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Differences in basic standards of common cements

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ABSTRACT

Considering that norms relating to cement are applied according to geographic scope, political or economic, can produce significant differences between them. In order to analyze the regulatory differences that may occur, this paper studied the regulations of the common basic standards for cement NCh (Chile), ASTM and UNE applied in Spain.

These differences manifest themselves in different classifications of cement, differences in specification, differences in the tests performed to fulfill given specifications, differences in the degree of development of regulations and its relation to legal codes and enforced.

I conclude that the regulations present differences in the case of the ASTM and UNE regulations, makes for greater harmonization difficult time. Cement standards including additions, contribute a product with lower environmental impact.

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1. Introduction

In order to appreciate the regulatory differences that may occur, it will highlight some aspects of the basic regulations for common cements. It includes the regulations of a developing country, as is the case of Chile, ASTM regulation, which is also adopted by the ACI Code and the UNE regulations applied in Spain. Those standards have also been applied in Chile have been quoted in the specifications on some major projects, with engineering that is not done in Chile.

2. The normalization of cement in Chile

The National Institute of Standardization is the body that's mission in Chile is to develop and disseminate the Chilean standards (NCh). The cement control in Chile is mandatory, and all the cement produced is controlled and certified. The imported cement are tested at entry into Chile, then in general, are not monitored systematically.

Cements are mainly produced with additions, those with a better performance to sulfate attack. The norm specification of cement is [1]. Considered as an addition to the granulated steel slag, the pozzolan and added type A (mix of material calcined clay limestone more than 900 °C and other silicon-based materials, aluminum and iron). This latest addition is not currently used. Do not consider other addictions, or mixture of them.

Does not provide additional requirements related to durability. In major projects this is solved if the specification includes the application of sulfate resistant cements, either ASTM or UNE. NCh 170 [3] specifies a limit on the water-cement ratio in concrete structures exposed to chemically aggressive environment. In smaller construction, or even larger construction, in that part of its concrete are exposed to an aggressive environment, but that its specifications do not include cements resistant to these environments, cements have been used to satisfy Chilean regulation, but according to ASTM and UNE standards are inadequate.

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It defines two kinds of resistance: Current and highly resistant, with minimum values, not maximums. Occurring that some cements are classified as current have much higher resistance than the minimum specified. The type of test pieces used for the control of cement is the 4x4x16 cm.

NCh 161 [2] is applied to analyze the pozzolanic activity, using the method of cylinder compressive strength of mortars with lime and pozzolan.

NCh 430 Of 2008 [4] Reinforced concrete adopts ACI 318-05 [5], with some modifications. This indicates that the Chilean norms take precedence over ASTM.

3. The cement ASTM standards

ASTM has a number of standards related to the specification and testing of cement. ASTM C 150 [6,12] is responsible for specifying the requirements for Portland cements and ASTM C 595 [7,8] Portland cement with additions. ASTM is constantly reviewing its rules requiring changes occur.

ASTM C 150 [6,12] classifies Portland cement into 5 types. Consider cements with incorporation of air (A). From a chemical point of view, highlights the following characteristics:

a. Are limited to C_3A cements depending on their needs for sulfate resistance, the only one that has no limitation is type I. Type II cement with 8% and cement type V, maximum 5% of C_3A.
b. The content of sulfur trioxide (SO_3) varies depending on the % of C_3A, 4.5 and 2.3%. It could use more of SO_3 if ASTM C 1038 demonstrates that the additional SO_3 produced no further expansion to 0.02% in 14 days.
c. One of the changes that took place in the 2004 regulation was the possibility of adding up to 5% limestone.
d. Also change the requirement for additional chemical Cement Type II, the amount of tricalcium silicate and tricalcium aluminate maximum of 58%, to 4.75 $C_3A + C_3S \leq 100$, only for Type II (MH).

From the physical point of view, it highlights the following characteristics:

a. Resistance to compression varies depending on the type of cement, only ask minimum: 3 and 7 days in the cement I and II, 1 and 3 days for cement type III, 7 and 28 days for the cement type IV, and 3, 7 and 28 days for cement Type V. According to test method [9], using cubic test piece of 50 mm side.
b. Type II cement (MH) and cement type IV, includes a maximum limit on the Blaine fineness of 430 m^2/kg. Type II cement has no requirements of fineness by Blaine.

ASTM C 495 [8], classifies the blended hydraulic Portland cements. It refers to a mixture of hydraulic cements for both general and special applications, using slag or pozzolan, or both, with Portland cement or Portland cement clinker or slag with lime. The norm has suffered in recent years major changes related to the composition and classification of cements. It incorporated new designations of binary and tertiary blended cements. Ternary blended cements hold the title for IT type ternary blended cement, which corresponds to composite cements.

Allows mixtures made in grinding jointly by a combination mixing and grinding and mixing.

About their chemical and physical requirements, we highlight the following characteristics:

a. Can be varied the content of sulfur trioxide (SO_3) specified, using test methods ASTM C 565 and ASTM C 265.
b. Different resistance to compression depending on the type of cement, resistances are requested minimum 3, 7 and 28 days in all cements, except in cements with more than 70% slag and low heat of hydration cement (LH).
c. Includes high sulfate resistance type (HS), which must fulfill to [11] test, with maximum expansion of 0.05 to 180 days and maximum expansion of 0.1% at 1 year.
d. Verifies the activity index Portland cement with slag and pozzolan. In the case of the slag only will be check if it is using less than 25%.
e. It can verify possible reactivity of pozzolans with cement, using test method ASTM C 227, with non-reactive sand, when amounts of pozzolan least 15% are used.

ASTM C 150 and ASTM C 495, contain several specifications of performance. One of these with trials that require long periods of time, however although it is laborious, it allows that cements with other standards could not be used in environments with sulfate, with these standards they are permitted.

ASTM norms are quoted in the ACI Code, in the case of ACI 318-08 [5], which specifies the requirements for structural concrete, in Chapter 4, durability, suffered major changes from the previous version; it included a category and class of exposure, the approach to those already made in European standards, since several years ago. Referring to sulfate attack of cement is performed according to their classification according to [6,7,10]. Also allows the use [11], to measure mixtures not included in the given table. The downside is that the trial is extended to 18 months.

4. The UNE norms

The European Community is tending to the unification of its regulations. Here we indicate some aspects of concrete rules that apply in Spain. According to RC-08 [13], UNE-EN-197-1-2000 indicates different cements of common use. Some are divided into subtypes A, B or C by adding content additions, resulting 27 types of cement.

There are three kinds of resistances: 32.5, 42.5 and 52.5, high initial resistance (R) or normal initial resistance (N). The specifications of initial resistance minimum of 2 days, except when the kind of resistance is 32.5 N, and normal resistance to 28 days with upper and lower limits, except when the kind of resistance is 52.5, which only calls for minimal resistance. The test of resistance is done with test pieces of 4x4x16 cm.

UNE 80303–1, 2001, specifies requirements for sulfate resistant cement (SR) and the UNE 80303–2, 2001, specifies requirements for seawater (SM). The requirements are according on C_3A and C_3A and C_4AF sum. In the case of CEM I, specifies maximum C_3A content of 5% for both cases. In CEM II cements, only considers the Portland cement with additions of silica fume, natural pozzolans, fly ash silica and blast furnace slag, specifying a maximum C_3A of 6% for cement (SR) and 8% for cement (MR). In the case of cement CEM III/B and CEMII/C, considers sulfate resistant without further requirements. Also considered cements with sulfate resistant additions to cement CEM III/A, CEM IV/A, CEM IV/B and CEM V/A, where they have maximum C_3A of 8, 6, 8 and 8% respectively. In the case of cement (MR), the limit rises by 2%.

UNE-EN-197-1-2000/A1: 2005, incorporates cements with the additional characteristic of low heat of hydration (LH). The maximum heat of hydration is 270 J/g to 7 days according to UNE-EN-196-8 and 41 hours according to UNE EN196-9. UNE EN 14216 gives the requirements for cements with low heat of hydration VLH. The heat of hydration will be maximum 220 J/g to 7 days according to UNE-EN-196-8 and 41 hours according to UNE EN196-9.

UNE norms are quoted in the case of Spain in the Instruction of Structural Concrete (EHE-08) [14], this includes general and specific kinds of exposure, the specifications that result in water/ cement ratio, minimum resistance and recommending types of cement. EHE also provides recommendations respect to the incorporation of additions, promoting its use as a measure of sustainability. Instruction for the reception of cement RC-08 [13], provides a fairly complete guide on the different aspects related to the cement.

5. Comparison and analysis of norms

There are evident differences in the standards studied, this occurs in different aspects of them. They analyzed the importance of complements that enable better and wider application of the rules, in this sense, codes, instructions and other regulations, clear legislation, contribute to its implementation. A comparison is given below of some aspects of the studied norms:

a. Updating norms: being the standardization process a slow process that requires resources, the updating of standards present major difficulties in underdeveloped or developing countries, with the possibility to adopt or adapt any international regulations or more advanced. In the case of Chile, the lack of updating has limited the development of new products, but also allowed in some cases, where the project specifications do not specify, use cement in concrete exposed to environmental attack, which fulfilled the national standard, but no other norms, that would not have accepted its use.
b. Nomenclature and naming types of cement. Is clear the diversity of the nomenclature of types and denominations, inherent to every standardization organization. Although there is some coincidences, these differences cannot occur in the names of special characteristics of cements. A difference in specification does not make this union feasible.
c. SO_3 content. This parameter is different in norms. ASTM allows modifying the performance limits through the cement. This parameter should also be related to the SO_3 content of the other components of concrete. In Chile is specified wrongly, 0.6 kg of water-soluble SO_4, as content in the concrete, other than indicated for cement. In Spain, SO_3 specified maximum of 0.8% for aggregates. At this point need to set content of sulfates in the aggregate, depending on the nature and amount of cement used.
d. The specification of resistance: the decision seems appropriate UNE norms specified by sections and incorporate resistance maximum resistance. It would be useful to unify the type and age of test used to evaluate the resistance.
e. Resistance to sulfates. Chilean regulation requires updating in this regard. ASTM norms along with the ACI 318 [5] code tend to a specification of performance. Although more complicated to apply, may be better in the assessment. UNE norms studied, specified by prescription.
f. Additions use. ASTM C 595 [7,8] allows production by blending Portland cements with additions. While this may be technically possible, it should also add additional tests, to measure the homogenization of the mixtures. The proposal may be risky in countries where control of the cement is not exhaustive. ASTM and UNE promote the use of additions, with the aim of improving environmental indices. Chilean regulation should update the types of additions so they can develop new products.

6. Conclusions

The norms have different types and naming nomenclature, which extends to its characteristics, which in the case of the ASTM and UNE standards, due to the way these are presented, makes for greater harmonization difficult time.

The special requirements of sulfate resistance in cements, present differences such that a given cement, depending on the standard being used may or may not be accepted.

About the SO_3 content in the concrete, the regulation should considered: the SO_3 content in cement, content and type of sulfates in the aggregate, and total sulfates in the concrete.

The regulations include, but are differences, the use of the additions, are fundamental in improving the durability with reduced use of clinker in cement, this contributing to a product with less environmental impact.

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