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Study of the dust produced in rehabilitation works

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Abstract

Urban rehabilitation is becoming more frequent nowadays. With cities full of falling buildings and no space to build new ones, the only solution is to rehabilitate the existing heritage in order to give new life to the vacant buildings and repopulate the cities. A large amount of the built heritage suffers from advanced degradation, making the recovery, increasing the complexity of the rehabilitation and restoration intervention and implying a highly specialized interdisciplinary component. In this type of works more dust is produced than in a new work. In addition, the origin and composition of existing materials is often unknown and can therefore pose many risks to the health of workers. Meaning, dust is breathable and can remain in the air for a long period of time, being invisible to the naked eye and very light. When a building is being demolishing, the production of dust increases significantly. Depending on the type of materials to demolish, the risk of occupational diseases, or risks, to the health of workers may be great. To avoid such risks, preventive measures must be taken in the execution of the tasks. In this study, the dust of two rehabilitation works in the district of Viana do Castelo was studied through experimental tests in order to verify the composition of the demolished materials. Particles characterization was done, using scanning electron microscopy (SEM). Then, with the tests results, the chemical composition of the existing materials was analyzed in detail. After that, the chemical components of demolished materials were carefully studied to identify which of these particles could represent a risk to the workers' health. As a conclusion the preventive measures that workers must take when performing rehabilitation works are presented, depending on what type of materials they are potentially exposed.

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1. Introduction

The objective of this article was to study the risks for the construction worker in rehabilitation or demolition jobs. According to P. Raposo (P., Raposo, P., Martins, J., Correia, J., Cristina Reis, et al, 2018), economic and cultural advantages can lead to the choice of preserve the built heritage but there are countless environmental hazards in construction that have consequences in regards to the health of workers. There is several operation conditions linked to the process, such as wet floors that can cause level drops, degraded equipment, the utilization of fragile equipment, and so on. Also, there are environmental conditions such as the presence of a dangerous substance, inadequate thermal environment, presence of noise, and so on.

This study is based in the analyses of dust from demolition and rehabilitation works on building in order to assess which health problems they can bring to the worker. The aim is to study the existing particles in order to understand the risks involved in its inhalation and the health problems that it can bring to the workers.

For this, several construction works, from different styles and years of construction, were chosen. The materials present in the collected dust were analyzed chemically and morphologically. With these results is intended to study the prevention measures and orientations directed to suitable procedures that aim a correct utilization by the workers and the employer.

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Nomenclature

nm	nanometer
SEM	Scanning electron microscope
EDS	Energy Dispersive Spectrometry
WDS	Weight Dispersive Spectrometry
DRX	X-Ray diffraction analyses

2. Rehabilitation

Urban rehabilitation is a way to keep heritage, in the whole or in a significant part of the territory, and to modernize it through remodeling or improvement, construction, reconstruction or altering the buildings.

Rehabilitation implies the removal of existing materials in the construction, replacing them for others. This rehabilitation allows cities to become more attractive and rejuvenated. This procedure implies, in several occasions, the demolitions of whole parts, which leads to the production of residue and dust. In current days, urban rehabilitation is seen by many authors as the best way to populate urban centers of big cities, avoiding the use of private transportation, adapting itself to the use of public transportation. Many times, what happens in rehabilitation works is the possibility of the existence of particles that stay in the buildings and that can present several components, depending on the types of materials existent in the construction, such as: gold, silver, titanium dioxide, copper, among others. These particles can present toxicity.

The development of studies to assess the impact of dust in public health and to know what the best preventive measurements to fight them are is an interesting case of study.

2.1. Materials used in rehabilitation

Many constructions dusts are classified as nano particles due to its dimension. According to Nuno Araújo Franco (2013), these are particles independent on its composition, shape, types of interactions and applications that present a nanometric size. According to Alberto Tielas (2014), the concept of nano particles and nanostructures that consist in particles with at least one dimension smaller that 100nm can influence biological, chemical and physical properties.

Depending on the type of construction works there are different materials in demolitions, at the time of its rehabilitation, such as: ceramic elements, cement glue, mortar, PVC pipes, bricks or ceramic tiles, concrete, metals, gypsum board, natural rocks, rock wool, paints, and so on.

For a fine characterization of the existing dusts in rehabilitation works it is necessary to characterize the materials and its chemical components and only after doing that it is possible to know if they are harmful or not to the health.

2.2 Materials with a toxic potential

From the literature of previous studies it is known that the grand hazard for human health that several materials present when in contact for long periods of time or in large quantities, can be found in diverse ways. The principal toxic components for public health are, for instance: asbestos, lead, silica, coal, iron oxide, barium sulfate and tin oxide, among others.

In construction and rehabilitation industry, the most common way to find these components is at the time of demolition, in the way of dust that travels through the air, to the air ways, or enter in direct contact with the body.

3. Methodology

In order to detect the content of particles and its hazardousness to human health, it was necessary to study the dust in some rehabilitation works. Two constructions were chosen, and dust from several phases and locals was collected. These collected dusts allowed the execution of tests with the chemical characterization of the materials as the final goal.

Two construction work's from different construction periods, were chosen being one, a recent villa in Afife, Viana do Castelo, and the other a villa built in the 50's at Quinta de Mujães, Viana do Castelo. Samples from these sites were collected and later analyzed using several types of tests that are described next.

For instance, see Fig. 1.

a  b 

Fig. 1. (a) Quinta de Mujães, Viana do Castelo; (b) Villa at Afife, Viana do Castelo.

4. Tests

There is a wide range of assays, each method focusing in more or less detail on certain characteristics to be studied, such as: physical, thermal, morphological, mechanical, tribological or chemical, like Scanning Electron Microscope (SEM); Dispersive Energy Spectroscopy, EDS; or Wavelength Detection, WDS; X-Ray Diffraction, XRD. In this study SEM was used for the analyses of the dust particles.

According to Monteiro (2005), SEM is a powerful tool used as support to scientific investigation, as well as in development and quality control of materials.

As for the EDS and WDS, Instituto Pedro Nunes (2013) claims that it allows determining the chemical composition of samples, of very small sizes, allowing for a punctual analysis. While the SEM allows us to visualize images, the EDS and WDS permit an immediate identification of its composition.

The X-Ray diffraction is a structural identification technique that allows for a quantitative and semi quantitative analysis of the components and its crystalline structure.

5. Discussion

Through the analysis of the images obtained by SEM, as it is possible to see in Figure 2, the samples of the kitchen on the house in Afife, had size heterogeneity.

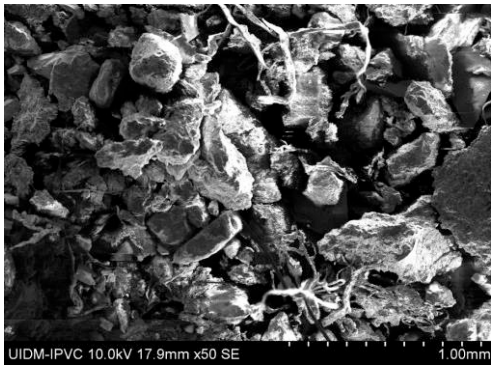

Fig. 2. Sample of the kitchen of the villa of Afife, Viana do Castelo 45X magnification.

Particles are identified in this sample and have different sizes, but there is not too pronounced differentiation.

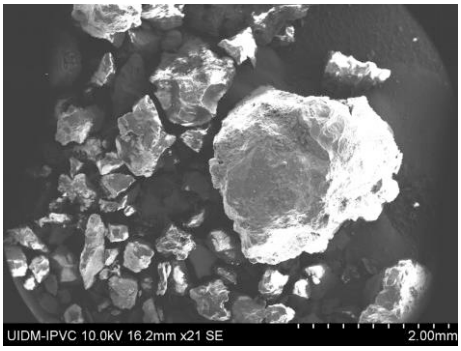

Fig. 3. Sample of the kitchen of the villa of Afife, Viana do Castelo 21X magnification

This sample has very different particle sizes. The shape of the particles is also very diverse, with the majority of particles showing a longer and sharper shape.

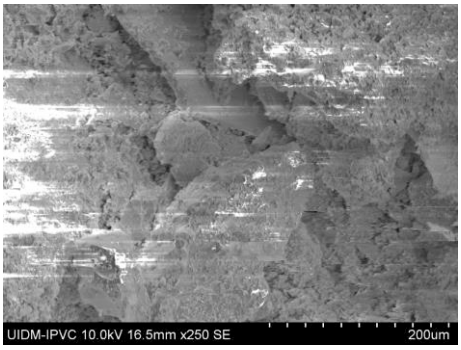

Fig. 4. Sample of the farm room of Mujões, Viana do Castelo 200X magnification

Observing this sample it may be considered that appears very homogeneous, in terms of particle sizes, being mostly small, a larger particle appears in the middle.

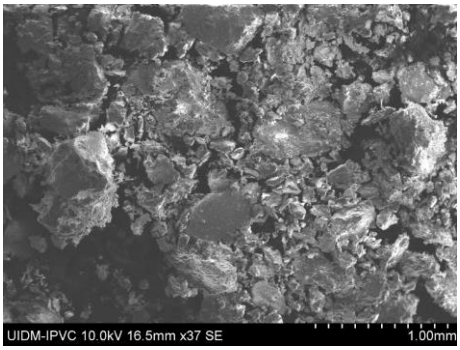

Fig. 5. Sample of the kitchen of the farm of Mujões, Viana do Castelo 37 X magnification.

This is a really heterogenic sample in what is concerned to the particles size. It presents very different sizes, as well as shapes.

Fig. 6. Fiber-cement roofing sample of Afife, Viana do Castelo house with 320X magnification

In this image it is possible to visualize a needle of asbestos fibers. The larger particles have 219,18 μm and the smaller ones 20,41 μm. The shape of the particles is rounded and they are dispersed all over the sample.

6. Preventive measures regarding dust

There are three ways of exposure to dust, being those through the skin, by ingestion and inhalation. The main preventive measures are:

- Give formation to the workers about the dangers that may come with the handling of potentially hazardous materials and the prevention measures and procedures to adopt;
- Delimit and signalize the work areas with the identification of the dangerous elements;
- Affect and make available machines and equipment with prior verification and maintenance;
- Set up planed collective protection equipment and make sure of the correct and effective usage of the individual protection equipment;
- Vacuum and wash the tools;
- After signalizing the work area with risk of chemical and physical exposure, the workers should always go through the decontamination area, for personal cleaning.

According to P.Braga (P. Braga, J. Gonçalves, C. Oliveira, J. A. F. O. Correia, J. F. Silva and C. Reis, 2019), adequate individual protection equipment must be chosen to deal with different types of exposure, for instance, to protect from inhalation, or ingestion: shell shaped protection masks are used, with or without valve. For protection to skin contact: protection gloves must be used (chosen considering the agent to be handled, and preferably disposable, in order not to lose its full effect). Protection suits should also be used when working with asbestos. Protection shoes should always be used.

7. Conclusion

After the development of this study it was possible to draw some conclusions in regard to the importance of the use of SEM in this particles characterization since was possible to assess the existence of elements that have a toxic potential to human health. In general, it is possible to conclude that the elements obtain in the analysis go accordingly to the elements present in the site, in the SEM analysis. The most effective way of prevention to the hazards is a good mix between the collective protection equipment and the individual protection equipment.

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