First steps of Natural Cement in Spain

Cristina Mayo Corrochano¹, Félix Lasheras Merino², David Sanz-Arauz³

1. Architect, PhD student in the Department of Construction and Architectural Technologies, Polytechnic University of Madrid.
2. Dr. Architect, Associate Professor, and member of the research group “Analysis and Intervention on the Heritage” (AIPA), Polytechnic University of Madrid.
3. Associate Professor UPM. Dr. CC. Geological david.sanz.arauz @ upm.es. ETS.Arquitectura. Department of Building and Architectural Technology. AIPA group

Abstract

Natural cement was patented in 1796 but it didn’t arrive in Spain until 1835. No one knows exactly where the production started in Spain, because it emerged independently at the same time in many places. Most of these outbreaks are concentrated in the north and northwest of Spain: Basque Country (Zumaya and Rezola) and Catalonia (San Celoní and San Juan de las Abadesas). Natural cement was extensively used to decorate historical buildings during the nineteenth and beginning of twentieth century in Madrid. It was the building material which realised the architects and builders dreams of mass-produced cast elements in a wide variety of styles. Its arrival replaced traditional materials that were used previously (lime, gypsum and hydraulic limes). However, its use was not extended in time, and soon it was replaced by the use of artificial Portland cements. During 20th century this building material disappeared from use. What remains is its memory, in thousands and thousands of “stone witnesses” in our cities. Final properties of the cement largely depend on raw materials used and its combustion temperature. However, it was characterised by an easily implementation on facade masonry, fast-setting (about 15 minutes), good resistance, an agreeable structural consistency and colour. This article aims to show first steps, evolution and decay of Natural Cement Industry in Spain and its application in Madrid.

Keywords: Natural cement, old mortars, Natural Cement Industry in Spain.

1. Introduction

Natural cements were first introduced in England in 1796 when James Parker patented his “Roman Cement”. It is produced calcining limestone (containing clays between 25–40%) at low temperatures (800 ~ 1200 °C, below the sintering temperature). (Weber and the ROCARE Consortium Team 2011)

Cements can be classified in:
- Quick natural cements: Cement manufactured with marl with a moderate clay content (about 25%). Temperatures of calcination ranging between 1000 and 1200°C for 12-20 hours. These cements were rich in lime, and had a quick setting time (<30 minutes).
- Slow natural cement: Cement manufactured with marl that had a high clay content (about 40%). Cooking temperatures ranging between 800 and 1000°C for 8-12 hours. These cements were rich in silica and had a slow setting time (30 minutes-12 hours). (Varas, Alvarez de Buergo, Fort, 2007)

However, natural cements importance was quickly eclipsed by the arrival of Aspdin Portland cement, more durable and stronger than its predecessor. (Kozłowski, Hughes, Weber 2010; Adamski, Bratasz, Mayr, Mucha, Kozlowski, Stilhammerova and Weber 2009).

Production of natural cement In Spain began between 1835 and 1858.

It is not known exactly where production started because it emerged simultaneously in several independent places (Basque Country and Catalonia).
In the nineteenth century the location of the cement industry was linked to the regional geology because transportation systems in these times were really poor and they needed to position the factories near marl and coal quarries. (Varas, Alvarez de Burgos and Fort, 2007)

2. History of cements in Spain

The production of natural cement in Spain was concentrated in the Basque Country and Catalonia (figure 1). In Catalonia there were two main cement areas at that time: San Celoni (Barcelona) and San Juan of Abbesses (Gerona).

In the case of the Basque Country, the natural cement industry was located in the Lower Urola (Guipúzcoa) district, which includes Zumaya, Arrona and Cestona towns.

![Figure 1: Geographical location of Spanish natural cement production.](image)

The location of the natural cement industry in this region meant a great economic and industrial development in the area. The plants produced “Quick Zumaya Natural Cements” of a high quality which were very popular not only in Spain but also abroad. This cement was characterised by a setting time of a few minutes and high resistance against the action of sea water.

In Guipúzcoa, natural cement production began in 1835 to 1836, during the First Carlist War, when British soldiers employed it in the construction of San Sebastian defenses. Soldiers instructed local people how to produce natural cement, showing them the abundance of raw materials in the environment and the advantages of the new product. (Irazusta, Ibáñez, Zabala and Torrecilla, 1999)

It’s not clear instead when the production of natural cement started in Catalonia. We only know that in the mid nineteenth century spanish religious immigrants coming from Italy used this technique for binder manufacture.

Originally, the production of natural cement was handmade, using discontinuous vertical kilns, also known as calero kilns. They were built right in the marl quarries. These kilns were loaded from the top, they put coal (lignite or coal) first and then marl.

At that time there was no exact knowledge about the marls’ chemical and mineralogical composition. They were introduced in kilns without previous manipulation, just as they were brought from the quarry.

Kilns were ignited from the bottom and left to burn for a few hours until it was found that the marls were sufficiently calcined (at a temperature about 900-1000°C). To turn off kilns they shut off air supply and then pulled out all material inside when it was cool. The calcined product was moved in animal traction carriages to mills located on rivers banks.
In the mills, the calcined product was crushed by large stone wheels, originally powered by stream. The cement obtained was moved to special places where it was hand sieved, packaged, stored and sold.

In later years there was a gradual increase of natural cement demand because of the start of numerous port works throughout Spain. This caused a significant growth and the establishment of factories of this sector in the area (Zumaya, Arrona, Estonian, San Celoní, St. John of the Abbesses ...).

In the late nineteenth century the manufacturing process of natural cement underwent developments in production. The following was seen:

- An improvement of raw materials transportation. Replacing animal traction carts by animal traction wagons, overhead wires and finally by rail.
- The replacement of vertical discontinuous kilns (calero kilns) by continuous vertical kilns and later by horizontal kilns.
- The replacement of vertical mills by horizontal ball mills of the Morel and Smith type.
- The replacement of hydraulic power to move mills by steam power and later in twentieth century, by electric motors.
- Chemical and physical tests were performed to determine mechanical properties of obtained cements (compressive and tensile strength, hardness etc.). It is at this time they began to manipulate and combine different marls to improve the quality of the final product. In addition, the difference between fast natural cement and slow natural cement was defined.

Around 1898 the first Portland cement factories appeared in Spain, these slowly won ground to natural cement. From 1926 on the business fell sharply and in 1936 a lot of factories closed. This was the
year of the beginning of the Spanish Civil War (1936) with its definitive effects on the development of
the cement industry, the subsequent recovery of which was complicated. (Varas, Alvarez de Burgos and
Fort, 2007)

Figure 4: Vertical mill in Rezola factory.

3. Natural cement in Madrid.

Natural cements was highly demanded in various sectors of civil engineering: sewerage and water
supply, canals, ports and tunnels. In the building sector, the use of cements at first was limited to building
foundations and masonry mortars, but never as a render mortar because it was considered an unsightly
material and vulgar. For renders traditional lime mortar was still used.

The Canal of Elisabeth II, the main water supply infrastructure for Madrid, is a noteworthy example of
the use of cement in the construction of a civil engineering project.

The first buildings constructed entirely in cement arise in Spain from 1898. Arbós in Madrid and
Gaudi in Barcelona were two architects that advocate this new material. Fernando Arbós revolutionised
the construction methods of his time and began to use different materials from ones traditionally used in
Madrid (granites, limestone, lime, etc.). One of these new materials was natural cement. Two of his
building can be highlighted; the Illustrious Men Pantheon and San Manuel and San Benito Church
(figures 5 and 6), where Arbós made history by using natural cement for the first time in building
construction. (Varas, Alvarez de Burgos and Fort, 2007). Illustrious Men Pantheon is a neo-Byzantine
building built in Madrid between 1892 and 1899. The use of various types of cement for its construction
is documented, but none are in sight.

Slow natural cements are present in the building construction as a part of concrete, mortars and as
joining mortar in external cladding. As as well quick natural cement, mortar appears in renders. The use
of artificial Portland cement imported from Marseille (Lafarge Portland), was used in paving.

San Manuel and San Benito Church was also built by Fernando Arbós in neo-Byzantine style,
between 1903 and 1910 in Madrid. Cements detected in this building are also hidden and are mostly slow
natural cements (mortar joining and rendering) and artificial cement (grout mortar).

Although natural cement was produced in Spain between 1836-1936, it did not arrive in Madrid until
1892. 410 buildings in Madrid of this period have been analysed and from this it is apparent that the use
of natural cement is concentrated in the city centre (figure 8), a great expansion area with high economic
resources at that time, which needed to face the construction of high quality buildings. In other areas of
with small economic resources or with an industrial use, others materials were used such as brick, mortar,
lime and sand or iron.
4. Conclusions

The natural cement industry in Spain began in 1835 while in Europe it was in 1796. The Spanish cement industry developed 40 years later than in the rest of Europe, where by this time Portland artificial cement already dominated the industry. The first cement factories appeared in the northern (Basque Country) and northeastern (Catalonia) areas of Spain.

At first, non-industrial production methods limited quantity and quality of the natural cements produced. Marls were placed into the kilns without previous manipulation. And firing temperatures did not exceed 1200°C (below the sintering temperature). From 1858 onwards, the manufacturing process of natural cement in the plants experienced improvements which led to increased amounts of production and a better quality of product.

The marls began to be manipulated to obtain the type of natural cement desired (quick-setting or slow-setting).

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References

salts in stone monument degradation using sulphur and oxygen isotopes: first results of the bourges
cathedral (france).
Microstructure and mineral composition of roman cements produced at defined calcination conditions.
to understand their specific properties
J. Weber and the ROCARE Consortium Team (2011): The EU project ROCARE: 19th century Roman
cements – historic binders with properties of interest for purposes of restoration and healthy
construction.
restoration.
Mortars.
Roman cement – key historic material to cover the exteriors of buildings.
low temperature.
using cement-stones from whitby.
Roman cement mortars to establish their compatibility
Klisińska-Kopacz1, R. Tišlova, G. Adamski, R. Kozłowski (2008): Control of the porosity structure to
produce roman cement mortars compatible with the historic substrate.
R. Kozłowski, D. Hughes, J. Weber (2010): Roman cements - key materials of the built heritage of the
nineteenth century.
Jahrhunderts.
M. Bouichou, E. Cailleux, E. Marie-Victoire, D. Sommain, (2008): Evaluation of compatible mortars to
repair 19th century natural cement cast stone from the French Rhône-Alpes region.
Romancement – key historic material to cover the exteriors of buildings.
E. Cailleux1, E. Marie-Victoire2, D. Sommain3, E. Brouard3 (2009): Microstructure and weathering
mechanisms of natural cements used in the 19th century in the French Rhône-Alpes region.
M.J. Varas *, M. Alvarez de Buergo, R. Fort (2007): The origin and development of natural cements: The
Spanish experience.
cemento como máximo representante de estos materiales de construcción.
J. Irazusta Rezola, M. Ibáñez Gómez, M. Zabala Llanos and M. José Torrecilla Gorbea (1999): Cementos
Rezola.