International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-11, Issue-11, November 2021

High-Strength Concrete Mixtures with the Addition of Super plasticizer

Juan Renteria Soto, Julio Roberto Betancourt Chávez, Rajeswari Narayanasamy, Arturo Tadeo Espinoza Fraire

Abstract— **High performance concrete (CAD) is a material that develops properties superior to those of conventional concrete. To be considered in this category need to achieve at least a compression strength of 700 kg / cm^2 or 70 MPa. In the present work, the influence of the superplasticizer and the limestone filler on concrete mixtures designed for a compression resistance of 700 kg / cm^2 was evaluated, forming two groups of samples, one using 15% filler and the other without filler. In which 0%, 10% and 20% of superplasticizer was added in each group, forming a total of 6 concrete mixtures, the compressive strength was measured at (7, 14, 28, 56 and 91) days. At an early age the results presented low load values, but at ages greater than 28 days the mixtures present considerable values.**

Index Terms— **high-strength concrete, superplasticizer, special concretes, structures.**

I. Introduction

Concrete is a material made up of a binder (a mixture of water and cement), stone aggregates and in some cases, it is combined with additives to give the concrete special characteristics, such as permeability, setting time or the inclusion of air. [1]. High performance concrete (CAD) is a material that exceeds the properties of conventional concrete. To be considered high performance it needs to have at least a compressive strength of 700 kg / cm2 or 70 MPa. Such resistance can be achieved with the appropriate selection of materials, inclusion of mineral or chemical additives and a low ratio between water and cementitious material [2].

During the 1970s, the compressive strength considered in the construction of high-rise buildings was greater than that used in smaller buildings. The application of these concretes was due to the fact that they exceeded the usual concretes. If the current standards were applied, they would define that they are conventional concretes, since they had the same manufacturing process, what made them different was that they selected and controlled the materials used [3].

Initially, superplasticizers were used to obtain greater fluidity in a concrete, however, when they were used to decrease the proportions of the water / cementing material (a / c) ratio, it was discovered that with the addition of the superplasticizer, the properties of the concrete increased. such as: greater fluidity, greater elastic modulus, greater resistance to bending, less permeability, greater resistance to abrasion and greater durability [4].

The purpose of filler in concrete is to reduce porosity in concrete by improving its properties. In this way, the presence of the filler increases the workability in the concrete. If the concrete does not contain the necessary amounts of fines, when it is placed and compacted, it could become segregated. To avoid some unwanted characteristics such as: low porosity and permeability, reduced durability and a low resistance to compression, it is opted for the modification of the amount of cement or the inclusion of additives, all these solutions bring with them the increase in cost. of concrete mixes. An effective way to counteract these undesirable effects is the incorporation of “limestone filler” and the use of superplasticizers, in order to improve workability and largely reduce exudation and shrinkage cracking [5].

Currently mixtures are designed for specific purposes, where there are limit values with respect to a range of properties that must be met. Said relationships are: the maximum water / cement ratio, minimum cement content, minimum resistance, minimum workability, maximum aggregate size and air content, within the stipulated guidelines [6].

The objective of the work is to evaluate the influence of the superplasticizer and the limestone filler in concrete mixtures, designed for a compressive strength of 700 kg / cm^2 and to describe the behavior of the different mixtures seeking to define which is the best performance up to 91 days they underwent curing and testing.

II. Mataterials and Mnetods

The physical-mechanical properties of materials are essential to determine their quantity. Hence the importance of having extensive knowledge of the materials to be used and control when using them. Material proportions are often measured by weight, since measurement by volume is not as accurate, but it is useful for small projects [7].

A. Materials

Materials from Gomez Palacio, Durango, Mexico was used. It is worth mentioning that the sand used was hybridized to be within the guidelines mentioned in the NMX-C-077-ONNCCE-1997 standard, since the bench sand did not have the requirements mentioned in the aforementioned standard. The materials used are the following:

- water
- CEMEX CPC 30R cement
- • coarse aggregate (crushed limestone)
- fine aggregate (hybrid sand, which results from the mixture of river sand and crushed limestone sand)
- filler (dust that passes through mesh # 100)
- superplasticizer masterglenium 3200

B. Methods

For the experimentation, the standards that base the quality and performance of the methods used in the different concrete mixtures that were produced were used. The quartering method was carried out based on the

NMX-C-170-ONNCCE-2019 standard. The determination of the distribution of the particles with a granulometric analysis was carried out based on the NMX-C-077-ONNCCE-1997 standard. In the materials laboratory, the absorption and density tests (fine aggregate) were carried out according to the NMX-C-165-ONNCCE-2004 standard. To determine the absorption and density of the coarse aggregates, the procedure indicated in the NMX-C-164-ONNCCE-2014 standard was used. The process to determine the moisture content was carried out based on the provisions of the NMX-C-166-ONNCCE-2006 standard. The volumetric mass was obtained with respect to the NMX-C-073-ONNCCE-2004 standard. According to the NMX-C-156-ONNCCE-2010 standard, the slump of fresh concrete was determined. Based on the NMX-C-159-ONNCCE-2016 standard, the specimens were elaborated. According to the NMX-C-109-ONNCCE-2013 standard, the. To determine the compressive strength of the specimens, the procedures shown in the NMX-C-083-ONNCCE-2014 standard were used.

C. Design of concrete mixes

The dosage of the concrete mixes was according to the absolute volume method established by American Concrete Institute (ACI 211.1-91). In order to have a greater amount of information, 6 concrete mixes analyzed in 5 ages (7, 14, 28, 56 and 91) days, and three specimens per age, were made, obtaining a total of 90 cylinders. The 3 specimens corresponding to each age were tested and the results obtained were averaged to obtain a final value. The proposed slump was 15 cm, with an approximate margin of ± 2.5 cm. Of the 6 concrete mixes, different concentrations of superplasticizer and filler were added to each. The values shown in table 1 are those used to carry out the dosages; the filler percentage refers to the sand replaced by the filler.

Obtaining the optimal filler percentage is an experimental derivation of the test known as "Standard Proctor". The suitable percentage of limestone dust was sought, which was capable of filling the spaces between the sand particles, in this way a theoretically uniform concrete mixture would be achieved as a solid rock. Subsequently, the sand substitution percentages were chosen, which were replaced by the filler (limestone dust); 10%, 15% and 20% were used for the analysis, obtaining 15% as the most appropriate value.

Table 1.- Concrete mixes.

Mixes	Superplasticizer	Filler
M1	0%	0%
M2	10%	0%
M3	20%	0%
M4	0%	15%
M5	10%	15%
M6	20%	15%

III. RESULTS

When testing the specimens, it is recommended that the load application faces be almost entirely flat, complying with perpendicularity to the axis, by no more than 0.5 ° and irregularities with respect to a plane | exceeding 0.05 are not allowed. mm, otherwise they must be headed according to what is indicated in the NMX-C-109-ONNCCE-2013 standard.

The objective of pitching the specimens is for the load to be evenly distributed on the top and bottom of the specimens, complying with a satisfactory test process. It is worth mentioning that for the testing of the specimens of this investigation, capping with sulfur was used, following the guidelines established by the indicated standard. The results of the laboratory tests at (7, 14, 28, 56 and 91) days are summarized in tables 2, 3, 4, 5, 6 respectively.

Table 2.- Compression results at 7 days.

Mixes	Additive %	Filler %	Load kg	f´c kg/cm^2	% f´c
M1	0	0	17,750	226.0	32.29
M2	10	0	23,250	296.0	42.29
M3	20	0	27,000	343.7	49.11
M4	0	15	20,750	264.1	37.74
M5	10	15	25,500	324.6	46.38
M6	20	15	27,500	350.1	50.02

Table 3.- Compression results at 14 days.

Mixes	Additive %	Filler %	Load kg	f´c kg/cm^2	% f´c
M1	0	0	21,500	273.7	39.11
M2	10	0	27,750	353.3	50.47
M3	20	0	28,750	366.0	52.29
M4	0	15	26,000	331.0	47.29
M5	10	15	34,250	436.0	62.30
M6	20	15	31,500	401.0	57.30

Table 4.- Compression results at 28 days.

Mixes	Additive %	Filler %	Load kg	f´c kg/cm^2	% f´c
M1	0	0	23,000	292.8	41.83
M2	10	0	24,750	315.1	45.02
M3	20	0	37,500	477.4	68.21
M4	0	15	29,000	369.2	52.75
M5	10	15	41,750	531.5	75.48
M6	20	15	33,000	420.1	60.02

Table 5.- Compression results at 56 days.

Mixes	Additive %	Filler %	Load kg	f´c kg/cm^2	% f´c
M1	0	0	23,250	296.0	42.28
M2	10	0	34,000	432.9	61.84
M3	20	0	37,750	480.6	68.66
M4	0	15	30,250	385.1	55.02
M5	10	15	46,750	595.2	85.03
M6	20	15	45,000	572.9	81.85

Table 6.- Compression results at 91 days.

Mixes	Additive %	Filler %	Load kg	f´c kg/cm^2	% f´c
M1	0	0	32,000	407.4	58.20
M2	10	0	36,500	464.7	66.39
M3	20	0	39,750	506.1	72.30
M4	0	15	33,250	423.3	60.47
M5	10	15	53,750	684.3	97.76
M6	20	15	50,250	639.8	91.40

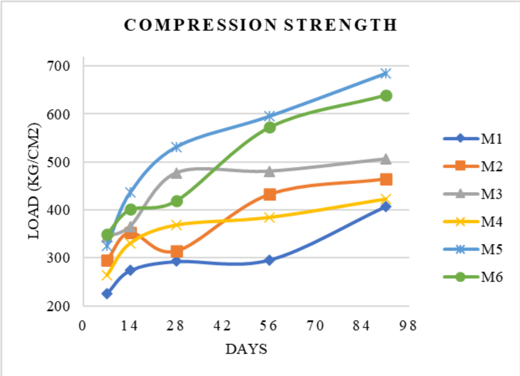

Fig 1.- Compression strength graph.

In fig 1, the results obtained are graphically represented for a better analysis.

Discussion

The results obtained from the tests at 7 days, are with very approximate values between them, having an ascending behavior, starting with the base mixture, until the one with the highest concentration, reaching 32% and 50% of the design resistance, the minimum and the maximum, respectively.

For the 14 days, they present significant variations, increasing the resistance in the 6 mixtures, the mixtures M1, M2 and M4 behave in a normal way increasing their resistance over time, the mixture M5 presents the same behavior, while M3 and M6 increased, but one index less as can be seen in figure 1.

The behavior at 28 days continued with the same descent, with the exception of the M2 mixture, resulting in a descending behavior, which could be attributable to the pitching work.

At 56 days an elevation in the resistance of the mixture M2 was shown, without leaving aside the fact that it showed offspring at 28 days. The remaining mixtures continued their increase in resistance, at this age the mixture with the lowest resistance was M1 with 41% and the highest reached 75%, being M5.

Finally, at 91 days it was observed that all the mixtures increased their resistance with respect to that shown at 56 days. The mixture that showed the greatest resistance was the one that added 10% superplasticizer and 15% filler (M5), obtaining a final resistance of 684.3 kg / cm^2, corresponding to 97.7%.

IV. Conclusion

From the results obtained, it can be concluded that the addition of the superplasticizer gives benefits to the mixtures by reducing the amount of mixing water, but with the use of the filler the results are better, understanding that limestone rock powder can be used as filler due to observed benefits.

The use of the filler could demand a greater amount of water, in this case it was not noticeable because all the mixtures behaved in the same way.

To work with mixtures of superior resistance it is necessary to consider additional materials and of greater capacity, since, in the tests, the aggregate failed.

The best proportion is the one made in the mixture of 5 of 10% of additive and 15% of filler, being the one that presented the highest resistance and continuous increase at each age.

Acknowledgment

The authors would like to thank the Faculty of Engineering, Sciences and Architecture of the Juarez University of the state of Durango for their support in carrying out the research. A special thanks is extended to the laboratory staff of the same faculty for their support in conducting the tests.

References

[1] Cemex, «" Concreto ", » October 2020. [Online]. Available: https://www.cemexmexico.com/productos/concreto.
[2] S. H. Kosmatka, B. Kerkhoff, W. C. Panarese and J. Tenasi, "Design and control of concrete mixtures", Skokie, Illinois, US: Portland cement association, 2004.
[3] P.C. Aïtcin, "High Performance Concrete", London: E & FN SPON, 1998.
[4] Y. Malier, "High Performance Concrete, From material to structure", London: E & FN SPON, 1992.
[5] M. Sümer, «" Filler and superplasticizer usage on high strength concrete ",» Building Materials, vol. 57, No. 287, pp. 75-80, 2007.
[6] Muziño Vélez and P. R. Santa Ana Lozada, «" Design of concrete mixtures ",» Laboratory of material structures and structural systems, Mexico City, 2017.
[7] [7] IMCYC, «" Basic Concepts of Concrete ",» June 2004. [Online]. Available: http://www.imcyc.com/cyt/junio04/CONCEPTOS.pdf.
[8] [8] ACI 211.1-91, «" Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass ",» American Concrete Institute, Farmington Hills, MI, USA, 1991.
[9] NMX-C-083-ONNCCE-2014, «" Construction Industry - Concrete - Determination of Compressive Strength of Specimens - Test Method ", » National Agency for Construction and Building Standardization and Certification, Mexico City, 2014.
[10] NMX-C-165-ONNCCE-2004, «" Construction Industry - Aggregates - Determination of Relative Density and Water Absorption of Fine Aggregate - Test Method ",» National Agency for Construction Standardization and Certification and Edificación, Mexico City, 2004.
[11] NMX-C-164-ONNCCE-2014, «" Construction Industry - Aggregates - Determination of Relative Density and Water Absorption of Coarse Aggregate ",» National Agency for Construction and Building Standardization and Certification, City from Mexico, 2014.
[12] NMX-C-077-ONNCCE-1997, «" Construction Industry - Aggregates for Concrete - Granulometric Analysis-Test Method ",» National Agency for Standardization and Certification of Construction and Building, Mexico City, 1997 .
[13] NMX-C-159-ONNCCE-2016, «" Construction Industry - Concrete - Preparation and Curing of Test Specimens ",» National Agency for Standardization and Certification of Construction and Building, Mexico City, 2016.
[14] NMX-C-109-ONNCCE-2013, «" Construction Industry - Hydraulic Concrete - Heading of Specimens ",» National Agency for Standardization and Certification of Construction and Building, Mexico City, 2013.
[15] NMX-C-156-ONNCCE-2010, «" Construction Industry - Hydraulic Concrete - Determination of Slump in Fresh Concrete ",» National Agency for Standardization and Certification of Construction and Building, Mexico City, 2010 .
[16] NMX-C-166-ONNCCE-2006, «" Construction Industry-Aggregates-Water Content by Drying-Test Method ",»

National Agency for Standardization and Certification of Construction and Building, Mexico City, 2006.

[17] NMX-C-170-ONNCCE-2019, «" Construction Industry-Aggregates-Reduction of samples of aggregates obtained in the field to the size required for the tests ",» National Agency for Construction Standardization and Certification and Building, Mexico City, 2019.

[18] NMX-C-073-ONNCCE-2004, «" Construction Industry - Aggregates - Volumetric Mass - Test Method ",» National Agency for Standardization and Certification of Construction and Building, Mexico City, 2004.L. Gutierrez de Lopez, *"Concrete and Other Materials for Construction,"* 2nd ed., R. Arango, Ed. Manizales Colombia: Universidad Nacional de Colombia, 2003.

Renteria-Soto Juan, is a research professor at the Faculty of Engineering, Sciences and Architecture of the Juarez University of Durango State, completed his master's degree in civil engineering at the Autonomous University of Ciudad Juarez and is currently studying his doctorate at the Autonomous University of Ciudad Juarez. It works on the characterization of mechanical properties of new materials and structural behavior.

Betancourt-Chávez Julio Roberto, obtained the degree at the University of Sonora through the Doctorate in Civil Engineering CUMex in March 2015, was Head of Postgraduate in the Faculty of Engineering, Sciences and Architecture of the Juarez University of the Durango State, during the period from February 2007 to September 2016. The Research Group "Construction Technology" belongs. He is currently a professor-researcher at the same Faculty and works on projects for the development of new materials in construction using waste as additives or replacement of aggregates. He has participated in congresses at the National and International level and published research articles in indexed journals.

Dr. Rajeswari Narayanasamy is Professor of Civil Engineering at the Universidad Juárez del Estado de Durango, Gómez Palacio, Durango. She completed her Bachelor of Civil Engineering and Master of Structural Engineering studies from PSG College of Technology, Bharathiar University, Coimbatore, Tamil Nadu, India. Afterwards, he finished his Doctorate at the Juárez University of the State of Durango in 2013. He obtained Recognition of Academic Merit from the State of Durango Secretary of Education, Durango, awarded by the State of Durango for high performance in the Doctorate in Engineering study program with a specialty in Planning and Construction Systems. She has published articles in various national and international magazines. She has a Desirable Profile Recognition granted by the Undersecretary of Higher Education, the Teacher Improvement Program since 2010 and the National System of Researchers (Candidacy Level) since 2020.

Espinoza Fraire Arturo Tadeo. He was born on April 19, 1983 in Torreon, Coahuila, Mexico. He obtained a degree in Electronics Engineering in the specialty of Automatic Control and Instrumentation in 2008 at the Instituto Superior de Lerdo, Durango, Mexico. He obtained the degree of Master and Doctorate of Science in Electrical Engineering in the specialty of Mechatronics and Control at the Technological Institute of La Laguna in 2011 and 2015 respectively. He worked at the company Ingeniería Mexicana de Sistemas from 2007 to 2008, carried out research stays at the Franco-Mexican laboratory at CINVESTAV Zacatenco in 2010 and a research stay at the Université de Technologie de Compègne in 2011 in France. Since 2017 he has been working as a Research Professor at the Faculty of Engineering, Sciences and Architecture of the Juarez University of Durango State in Gómez Palacio Durango, Mexico. Dr. Arturo Tadeo Espinoza Fraire is part of the international technical committee of the International Conference on Unmanned Aircraft Systems and level 1 of the national system of researchers (SNI). His areas of interest are: unmanned aerial vehicles, linear and non-linear control, embedded systems and applications with unmanned aerial vehicles.