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Study of Nanotechnology in Concrete Compounds and Properties when Adding Polypropylene Fibers to Design a Concrete Mix

Hasanain S. Al Tamemi[1], Murtadha AL-Kaabi[2]

[1]Student, Civil engineering Department, Azad College of Engineering, Kermanshah, Iran

[2] Ministry of Education/ Rusafa 3 Department / School Building Department, Baghdad, Iraq

*Corresponding author: herowert1@gmail.com

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Abstract

The urgent need to develop concrete and understand its behavior began as a result of the need for it to confront either natural factors such as earthquakes or floods or factors caused by man himself. Therefore, the idea of strengthening concrete came almost since the end of the seventies of the last century, especially in Asian countries, where it began to use fibers to increase strength and facility by moving and positioning them. In this study, we referred to the design of a concrete mix reinforced with polypropylene fibers in addition to the use of plasticizers according to the Iraqi Standard (ISS 1431/1989) with polypropylene fibers with a length of 15 mm. Several mixtures were used to obtain an ideal mixture and the use of concrete samples cubes and cylinders in addition to the prism for the purpose of showing the compressive and tensile strength. Where the study showed an increase in the strength of the resistance when adding propylene fibers, but with a slight decrease in the properties of other operational concrete, but within the permissible limits.

Introduction

Self-Cohesive Concrete (SCC) is concrete other than the conventional concrete because it differs from other types of concrete when it is in its soft state (before the state of hardening or freezing), as it can occupy the space of any mold or the place designated for it to be placed in it without the use of vibrators and without fear of isolation Concrete mixture components. However, this type is characterized by low resistance and easy to break after the freezing stage compared to other types of concrete. This type of concrete has been used since the end of the seventies for areas that are exposed to earthquake activity and tremors [1], because it has a high operability that results in a reduction in costs due to the reduction

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of labor and time saving significantly. In addition to the fact that it occupies the mold space very quickly with its high resistance to prevent isolation between the components of the concrete, and so we benefit from this feature greatly for the purpose of increasing the distance between the concrete pumps and the place where concrete is to be poured. For all these features, countries interested in this field made special specifications for them in 2002. The fiber-reinforced self-cohesive concrete has the advantages of self-cohesive concrete and the characteristics of the cohesive strength of the fibers after gaining the final hardening (final strength) [2], taking into consideration the resulting negatives of the fibers on the properties of rheology. For this purpose, polypropylene fibers with a length of 15 mm were used in this research in order to increase the strength of the self-adhesive concrete. The aim of this study is to study the behavior of self-cohesive concrete mixed with polypropylene fibers by showing its resistance and the resulting changes to it and to indicate the effect of using fibers on the components of the concrete mix and on the properties of concrete compounds.

Literature review

Nan Su et al (2001) discussed a different method from what came in JRMCA standard, where it worked on forming a specific mixture to fill the spaces formed between the gravel to form a mixture of high flowability and withstand good compressive strength [3]. Paratibha et al (2008). In this study, the researchers conducted a modified experimental concrete mix design designed to resist compression after improving it to be suitable for the purpose for which it was established. He used cubes at ages 7, 28 and 90 days, and compared them and studied them to find out the deformation, strain and stress resulting from them[4]. Nuha H. Aljubory et al (2020) showed the adoption of the principle of comparison and research among other studies for the purpose of obtaining a concrete mixture of acceptable specifications[5]. While, Krishna Murthy et al (2012) added a specific type of additive to improve the workability of the concrete mix. The advantages and disadvantages of this type of additive have been investigated to study any improvement of the mixture to suit the most use and the widest scope for it despite the cost of these materials and the difficulty of achieving a balance for them compared to what has been done. In our proposal to the same type of additives, adding polypropylene fibers is cheaper and more efficient than what was discussed in the research [6]. Finally, S.Deepa Shri et al (2012), studied the stages of development of self-cohesive concrete when adding polypropylene fibers to it by means of an experimental mathematical relationship to know the context of the results and whether it is possible to give semi-accurate results for the mixture [7].

Research methodology and materials used

Several concrete mixtures were made in order to achieve the best concrete mixture suitable for this type. Polypropylene fibers were added in limited proportions to achieve the required efficiency and compared with the Iraqi standard specifications to verify the efficiency of the mixture used [8].

1. Materials used

- Medium grit (gravel): It is from Karbala quarries, with a fineness of 94 and a fineness of 4.5 according to the Iraqi Standard (I.S.S.45/1984)[8].
- Fine sand: - from Karbala quarries with an equivalent of 87 and a coefficient of fineness of 1.8.
- 19mm coarse gravel.

- Plasticizers were used according to the Iraqi Standard Specification (I.S.S.1431/1989)[8] and performance requirements for the first type of additives for concrete mix.
- Ordinary Portland cement manufactured in Karbala factory was used according to the Iraqi Standard (I.S.S. 5/1984) [8].

2. Working stage

The first stage: -

Initiating the design work of a group of ordinary mixtures without polypropylene fibers according to Table 1 with a quantity of 1 m^3

Table 1. Amount of components for ordinary concrete without propylene fibers

Subject	Medium grit	Soft sand	Coarse gravel	Cement	Filler	water	Plasticizer
Weight (kg/m3)	890	350	200	350	240	210	15

The result was the following: -

- Result Dm was 600mm≤ Dm ≤700mm; where it was 650 mm according to the requirements(Dreux) of the Abrams cone for standard mixtures.
- h2/h1 ratio was 0.98>0.8 so its ok
- The ratio of the remainder on the standard sieve between the 5 mm sieve to the total amount of the total and its quantity is 8 kg, where the amount of $\pi = 13\%$, which is a good amount within the range ($0\%<\pi<15\%$) and therefore it is considered stable

The second phase:-

Polypropylene fibers are added according to the following ratio as follows in Table 2 as follows:

Table 2. Polypropylene quantity

220	600	1200	1400	1700	1900	gr/m^3

Because of the addition of this substance, the properties of the concrete mixture change, so the amount of plasticizer must be changed to obtain a stable mixture that can be worked with it [9], as the quantity in Table 3 is as follows: -

Table 3. Amount of components for ordinary concrete with propylene fibers

Subject	Medium grit	Soft sand	Coarse gravel	Cement	Filler	water	Plasticizer
Weight (kg/m3)	885	340	180	350	250	210	18

In order to determine the amount of Dm, it is extracted according to Figure 1, which is the relationship between Dm and the proportion of fibers

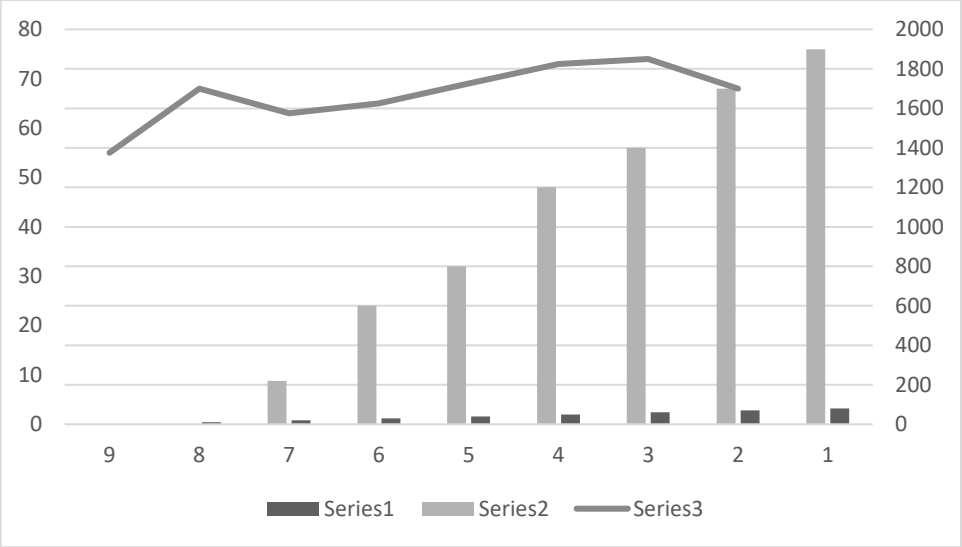

Figure 1. the amount of Dm

In order to determine the ratio (h2/h1) of the concrete mix, a relationship was made between the amount of fibers in the concrete mix and the ratio (h2/h1) as in Figure 2 below.

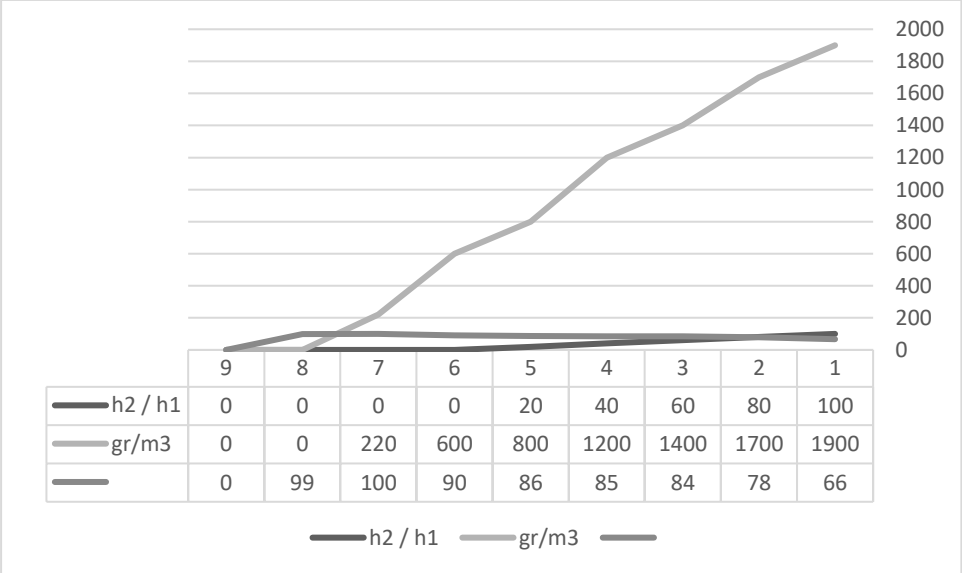

Figure 2. determine the ratio (h2/h1) of the concrete mix,

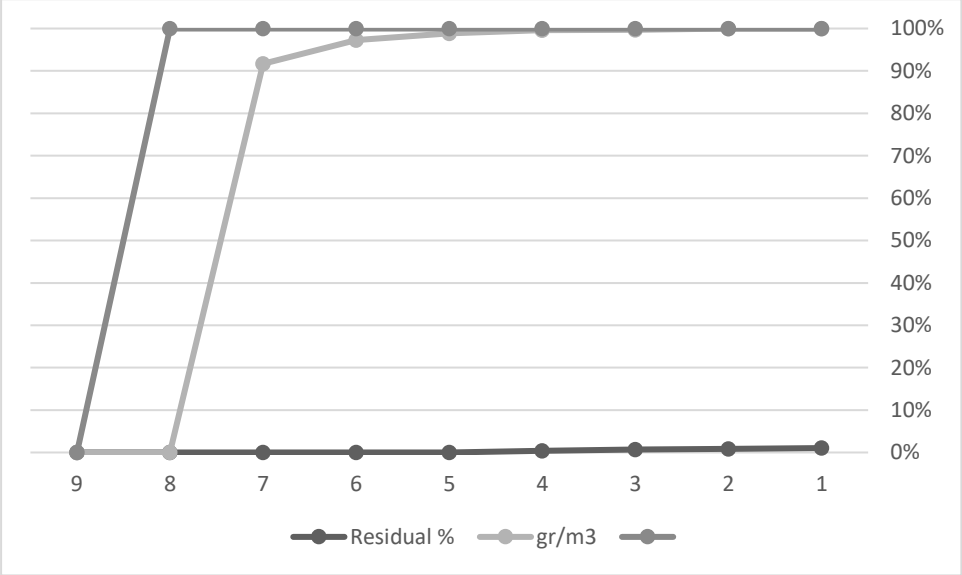

Figure 3. the percentage of the residue on the sieve π

Results and discussions

The results of the above tests of concrete in the second stage in the case of adding polypropylene fibers showed a decrease in the resistance of the concrete mixture as the percentage of fibers increased. Note that the increase in fiber contributes to increasing the balance of the mixture and not isolating the components of the concrete mixture[10]. Where Figure 4 shows that with an increase in the amount of fibers in the concrete mixture, its Dm value decreases

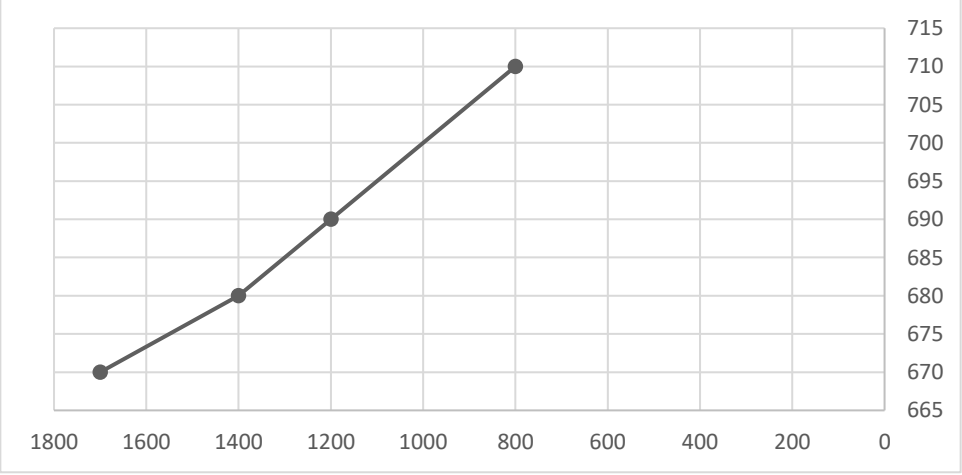

Figure 4. Dm value decreases

Where Dm max was at its largest value due to the lack of fibers used in this component, which amounted to (800 gr/m^3), and this value decreases with the increase in the proportion of fibers in the concrete mix.

Figure 5 shows the relationship between the amount of polypropylene fibers in the concrete mix and the ratio of h2/h1

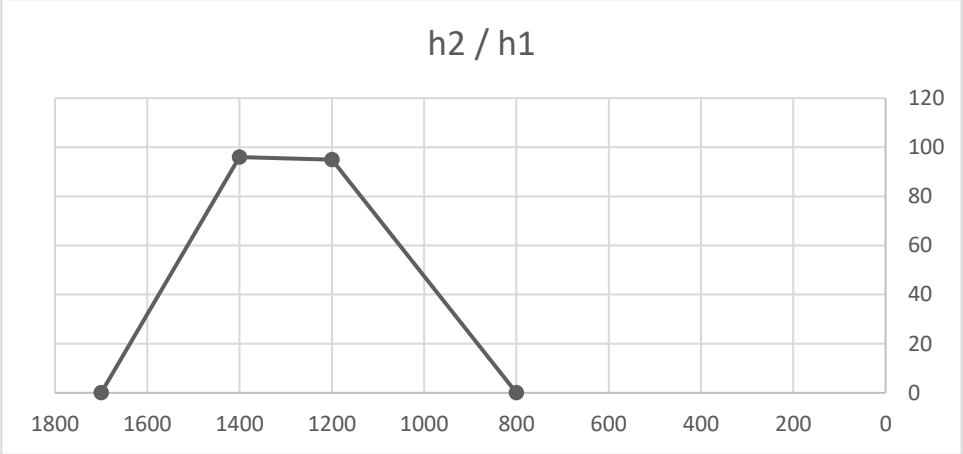

Figure 5. amount of polypropylene fibers in the concrete mix and the ratio of h2/h1

Where it was found that the higher the percentage of fibers in the concrete mix, the lower h2/h1% (movability ratio in L-BOX) as for the percentage of acceptability in the remainder on the sieve and ensuring that it remains within the specification limits, which is 800gr/m3. Where the remainder was 8%, then the number diminished to the lowest, which is $\pi = 2\%$. In which the concrete mixture mixed with polypropylene fibers is completely stable and well [11]. To conduct this study, we used Concrete mix with polypropylene fibers, which are shown in Table 4 below:

Table 4. The models used in this study

Prism 10×10×50	Cylinder 15×30	Cubes 15×15×15	Concrete mix with polypropylene fibers gr/m^3
3	3	3	0
3	3	3	800
3	3	3	1200
3	3	3	1400
3	3	3	1700

The results obtained from the samples showed that the resistance increases when the amount of polypropylene fibers increases. Where the torsion device was used to examine the samples of the prism[12,13], while the samples of the cube and the cylinder were examined on the anti-compressive device to indicate the amount of strain and stress for each sample and to determine the course of the strain and stress for them as shown in Table 5 below

Table 5. It shows the amount of compressive and torsional strength of all samples

The percentage of fiber in the mixture					sample/stress
1700	1400	1200	800	0	
39	35	33	29	27	Cylinder mpa
48	37.4	29	27.2	--	Strength %
38.4	34.8	32.3	30.1	24	Cube mpa
46.5	36.7	29.9	25.2	--	Strength %
8.4	7.5	7.7	7	5	Tension (tensile) mpa
88.2	66.8	44.2	35.1	--	Strength %
4.9	4.8	4.5	3.4	3	Resistance development mpa
88.1	78.6	52.3	31.7	--	Strength %

It is now possible to show the relationship between stress and strain when the proportion of propylene fibers is 1700 gr/m^3, according to Figure 6 below.

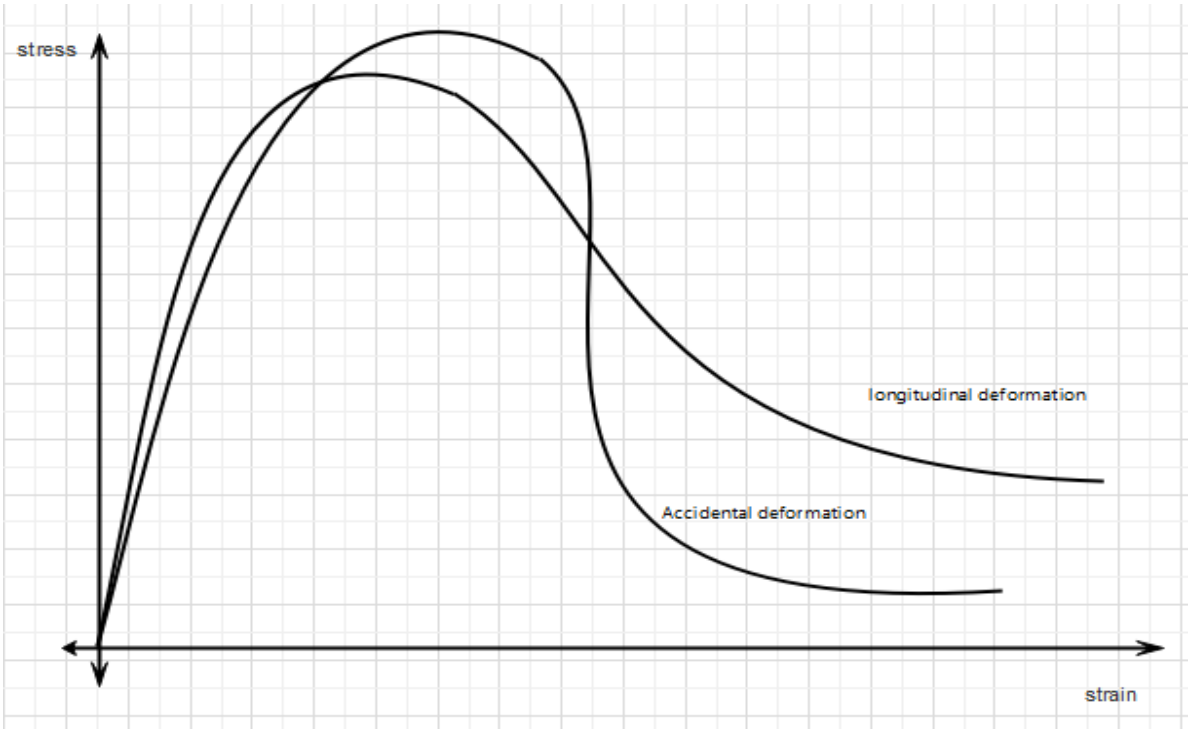

Figure 6. relationship between stress and strain

And the relationship between stress and strain for polypropylene fibers if it is 1200gr/m^3, as shown in Figure 7 below.

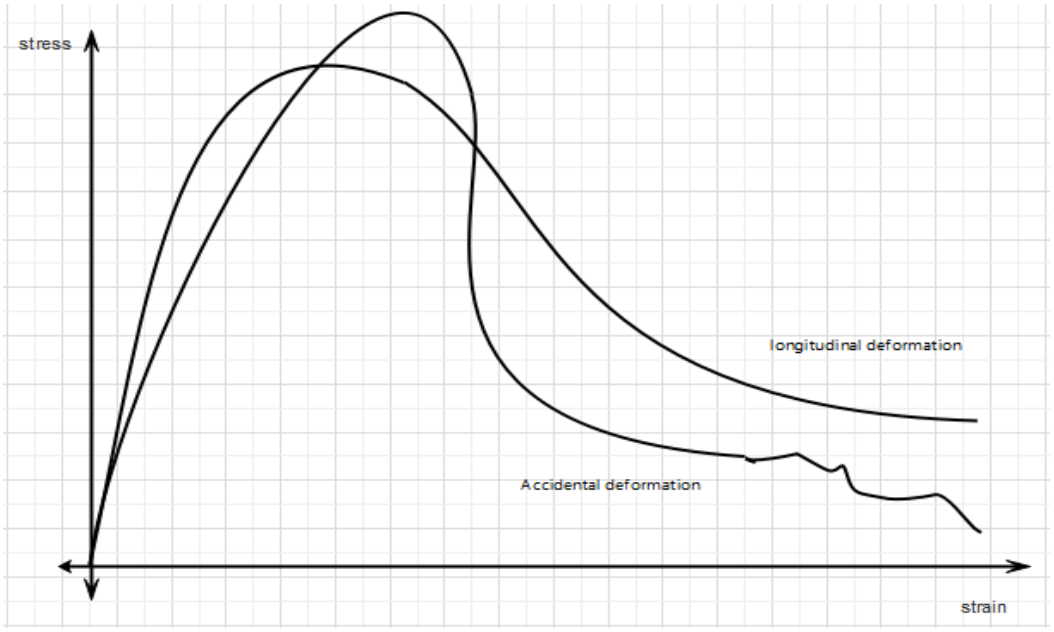

Figure 7. relationship between stress and strain for amount fibers

Conclusion and Recommendations

For all the above, the study concluded the following:

1) The behavior of concrete changes when adding polypropylene fibers, as it begins to lose its intrinsic properties, but this does not lead to the collapse or failure of the mixture, as it remains within the required level with an emphasis on adherence to the Iraqi standard specifications.
2) The addition of polypropylene fibers to the concrete mixture helps to homogenize the mixture and prevent causing isolation of its components.
3) The use of propylene fibers in the mix leads to an increase in the resistance of the concrete mix, within the ratios that range between (800-1700 gr/m^3), as the ratio of 1700 gr/m^3 is the best ratio for the resistance, or 800gr/m^3 is the best ratio for the homogeneity of the concrete mix.

As for the recommendations, they are as follows: -

1) Providing the appropriate environment for the purpose of expanding the conduct of research and laboratory tests for the purpose of the success of this type of mixture, as it represents a new radiance and a window for the development of concrete and benefit from it in all fields.
2) Finding the appropriate relationships for the purpose of determining the stresses, strains and deformations when changing the mixture compounds or the bonding of materials with concrete, as they affect the elasticity coefficients directly and the form of deformation in its concrete form.

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