



18th International Conference on Rehabilitation and Reconstruction of Buildings 2016, CRRB  
2016

## Experimental Verification of Utilization of Fly Ash from the Flue Gas denitrification process as a filler to epoxy patching mortar

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### Abstract

The paper deals with the possibility of using of the fly ashes, which is formed by the high-temperature combustion and contaminated by a denitrification process. The main aim of this work is to verify the application of these fly ashes as a filler for polymer patching mortar to achieve as the ecological and the economical requirements, as it is the most considered theme of a present. The maximum possible proportion of the fly ash is determined by experimental testing of the physical and mechanical properties of the epoxy patching mortar. Bulk density and strength properties are determined and on the basis of the test results of the flexural and compressive strength the possibility of replacing the commonly used filler, quartz sand Dorsilit, by the contaminated fly ash is assessed. Furthermore, application of X-ray tomography (CT scanner) for distribution of the fly ash particles and for pore-related characterization in the epoxy matrix was explored in this paper.

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Peer-review under responsibility of the organizing committee of the 18th International Conference on Rehabilitation and Reconstruction of Buildings 2016

*Keywords:* epoxy resin; fly ash; denitrification process; flexural strength; compressive strength; bulk density; patching mortar; microstructure

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### 1. Introduction

With the discovery of a toxicity ratio for nitrogen oxides (NO<sub>x</sub>), contained in flue gases, interest in their production process research has increased, and on the basis of this research even new technologies for their removal

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are developed. The crucial change came after the Czech Republic entered the European Union (EU), if it had to comply with emission limits according to Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (integrated pollution prevention and control). This directive, valid since January 1, 2016 sets more strict emission limits for combustion plants with a thermal power above 50 MW.

Under the term nitrogen oxides, generally designated as NO<sub>x</sub>, we most often think of nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). Caneghem et al. [2] stated that in industrialized countries, the primary anthropogenic source of NO<sub>x</sub> is fuel combustion with traffic and power generation being the most important sectors. The basic principle of NO<sub>x</sub> emission reduction lies in their production reduction, directly during the fuel burning process in the fireplace – primary measures, or in an application of the flue gas denitrification technology – secondary measures. Firstly, it is possible to reach the emission limits for NO<sub>x</sub> via primary measures – by burning process optimization, which generally means a significant increase in investment costs, which are often unacceptable. Hence the secondary measures are implemented – the removal of the already created NO<sub>x</sub> from the flue gas. However, this leads to the need a solution of another problem – the negative effect on fly ash or other waste products properties created during the process of burning.

Installation of denitrification technologies is predominantly performed for the purpose of the reduction of the negative effects on the environment, albeit mostly driven by the economic viewpoint of the entire process. For the purpose of investment minimalization into the secondary measures, technologies with the selective non-catalytic reduction (SNCR) method are often installed in the Czech Republic, during which an injection of an urea solution or ammonia water (NH<sub>3</sub>) into the burning chamber is performed and so the result is a reduction of NO<sub>x</sub> to nitrogen and water. It has been demonstrated [1] that denitrification (DeNO<sub>x</sub>) efficiency of the high-temperature SNCR process is just approximately 30 - 40% in practice and cannot meet the requirements of the emission standards by itself; a selective catalytic reduction (SCR) reactor is usually required to meet the rigid emission standards. The crucial disadvantage of SNCR technology is its effect on the resulting quality of the produced fly ash, which, moreover, reacts boisterously in an alkali environment under a massive ammonia (NH<sub>3</sub>) release. Therefore it is impossible to use it as an active admixture for concrete as it was with fly ash, which was not contaminated by the effects of SNCR technology. Also because of this, new optimal areas for the use of this fly ash need to be found and the best would be in the construction industry, where fly ash is predominantly used. Nevertheless, the effective use of this fly ash represents a minimum risk for the environment and the maximum benefit for the practice.

One of the possibilities for the use of contaminated fly ash is to use it as a filler for patching mortars with polymer matrices, which has become the subject of our research.

## 2. Identification of the fly ash and sample preparation

The chemical composition of fly ash, influenced by the denitrification process from the thermal power plant burning powdered lignite, which was used for the experimental verification, is shown in Table 1. It is clear from the table that a large number of ammonia ions, contained in this fly ash, limit its further use in the construction industry – predominantly within applications which ordinarily use high temperature fly ash, unaffected by the DeNO<sub>x</sub> process.

Table 1. Chemical composition of the contaminated fly ash.

Parameter	Amount
Dry matter [%]	99.95
Ammonium ions [mg/kg dry]	3.79
Sulphates SO <sub>3</sub>	0.255
SiO <sub>2</sub> [% dry]	53.4
CaO [% dry]	4.13
Total organic carbon [% dry]	5.2
Hydrocarbons C <sub>10</sub> -C <sub>40</sub> [mg/kg dry]	<10

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