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Cement type Hs and type V: determination of resistance against moisture and sulfate attack

Abstract

The moisture content and the level of saltpeter to which a land is exposed is a topic of great importance in the field of Civil Engineering, that is why in this work we aim to make a comparison between the properties offered by a cement type V and an HS type, to then determine the most resistant in places with high presence of moisture and sulfates. The research is of the descriptive and explanatory type because the results obtained after having carried out an experimental process with the materials to be used (cement type HS and type V) were manifested. The result of having carried out a good comparison between the properties of both types of cement led us to determine which has better behavior in the presence of these attacks, resulting in the Cement Type HS more resistant to the attack of sulfates, this being a potential successor to type V cement. In conclusion, for the present research a comparison was made between the properties of these two types of cement, which led us to be able to be able to affirm that the cement type HS is an extraordinary substitute against the type V when combating the areas where moisture and sulfate are present.

Keywords: water table, construction process,sulfates, cement type HS, cement type V

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Introduction

The foundation is the most transcendental part of a structure, since all the weight of the building is transmitted to it; these loads are transmitted through the columns and walls in a confined masonry structural system. For this reason, the type of soil on which the construction is planned must be taken into consideration, since there is a great variety of soils, such as soils with soluble salts and wet soils. Deficiencies in these soils can cause structural failures such as settlement and foundation degradation. To prevent these problems, we must carry out studies beforehand or design structures that include the use of certain materials, which allow us to guarantee the safety and useful life of the structure. The increasing progress that the world has experienced in recent years has brought great changes, including the manufacture of numerous materials that can be used in Civil Engineering. These materials make it easier for us to project works even in lands with deficiencies. For example, Monroy[1] tells us that as a product of research, various materials have been appearing to be used in the construction of civil works, which allow us to optimize their properties of mechanical strength, durability, economic factors and availability. At present, the production of materials such as translucent concrete and waterproof concrete has this material has increased, allowing the construction process to be accelerated in humid areas because it prevents the passage of water from the moment of construction and prevents the appearance of humidity.

On the other hand, Molero and Ríos[2] state that Anti-Saltpeter cement has a low heat of hydration and high sulfate resistance, as well as low reactivity with alkali-reactive aggregates. These characteristics are ideal for any construction in humid and salty areas, and exposed to seawater. In this context, civil engineering faces many challenges when it comes to the construction of infrastructure, especially in soils with high salinity content and presence of moisture. In order to determine the most resistant type of cement in places with high presence of moisture and sulfates, the present study focuses on a comparison between the properties offered by a type V cement and those of a type HS cement. In this study, we seek to determine the type of cement that presents a better behavior and resistance in projects with these deficiencies, thus controlling the bases of the buildings and guaranteeing an adequate construction process, this comparison will be descriptive.

Materials and methods

The methods applied in the research present a mixed approach, covering both qualitative and quantitative aspects. The qualitative approach focuses on the study of the materials, specifically the types of cement. On the other hand, the quantitative approach was used to produce graphs and comparative tables. After conducting several researches, we can affirm that, when executing a building project in adverse conditions, the most transcendental work is to build solid bases and foundations. For this, it is crucial to use a cement that offers good impermeability and maximum resistance to sulfate attack. In any construction that involves sewage treatment plants, drainage systems or water tables, it is essential to have a concrete waterproofing admixture. This additive protects the construction from water and other substances such as saltpeter, sand, rocks and chemical agents. Technical standards suggest improving the ground to prevent moisture due to efflorescence from the water table; however, these conditions are further improved with a waterproofing concrete, providing the necessary strength and durability.

In constructions that require a long service life, it is crucial to use a cement that is highly resistant to sulfate attack. NTP 334.009 “Portland Cements Requirements” recommends the use of Type V cement for concrete exposed to severe sulfate action, especially in soils and groundwater with high sulfate concentrations. In addition, Alfaro and Laura[3] conclude that Type HS Ultra Impermeable Portland Cement can supplant Type V, due to its excellent resistance to sulfates. To determine which type of cement performs better, comparisons were made between the properties of the two materials under study. The tests performed included the specific surface area of the cement, expansion in autoclave, initial setting with the Vicat apparatus, and air content in the mortar. Compressive strength, sulfate resistance and alkali/aggregate reaction were also evaluated. These tests were performed by reliable sources. Molero and Ríos[2] point out that, due to the importance of this issue in the practical engineering and safety of concrete structures, the tests were carefully conducted. Likewise, Yura SA[4] in its latest study on the technical characteristics and properties of concrete, provides very relevant information on the efficiency of Type HS cement, which will be used later.

Results

The results obtained, which are based on experimental studies, are presented below. To analyze and make the comparisons, the requirements proposed in NTP 334.082 and NTP 334.009 were used as a basis, as well as ASTM C-1157 and ASTM C-150, which specify certain criteria that must be met to consider a type of cement as such. This table has been adapted from "Concrete with portland cement type HS for structures affected by sulfate and chloride", by Molero and Ríos.[2] Table 1 shows some specific requirements which are compared between what the standard proposes for a conventional type V cement and the performance of Yura Anti-Saltpeter cement type HS. The tests taken into account for this table are: specific surface area, expansion in autoclave, initial vicat setting and mortar air content. Table 2 shows the resistance of Yura Anti-Saltpeter type HS cement to sulfates, measured after performing the expansion test. The results obtained are compared between what is indicated in NTP 334.082 for a conventional type V cement and the performance of Yura Anti-Saltpeter type HS cement after 6 and 12 months. Analyzing the comparison between the percentages of expansion, it can be seen that Yura Anti-Saltpeter cement, Type HS, far exceeds the resistance to sulfate attack required of conventional type V cement (Table 3) (Figure 1 & 2).

Table 1 Technical characteristics yura anti-saltpeter cement type HS ultra-waterproof

Specific Requirements	Requirements technical standard NTP NTP 334.082 ASTM C-1157	Requirements technical norm cement type V NTP 334.009 / ASTM C-150	Performance yura anti-saltpeter cement type HS
Blaine specific surface (cm2/g)	-	2600 minimum	4800 - 5200
Expansion in autoclave (%)	0.80 maximum	0.80 maximum	-0.07 a -0.02
Initial Vicat setting (min)	45 minimum	45 minimum	190 - 270
Mortar air content (%)	-	12 maximum	3 a 8

Note: The table was prepared based on what is proposed by NTP and ASTM, adding in the last column the performance of Type HS cement.

Table 2 Sulfate resistance yura anti-salitre type HS cement

Sulfate resistance	NTP - % Expansion	Performance cement yura antisalitre type HS
6 months	0.05% Maximum	0.02
1 year	0.1% Maximum	0.03

Note: The data were obtained after performing the expansion test, which will be compared to the proposed standard.

Table 3 Compressive strength yura anti-salitre type HS cement

Compressive Strength	NTP 334.082		NTP 334.009		Yura anti- saltpeter HS Type	
	Kg-f/cm2	Mpa	Kg-f/cm2	Mpa	Kg-f/cm2	Mpa
3 days	112	11	82	8	165 - 195	16.2 - 19.1
7 days	184	18	153	15	210 - 230	20.6 - 22.5
28 days	255	25	214	21	280 - 320	27.4 - 31.4

Figure 1 Type HS ultra-waterproof Portland cement.

Figure 2 Type V Portland cement.

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Figure 3 shows a comparison of the evolution of compressive strength between the proposals of the Standard for a conventional type V cement and a Yura Anti-Saltpeter cement type HS after 3, 7 and 28 days. Figure 4 consists of a bar graph showing the comparisons made on the resistance to sulfate attack between cements type V, HS and what is parameterized in ASTM C-1157 and NTP 334.082. It can be seen that the blue bar, which represents the behavior of cement Type HS has low values which indicates that Yura Anti - Salitre cement Type HS, has greater resistance to sulfate attack, compared to cement Type V, due to its low percentage of expansion. Figure 4 shows a scatter plot with straight lines joining the points of the expansion percentage due to the Alkali-Aggregate reaction with the passing of the days. The graph is made in a way comparison between a Type V cement and a HS cement. As a result, Yura Anti-Saltpeter cement type HS neutralizes this reaction, protecting the concrete against these types of attacks. Then, with the results obtained after having made a series of comparisons between the properties of one cement with those of the other, all based on what the standards indicate and referencing the results obtained by Molero and Ríos[2] in their thesis, we can affirm that Yura Portland Cement Type HS Ultra Impermeability is a very good substitute for Type V Cement, as indicated in NTP 334.009 "Portland Cements Requirements". This statement is made because Type HS cement outperforms Type V cement in all the tests studied. In addition, this cement has highly waterproofing properties and solves our problem. because it will allow us to use it in all types of concrete constructions, whether exposed to humid areas, sea breezes, salty soils, high presence of sulfates and other chemical substances. In other words, the most suitable type of cement to be used in the construction of buildings where the presence of moisture and sulfates is high should be HS.

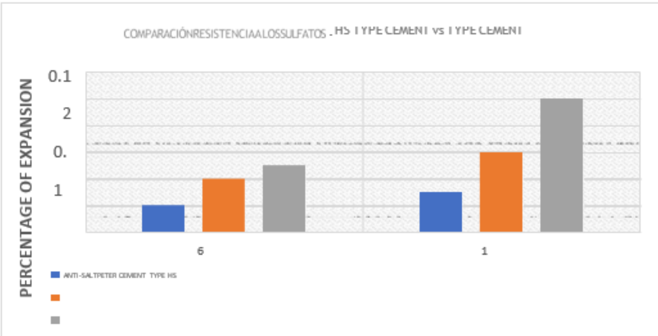

Figure 3 Comparison of sulfate resistance - type HS cement vs. type V cement.

Note: The performance data for cement TYPE HS is being compared based on the Peruvian technical standard – NTP 334.082 and NTP 334.009.

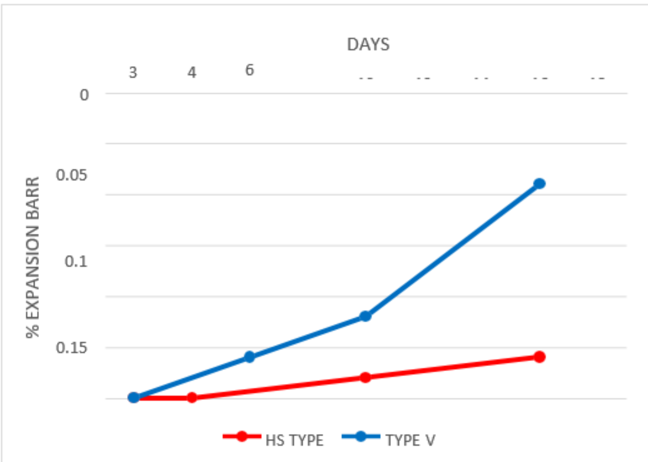

Figure 4 Expansion caused by the alkali - aggregate reaction.

Note: This figure shows the percentage of expansion caused by the alkali-aggregate reaction in type HS and Type V cement after a few days. Taken from "Ficha técnica 2021/V.1", issued by YURA S.A. (2021).

Discussion of results

With the results obtained, it can be deduced that the addition of pozzolan in Yura type HS cement plays an important role in providing greater resistance to chemical agents. On the one hand, the pozzolan and the high degree of fineness of this cement reduces capillary porosity, thus making the concrete more impermeable and protecting the components inside the construction. On the other hand, the pozzolan in this cement removes the alkalis from the cement paste before they react with the aggregates, thus avoiding cracks in the concrete due to the expansive reaction of the alkali - aggregate. The limitation that stopped our experimental trials was the lack of economic resources, so our results were referred from other sources. Thus, future research is expected to be carried out considering the application of various concrete admixtures as study variables. Finally, the results provided by Yura SA[4] were similar to those provided. Experimental trials found by Molero and Ríos.[2]

Conclusion

Type HS cement significantly outperforms Type V cement in compressive strength and durability tests under adverse conditions, thanks to its waterproofing properties and its ability to resist chemical attack, such as alkali-aggregate reaction and sulfate attack. It is ideal for use in areas with high humidity, exposure to seawater and soils with a high presence of sulfates and other chemical agents, and is suitable for applications where durability and structural integrity are critical. The addition of pozzolan is crucial to the performance of Type HS cement, as it reduces the capillary porosity of concrete and removes alkalis before they can react with the aggregates, preventing cracking. The results of the study are in line with technical standards such as NTP 334.009 and ASTM C-1157, which recommend the use of cements with high sulfate resistance to improve the quality and durability of structures. Type HS cement meets and exceeds these requirements, establishing itself as a better alternative to Type V cement. The use of Type HS cement ensures greater durability and strength in construction, solving common problems in soils with moisture and soluble salts, especially in coastal areas and salty soils. The study suggests future research on the application of various concrete admixtures to better understand the additional benefits of Type HS cement and its behavior in different conditions.

Acknowledgments

None.

Conflicts of interest

The authors declare that there is no conflicts of interest.

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