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Addition of aloe vera gel as a replacement for super-plasticizer in self-compacting concrete f'c = 280 kg/cm²

Adición del gel de aloe vera como reemplazo del superplastificante en el concreto autocompactado f'c = 280 kg/cm²

Filiberto Freddy Peñaranda Tavera I Universidad César Vallejo, Perú
Javier Reynoso Oscanoa I Universidad César Vallejo, Cuba

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Abstract

The main objective of this research work focuses on determining the effect of adding aloe vera gel as a replacement for superplasticizer in self-compacting concrete f'c = 280 kg/cm2.

The present research work is considered according to the type of data, it is of a quantitative approach and a quasi-experimental design with a scientific, hypothetical-inductive method, and of a correlational level. For the investigation, 3 designs of self-compacting concrete were carried out, including the standard sample with superplasticizer additive and the replacement additions of aloe vera gel, where the tests of physical characteristics in the fresh state, fluidity and passage capacity were carried out. The evaluation of the mechanical property to the hardened state, compression resistance was also carried out. In addition, the significant incidence (Sig. <0.001) of the direction by values in the implementation of the process was found through the ANOVA with the SPSS program.

It is concluded that the addition of aloe vera gel does not have a greater incidence with respect to the superplasticizer additive in self-compacting concrete considering the expansion flow, viscosity and passage capacity, in terms of compressive strength of aloe vera gel additions. they exceed the specific compressive strength, but fail to overcome the standard strength. Of the percentage of additions, the highest performance was 3% with 448 kg/cm².

Keywords: Self-compacting concrete, fluidity, viscosity and compression.

Resumen

El objetivo principal del presente trabajo de investigación se enfoca en determinar el efecto de la adición del gel aloe vera como reemplazo del superplastificante en el concreto autocompactado f'c = 280 kg/cm2.

El presente trabajo de investigación se considera según el tipo de datos es de enfoque cuantitativo y diseño de cuasi experimental con método científico, hipotético-inductivo, y de nivel correlacional. Para la investigación se realizaron 3 diseños de concreto autocompactado entre ella la muestra patrón con aditivo superplastificante y las adiciones de reemplazo de gel de aloe vera, donde se efectuaron los ensayos de características físicas en estado fresco, fluidez y capacidad de paso. También se realizó la evaluación a la propiedad mecánica al estado endurecido, resistencia a la compresión. Además, se halló la incidencia significativa (Sig. <0,001) de la dirección por valores en la implementación del proceso mediante el ANOVA con el programa SPSS.

Se concluye que la adición del gel de aloe vera no tiene mayor incidencia respecto al aditivo superplastificante en el concreto autocompactado en consideración al flujo de expansión, viscosidad y capacidad de paso, en cuanto a la resistencia a la compresión las adiciones de gel de aloe vera superan la resistencia a la compresión especifica, pero no logran superar la resistencia patron. De los porcentaje de adiciones se tuvo mayor desempeño fue el de 3% con 448 kg/cm².

Palabras clave: Concreto autocompactante, fluidez, viscosidad y compresión.

INTRODUCCIÓN

From the last century to the present, there has been a high world preference for the construction of durable and sustainable buildings based on the knowledge of the behaviour of new construction materials, in their composite use and construction techniques, which prolong the useful life of buildings, in order to avoid the depreciation of some natural resources such as water and aggregates. Concrete is the most used material worldwide in the various buildings that can be found in a city. Since it is in its fresh state, it is adaptable to moulding, and in its hardened state, it can withstand the high resistance loads to which it is exposed. The problem in the international environment was preceded by the valuable life in severe climates such as Canada, which fluctuates between 50 to 75 years due to the low and high temperatures presented in winter and summer seasons. The structures are exposed to corrosion attacks due to the lack of cementitious particle distributor additives and mineral additives. In the American region, a large number of constructions have reached half of their useful life, generating expenses in their repairs of millions of dollars, causing detrimental impacts on the economic activity and the quality of life of the population due to the decrease in the contribution of services, interruption in traffic, among others (Sotomayor, 2019, p. 1).

Peru is a country with diverse climatic scenarios in its different regions, with high and low temperatures, the presence of heavy rainfall, and salinity of seawater on its coasts. For this reason, concrete presents problems of humidity attacks, corrosion in its steels, and cracking in its structural elements. Consequently, an initial study of natural viscous components derived from aloe vera gel and cactus stalk was carried out. From the studies carried out, it was found that aloe vera contains aloin, water, resin, catalyst, proteins, vitamins, etc. Aloe vera consists of more than 100 components with different molecular masses; its green-coloured shell is chagreen-coloured inside and is a viscous pulp containing aloin (Aburto et al., 2018, p. 107).

For this reason, the characteristic of the use of green inhibitors (aloe vera) in its control of corrosive time reduction in steel in structures with self-compacting concrete that can quickly enter the reduced spaces of the different types of formwork and can obtain adherence in the dense steel reinforcements was thought of. Likewise, it should preserve the safety and profitability of the production process without presenting porosities or voids in its structure, taking into account the required compressive strength (Ortega et al., 2021, p. 164).

Perez et al. (2019) pointed out in their article that the plant Aloe vera is commonly called aloe vera. This name descends from the Arabic “Allah”, meaning “shiny bitter substance”, and “vera” represents in Latin “true”. Aloe vera gel is among the 250 varieties of Aloe; its scientific name is “aloe barbandensis”. This gel has currently become one of the products with the highest commercial value due to its favourable effects on human health. Its natural properties and its use in various industries (cosmetic, pharmaceutical and food) are now last tested in construction (p. 902).

One of the options that arises for the use of aloe vera as a natural additive in the elaboration of self-compacting concrete, given that this prototype of concrete contains a higher amount of cementitious material than is handled in conventional concrete dosages in order to meet the rheological requirements that this type of concrete must present.

For this reason, the general problem of this research was: What is the effect of the addition of aloe vera gel as a replacement of the superplasticizer in self-compacted concrete f’c = 280 kg/cm2? Also, the following specific problems were considered: What is the effect of the addition of aloe vera gel on the flow and viscosity? What is the effect of the addition of aloe vera gel on the flow capacity of self-compacted concrete? What is the effect of the addition of aloe vera gel on compressive strength?

The justification of research is described in specific paragraphs in accordance with all types of justification; it is essential when making the justification not to relate to different topics that have not been mentioned in the variables of the present research project (Arias & Covinos, 2021, p. 63).

The current research was socially justified because the purpose is the development of the design of self-compacted concrete with the addition of aloe vera gel as natural aggregate, which will reduce the economy of the concrete

mix, interacting with the hydrating-cementing system; it will also be relative for future buildings with similar structures, being of benefit to the community.

The research project was justified in practice because it demands a self-compacted concrete mix design that complies with the standards of each test to be performed. At the same time, this design will serve to improve the workability of the concrete in the fresh state, which will allow access to densely reinforced areas and formworks with reduced spaces; it should also reach or exceed the breaking strength in the hardened state.

The proposed research sought, through theoretical application, to expand the knowledge regarding the benefits of aloe vera in the specific properties that will be presented in concrete, such as its behaviour in the fresh and hardened state. For this purpose, the ACI 237R method and NTP 339.034 will be used, which implies knowing the physical and mechanical characteristics of concrete in the fresh and hardened state, respectively, respecting the parameters indicated in the standards to be used in the research.

The research was methodologically justified since the data collection will be used in the preparation of self-compacted concrete designs and fresh and hardened concrete tests. Moreover, thus, determine with the results obtained the most appropriate method for the addition of percentages of aloe vera.

The objectives of a research study determine the effect that one wants to find, since first of all, a problem is approached, which must be observed; for the objectives, it has to solve the problem; it is also advisable to find out about the problem. However, it does not define giving solutions (Arias & Covinos, 2021, p. 32).

In keeping with what was mentioned in the preceding paragraph, the general objective of the research was to determine the effect of the addition of aloe vera gel as a replacement of the superplasticizer in self-compacted concrete f'c=280 kg/cm2. The additions will be 3% and 5% in water in relation to the weight of cement during concrete mixing. Then, the following specific objectives determined in the present research work were presented: to verify the incidence of Aloe vera gel incorporation on flow and viscosity, to evaluate the incidence of aloe vera gel incorporation on the passing ability of self-compacted concrete, and to analyze the addition of aloe vera gel incorporation on compressive strength.

The exposition of hypotheses are definitions of tentative tests in the correlation between two or more variables" (Arias & Covinos, 2021, p. 39).

The current research project considered a hypothesis that the addition of Aloe vera gel significantly influences the replacement of superplasticizers in self-compacted concrete f'c = 280 kg/cm2. The following specific hypotheses were then presented. The incorporation of Aloe vera gel significantly influences flow and viscosity by 5%, incorporating Aloe vera gel significantly influences the flow capacity of self-compacted concrete by 3%, and incorporating Aloe vera gel significantly influences compressive strength by 10%.

METHOD

2.1. Type and design of research

2.1.1. Type of research

According to Esteban (2018), in his scientific article. The type of research was oriented to solve specific difficulties that originate in the methods of production, marketing, and consumption of goods and services of any human activity. Oriented in the inquiry and consolidation of knowledge for its application and, therefore, for the benefit of cultural and scientific progress (p. 3).

Consequently, and having understood the author's statements, this research was oriented to the applied type because it sought to provide a solution to a situation that arose in reinforced concrete structures, reducing the cost of concrete casting and improving the quality of the structures, using a self-compacted concrete design with the incorporation of aloe vera as a natural additive.

The scientific research method, according to Mejía (2021) in his article. He indicated that it is a set of methodologies and procedures of scientific

information and evidence that researchers use to learn about data and facts and determine the interpretation according to certain elements and standards (p 40).

The present research was considered a scientific, logical, hypothetical and inductive research method due to the test procedures to be performed on self-compacted concrete with superplasticizer admixture and with 3% and 5% incorporation of aloe vera as a replacement of the superplasticizer.

Hernandez, C., Carpio, N. (2019). It is designed to respond to the principles of social or physical events and phenomena. It is oriented to reveal why a phenomenon happens and under what conditions it occurs. The objective of the study is to know and to lead a variable by knowing the behaviour of another variable (p. 76).

For these reasons, research is at the explanatory level.

2.1.2. Research design

Variables

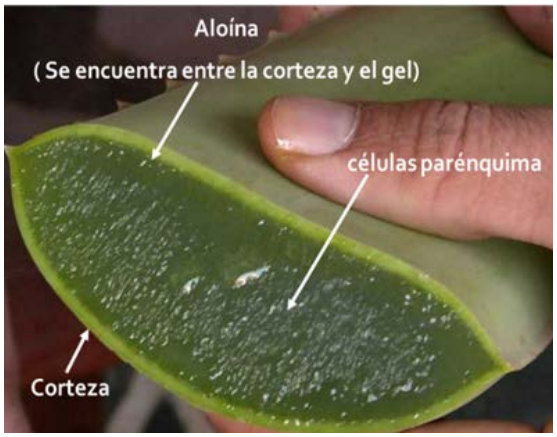
a) Independent: Aloe vera as a natural additive.

It is a perennial plant with tall green leaves in rosettes on stems. Its leaves consist of a thick cuticle surrounding it, which can differentiate into parenchyma cells that form a gel or pulp that represents 65% to 80% of the weight of the plant. This plant is also called aloe, acíbar or Barbados aloe. Easy to grow in areas with dry soil. Its characteristic is 80 to 100 cm in height at maturity in 4 to 6 years, and its life span is approximately 50 years (Artunduaga et al., 2021, p. 8).

Operationally, aloe vera was added in 3% and 5% to the water of the concrete mix in proportion to the weight of the cement.

Figure 1

Structure of aloe vera



b) Dependent: Superplasticizer

These are admixtures that perform functions equivalent to plasticizers, i.e., they increase the workability of the mortar pastes and, therefore, the fresh state of the concrete. This increase makes it possible to decrease the moisture content, maintaining the flow of the material and its strength (Sika et al., 2020, p. 23).

Operationally, a self-compacting concrete design was developed through the ACI 237R methodology. During the development of the mix, the superplasticizing admixture was added together with the water in the mix, with the objective of meeting the flow properties and mechanical properties.

In the flow test, the diametral expansion time of 50 cm was controlled in a range of 2 to 10 seconds, and the expansion diameter was also measured, whose range was within 55 to 65 cm.

In the test of the passing ability of boxes L and U, the distance and time of 20 cm and 40 cm of its path in box L and the final elapsed time were measured, which was less than 8 seconds. In the case of box U, the heights acquired were measured.

In the compressive strength tests, the strengths achieved at the curing ages of 7, 14 and 28 days were verified. The compressive strengths of the standard samples of the self-compacted concrete design without the incorporation of aloe vera and the strengths of the samples with the addition of 3% and 5% aloe vera were purchased.

The details of the operationalization matrix of the variables are attached in Annex Nº 01.

2.3. Population, Sample and Sampling

2.3.1. Population

"The population is a grouping of all the elements or units of accessible analysis that create part of the spatial environment where the research work will be carried out" (Arias & Covinos, 2021, p. 113).

The population of this research corresponded to 03 self-compacted concrete mix designs, 01 standard mix and 02 mixes with added percentages of aloe vera gel. They complied with the extension flow in a range of 55 cm to 65 cm in diameter, where the components were aggregates (fine and coarse), cement, water, superplasticizer admixture and aloe vera gel.

A total of 63 tests were established between fresh and hardened states, which were 9 tests of expansion flow, 18 tests of passing capacity, 12 tests of filling capacity, and 24 tests of compressive strength.

Table 1

Test sample for study in a fresh state.

Nombre de la prueba	Características	Grupo patrón	Grupo control 3%	Grupo control 5%
Flujo de asentamiento	Capacidad de llenado	E-1	E-1	E-1
		E-2	E-2	E-2
		E-3	E-3	E-3
Anillo J	Habilidad de paso	E-1	E-1	E-1
		E-2	E-2	E-2
		E-3	E-3	E-3
Caja L	Habilidado de paso	E-1	E-1	E-1
		E-2	E-2	E-2
		E-3	E-3	E-3
Caja U	Capacidad de llenado	E-1	E-1	E-1
		E-2	E-2	E-2
		E-3	E-3	E-3
Cono V	Capacidad de llenado	E-1	E-1	E-1

Source: Own elaboration.

Table 2
Sample specimens for study in hardened state.

Días de curado	Muestra patrón	Adición a 3%	Adición a 5%
	N° de espécimen	N° de espécimen	N° de espécimen
7	2-p	2-p	2-p
14	3-p	3-p	3-p
28	3-p	3-p	3-p

Source: Own elaboration.

Inclusion criteria:

The concrete dosages with 3% and 5% that obtained the characteristics of the parameters established by the standard and in turn exceeded the f'c=280 kg/cm2.

Exclusion criteria:

The concrete dosages with 3% and 5% that did not obtain the characteristics of the ranges established by the standard and those that did not reach the f'c=280 kg/cm2.

3.3.2. Sample

According to the article by Hernandez and Carpio (2019), it mentioned that the census sample is all the research units that form referents as a sample. Therefore, the population to be investigated is determined as a census because it is a parallel universe, population and sample (p. 78).

The present research report was based on the type of census sample.

3.3.3. Unit of analysis

The physical testing of aggregates for concrete batching was carried out by the laboratory LabGeo Group SAC, where sieve equipment, scales, Fiola, unit weight moulds, data collection instruments, and printed forms were used.

The designs of the self-compacted concrete and the tests of the physical properties of the concrete in its fresh state were carried out and analyzed by one of its concrete specialists. Where 3 slump flow tests, 3 J-ring tests, 3 L-Box tests, 3 U-Box tests and 1 V-cone test were obtained. Using 114 kg of material (cement, water, fine and coarse aggregates, additives), which is equivalent to a volume of 50 m3 per batch of concrete mix, 24 cylindrical specimens of 15 cm x 30 cm of self-compacting concrete were moulded from the samples of the standard design and from the samples of the design with the addition of 3% and 5% aloe vera.

3.4. Data collection techniques and instruments

Techniques

Direct observation is interpreted by the fact that the researcher does not intervene, nor does he modify the space where the activities in which the tests have been developed take place. Otherwise, the results obtained will not be admitted. (Martínez, 2019, p. 774).

Documentary analysis is a method that considers the potential relevance of documents proposed to demonstrate compliance with the indicators. It is a pragmatic and practical approach to choosing notable ideas from a document where its content can be formulated without mistakes (Escobar & Mercado, 2017, p. 6).

The techniques applied in the research were direct observation and documentary analysis, where fresh state testing methods were used, as well as hardened state testing, in which an inventory of the results obtained and measurement ranges were available.

Instruments

For Useche and Artigas (2021), data collection is a symbolic, numerical or alphabetical representation that can express information. The data obtained are recorded and show a series of responses, where the results will be interpreted and define whether the variable under study meets the ranges established in the research (p. 29).

The research instruments were given by the data collection formats of the assays standardized by the laboratory. Our data selection is related to the test methods presented in the ACI 237R-07 standard since it shows the testing process accurately and objectively, as well as the appropriate intervals or quantifications, and offers normative support since the use is the most applied in America.

The test reports used in this research are mentioned below.

· Aloe vera pH and density report.

· Aggregates report (including granulometric analysis, maximum size, fineness modulus, percentage of passing N° 200, moisture content).

· Aggregate specific gravity and absorption report.

· Aggregate unit weight report.

· Concrete mix design report (compilation of aggregate physical test results and raw material weights).

· Fresh concrete properties report (including temperature, slump, specimen sampling number).

· Self-compacting concrete test report (T-50 flow, expansion diameter, J-ring, L-box passing time, V- and U-box filling time).

· Concrete core compressive strength report.

Validity

Useche et al. (2021), the validation of an instrument is pronounced with the capacity to measure in ranges. This aspect shows whether the results obtained in the measurement express an accurate or true precision (p. 55).

To certify the validity of the selection of information obtained in the present investigation without any doubt or confusion, it is specified that the documents presented were examined and approved by a registered engineer, laboratory and tests accredited and tested by INACAL.

Reliability

Useche et al. (2021), the reliability of the instrument is characterized by the degree to which the study of the reporting agents gives replicated results, guaranteeing the accuracy of the tests under the same conditions, so it is not sensitive to changes or doubts between evaluators and observers of the variable (p. 61).

That is, research reliability is measured by the range in which the equipment, tools and instruments measure the results. Through the periodic application of the equipment, updated calibration certificates will be presented for the elaboration of tests in the laboratory accredited by INACAL.

3.5. Procedure

The following is the procedure of the methodology that was followed to achieve the proposed objectives:

STAGE 1 - Cabinet

· Compilation of information: this includes gathering information from multiple scientific articles, master's theses and reliable information sources in which the processes of the variables under study are detailed.

· Acquisition of materials includes the search for the place where the aloe vera stalks and the necessary materials that make up the development of the self-compacted concrete design will be obtained.

· The devices or equipment to be used will depend on the necessary tests, which must comply with the requirements mentioned in ACI 237R-07.

· Determination of the tests includes identifying the physical tests of the aggregates and tests in the fresh and hardened state of the self-compacted concrete. In addition, evaluate which laboratories are accredited by INACAL and have the equipment for special concrete.

STAGE 2 - Field

· The manual collection of aloe vera stalks of approximately 2 years of maturity (between 40 cm. to 60 cm. long and 8 cm. to 12 cm. wide) was carried out at the weed collection points in the parks of the Mayorazgo urbanization and in the orchards located on the banks of the Rimac River between the Fuerzas Policiales association in the district of Ate.

· Subsequently, it was washed to remove dirt and left to stand in buckets with drinking water for 24 hours, where the aloin found in the plant was eliminated.

· Once the period of 24 hours had elapsed, the separation of the aloe vera bark was carried out; the leaves were opened at the edges with the use of a knife. Once opened with a spoon, the gel or pulp of the plant was extracted.

· Once the aloe vera pulp was obtained, it was liquefied with a domestic blender until a viscous consistency was obtained. It was kept in the refrigerator until the next day when the self-compacted concrete mix designs were started.

Figure 2

Preparation of aloe vera gel

➢ As for aggregates, the quality was verified according to NTP 400.037 and physical tests for mix design such as:

· Aggregate Moisture Content (ASTM D2216)

· Aggregate particle size analysis (ASTM C136)

· Relative density and absorption of coarse aggregate, (ASTM C127)

· Relative density and absorption of fine aggregate, (ASTM C128)

· Aggregate unit weight, (ASTM C29)

· Percentage of fines passing 200 mesh, (ASTM C117)

➢ Laboratory data record forms were prepared for the various tests.

Figure 3

Laboratory visit, aggregate testing activity.

STAGE 3 - Laboratory

➢ The following tests were carried out on aloe vera

· pH level

· Density

➢ The following tests were performed on fresh and hardened self-compacted concrete:

· Concrete Mix Designs (ACI 211)

· Fresh concrete temperature (NTP 339.184)

· Determining slump flowability (ACI 237R-07 / ASTM C1611)

· Test for static segregation (ACI 237R-07)

· Determine ability to pass (ACI 237R-07)

· Fabrication and curing of concrete specimens (NTP 339.034)

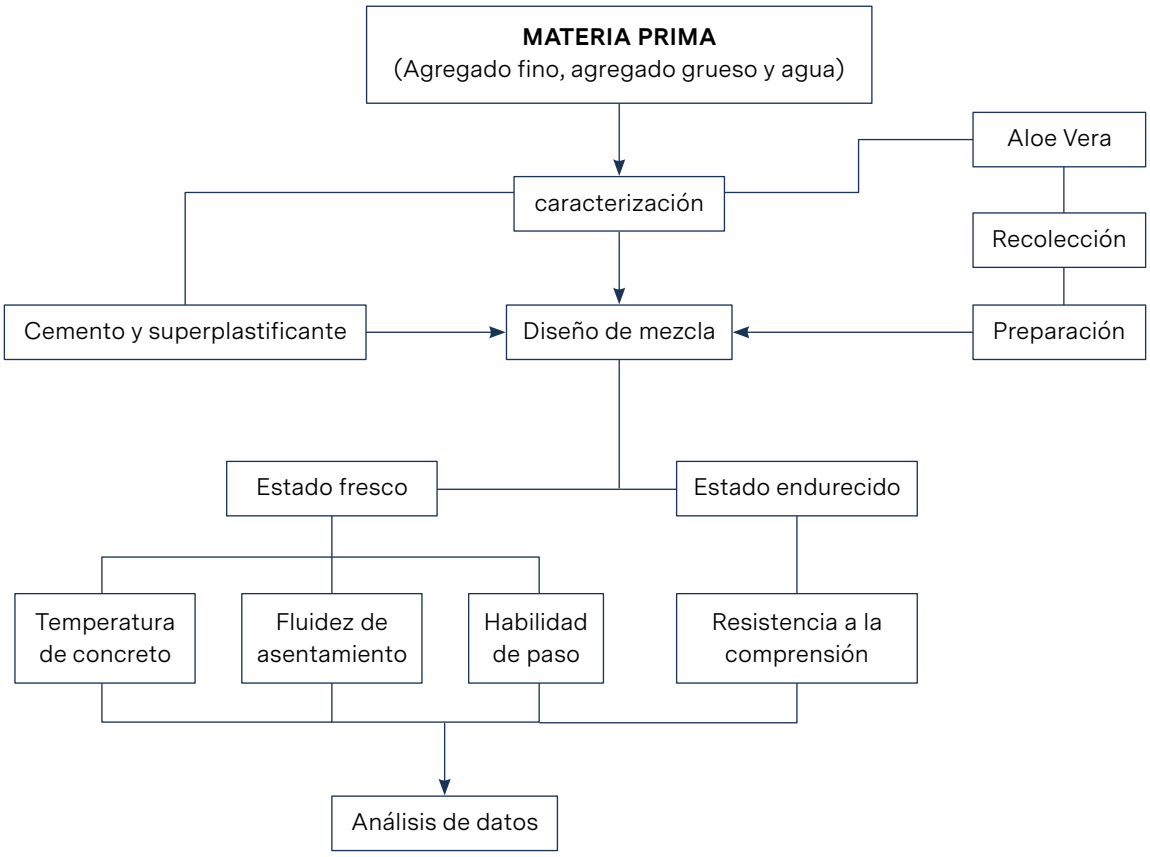
· Cylindrical Core Compressive Strength (NTP 339.034)

STAGE 4 - Cabinet

Finally, the diagram of the experimental process is presented, with which the information for the interpretations, conclusions, discussions and recommendations of the research topic will be obtained.

Figure 4

Experimental process diagram



3.6. Data analysis method

The method of analysis for data collection was by means of test formats, where the control groups (standard sample and empirical sample) were evaluated, that is, to evaluate the results of the physical tests of self-compacted concrete with superplasticizer and those with the addition of 3% and 5% of aloe vera gel, for which the use of the SPSS tool was applied, as well as Microsoft Excel spreadsheets, to obtain the frequency distribution tables necessary for the graphical analysis. The values obtained presented a normal distribution, so they were parametric tests, applying the Shapiro Wilk tests, due to the sample size of less than 50 trials, as well as the quotient of two random variables for which the Fisher F test was used and the analyses that did not present normality, the non-parametric Kruskal-Wallis test was used.

3.7. Ethical Aspects

The researcher was involved in being responsible and honest with the data obtained based on the values exposed by the assigned laboratory where the pertinent tests were carried out; likewise, what was determined in the ISO 690-2 standard, which supports and respects the exclusive author's rights, was complied with. Regarding beneficence, contributions were made to the addition of aloe vera gel as a replacement for the superplasticizer in concrete; regarding non-maleficence, the results provided by the accredited laboratory were not altered; regarding autonomy, the advice and opinions of the technicians who participated in the tests were respected in order to propose reliable data; and regarding fairness, the origin of the information was respected and is evidenced in the references item.

RESULTS

4.1. General (materials)

Cement is a binder formed from a mixture of carbonized and then ground limestone and clay, whose properties tend to harden after contact with water.

Aggregates, specified as construction materials, are granular minerals (small pieces of rock, sand and gravel) used in the construction of public and private works. The result of stone materials on the properties of concrete is not only critical for the final finish but also clearly affects workability, strength, flexibility, thermal properties, etc. (Cedeño et al., 2022, p. 25).

Figure 5

Fine aggregate granulometry curve

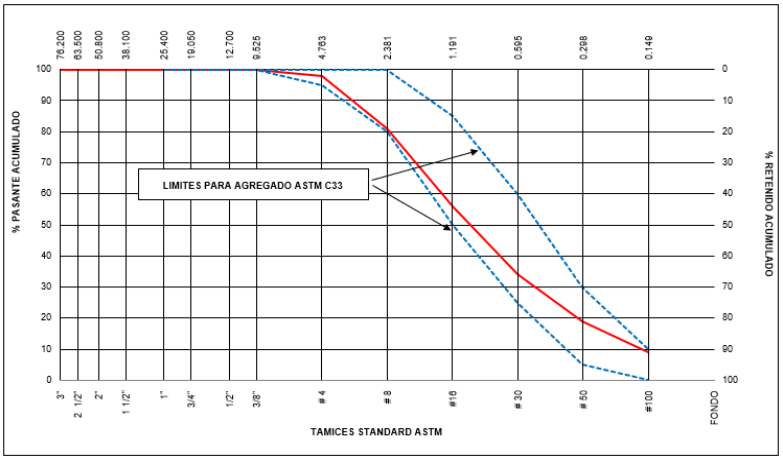
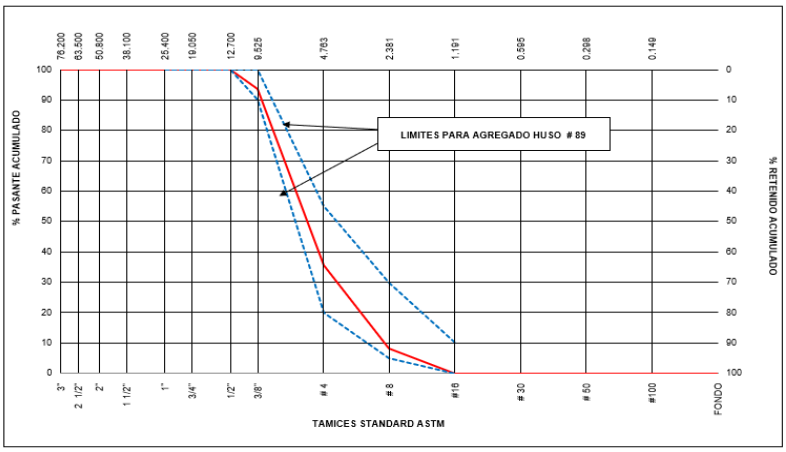


Figure 6

Fine aggregate granulometry curve



Water is a substance whose molecules consist of two hydrogen atoms and one oxygen atom joined by a covalent bond. The dosage of fresh concrete should be sweet and clean, free of impurities (Valdivielso et al. es el agua, 2023, para. 3).

Additive (superplasticizer): These are additives whose function is similar to plasticizers, i.e. to improve the workability of mortar pastes and, therefore, the fresh state of the concrete. This increase makes it possible to decrease the moisture content, maintaining the flow of the material and its strength (Sika et al., 2020, p. 23).

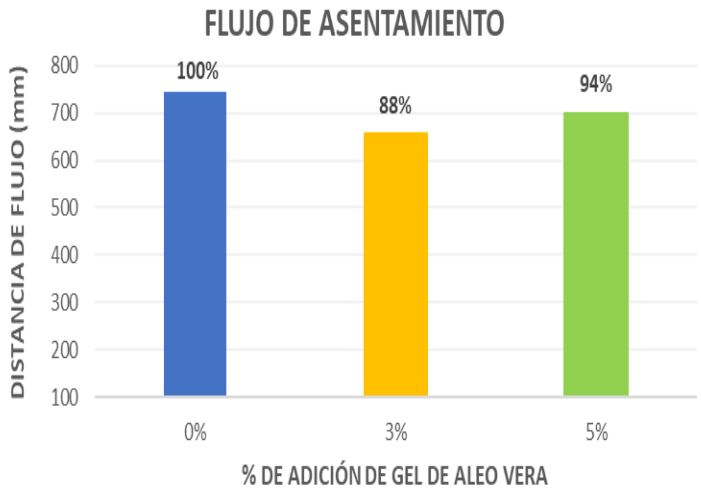
Aloe vera gel's structure includes carbohydrates, polysaccharides, minerals, amino acids and antioxidants.

4.2. Specific Objective No. 1:

To verify the incidence of the incorporation of aloe vera gel on the flow and viscosity.

Graph 1

Average expansion flow of self-compacted concrete.



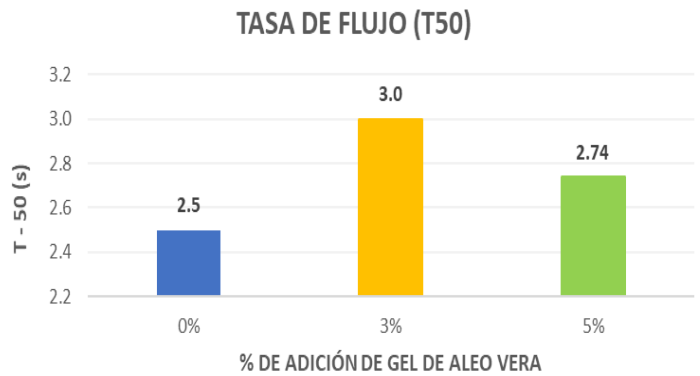
Source: own elaboration

Interpretation:

The graph shows that the standard sample obtains an average expansion diameter of 745 mm, equivalent to 100%, and with the addition of 5% aloe vera gel, 6% less expansion capacity was obtained, referring to the standard sample.

Graph 2

Average expansion flow of self-compacted concrete.



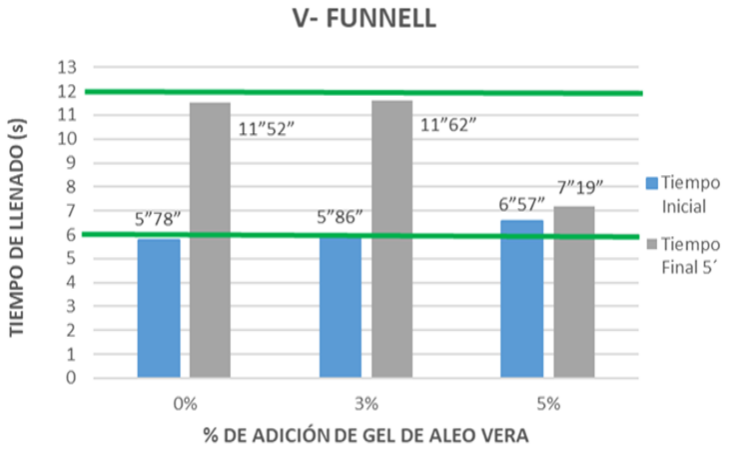
Source: own elaboration

Interpretation:

In the period, T50 is a secondary indicative of the expansion flow, where the time range should be between 3 to 7 seconds. The graph shows that with the addition of 5% aloe vera gel, a shorter filling capacity time is obtained, which is considered a greater fluidity.

Graph 3

Filling capacity of V-FUNNELL self-compacted concrete.



Source: own elaboration

Interpretation:

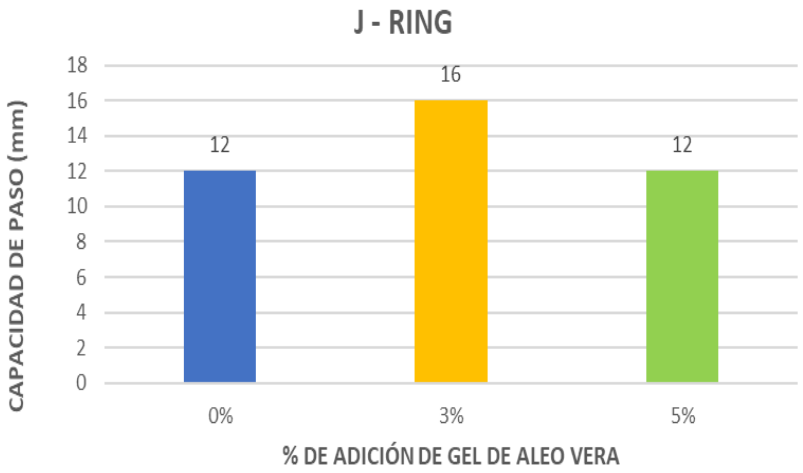
With the addition of 5% aloe vera gel, it was possible to obtain start and end times within the optimum filling range, achieving greater fluidity compared to the standard sample, even in the 5-minute rest time.

4.3. Specific Objective No. 2:

To evaluate the incidence of the incorporation of aloe vera gel on the flow capacity of self-compacted concrete.

Graph 4

Passing capacity of J-Ring self-compacted concrete.



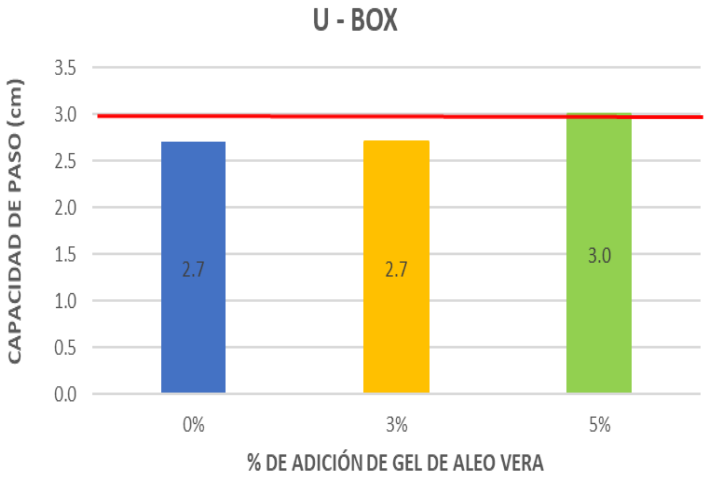
Source: own elaboration

Interpretation:

It can be observed in the graph that with the addition of 5% aloe vera gel, a higher passing ability similar to the standard sample (12 mm) was achieved. In comparison, with the addition of 3%, a lower passing ability was obtained with 16 mm height.

Graph 5

Passing ability of U-Box self-compacted concrete.



Source: own elaboration

Interpretation:

It is observed in the graph detailed that the samples are within the maximum limit of height difference, whose range is 0 to 3 cm.

Graph 6

Results of compressive strength at 28 days.

Source: own elaboration

Interpretation:

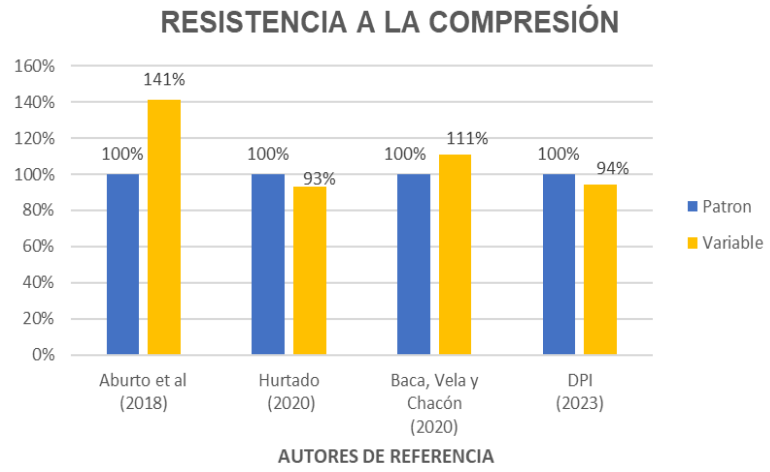
The graph shows the compressive strengths obtained as a percentage of the design strength, where a difference of 10% and 21% of the aloe vera gel additions at 3% and 5%, respectively, compared to the standard sample is evident.

DISCUSSION

Regarding the general objective, it was possible to determine the effect of the addition of aloe vera gel as a replacement of the superplasticizer in self-compacted concrete f'c = 280 kg/cm2. The analysis by Aburto et al. (2018) points out that when "determining the use in percentages of addition of aloe vera in conventional mix concrete of 210 kg/cm2. They obtained negative results in fresh concrete and positive results in its compressive strength. The best result of aloe vera addition was 2%, which was the best percentage used, with a decrease in a slump of 2" and a resistance of 355 kg/cm2 equivalent to 41% of the standard resistance" (p. 112). In the present investigation, the fresh state result of the self-compacted concrete was 280kg/cm2. A similarity was obtained in some tests in relation to the standard design, with respect to the flow of settlement or expansion corresponding to the addition of aloe vera gel; 12% and 6% less than the standard design were obtained. In the filling time of the V-Funnell, the 3 samples were within the parameter determined by the ACI 237R-07 standard and in the L-Box passage capacity test, the results obtained from the 3 samples were above the 0.80 of the established ratio (0.80 to 1.00) and in the U-box test, the 3 samples had the same result of 3 cm difference in height. As for the hardened concrete, positive results were obtained in terms of the nominal strength and the safety factor of the mix design. The compressive bearing capacity respectively of the aloe vera gel additions was 6% and 12% less than the standard design with 475 kg/cm2.

Graph 7

Comparison with respect to compressive strength.



Source: own elaboration

CONCLUSIONS

1. The general objective was to determine the effect of the addition of aloe vera gel as a replacement of superplasticizer in self-compacted concrete f'c = 280 kg/cm2. It was determined that the addition of aloe vera gel has effects on self-compacting concrete in the fresh and hardened state.

2. Specific Objective 1 is to verify the incidence of the addition of aloe vera gel on flow and viscosity. It is concluded that the incorporation of aloe vera gel has an incidence in replacement of the superplasticizer admixture in both the expansion flow and viscosity of self-compacted concrete. The best-performing admixture was 5%, with 700 mm of expansion flow and an average viscosity of 2.74 seconds.

3. Specific Objective 2, to evaluate the incidence of the incorporation of aloe vera gel on the flow capacity in self-compacted concrete when replacing the superplasticizer admixture, it is concluded that in the J-ring and U-box tests,

it does not affect the flow capacity, obtaining similar results to the standard sample. In contrast, in the L-box test, it has an incidence of 0.021.

4. Specific Objective 3: Analyze the addition of aloe vera gel incorporation in the compressive strength; it is concluded that the additions of aloe vera gel percentages have a lower incidence than the standard sample but exceed the specified compressive strength and even the safety factor of the standard design. Among the additions that had the best performance in compressive strength was 3% with 448 kg/cm2.

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