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Performances of cementitious mortars containing recycled synthetic fibres under hot-dry climate

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ABSTRACT

The use of recycled synthetic fibres in cementitious materials can be considered as resources conservation and an adequate solution to some environmental problems. In this investigation, numerous tests have been carried out to study the performances of cementitious mortars reinforced by recycled synthetic fibres under hot-dry climate. These tests considered parameters such the consistency, the free and endogenous shrinkage, the flexural and the compressive strengths. The results revealed that recycled synthetic fibres can be successfully used as reinforcement for mortars exposed to hot-dry climate. The addition of recycled synthetic fibres to mortars leads to a lack of consistency for the mixture but reduces considerably the shrinkage and contributes to maintaining the mechanical behaviour. Indeed, mortars reinforced by 1% of recycled synthetic fibres and cured for a period of more than six months in hot-dry climate had their shrinkage reduced by 50% and their flexure and compressive strengths relatively maintained compared to the mortar without fibres. It is found that high temperature and low humidity conditions, which characterise a hot and dry climate, amplify the free shrinkage and decrease the long-term mechanical strengths of cementitious mortars, particularly in tension.

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Cementitious mortars; recycled synthetic fibres; hot-dry climate; consistency; shrinkage; mechanical strength

1. Introduction

The climate in general has an important effect on the properties of the cementitious materials. Hot-dry climate is characterised by an intense heat, a low humidity, highly dry winds and large daily temperature fluctuations. Under these relatively sever climatic conditions, cementitious mortars are subject to high water evaporation from the early ages. The evaporation has a direct negative impact on the continuity of the cement hydration reaction, which needs a sufficient amount of water to be completed and to offer good-quality hydrates. The rate of evaporation under hot-dry conditions is about 10 times that under hot-humid conditions (Almusallam, 2001). It is recommended that, during the plastic phase of concrete, the water evaporation should not exceed 1 kg/m^2 per hour (Al-Fadhala & Hover, 2001; Neville, 2000). The water loss does not influence only the hydration reactions, but it also leads to cracking in the material. These premature cracks constitute passageways for aggressive agents that affect the materials durability. The combined effect of elevated temperature, windy conditions and low relative humidity creates wider and longer cracks in concrete by comparison to moderate conditions of climatic exposure (Almusallam, 2001). Higher temperatures generally increase the cracking risk of concrete

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(Lura, van Breugel, & Maruyama, 2001). The continuity of the cement hydration reactions is then an essential condition so that the mortar reaches its long-term desired mechanical strengths so that it can withstand any aggressive environmental conditions and support the prescribed loadings without any suffering. However, in hot-dry climate, the hydration reactions can stop prematurely at a very early stage, affecting negatively the evolution of the mechanical behaviour. In the case of exposure to hot-dry climate, adequate curing should be applied to any cementitious mortar in order to achieve the targeted strength and guarantee an acceptable durability at the longer term (Al-Amoudi, Maslehuddin, Shameem, & Ibrahim, 2007). Indeed, the curing regime and its duration have a significant effect on the compressive strength of mortars (Sajedi, 2012). In this sense, the performances of mortars conserved under 40 °C are improved at early age, but they become weaker at long-term, compared to those of mortars cured in water (Çakir & Aköz, 2008).

The reinforcement of concrete by fibres is an additional measure to prevent its cracking in these situations (Al-Tayyib, Al-Zahrani, Rasheeduzzafar, & Al-Sulaimani, 1988). The effect of fibres on the cementitious materials properties is influenced by various factors, such as the fibre length, the fibre content, the nature of matrix and the quality of bonding fibre matrix. Through their numerous advantages, such as hydrophobic nature, chemical neutrality, low weight and low price, the synthetic fibres are among the most used fibres for the reinforcement of concrete and mortars. Due to their high deformation capacity, they disperse easily in the matrix and then control effectively the cracks of plastic shrinkage (Banthia & Gupta, 2006; Song, Hwang, & Sheu, 2005). The presence of synthetic fibres of polypropylene in the concrete does not change the crack pattern, but it reduces the crack widths (Suji, Natesan, & Murugesan, 2007) and improves the cracking resistance of the material (Zhang & Zhao, 2012). Polypropylene fibres slightly increase the mechanical properties of the concrete, but greatly increase its ductility (Cifuentes, García, Maeso, & Medina, 2013). By adding polypropylene fibres, the failure crack pattern changed from a single large crack to a group of narrow cracks (Nili & Afroughsabet, 2010). They also reduce the permeability of the hardened cementitious mixture, restrain the amount of shrinkage that it may be subjected to and limit any possible expansion of the concrete mixture, parameters that can seriously affect the lifespan of the structure (Kakooei, Akil, Jamshidi, & Rouhi, 2012). Spadea, Farina, Berardi, Dentale, and Fraternali (2014) have concluded that recycled PET fibre-reinforced concretes might be a good match for earthquake-resistant structures. The use of recycled fibres as reinforcement of cementitious materials does not improve only their performances, but it also leads to an economical gain for the construction industry and represent important environmental benefits (Bendjillali, Chemrouk, Goual, & Boulekbache, 2013; Borg, Baldacchino, & Ferrara, 2016; Meddah & Bencheikh, 2009; Pešić, Živanović, Garcia, & Papastergiou, 2016; Sadrmomtazi & Haghi, 2008; Silva et al., 2005; Spadea, Farina, Carrafiello, & Fraternali, 2015).

In this study, the effect of the hot-dry climatic conditions on the performances of recycled synthetic fibres-reinforced mortars is investigated by measuring the consistency of the mortars mixture, their free and endogenous shrinkage, their flexural strength and their compressive strength.

2. Experimental programme

Limestone sand, Portland cement, water, superplasticiser and synthetic fibres were used for mortar preparations. The limestone sand was a fine natural crushed sand of a maximum particle size of 2 mm; its characteristics are given in Table 1. The binder used was a Portland cement CEM II/A 42.5 characterised by a Blaine fineness of 3200 cm^2/g; its chemical composition is shown in Table 2. The superplasticiser

Table 1. Physical properties of sand.

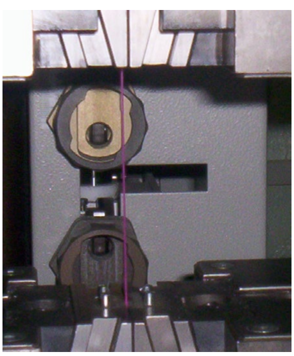
Specific gravity (g/cm^3)	2.52
Fineness modulus	1.80
Sand equivalent (%)	63
Fines < .063 mm (%)	6.00
Methylene blue value	.13
Water absorption (%)	4.50

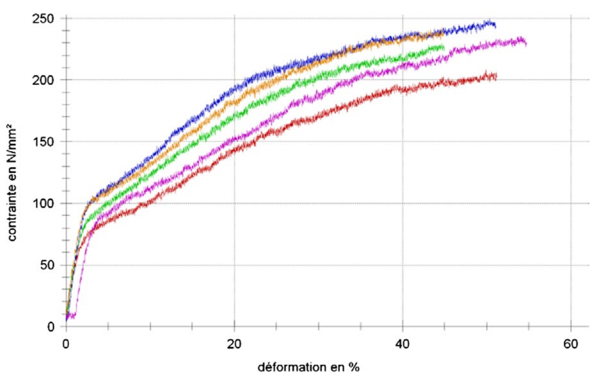
used to compensate for the loss of workability with lesser amount of mixing water was a new-generation polyvalent admixture, uncoloured, based on acrylic copolymer. The recycled synthetic fibres used were polypropylene fibres coming from the waste of domestic plastic sweeps' fabrication (Figure 1(a)). The used fibres have a specific density of .99 g/cm^3, a diameter between .38 and .51 mm, a length of 20 mm, a tensile strength of 250 N/mm^2, an elasticity modulus of 5 GPa, a high chemical resistance and no water absorption. The tensile strength and the elasticity modulus of the fibres were determined using ZWICK ROELL Z 100 machine with a maximum testing force of 100 kN and a speed of 10 mm/min, under $T = 20$ °C (Figure 1(b)). The test data were digitally recorded using a numerical acquisition system by the software testXpert II connected to a device that plotted the load/deformation curve (Figure 1(c)). The mixes were prepared according to the European Standard EN 196-1 (2005) which consist of a first mixing of the whole quantity of cement and half of the water quantity in a mixer for about 30 s. To ensure a good dispersion of fibres, the sand and the fibres were previously mixed dry together before being added to the mix in a sand/cement ratio of 3. The mixing was then proceeded for 30 s. The remaining water mixed with the superplasticiser was added in the last step and a further

Table 2. Chemical composition of the Portland cement.

CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	K_2O	Na_2O
65.90	21.94	4.82	3.94	1.65	.98	.60	.10

(a) Type of synthetic fibres used





(b) Testing of fibres

(c) Load-deformation of fibres

Figure 1. Recycled synthetic fibres.

Figure 2. Samples to measure the endogenous shrinkage.

mixing for more 30 s was allowed; the mixer was stopped during 1 min 30 s for the scraping of the cuve's walls and then left to continue mixing for 60 s. The water/cement ratio was .55 and the fibres were added in weight contents of .5 and 1% (per total mortar weight).The mortars tested were noted M0 (mortar without fibres), M0.5 (mortar reinforced by .5% of synthetic fibres) and M1 (mortar reinforced by 1% of synthetic fibres). For each mortar formulation, three samples 40 × 40 × 160 mm were produced and the consistency of the mortar was measured through the flow time according to the French Standard P 18-452 (1988). After one day, the samples were demoulded to cure in water for two weeks (14 days) at 20 °C, followed by continuous curing in hot-dry chamber at 45 °C and 30% RH until the age of testing. For comparison, other samples were cured under controlled conditions at 20 °C and 50% RH. The mechanical tests for flexure and compressive strengths were conducted on mortars according to the European Standard EN 196-1 (2005) after 07, 14, 28, 56, 91, 120 and 180 days curing. The mortars cured in water during two weeks were taken as reference samples. The standard deviations of the strengths results did not exceed 3% of the average values, both in flexure and in compression. The free and endogenous shrinkages were measured for each mix on three samples from the age of 1 day to the age of 190 days. The endogenous shrinkage was measured to evaluate the deformation of material without any humidity exchange with the external conditions; the samples were covered with a double self-adhesive aluminium paper (Figure 2).

3. Experimental results

3.1. Consistency

When recycled synthetic fibres were added, the flow time of mortar increased (Figure 3) and the mortar mixture becomes less workable. The increase is more important for higher fibre weight contents; it is probably due to a lower stiffness of the mortar induced by the presence of fibres, which act as inclusions with a high specific surface that imprison more cement paste. According to several studies (Hsie, Tu, & Song, 2008; Karahan & Atiş, 2011; Puertas, Amat, Fermández-Jiménez, & Vázquez, 2003; Siddique, Khatib, & Kaur, 2008; Yin et al., 2015), the addition of fibres to cement materials generally decreases its workability and hence constitutes a critical problem that needs to be solved. However, by comparison to other types of fibres, polypropylene fibres tend to disturb less the workability of fresh concrete (Dreux & Festa, 2002). Moreover, the mixing difficulties of cement matrix materials are more important with metallic fibres than with polypropylene fibres (Meddah & Bencheikh, 2009). Generally, the loss of workability which results from the use of fibres in cementitious mixtures is compensated correctly using appropriate amount of superplasticiser (Bendjillali, Goual, Chemrouk, & Damene, 2011; Söylev & Özturan, 2014).

3.2. Shrinkage

To estimate the water loss in the hydration process, a comparison between the free shrinkage measured in both hot-dry and controlled chamber and the endogenous shrinkage (Figures 4–6) is made. The endogenous shrinkage is an intrinsic characteristic which results from chemical and physical phenomena without any change of humidity with the external environment. It can be seen that the curing conditions of the hot-dry chamber have a high influence on the free shrinkage value and also on its development. The curing conditions influence both the initial rate and the ultimate values of the drying shrinkage(Tolêdo Filho, Ghavami, Sanjuán, & England, 2005).Rising the curing temperature amplifies significantly the rate and the magnitude of the total shrinkage (Bouziadi, Boulekbache, & Hamrat, 2016). All mortars cured in hot-dry chamber reached the highest free shrinkage, which evolves rapidly and stabilises earlier due to the rapid loss of mixing water caused by high temperature (45 °C) and low humidity (30%) conditions. At 190 days of age, the free shrinkage of mortar without fibres decreases from 1360 μm/m in hot-dry chamber to 880 μm/m in controlled chamber, a reduction of about 35%. Under the sever hot-dry conditions, the hydration heat was higher because hydration reaction is very much activated by the temperature which accelerates water departure and then increases the free shrinkage risk. In hot-dry chamber, the values of the free shrinkage are almost three times those of the corresponding endogenous shrinkage, particularly when no fibres are used. This result illustrates the harmful effect of the arid conditions on the properties and the durability of cementitious materials and

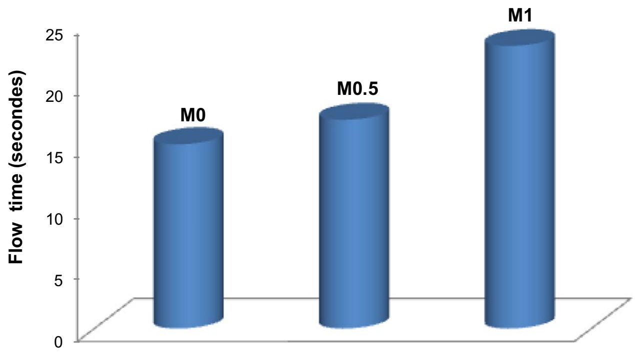


Figure 3. Consistency of mortars.

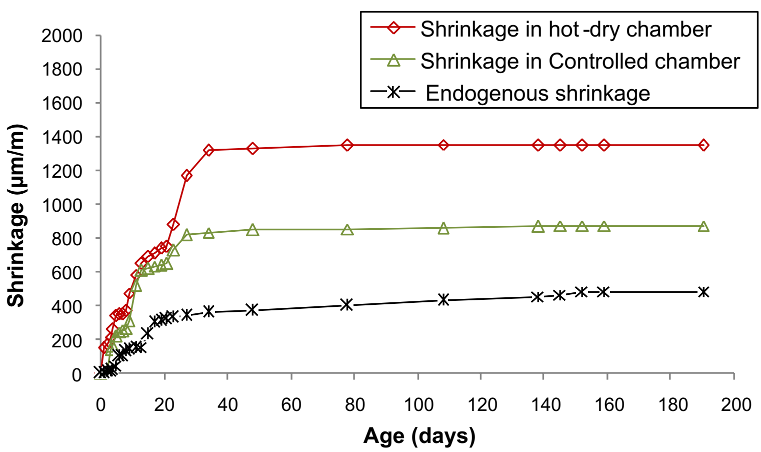


Figure 4. Comparison of shrinkages in mortar without fibres M0.

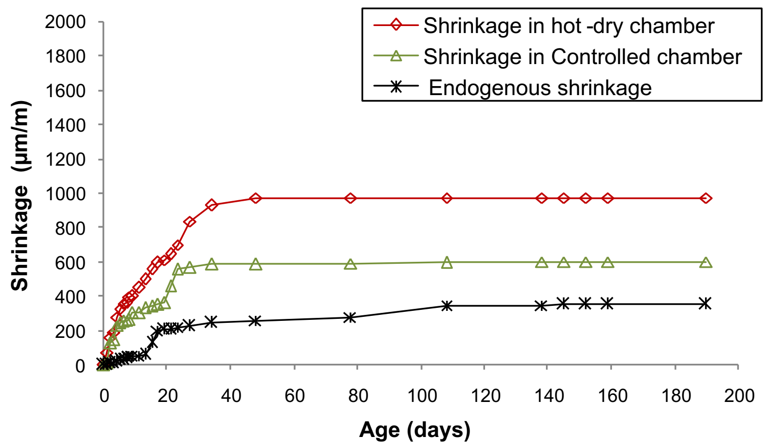


Figure 5. Comparison of shrinkages in mortar M0.5.

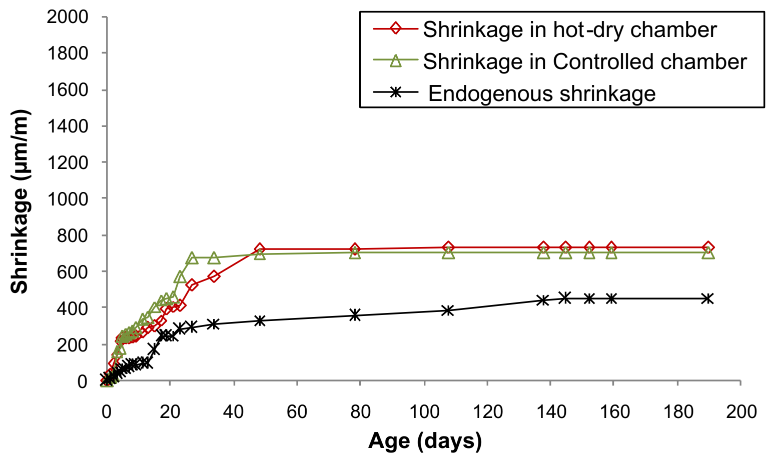


Figure 6. Comparison of shrinkages in mortar M1.

raises the necessity of adequate solutions based on detailed studies. In this sense, the reinforcement of the mortar by recycled synthetic fibres considerably reduces free shrinkage, particularly in hot-dry chamber; an introduction of 1% of fibres in the mortar conserved in hot-dry chamber reduces the free shrinkage by more than half. The reinforcement of the cement materials by fibres constitutes obstacles to any shrinking movement which occurs mainly within the cement paste. Depending on their types, the fibres can reduce the shrinkage by 40 to 85% in ordinary concrete (Branch, Rawling, Hannant, & Mulheron, 2002). The addition of polypropylene fibre to cement mortar decreases the number of larger cracks and increases the number of finer cracks (Ma, Zhu, Tan, & Wu, 2004). The reinforcement of mortar slabs by recycled plastic fibres significantly reduced the total crack areas and the crack widths (Al-Tulaian, Al-Shannag, & Al-Hozaimy, 2016). In this sense, a cementitious mix with nano-synthetic fibres presented 33.6% less crack area compared to a mix with steel fibres (Lee & Won, 2016). In the presence of recycled synthetic fibres, the endogenous shrinkage tends to reduce slightly; some fibres such as cellulose fibres have the capacity of internal curing to prevent the endogenous shrinkage in cementitious matrix (Kawashima & Shah, 2011). Owing to their good dispersion in the mortar and their bond with the cement paste, recycled synthetic fibres have presented a high capacity to reduce the free shrinkage and to a certain extent the endogenous shrinkage. No shrinkage cracks were observed on the surface of mortars containing fibres and cured under arid conditions. In this sense, it is reported that (Almusallam, 2001) shrinkage strain in concrete exposed to hot and dry conditions will be more than that in concrete exposed to arid conditions with moderate temperature.

3.3. Flexural strength

The flexural strength of mixes obtained at each age under both hot-dry curing and controlled chamber curing is usually higher than the reference values (Figures 7 and 8), expressing a continuation of the hydration process of the cement. The most important flexural strengths of mortars are obtained in hot-dry climate after only 14 days curing and then they decrease remarkably. After two weeks curing under hot-dry climate, the flexural strength increases vary between 116, 86 and 101% in the mortars M0, M0.5 and M1, respectively, compared to the reference mortar which is water cured for 14 days. On the contrary, in the controlled chamber conditions, the mortars continue to increase slowly in strength up to 56 days curing. For comparison purposes, the percentage of strength gain after two weeks curing in controlled chamber reached about 60, 36 and 30% in the mortars M0, M0.5 and M1, respectively, in relation to the reference mortar. This behaviour could be attributed to the effect of the standards temperature and humidity conditions in a controlled chamber (20 °C, 50% RH) on the evolution of the mechanical strength of cementitious materials. By comparison to hot conditions, in the controlled chamber, the hydration reaction lasts longer and produces maximum hydrates with a higher quality that affects positively the continuity of the mechanical strength evolution. It can be noted, however, that 50% of relative humidity for the conditions of controlled chamber seems to be an insufficient humidity for an efficient strength evolution; this justifies the slight reduction of strength between 56 days and 90 days for the controlled chamber conditions. To understand the real influence of the curing conditions of the two environments on the flexural behaviour of the mortar, the strength variations in the two environments were assessed. After 7 days curing, the flexural strength measured in hot-dry chamber is 51, 47and 38% higher than that obtained under controlled conditions in mortars M0, M0.5 and M1, respectively. These percentages fall to 7, 16 and 22% after 28 days curing in the two environments, respectively. Beyond 56 days curing, the flexural strength becomes higher in the controlled chamber with a percentage increase of 62, 26 and 34% in mortars M0, M0.5 and M1, respectively, compared to the strengths reached in the hot-dry chamber. The hot-dry environment has a rapid stimulation for the hydration reaction, which tends to be limited in duration since it stops prematurely before being complete. In the controlled environment, however, the hydration process starts slower and continues longer in time until almost complete hydration of the cement. From the present test results and from others (Kriker, Bali, Bouziane, & Chabannet, 2008), the hot-dry environment has a beneficial effect on the

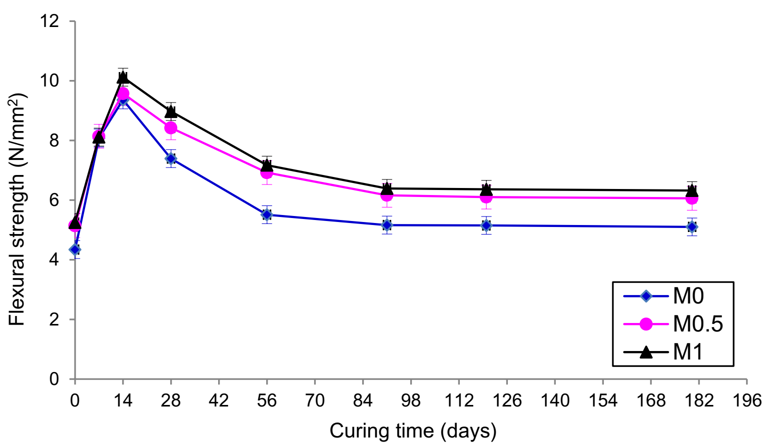


Figure 7. Flexural strength evolution of mortars cured in hot-dry chamber.

performance of concrete at early ages only where a maximum strength is reached after 14 days curing, that is at 28 days of age. After six months curing in hot-dry chamber, the strength decreased from the highest values reached after 14 days curing in hot-dry chamber to values around 18, 18 and 20% of the reference strength (strength after 14 days water cured) for mortars M0, M0.5 and M1, respectively. This strength decrease is due to the high temperatures which accelerate the cement setting and the evolution of the mechanical behaviour at a short term. At the longer term, the high temperature and the relatively low humidity cause the evaporation of the mixing water and hence stop the hydration process of the cement prematurely, resulting in the weakening of the hydrates formed and leading to the reduction of the mechanical strengths. The porosity created by the loss of water through evaporation leads to the reduction of the finale strength of the material and favours its deterioration. The quality of the bond of the cement paste with the aggregate particles (sand in this case) seems to be particularly affected by the hot and dry climate, leading to the weakening of the tension behaviour of the material after the age of 28 days as expressed by the flexural strengths (Figure 7). After more than six months curing in hot-dry climate, the decrease in the flexural strength has reached more than 45%. This raises the question of considering the flexural strength at 28 days of age as a design parameter.

The addition of synthetic fibres has slowed down the strength reduction after 28 days, and reduced the strength loss. The strength reduction was reduced to 37% when 1% of fibres were used. The stabilisation of the flexural strength appears to occur at around the age of 90 days. For safety considerations, it becomes tempting to consider the flexural strength at 90 days as a design parameter for hot and dry climates. In several experimental investigations (Al-Tulaian et al., 2016; Habib, Begum, & Alam, 2013), the beneficial effect of synthetic fibres on the flexural behaviour of mortars was approved.

Previously, Ahmadi (2000) had also reported that the hot weather conditions reduce the initial setting time of cement and favour the evaporation of the mixing water of concrete in general. The cement setting is also accelerated by the addition of fibres (Qi, Weiss, & Olek, 2003). As a comparison, after six months curing under controlled conditions, the strength was higher than that obtained in hot-dry conditions (Figure 8); they reached values of 57, 45 and 42% of the reference strength (strength after 14 days water cured) as compared to 18, 18 and 20%, respectively, for mortars M0, M0.5 and M1.

Moreover, reinforcing cementitious materials by recycled synthetic fibres affects positively the post-cracking behaviour by bridging the opened cracks and enhancing the ductility of the material; this result was also reported in other studies (Pereira de Oliveira & Castro-Gomes, 2011; Yin et al., 2015). The addition of fibres prevents crack development through the fibres' bridging and stitching of the two faces of a crack (Kim, Park, Lee, Lee, & Won, 2008). The ductility of recycled PET fibre-reinforced

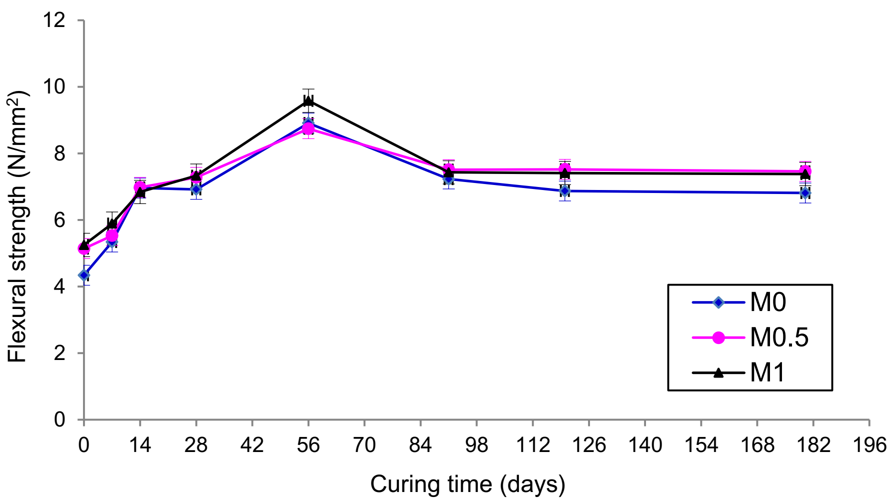


Figure 8. Flexural strength evolution of mortars cured in controlled chamber.

concrete is approximately 7 to10 times greater than that of concrete without fibres (Kim, Yi, Kim, Kim, & Song, 2010).

3.4. Compressive strength

The results of the compressive strengths obtained in hot-dry climate and in controlled chamber are given in Figures 9 and 10, respectively. Compared to the reference strengths, it can be noticed an increase in the compressive strength with the curing time in the two conservation chambers. Mortars conserved in controlled chamber had higher long-term compressive strengths because under these standard conditions (20 °C, 50% RH), the hydration process takes longer time and results in better hydrates which are responsible for strength evolution. The reduction of the compressive strength observed after 56 days curing in controlled chamber conditions (that is at 14 + 56 days of age) was negligible and the resulting strength was still higher than that at the age of 28 days (14 days water cured +14 days under controlled conditions curing), a strength considered as a reference for any design. The strength reduction beyond 56 days of controlled condition was probably due to the lesser relative humidity (50%) of the controlled chamber. The mortars cured in hot-dry climate reached a relatively

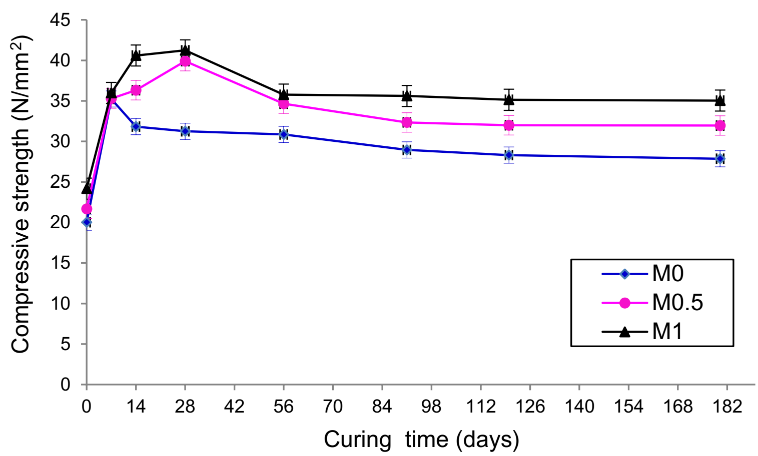


Figure 9. Compressive strength evolution of mortars cured in hot-dry chamber.

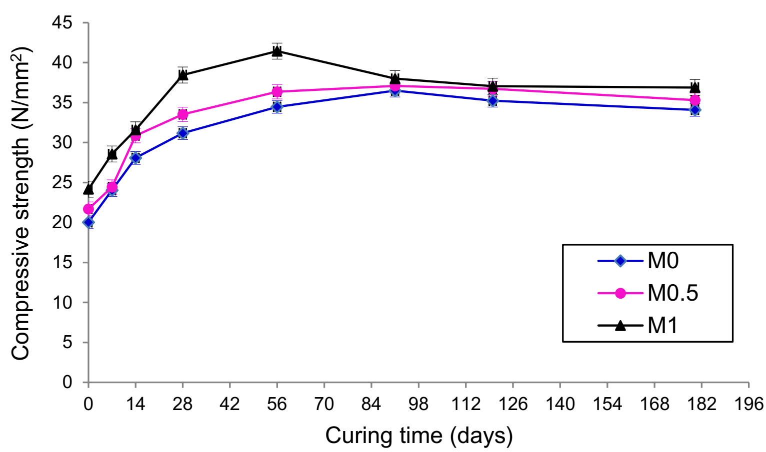


Figure 10. Compressive strength evolution of mortars cured in controlled chamber.

higher compressive strength after 14 days curing under these conditions. The percentage increase in the compressive strength at 14 days curing in hot-dry climate, that is at 28 days of age, is around 76, 63 and 49% in mortars M0, M0.5 and M1, respectively, compared to the reference strengths taken as that at 14 days water cured. By comparison, in the controlled chamber, these increases did not exceed 20% at the same age. The possible explanation of this phenomenon is that the higher curing temperature accelerates the hydration at younger ages, which in turn evolves heat and increases further the temperature resulting in more water evaporation. This behaviour justifies the compressive strength increase until about 14 days curing in hot-dry climate (that is after 28 days of age) and its decrease after complete evaporation of the remaining water. This distinct strength evolution with age would be even sharper as the curing temperature increases (Yi, Moon, & Kim, 2005). For comparing the effect of the environment on the compressive behaviour of the mortar, the variation of the strength was measured in the first environment (hot-dry) with regard to its value obtained in the second one (controlled chamber). Until 28 days curing, the higher compressive strengths were measured under hot-dry conditions. After 7 days hot-arid curing, the strength values were higher by 47, 44 and 26% in mortars M0, M0.5 and M1, respectively, compared to those obtained under controlled conditions. However, beyond 56 days curing, the compressive strength becomes higher in the controlled chamber, with increases in percentages of about 12, 5 and 16% for the mortars M0, M0.5 and M1, respectively, compared to the compressive strength values reached under the hot-dry conditions. It is reported that high temperatures develop weaker hydration products that lead to weaker mechanical behaviour. Once the curing temperature changes, the composition of hydrates also changes (Yi et al., 2005). Some authors (Gallucci, Zhang, & Scrivener, 2013) explain the lower final strengths obtained in materials cured under elevated temperatures (60 °C) by the coarser and porous microstructure of the cement paste which is the consequence of the increase of the C-S-H apparent density. A close examination of the strength evolution under hot-dry conditions reveals that it could be unsafe to consider the strength at 28 days of age as a reference in reinforced concrete design since this strength will decrease and stabilise at a lower value at around 90 days of age onward. After a stabilisation of the strength at around 90 days of age, an average strength reduction of 21% was recorded in mortars without fibres and of 13% in mortars with fibres by comparison with that at 28 days of age. The fibres have contributed to slow down the strength reduction after 28 days of age and hence reduce the loss of strength.

In the controlled chamber, the cement hydration is slower and the mortars need more time to strengthen and to achieve their desirable compressive strength. After 14 days curing under these conditions, the strength gain varies between 40, 42 and 31% in mortars M0, M0.5 and M1, respectively, compared to the reference strengths (strengths at 14 days of age water cured). In hot and dry climate, the strength reaches a peak value at around 28 days of age and then decreases to stabilise at a strength lower than that at 28 days at around 90 days onward. In a controlled climate, the strength continues to increase after 28 days of age to stabilise at a strength higher than that at 28 days of age at around 90 days of age. This raises the question of considering the strength at 28 days of age as a design parameter in hot-dry climate.

In general, the addition of recycled synthetic fibres to mortars had a positive effect on the compressive strength under hot-dry climate in a sense that fibres slow down the strength reduction after 28 days of age. The difference in behaviour after 28 days is clearly appreciable in Figure 9, particularly after stabilisation at 90 days of age onward. On the contrary, in a controlled climate, synthetic fibres do not seem to have an important effect on the strength at the longer term as in figure 10 where no beneficial strength effect seems to be apparent after 90 days of age. This is in line with some literature reports, which stipulate that the benefit from adding fibres is not in compression, which may even reduce (García Santos, Rincón, Romero, & Talero, 2005; Ramezanianpour, Esmaeili, Ghahari, & Najafi, 2013). Indeed, when adding higher fibre dosages, it becomes difficult to achieve full compaction and may even engender certain porosity (Bentur & Mindess, 2007), which reduces the compactness and then the compressive strength. In general, mortar without fibres failed in a brittle manner, whereas in the presence of recycled synthetic fibres, the fragile failure becomes more ductile due to the ability of fibres to absorb more energy. Besides their beneficial effects on shrinkage and strength in hot-dry climate, the ductile behaviour at failure exhibited by mortars containing fibres renders them even more structurally useful in hot and dry climate.

4. Conclusions

In this paper, the performances of cementitious mortars containing recycled synthetic fibres and conserved under hot-dry climate were investigated. The following main findings were achieved:

(1) The use of recycled synthetic fibres in cementitious mortars is an interesting reinforcing solution for this material in severe conditions such as hot-dry climate.
(2) The consistency of mortars decreases by the addition of recycled synthetic fibres.
(3) The free shrinkage of mortars, conserved under hot-dry climate, evolves rapidly and stabilises at an early age after reaching considerably higher shrinkage values. The values of the free shrinkage are almost three times those of the corresponding endogenous shrinkage.
(4) The addition of recycled synthetic fibres to mortars exposed to hot-dry climate reduces the shrinkage risk by a considerable amount. With the reinforcement of mortars by 1% of recycled synthetic fibres, the free shrinkage is reduced by more than half.
(5) The high temperature accompanied by low humidity of hot-dry climate enhances considerably the initial flexural strength gain of cementitious mortars but decreases their final flexural strength at the longer term after 28 day of age. After more than six months curing in hot-dry climate, the decrease in the flexural strength has reached more than 45%. This raises the question of considering the flexural strength at 28 days of age as a design parameter. The addition of synthetic fibres has slowed down the strength reduction after 28 days and restrained the cracking. The strength reduction was reduced to 37% when 1% of fibres were used. The stabilisation of the flexural strength appears to occur at around the age of 90 days. For safety considerations, it becomes tempting to consider the flexural strength at 90 days as a design parameter for hot and dry climates.
(6) In the same manner, hot-dry climate enhances the initial compressive strength gain of cementitious mortars but reduces their final compressive strength at the longer term by comparison to the strength at 28 days of age. After more than six months curing under hot-dry climate, the compressive strength has decreased by more than 21%. The addition of fibres has slowed down this compressive strength reduction to 13%. The reduction in the strength of cementitious materials, though not exceeding 25% reveals that, under sever hot and dry climatic conditions, the compressive strength at 28 days of age may not be a safe design parameter, but could reasonably be replaced by that at 90 days since stabilisation of the mechanical strengths appears to start from that age onward.
(7) The presence of recycled synthetic fibres into mortars has improved the failure mode by making it more ductile through an effective fibre bridging of the cracks.

Disclosure statement

No potential conflict of interest was reported by the authors.

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