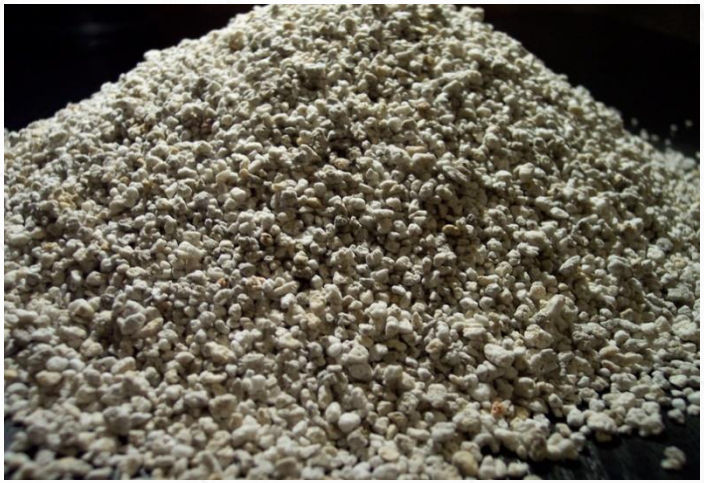
Typical chemical composition of perlite

Expanded perlite

- the perlite ore is calcined at 900-1100°C
- water contained in individual grains of perlite ore causes their swelling and volume increase, even up to 20 times (expanding process)



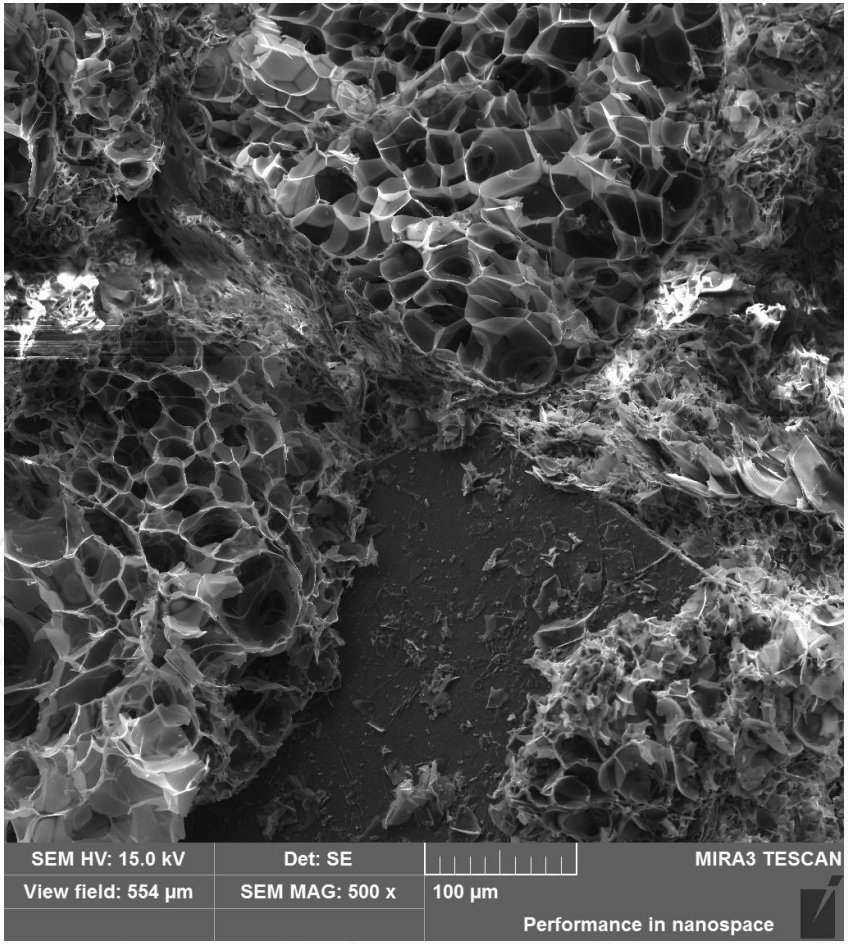
Raw perlite vs expanded



Expanded perlite grains

Expanded perlite – properties

- chemically inert
- good thermal insulation properties
- low density
- sound absorption
- resistant to moisture
- permeable
- incombustible
- resistant to biological agents
- sorption properties
- resistant to temperatures from -200°C to 900°C (does not emit any toxic substances during heating)



Fracture of expanded perlite granis

Fire resistance - introduction

- All construction materials should have a fire classification
- According to this classification, the materials are divided into seven classes in terms of reaction to fire with additional criteria connected with emmision of smoke and fire droplets
- Fire resistance classes characterize the product in terms of:
  - the amount and speed of energy production during the burning of the product
  - time to ignite the product when in contact with a burning object
  - speed and range of flame spread

Fire classification

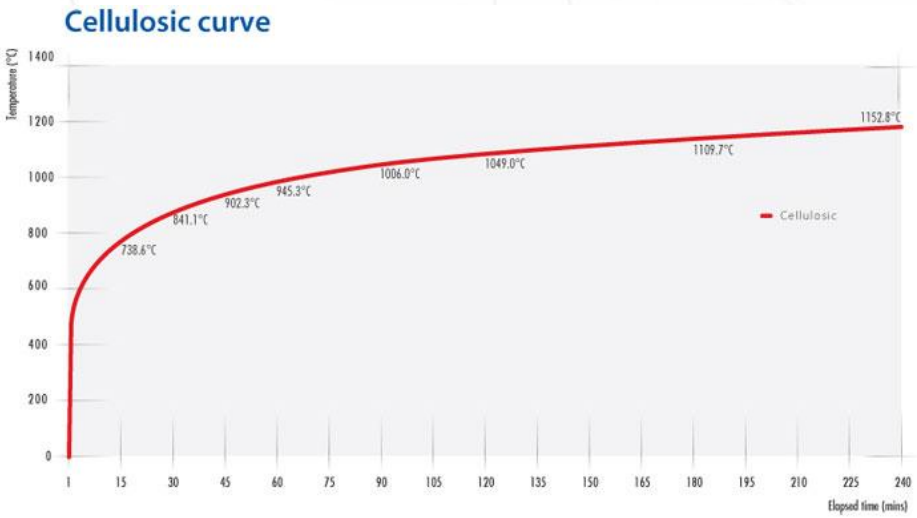
Class	Properties	Flashover risk	Examples of products
A1	non-flammable	no flashover, minimal value of combustion heat	concrete, steel, rock wool, glass wool
A2	non-flammable	no flashover, low value of combustion heat	drywalls, high-density mineral wool
B	ignitability with a small flame for 60s Fs < 150 mm, limited participation in a fire	no flashover	hard PVC
C	ignitability with a small flame for 60s Fs < 150 mm, limited but noticeable participation in a fire	flashover not earlier than after 10 minutes with a heat flux of 300 kW	some polyurethane foams, drywall with wallpaper
D	ignitability with a small flame for 60s Fs < 150 mm, significant participation in a fire	flashover not earlier than after 2 min with a heat flux of 100 kW	most polyurethane foams, unimpregnated wood
E	ignitability with a small flame for 20 s Fs <150 mm, very high participation in a fire	flashover not earlier than after 2 min with a heat flux of 100 kW	foamed plastics characterized by reduced flammability
F	very high participation in a fire or no requirements	has not been tested or does not fulfil any criteria	foamed plastics

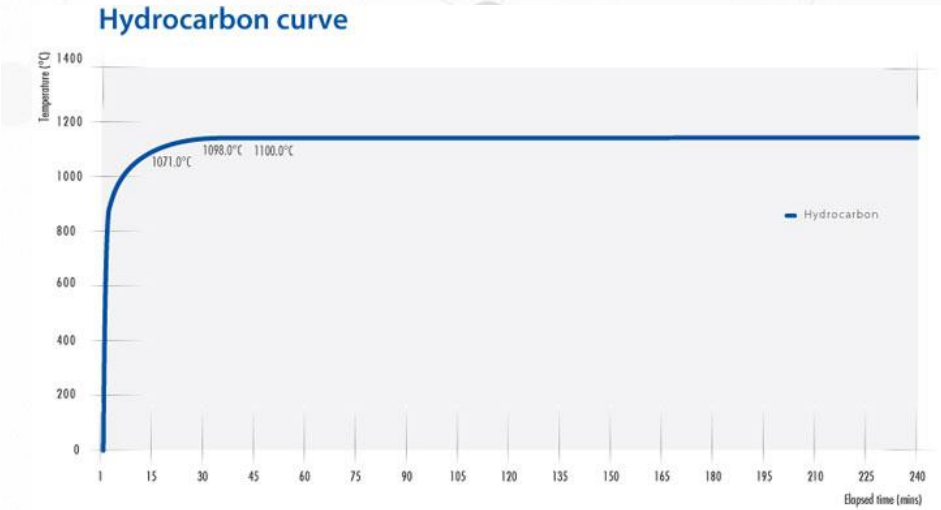
Fs – flame propagatin, mm

Fire curves

- Although all uncontrolled combustion process of combustible materials is referred as a fire, the size and nature of the fire depends on many factors - type of combustible material, ventilation, thawing factors, etc.
- To have a certain reference point, the so-called temperature curves (describing changes of temperature in time) was assumed
  - two types of model fire
    - cellulosic
    - hydrocarbon

Fire curves





- The fire that occurs most often concerns commercial buildings and infrastructure, the combustible material are materials used every day - paper, wood, textiles
- In this type of fire, the temperature of the system grows relatively slowly and up to 900°C occurs only after about an hour, however, the temperature of 500°C is achieved after about 5 minutes from the moment of the fire being ignited

- Hydrocarbon fire is much more dangerous and is mainly associated with large industrial installations, it occures most frequently on mining platforms, petrochemical plants, gas installations, the combustible material are flammable oils, gases, and chemicals
- This type of fire is characterized by an extremely rapid temperature increase, where in a few minutes a temperature of 1000°C is achieved in the system, the fire is spreading rapidly

http://www.rynekfarb.pl/rodzaje-pozarow-farby-ogniochronne/

Fire resistance

- the measure of fire resistance is expressed in minutes, the time from the beginning of a fire until the building element achieves one of three threshold criteria, i.e .:
  - fire load bearing
  - fire integrity
  - fire insulation

- Fire load bearing (R) is a state in which the test element no longer fulfils its load bearing function due to mechanical destruction, loss of stability and the exceeding of the limit values of displacement or deformation
- Fire integrity (E) is a state in which the test element no longer fulfils its separating function due to the appearance of flames on the unheated surface, cracks or gaps with dimensions exceeding the limit values which are penetrated by flames, gases, or a state in which the test element comes off the structure
- **Fire insulation (I) is a time, expressed in minutes, during which an element of the building under fire conditions ceases to fulfil the function of safe isolation due to the excessively high temperature of the unheated surface**

The aim

The aim were focused on determining the influence of various mineral binders used to bind insulating boards of expanded perlite, with the aim to increase their fire resistance by extending the insulation time under cellulosic or hydrocarbon fire conditions

Expanded perlite composites

Materials

- expanded perlite insulating boards (800x400x50 mm^3) produced by Kadet Izolacje Ogniotrwałe
- boards were produced with the identical parameters of process but the used binders were characterized by varoius molar fractions of alkaline substances

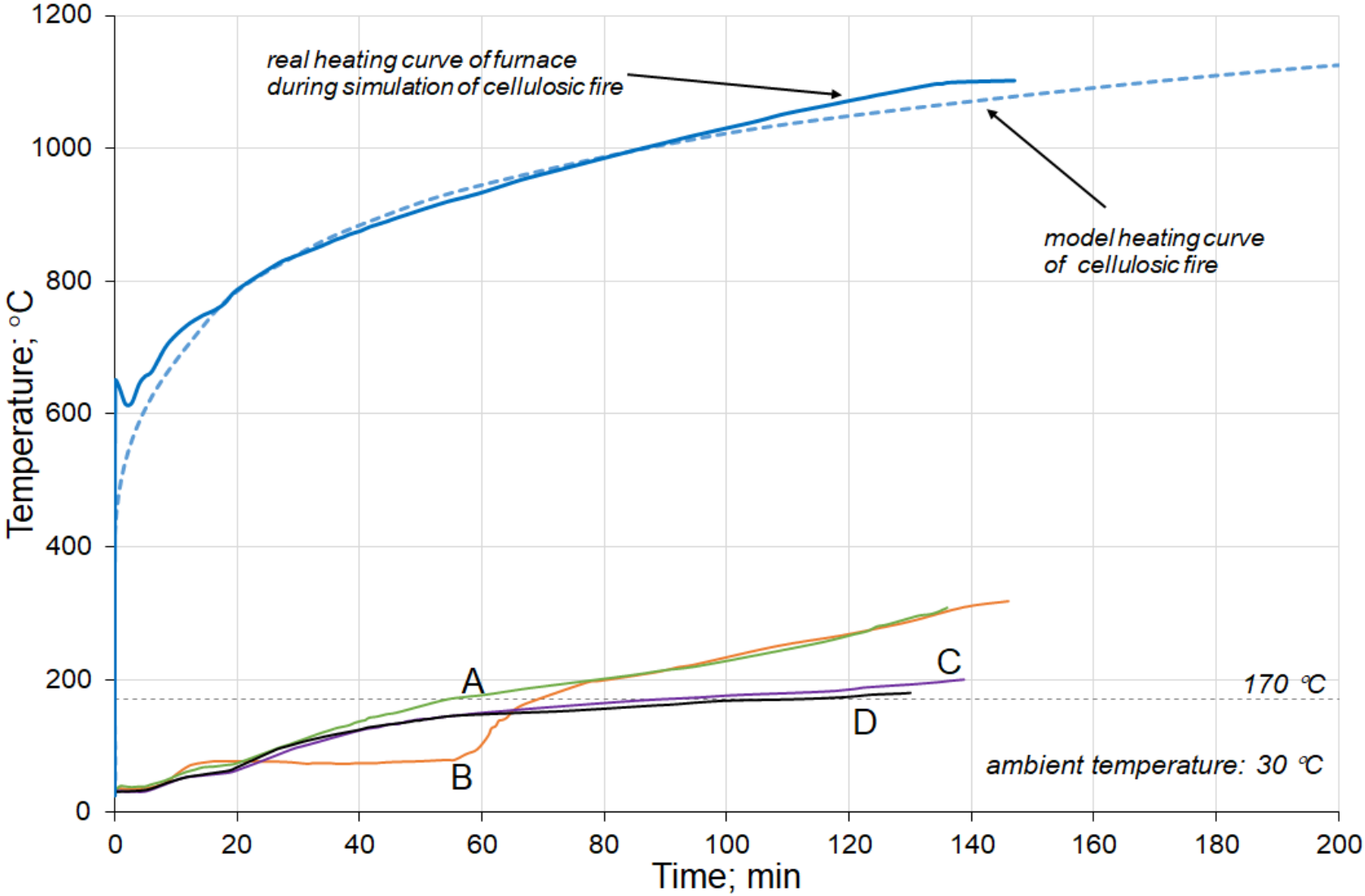
Property	Type of perlite board			
	A	B	C	D
Bulk density; g/cm^3	0.31	0.31	0.26	0.25
Apparent density; g/cm^3	0.33	0.30	0.27	0.24
Open porosity; %	80.9	83.7	84.3	87.8
Water absorbability; %	249	283	311	375
Compressive strength; MPa	1.0	0.9	0.8	0.4
Thermal conductivity λ; W/(mK)				
At ambient temperature	0.098	0.107	0.086	0.066
At 150°C	0.109	0.107	0.115	0.085
At 300°C	0.121	0.116	0.115	0.093

Methods

- special test stand which allowed to bring closer the temperature conditions under cellulose or hydrocarbon fire
- for the fire resistance criterion, the **fire insulation** was selected ie. the time after which the temperature increase by 140°C with reference to ambient temperature
- temperature measurements on the unheated surface of the perlite boards were made using a Raytek PM optical pyrometer with the emission factor of 0.80

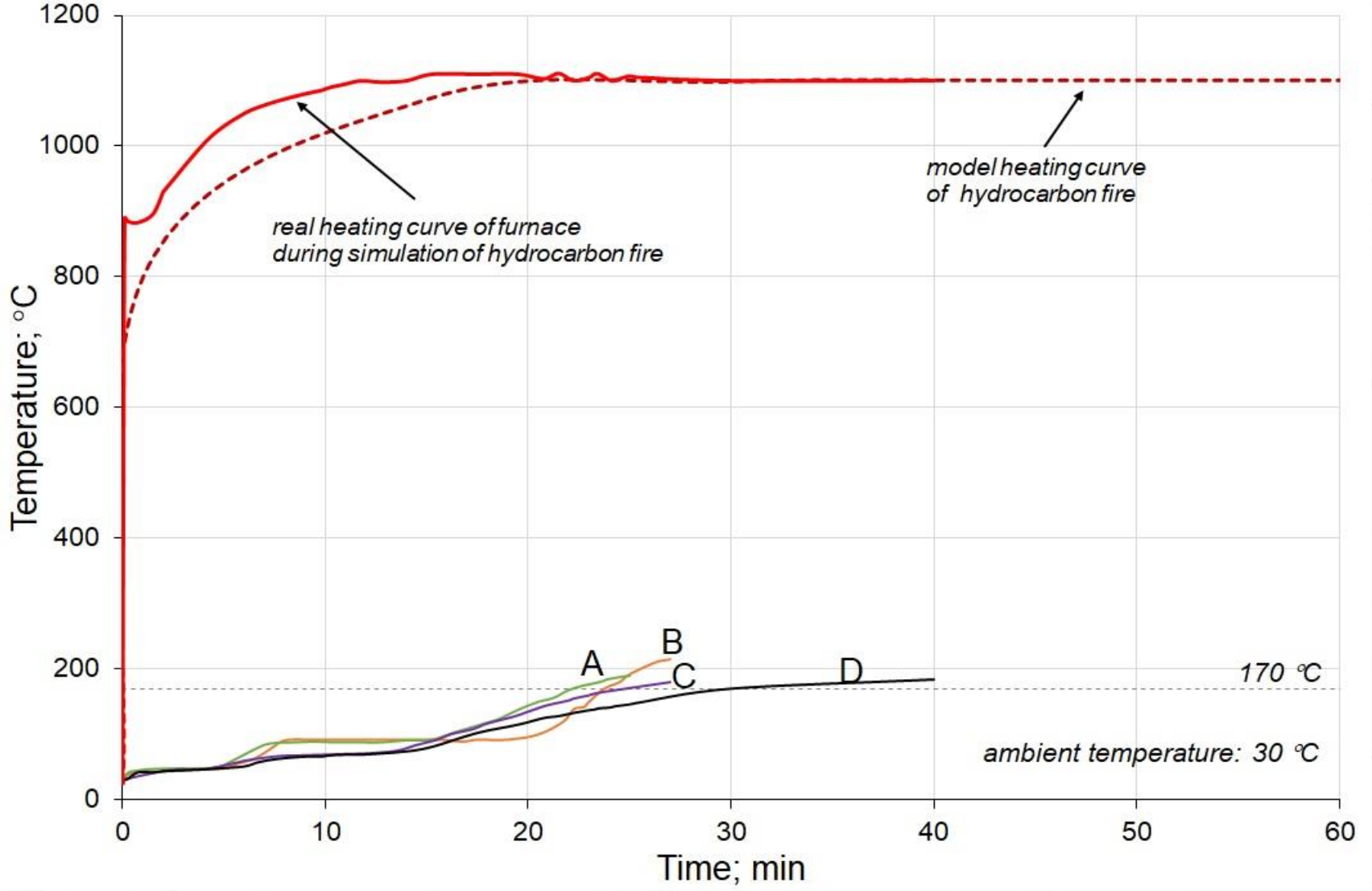
Test stand with mounted perlite board

Results – cellulosic fire



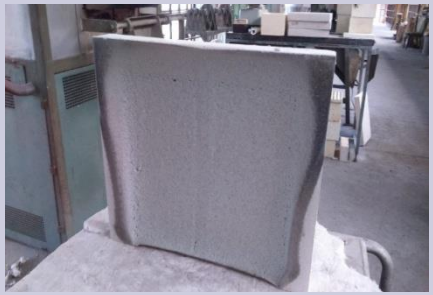
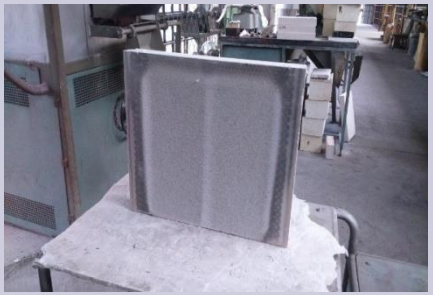
A = 54 min B = 70 min C = 85 min **D = 98 min**

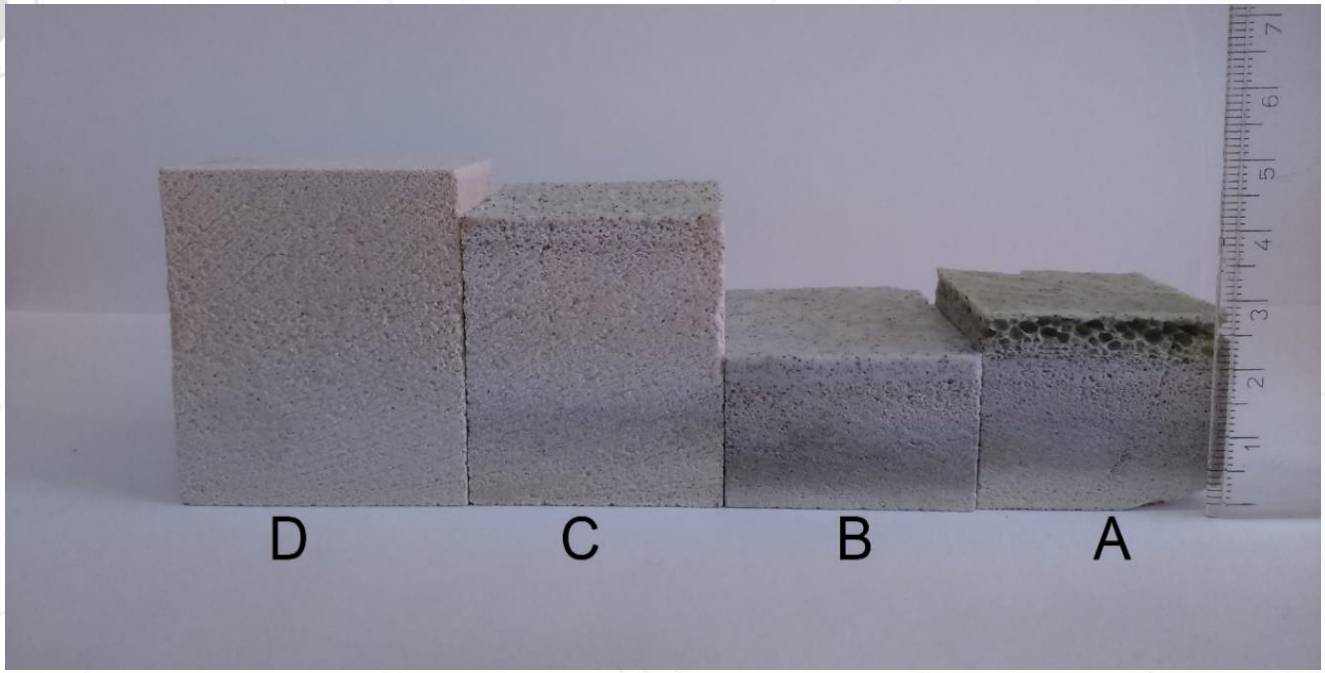
Results – hydrocarbon fire



A = 22 min B = 24 min C = 24 min **D = 30 min**

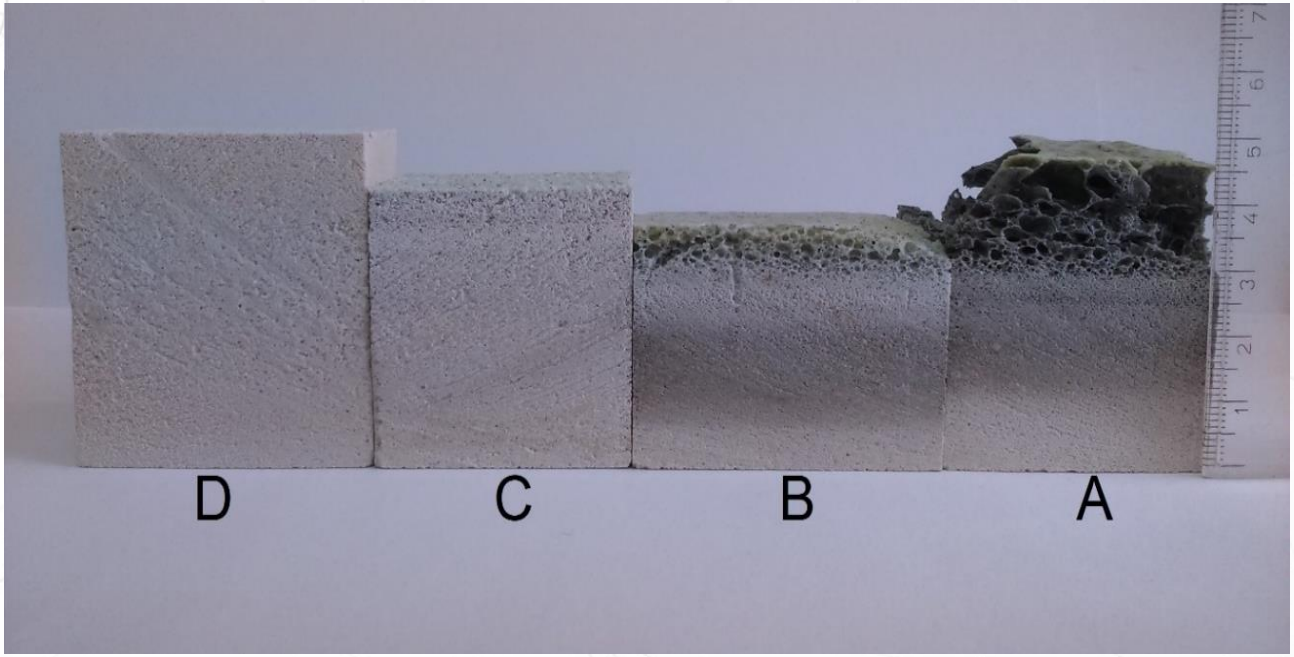
Materials after test – cellulosic fire

A	B	C	D
			



Materials after test – hydrocarbon fire

A	B	C	D
			



Conclusions

The results of the conducted investigations allow formulating the following conclusions:

- boards manufactured from expanded perlite and liquid mineral binders are light materials, characterized by good thermal insulation and fire resistance
- physical properties of the obtained perlite boards are similar to those of other products with similar applications
- physical properties and fire resistance of perlite products can be modelled and shaped with respect to specific applications, taking into consideration also the economic aspect
- use of different binders allow for shaped fire insulation time of perlite boards, esspecially against cellulosic fire

Acknowledgements

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