Improvement Interfacial Transition Zone of Green Concrete by utilization of nano-SiO_2 particles

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Extended abstract

Introduction

Concretes made by the recycled aggregates are one of the green concrete subgroups. Reuse of construction demolitions in order to produce construction materials has become one of the most important parameters in the development of green concrete industry, regarding to solving the environmental complexities and ecological problems [1]. Besides, developing this new industry, because of the results it surely has, can form one of the strong factors along with the move toward sustainable development [2]. Hence, the development of green concrete industry and specifically concretes made by the recycled aggregates can play a significant role in moving toward the sustainable development of concrete industry. However the too slow and unsecure development of recycled aggregate concrete is a considerable point, since in the first step, constructing a high quality concrete is the target and in the next step, producing a green concrete is our priority. Therefore, production of high quality green concrete has become the main aim of concrete investigators. Alongside, by the aid of different pozolans and specific mix procedures, the quality of recycled concretes has remarkably been enhanced [3,4].

In this study, according to appearance of the nano-technology resulted the presence of nano-materials and also appropriate application of nano-particles in the structure of cement based materials, the chosen target is enhancement of recycled concrete with the help of nano-SiO_2 particles. Because the enhancement of concrete quality is a result of enhancement in the quality of interfacial transition zone (ITZ) between paste and aggregates [5], the micro-performance in this zone and also macro-performance effect on the mechanical properties of concretes made by the recycled aggregates are investigated. Consequently, mixtures with constant W/B ratio of 0.4 and cement amount of 400 kg/m^3 were constructed. In addition, regarding to examining the ITZ and mechanical properties of recycled concrete, Scanning Electron Microscopy (SEM) test and compressive strength have been applied respectively. The results show notable development in the ITZ properties and compressive strength of recycled concretes.

Experimental procedures

The cement used is Portland cement type I-425. Fine aggregate is natural river sand and used in all mixtures. The coarse aggregate used is crushed limestone with a nominal maximum size of 20 mm for production of parent concretes which used for demolition process. The fine and coarse aggregates had specific gravities of 2.74 and 2.65, and water absorption of 1% and 0.8%, respectively. Also, the coarse recycled aggregates had specific gravity of 2.42 and water absorption of 4.8% with a nominal maximum size of 20 mm similar to natural coarse aggregate. The water reducer superplasticizer (naphthalene-type) is employed to aid the dispersion of nano-particles in concrete and achieve good workability of concrete. The colloidal nano-silica are purchased from asanceram Co (Tehran, Iran). Physical and chemical properties of cement and nano-silica particles are provided in Table 1, respectively.

The mix proportions of control concrete (NC-400), concrete containing just coarse recycled concrete aggregates (RA1-400) and concretes containing coarse recycled concrete aggregates and different dosages of nano-silica particles (1.5% and 3%), are summarized in Table 2.

The specimens are de-moulded at 24 hours and then cured in a curing room (relative humidity in excess of 95%, temperature 20±2) for 3, 7 and 28 days. For each mix, 8 specimens of 100 mm cubes for compressive strength were made. Compressive strength was determined according to BS 1881: Part 117: 1993 at various ages (3,7 and 28 days). The workability tests were carried out in accordance with the requirements of ASTM C143-98.

	Cementitious materials(%)	
Item	***Cement***	***Nano-silica***
SiO2	***21.4***	***99.8***
Al2O3	***6***	***-***
Fe2O3	***3.4***	***-***
CaO	***64***	***-***
MgO	***1.8***	***-***
Cl	***-***	***-***
SO3	***1.4***	***-***
KO+Na2O	***1***	***-***
L.O.I	***3***	***2.8***
Particle Size (nm)	***-***	***40***
Specific Area (m2/kg)	***3110***	***200000***

Table 1: Chemical composition and physical properties of binder materials

Mix No.	*Description*	*w/b*	*Water (kg)*	*Cement (kg)*	*Gravel (natural or recycled) (kg)*	*Sand (kg)*	*Superplasticizer (kg)*	*Nano-silica (solid) (kg)*
NC-400	***Control mix***	***0.4***	***177.2***	***400***	***646.4***	***1200.4***	***1.2***	***0.0***
RA1-400	***CRA***	***0.4***	***201.6***	***400***	***625.1***	***1160.9***	***1.4***	***0.0***
RA2-400	***CRA + 1.5% NS***	***0.4***	***186.7***	***394***	***611.6***	***1135.8***	***1.4***	***6***
RA3-400	***CRA + 3% NS***	***0.4***	***171.8***	***388***	***598.1***	***1110.7***	***1.4***	***12***

Table 2: Concrete mixture proportions used in the study

Results and discussion

The results of compressive and workability tests are shown in Table 3.

Mix No.	*Curing days*			*Workability (mm)*
	3	***7***	***28***	
NC-400	***15.2***	***24.3***	***34.2***	***120-130***
RA1-400	***12.6***	***19.6***	***28.1***	***90-100***
RA2-400	***13.9***	***22.9***	***32.4***	***60-70***
RA3-400	***15.9***	***24.6***	***35.3***	***30-40***

Table 3: Workability and average compressive strength (MPa) at different test ages

As shown in Figures 1 and 2, the application of recycled aggregates create voids with too small dimensions because of absorbing cement particles on the surface of aggregates and consequently existing excessive cement paste. Therefore, the porosity of ITZ of these types of concrete are little more than that of conventional concretes. On the other side by comparing Figures 3 and 4, it can be seen that by adding silica nano-particles, the transition zone of recycled concrete has become denser and more uniform and even extremely small voids have been omitted, especially because of exclusive performance of nano-particles. These particles combine with calcium hydroxide crystals ($Ca(OH)_2$) and produce dense calcium-silicate-hydrate gel by making pozzolanic reaction and gel is the main reason of more uniform and denser transition zone.

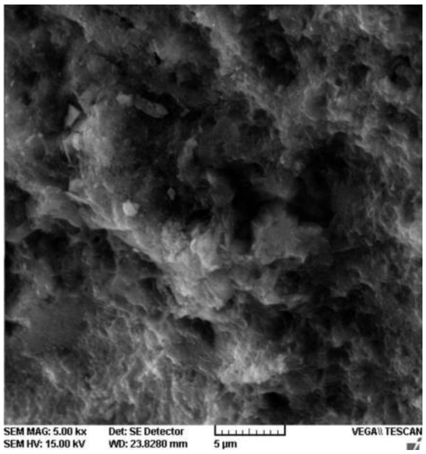

Fig. 1. Control mix (NC-400)

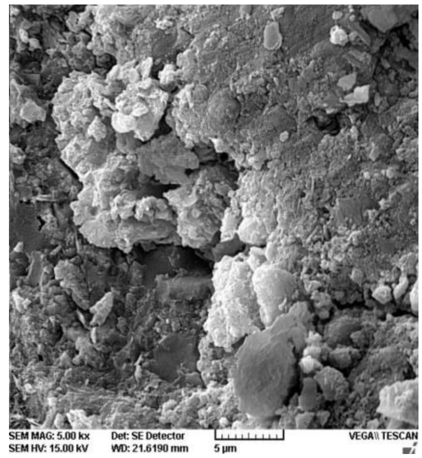

Fig. 2. Recycled concrete (RC) & 0% Nano (RA1-400)

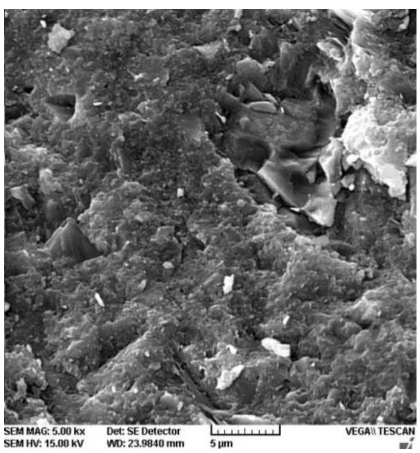

Fig. 3. RC & 1.5% Nano (RA2-400)

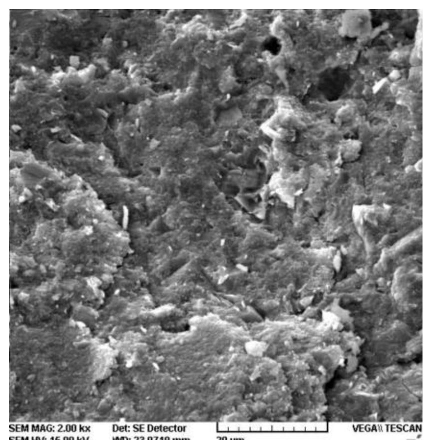

Fig. 4. RC & 3% Nano (RA3-400)

Conclusion

Under the conditions laid down in this research work, the following conclusions can be drawn:

- Replacement of coarse natural aggregates by 100% coarse recycled aggregates decreased 15%-20% compressive strength of specimens.
- It was observed that by increasing the amount of nano-silica as replacement of cement, the compressive strength of specimens has been developed.
- Using 3% of nano-silica, caused to enhancement in compressive strength and even presented higher strength to those of conventional concrete.
- Development in the compressive strength is a result of remarkable performance of nano-particles in ITZ, since the nano-particles have caused to denser and more coherence transition zone.

References

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