Faculty of Earth Science and Engineering

Institute of Raw Material Preparation and Environmental Processing

Preparation of geopolymer raw materials and its effect on the final product

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Geopolymer Camp, Saint-Quentin, France

9-11th July 2018

Contents

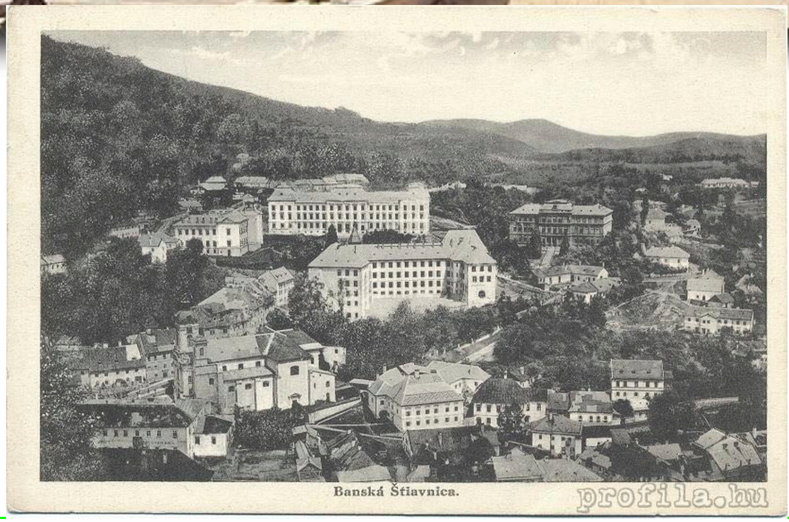
- Faculty and University
- Raw Materials
- Results:

  - Effect of various fly ash

  - Different mills

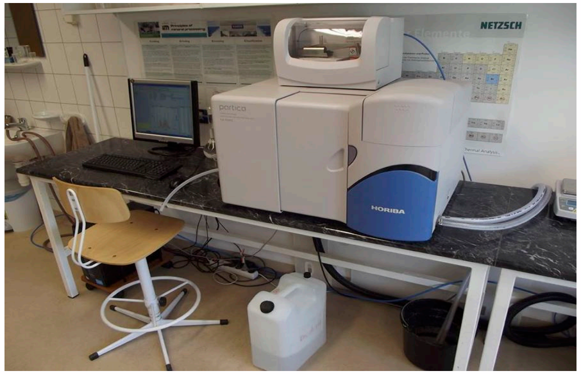
  - Synegetic utilization of wastes (geopolymer composites)
- Conclusions

University of Miskolc



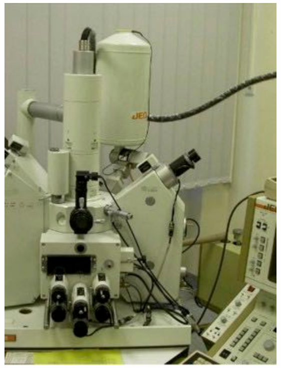
- Estabilished in *1735 (Selmecbánya)* **the** **first higher education institution of the world in field of mining.**
- 85 hectare, 700 lecturers, more than 10 000 students
- 8 Faculties (Mechanical and IT-, Earth Sciences-, Materials Sciences, Law, Economics, Fac. of Arts, Art of Music, Medical Fac.)

Center of Excellence for Sustainable Natural Resource Management



Focus areas

- Raw Matrial Management
- Energy management
- Geoinformation Processing
- Water Management and Sustainable Soil Utilisation



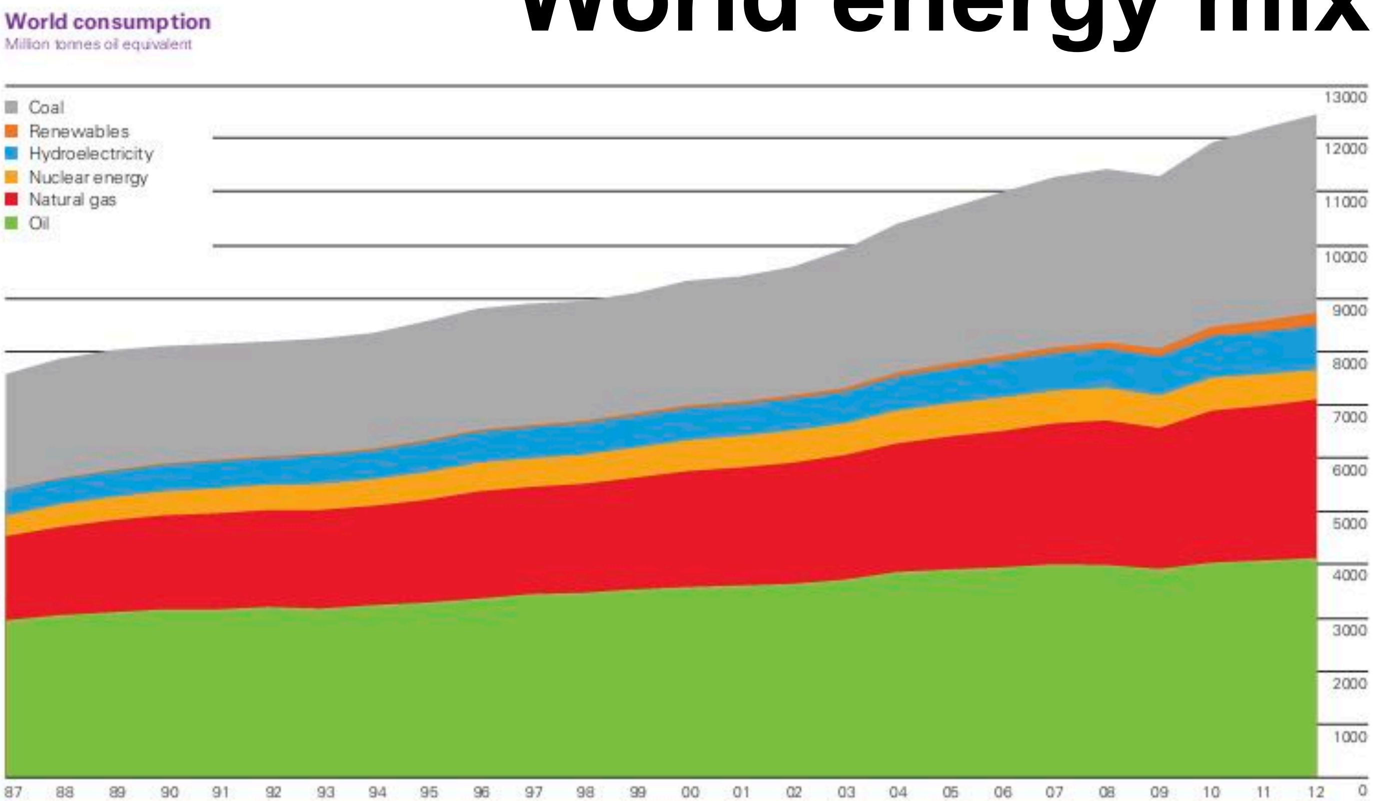
Research goal

1. To investigate the effect of Mechanical Activation (MA) of various fly ash with different origin (lignite, brown coal and black coal) on the geopolymerization using FTIR, XRD, SEM, ICC analytical tools and mechanical properties.
2. To study the device of MA in order to compare various mills, i. e. low, medium and high energy density mills.
3. To investigate the synergetic utilization of various waste based raw materials to develop geopolymer composites.

Raw materials

Fly ash and other industrial waste materials

World energy mix



World primary energy consumption grew by a below-average 1.8% in 2012. Growth was below average in all regions except Africa. Oil remair
accounting for 33.1% of global energy consumption, but this figure is the lowest share on record and oil has lost market share for 13 years in a
and other renewables in power generation both reached record shares of global primary energy consumption (6.7% and 1.9%, respectively).

Fly ash land fill,
Visonta (Hungary)

Basic problem

Power station fly ash - **800 million tons** yearly.
Steel slag - **450 million tons** (280 million t iron- and 170 million t steel industry).

EU regulations, it is crucial to develop **new technologies** that allow the **recycling** of various industrial **by-products** (coal fly ash and steel slag) into **added-value products**.

Another important goal of the European Union is to **reduce** significantly the **CO_2 footprint**.

Two of the biggest CO_2 emission sources beside the **cement plants** (clinker burning, electric energy) are the **solid fired power stations** and the **iron/steel industry**.

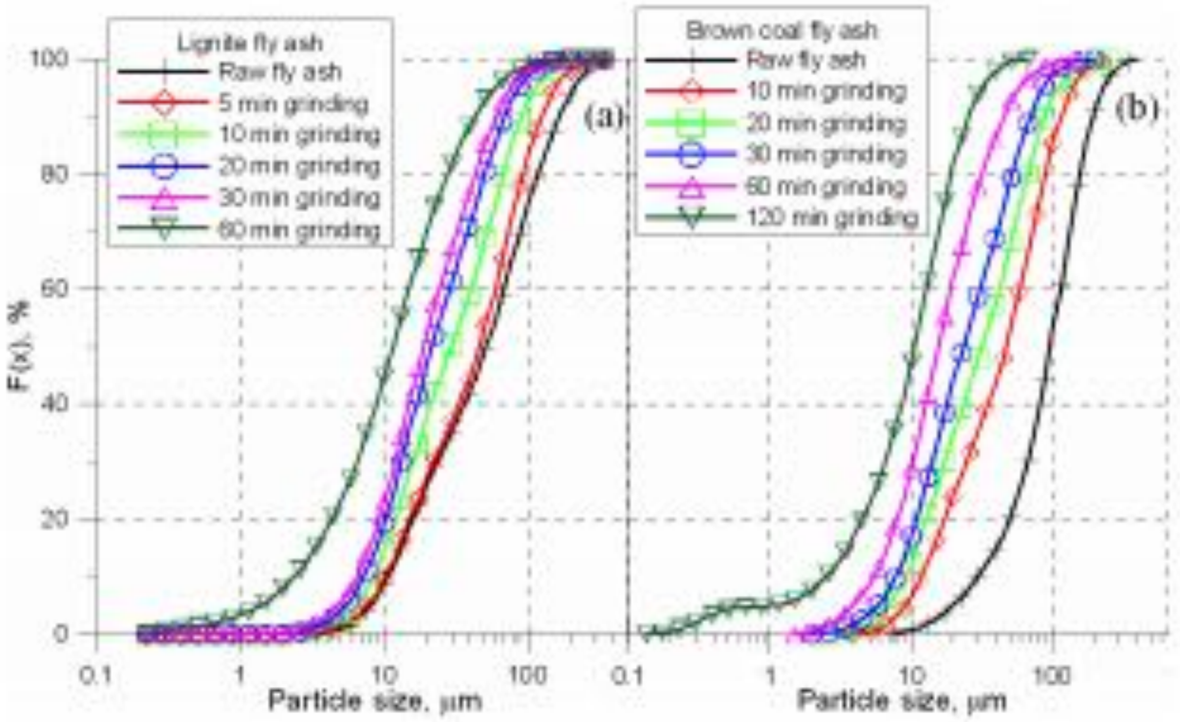
Target

Effect of **fine grinding** and **classification** on material/product properties (and reactions)!

Control reactivity!

Waste Recycling and **Advanced Minerals** by **Mechanical Activation** Research Group

Fly ash with different origin



Chemical composition of fly ash samples for main components. L.O.I. — loss on ignition

Fly ash	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	L.O.I.
brown coal	61.32	4.27	26.71	1.50	0.89	1.06	1.72	0.25	1.92
lignite	45.85	12.05	16.82	12.97	2.90	0.50	1.83	3.76	2.25

Vol. **126** (2014) *ACTA PHYSICA POLONICA A* No. 4

Proc. of the International Conference on Mechanochemistry and Mechanical Alloying, Kraków, Poland, June 22–26, 2014

Geopolymerisation of Mechanically Activated Lignite and Brown Coal Fly Ash

G. Mucsi[a,*], Z. Molnár[a] and S. Kumar[b]

[a]Institute of Raw Material Preparation and Environmental Processing, University of Miskolc, Hungary

[b]CSIR-National Metallurgical Laboratory, Jamshedpur, India

Fly ash with different origin

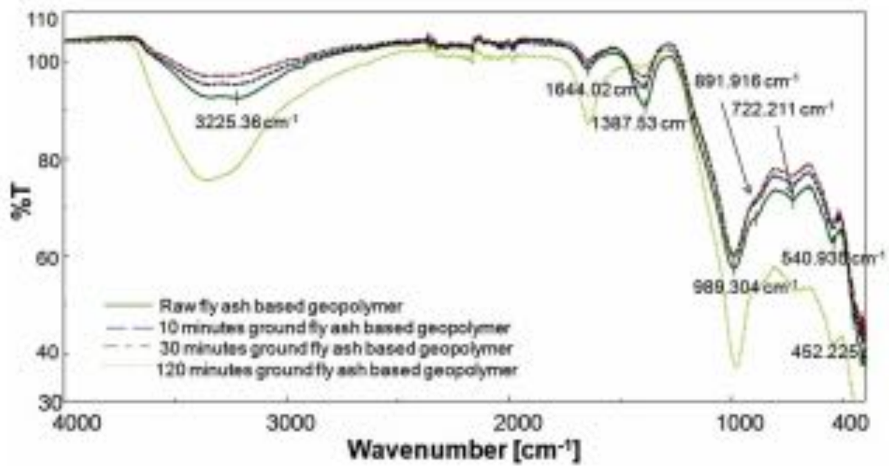


Fig. 3. Brown coal fly ash based geopolymer.

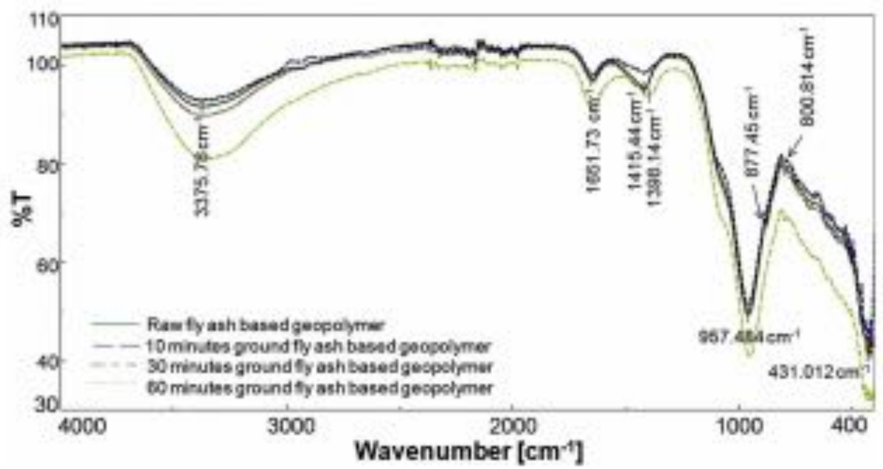


Fig. 4. Lignite fly ash based geopolymer.

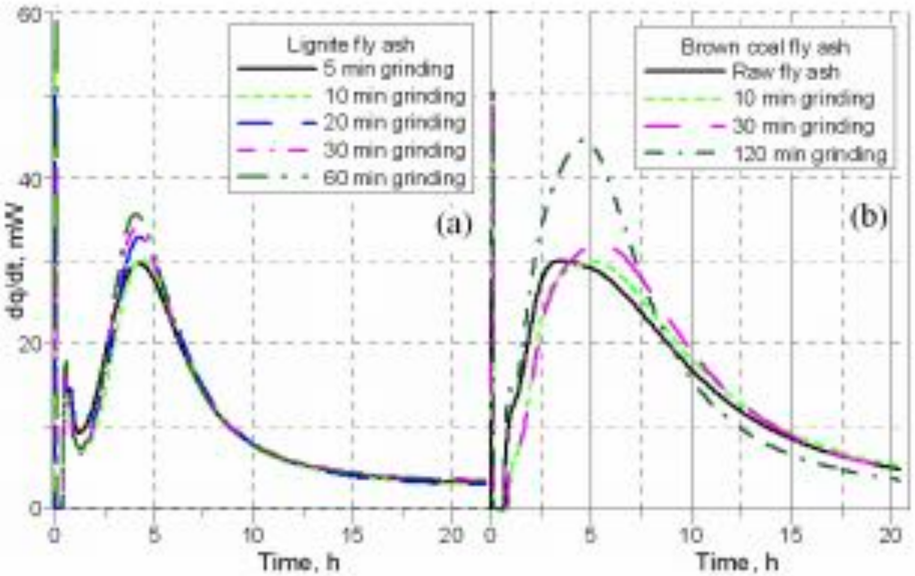
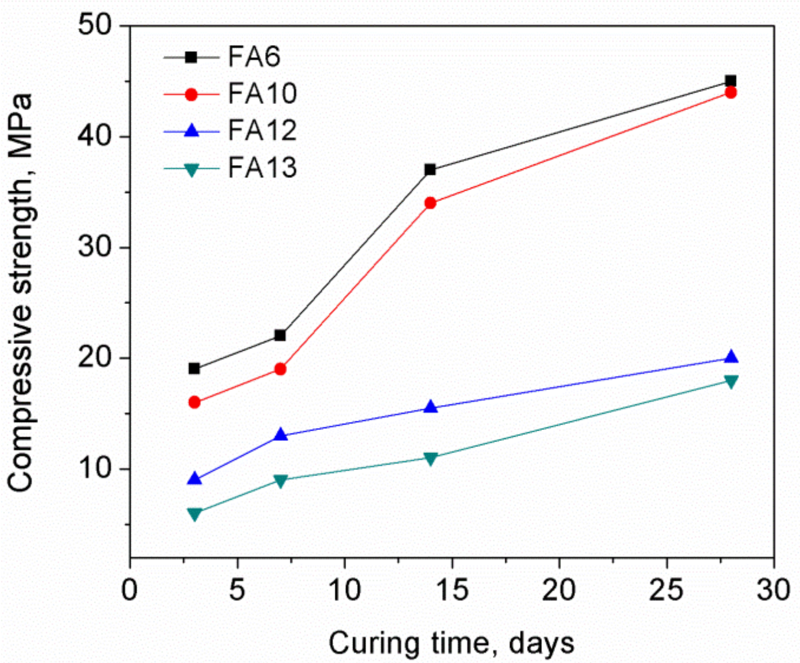


Fig. 5. ICC results of (a) lignite and (b) brown coal fly ash.

Effect of classification



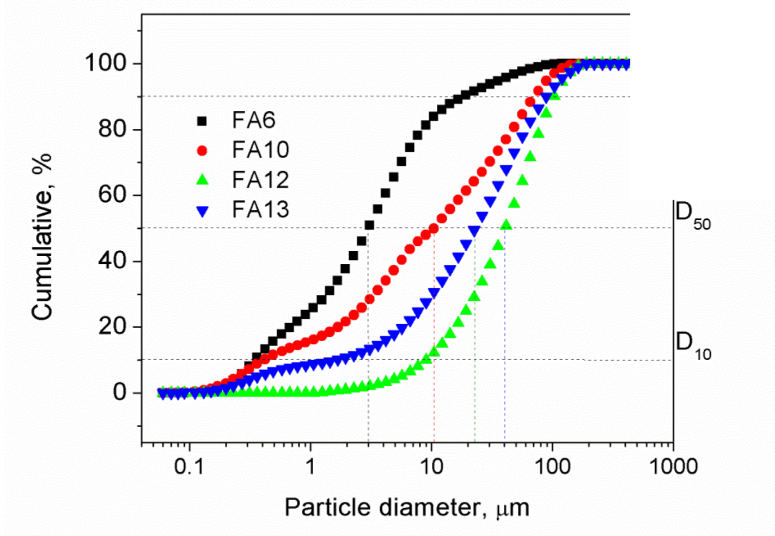
Advanced Powder Technology

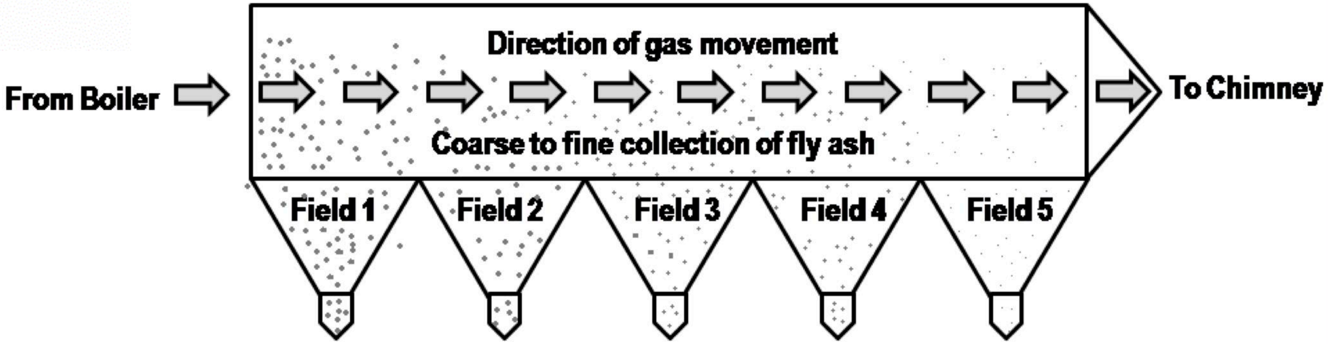
Volume 26, Issue 1, January 2015, Pages 24-30

Original Research Paper

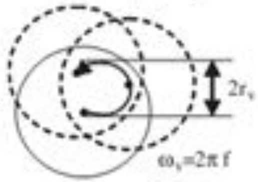
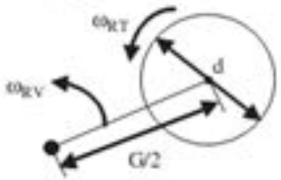
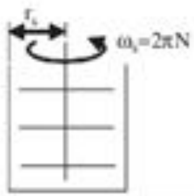
Geopolymerisation behaviour of size fractioned fly ash

Sanjay Kumar [a], Ferenc Kristály [b], Gabor Mucsi [b]





Control of final product properties by grinding

Driving method	Machine name	Mechanism	Maximum acceleration
Vessel drive	Tumbling ball mill (rotating vessel)		$a_{tum} = 1\,g$
	Vibrating ball mill		$a_{vib} < 30\,g$
	Planetary ball mill		$a_{pla} < 150\,g$
Agitator drive	Agitating ball mill		$a_{agt} <$ Hundreds of g

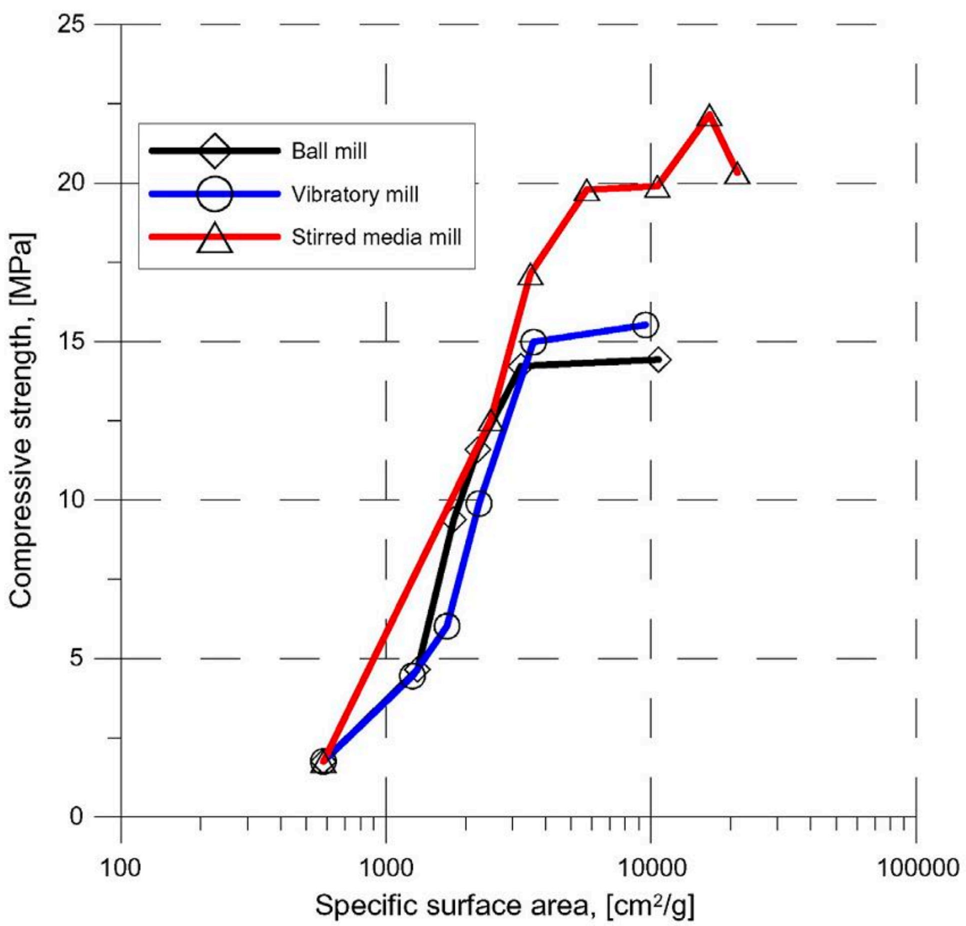
T. Yokoyama and Y. Inoue

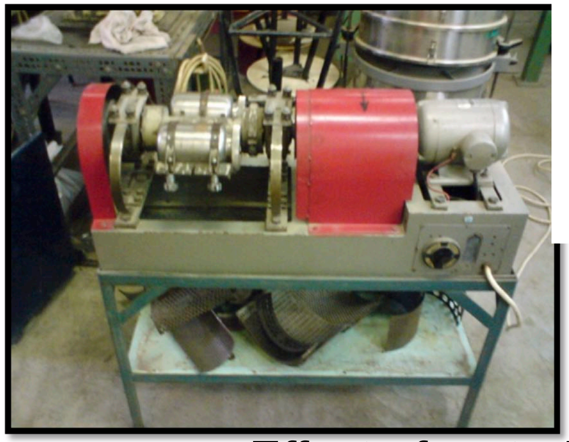
Stress intensity and stress number!

$$SI_{GM} = d_{GM}^3 \cdot \rho_{GM} \cdot v_t^2$$

$$SN_F^{**} = n\,t\,\frac{(1-\varepsilon_{GM})x^3}{\varepsilon_{GM}(1-\varepsilon_a)d_{GM}^2\,\varphi_m}$$

Effect of various mills



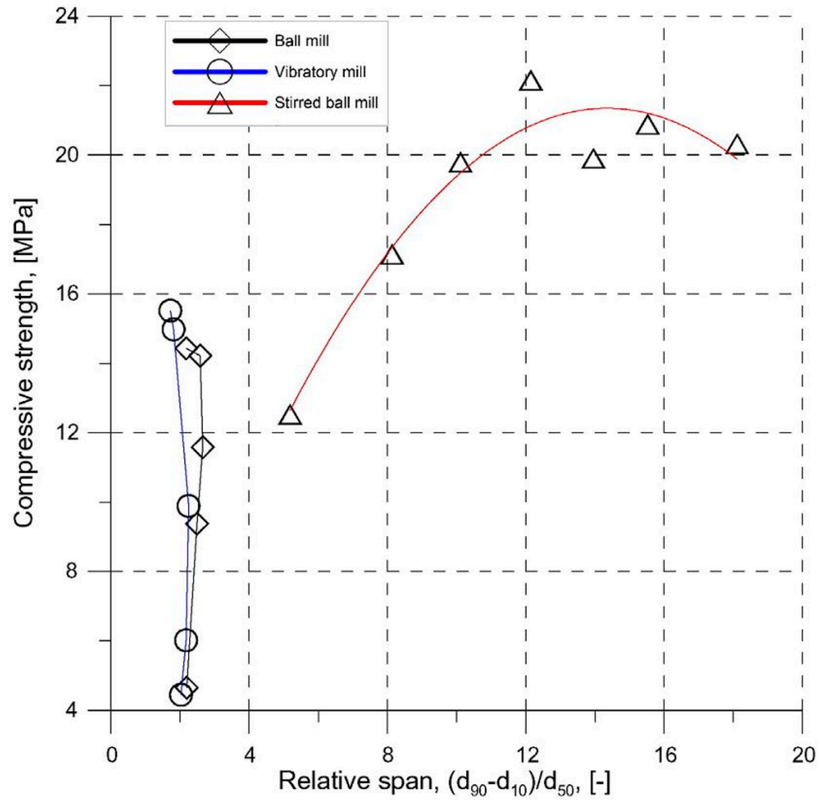


Effect of material fineness and mill type on geopolymer compressive strength!

Effect of various mills

Table 1
Chemical composition of deposited brown coal F-type fly ash originated from Tiszaújváros.

Composition	Fly ash, wt.%
L.O.I.	1.92
SiO_2	61.32
Fe_2O_3	4.27
Al_2O_3	26.71
CaO	1.50
MgO	0.89
Na_2O	1.06
K_2O	1.72
SO_3	0.25



Inter

Fig. 10. Geopolymer compressive strength as function of relative span.

Contents lists available at ScienceDirect

International Journal of Mineral Processing

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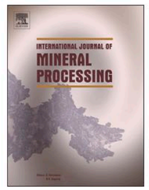


Control of geopolymer properties by grinding of land filled fly ash

CrossMark

Gábor Mucsi [a,*], Sanjay Kumar [b], Barnabás Csőke [a], Rakesh Kumar [b], Zoltán Molnár [a], Ádám Rácz [a], Ferenc Mádai [a], Ákos Debreczeni [a]

[a] *University of Miskolc, Miskolc, Hungary*
[b] *CSIR-National Metallurgical Laboratory, Jamshedpur, India*

Effect of various mills

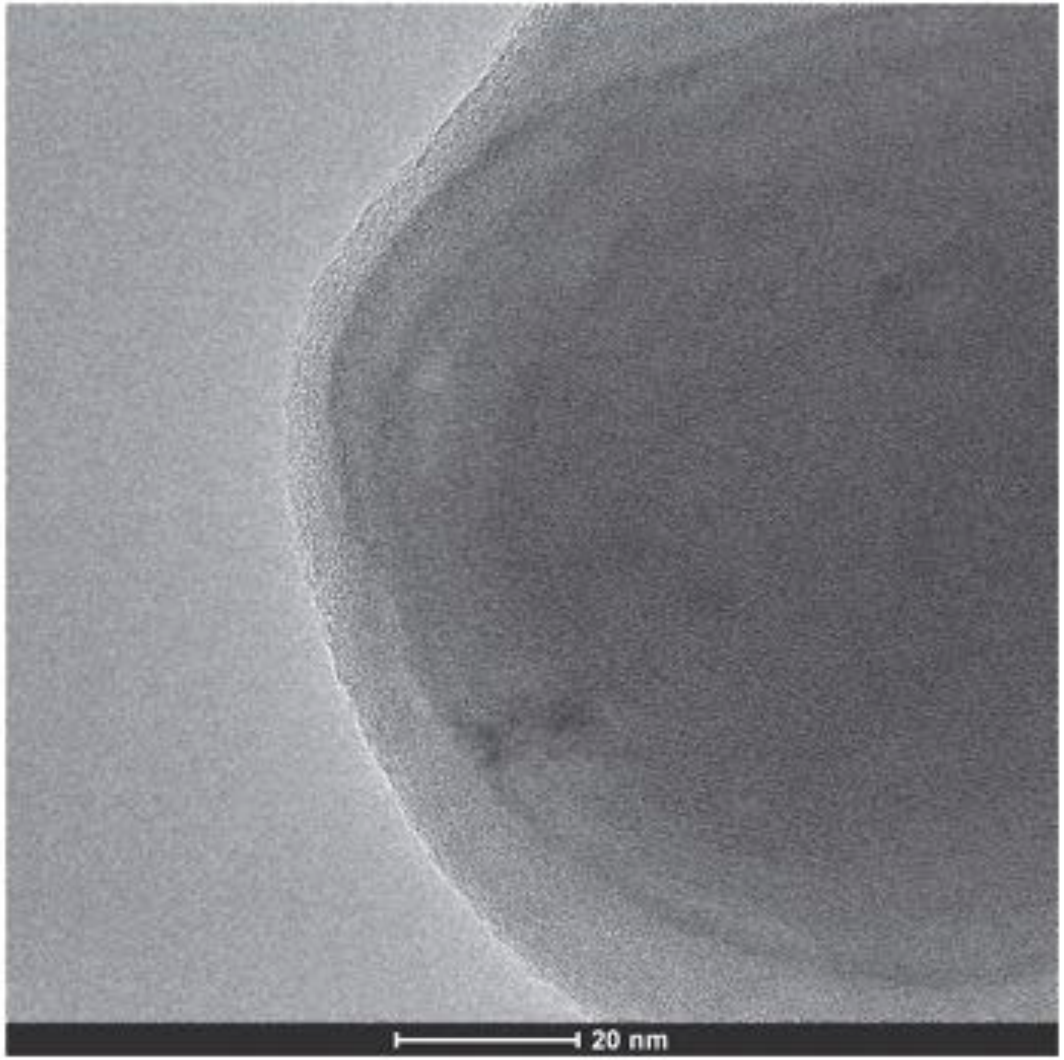
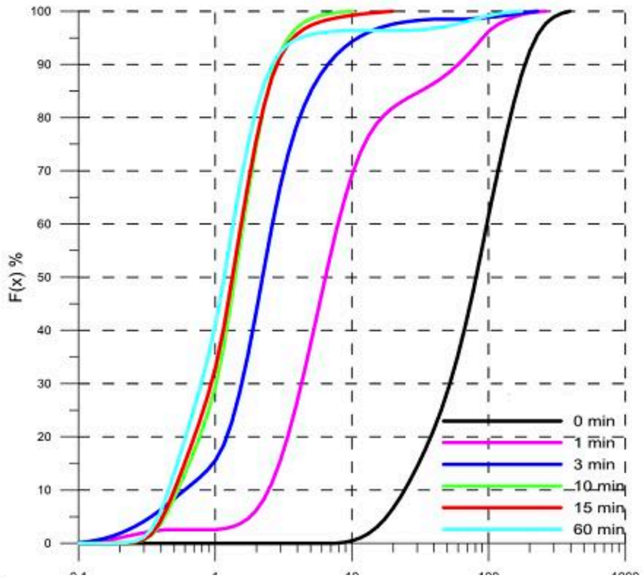


Fig. 2. TEM image of MA fly ash particle after 60 min grinding time [21]
2. ábra Mechanikailag aktivált pernye szemcse TEM felvétele 60 perces őrlést követően [21]

Effect of various mills



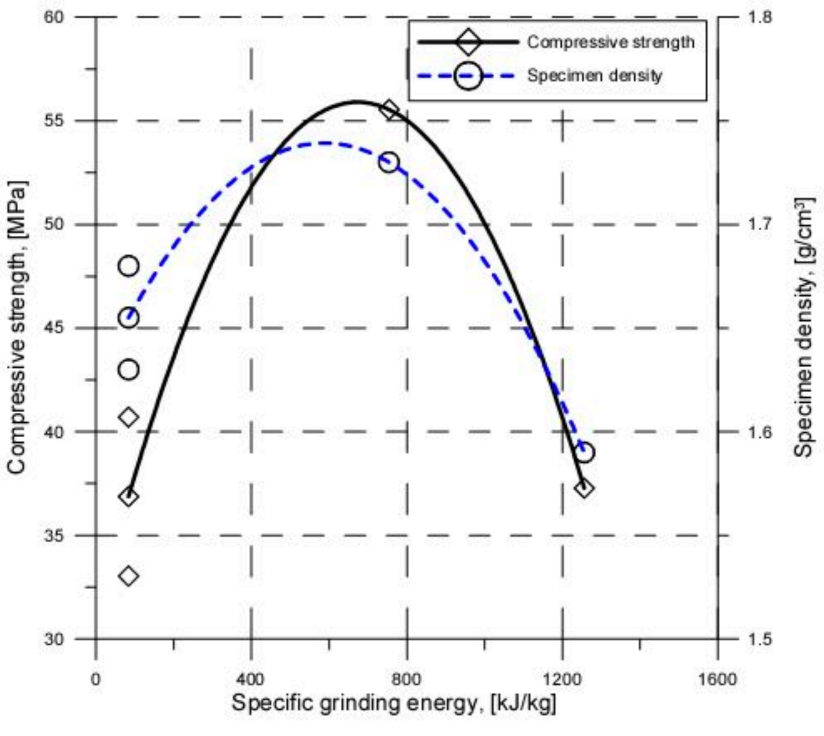
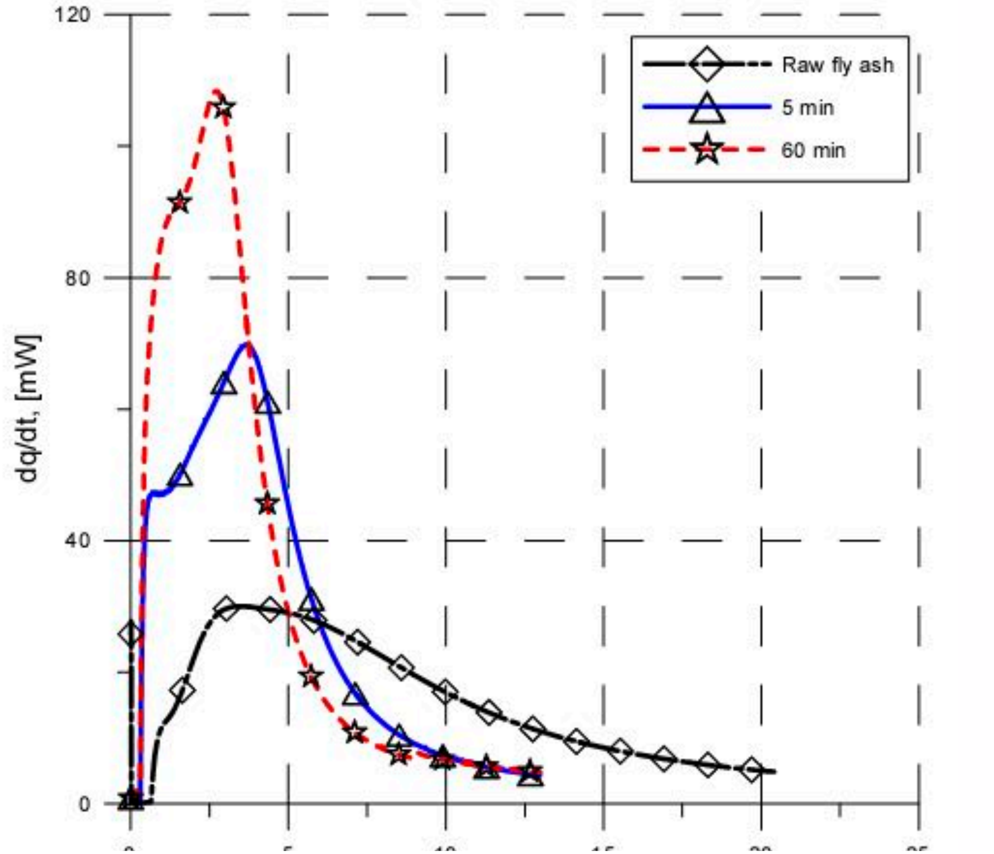


Figure 5 – Geopolymer physical properties



IMPC 2016: XXVIII International Mineral Processing Congress Proceedings - ISBN: 978-1-926872-29-2

EFFECT OF MECHANICAL ACTIVATION OF FLY ASH ON GEOPOLYMER PROPERTIES

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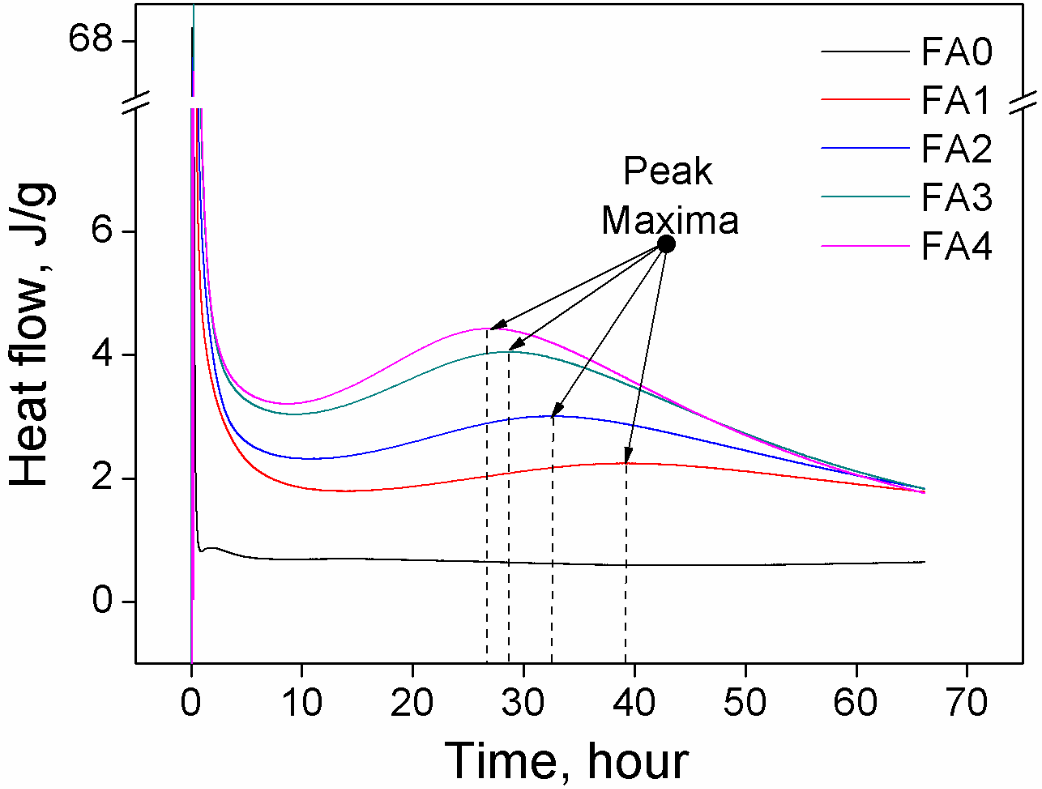
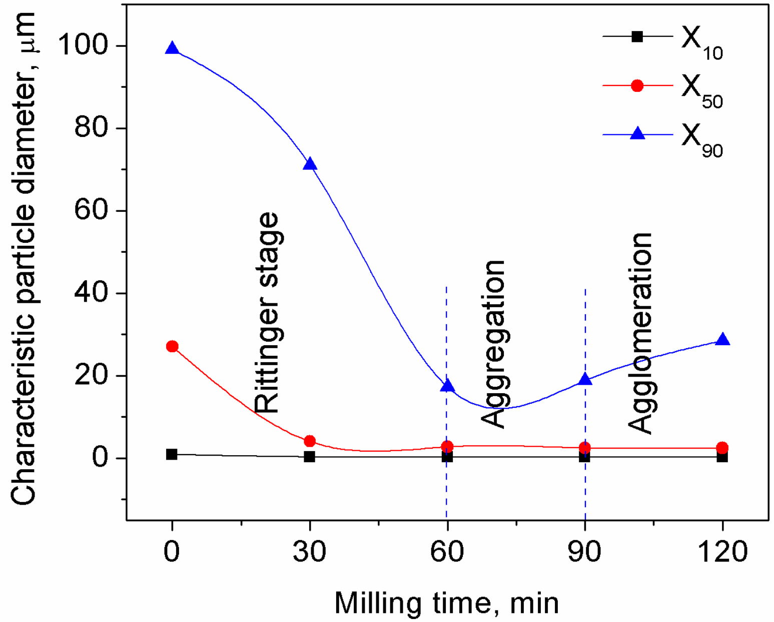
* *Corresponding author: E-mail: ejtmucsi@uni-msikolc.hu*

[2] *CSIR-National Metallurgical Laboratory, Jamshedpur, India*

Effect of various mills





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Advanced Powder Technology
Volume 28, Issue 3, March 2017, Pages 805-813
Original Research Paper

Mechanical activation of fly ash and its influence on micro and nano-structural behaviour of resulting geopolymers

Sanjay Kumar [a], Gábor Mucsi [b], Ferenc Kristály [b], Péter Pekker [c]

Synergetic utilization of varius wastes

Geopolymer concrete from fly ash and steel slag – GOP project (2013 - 2014)

Mining Science, vol. 21, 2014, 43−55

www.miningscience.pwr.edu.pl

Mining Science
(previously Prace Naukowe Instytutu Górnictwa Politechniki Wrocławskiej. Górnictwo i Geologia)

ISSN 2300-9586
previously 0370-0798

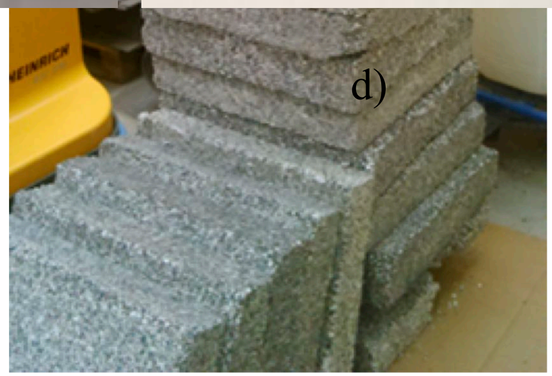
Received: April 7, 2014, accepted: 27 August, 2014

SYNERGETIC USE OF LIGNITE FLY ASH AND METALLURGICAL CONVERTER SLAG IN GEOPOLYMER CONCRETE

Gábor MUCSI[1*], Ádám RÁCZ[1], Zoltán MOLNÁR[1], Roland SZABÓ[1], Imre GOMBKÖTŐ[1], Ákos DEBRECZENI[2]

Polystyrene waste recycling– PIAC (2014 - 2016)

a)



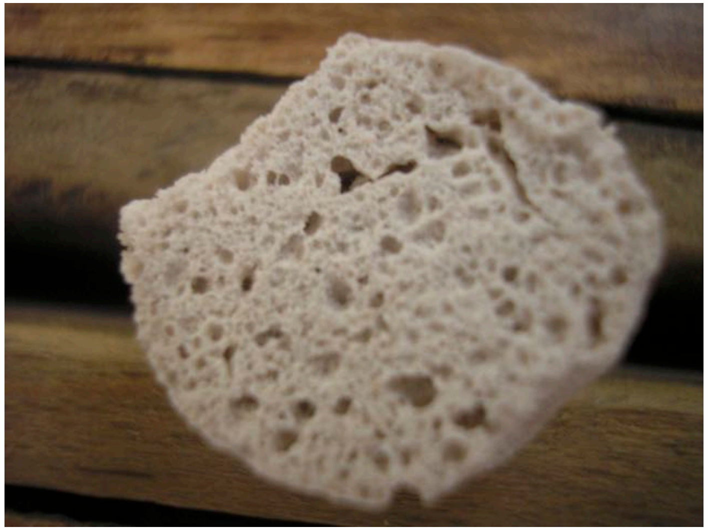
d)

IMST 2017 IOP Publishing
IOP Conf. Series: Materials Science and Engineering **251** (2017) 012079 doi:10.1088/1757-899X/251/1/012079

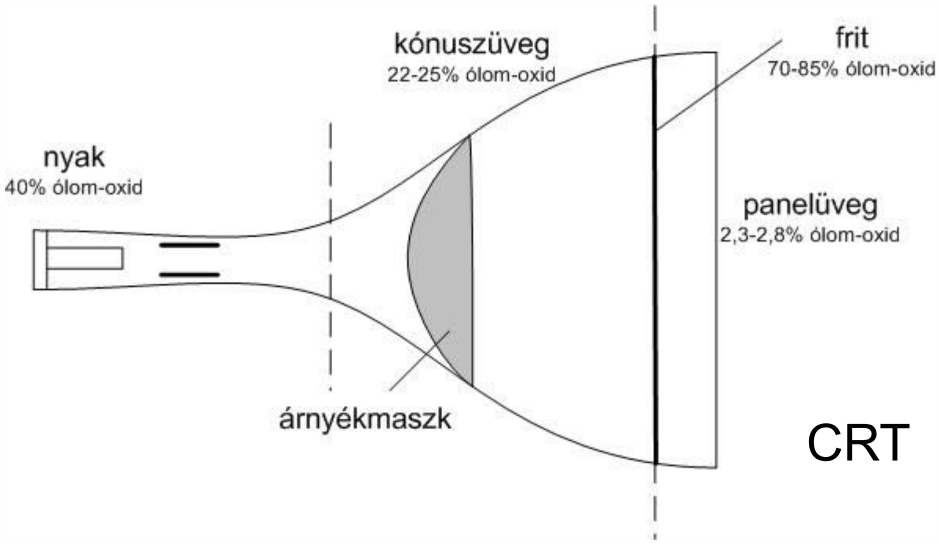
Development of polystyrene-geopolymer composite for thermal insulating material and its properties with special regards to flame resistance

G Mucsi[1], R Szabó[1], S Nagy[1], K Bohács[1], I Gombkötő[1], Á Debreczeni[2]

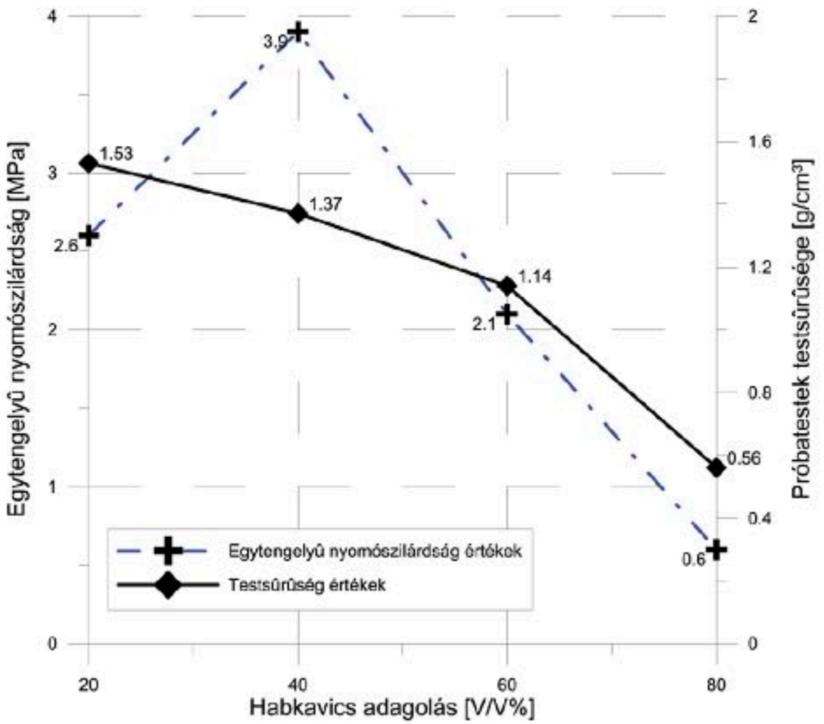
Glass foam from waste



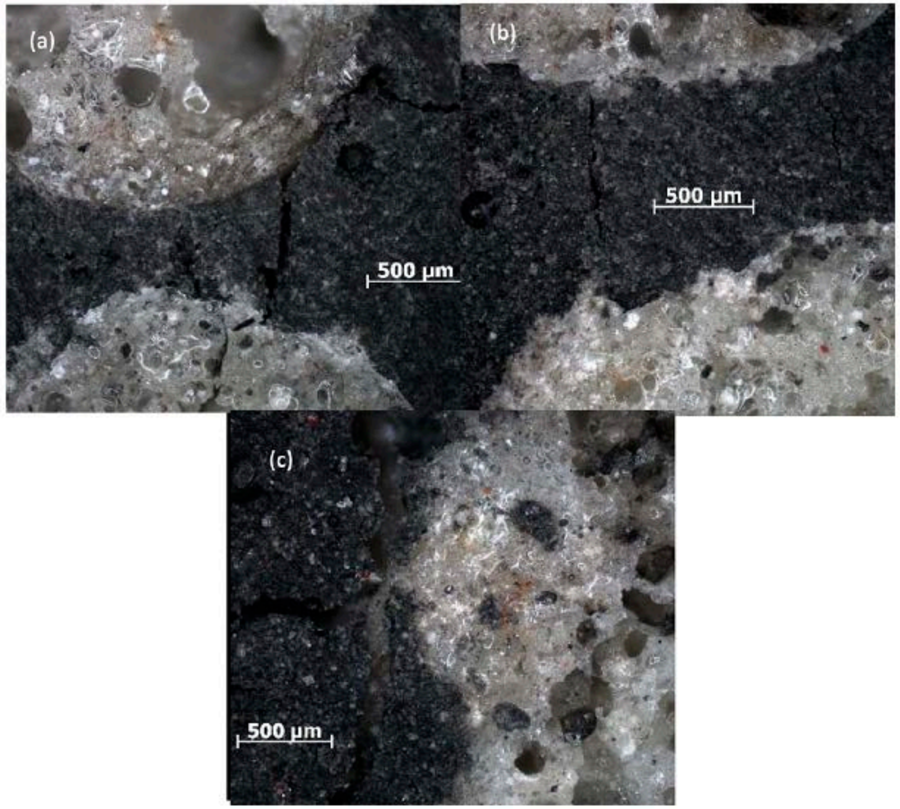
The recycling ratio by 2035
should be 80-90 % from 25 %!!!



GP – GlassFoam composite (2015 -)



6.ábra *Geopolimer kompozit próbatestek 7 napos nyomószilárdságának és testsűrűségének változása a4-6 mm-es habkavics adagolási arány függvényében*
Fig. 6. *Variation of 7 day compressive strength and specimen density of geopolymer composites consisting of 4-6 mm size glass foam particles*



8. ábra *(a) 2-4 mm; (b) 4-6 mm és (c) 6-8 mm habkavics frakciókat tartalmazó minták optikai mikroszkópos felvételei*
Fig. 8. *Optical microscopy images of geopolymer composites consisting of glass foam size fractions (a) 2-4 mm, (b) 4-6 mm, (c) 6-8 mm*

Geopolimer alapú kompozit fejlesztése melléktermékekből

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Érkezett: 2015. 12. 22. ▪ Received: 22. 12. 2015. ▪ http://dx.doi.org/10.14382/epitoanyag-jsbcm.2016.5

Development of geopolymer based composite from secondaries

Geopolymer foam

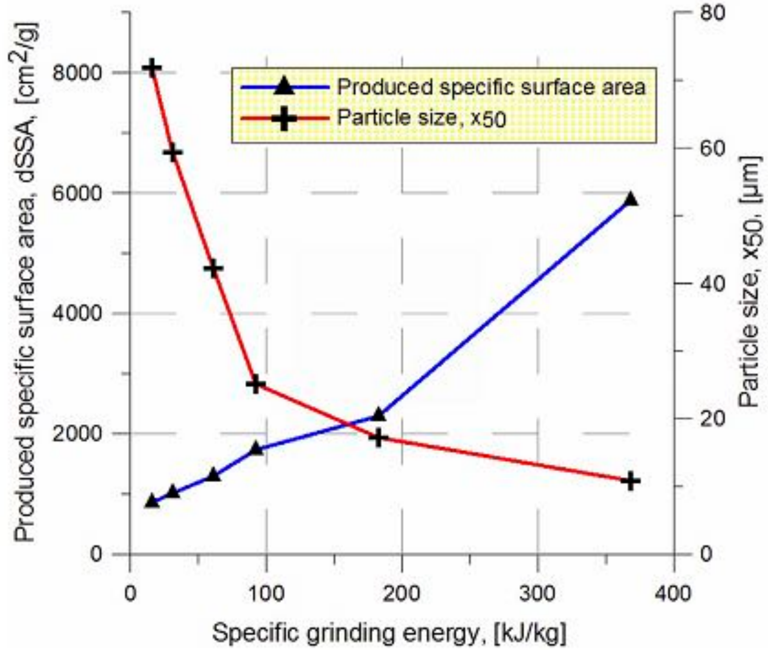


Fig. 2. Grinding kinetics of fly ash

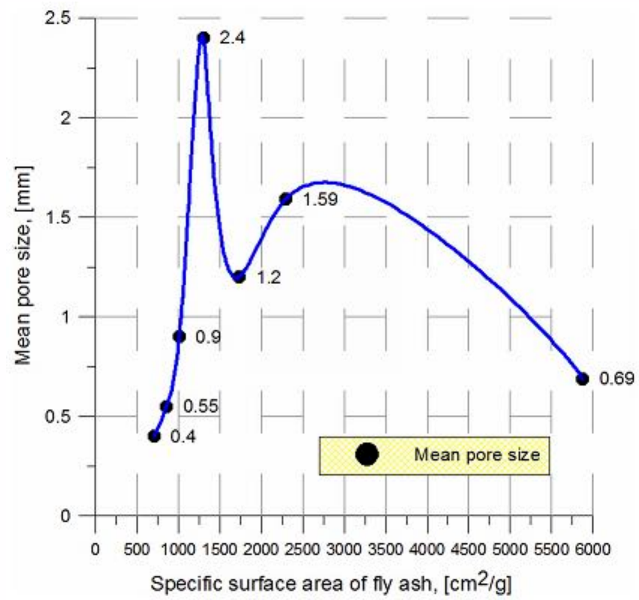


Fig. 5. Mean pore size of geopolymer foam

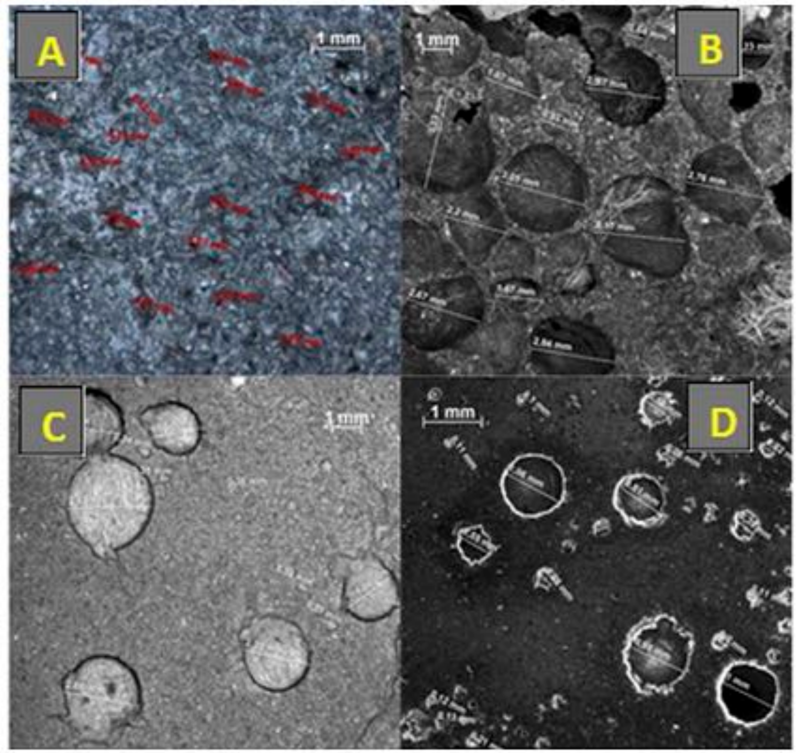


Fig. 6. Optical microscopy images of GPF (A. 0 min, B. 20 min, C. 60 min, D. 120 min grinding time of fly ash)

Arch. Metall. Mater. **62** (2017), 2B, 1257-1261

DOI: 10.1515/amm-2017-0188

R. SZABÓ*[#], I. GOMBKÖTŐ*, M. SVÉDA**, G. MUCSI*

EFFECT OF GRINDING FINENESS OF FLY ASH ON THE PROPERTIES OF GEOPOLYMER FOAM

Fiber reinforced geopolymer from waste tyre (2015 - 2016)

Journal of Cleaner Production 178 (2018) 429–440

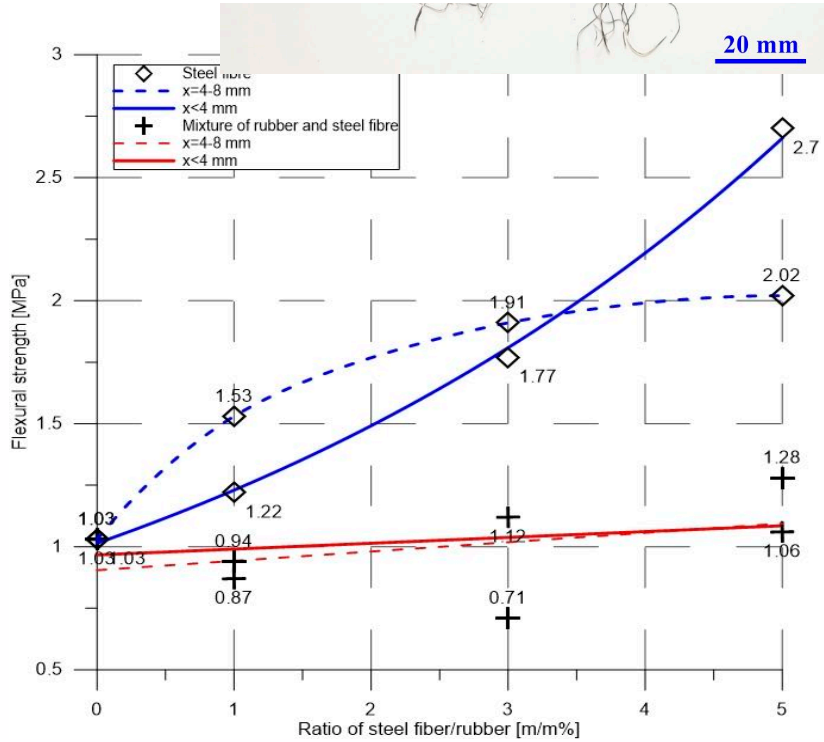
Contents lists available at ScienceDirect

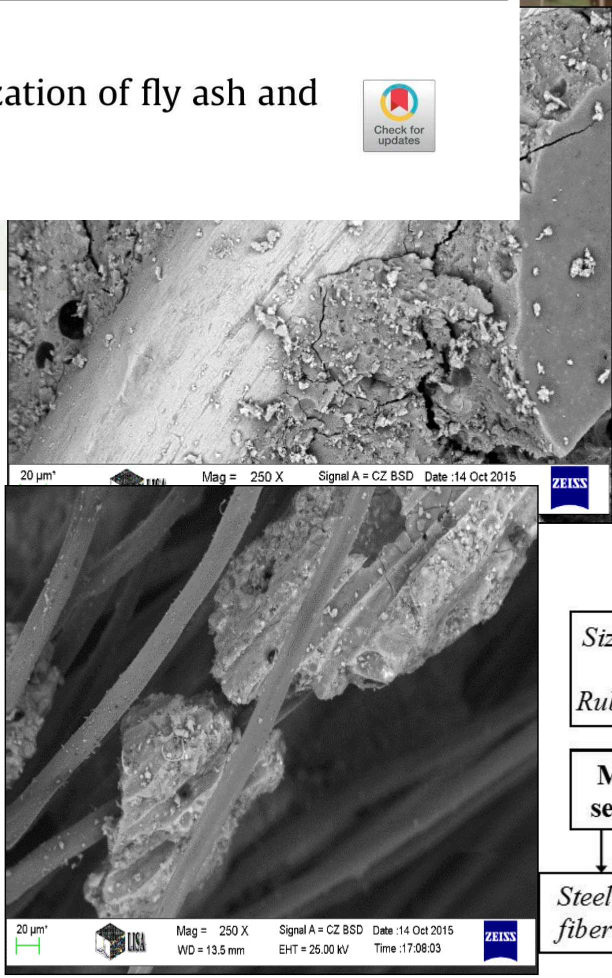
Journal of Cleaner Production

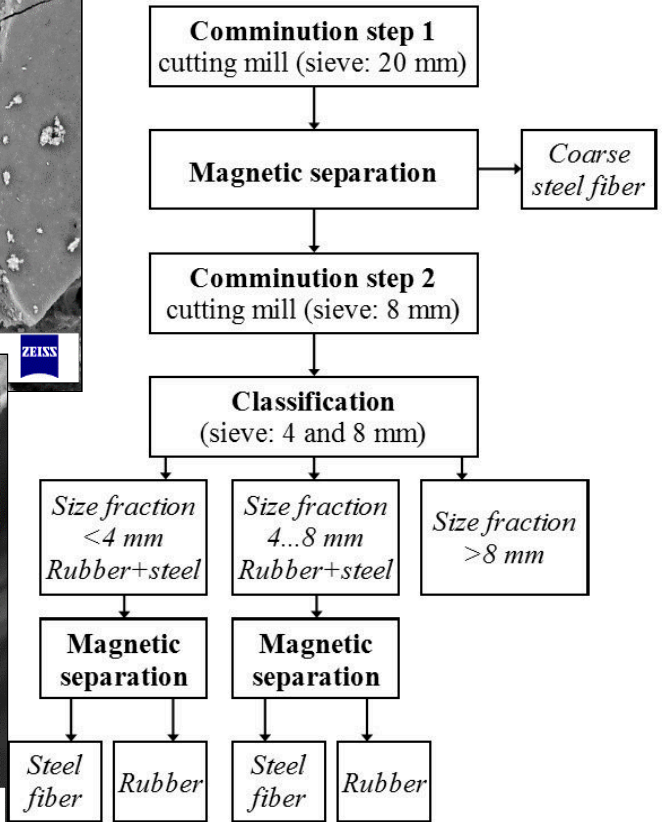
journal homepage: www.elsevier.com/locate/jclepro

Fiber reinforced geopolymer from synergetic utilization of fly ash and waste tire

Gábor Mucsi*, Ágnes Szenczi, Sándor Nagy







Conclusions

The following conclusions can be drawn from the research results:

• due to the fine grinding (mechanical activation) of fly ash, the activity can be readily controlled,

• mechanical activation of the raw fly ash has a positive effect on the geopolymerisation, the fly ash fineness - compressive strength relation curve has maximum

• synergetic utilization of various wastes is a feasible way to produce geopolymer composites with better properties.

Thank you for your attention!

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The described work/article was carried out as part of the „**Sustainable Raw Material Management Thematic Network – RING 2017", EFOP-3.6.2-16-2017-00010** project in the framework of the Széchenyi2020 Program. The realization of this project is supported by the European Union, co-financed by the European Social Fund.