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EFFECTS OF PLASTICIZERS ON RECYCLED CONCRETE

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ABSTRACT
Concrete recycling constitutes one of the most recent research domains in material engineering and environment sciences. It consists of crushing and screening the concrete provided by demolishing the old constructions, and of using the resulted small pieces as aggregates in new concrete compositions.
Our previous researches have demonstrated that recycled aggregates diminish the strength of concrete due to the addition of water. The present communication treats of the effects of plasticizers on recycled concrete. The principal aim is to recapitulate the original strength by increasing the concrete workability without adding water.

KEY-WORDS: RECYCLED CONCRETE, AGGREGATES, STRENGTH, WORKABILITY.

DEFINITIONS
The Recycled Aggregates are obtained when screening the demolished concretes. The new mix of concrete containing a percentage of recycled aggregates is called Recycled Concrete.

NEED TO RECYCLE THE CONCRETE
Since the fiftieth, the Middle East Region was continuously suffering from wars which had provoked damages in constructions and problems in the national economy of each country.
In July 2006, Lebanon has been attacked by Israel with the most recent and fatal bombs. The result was, in addition to the lives loss, the demolition of different types of constructions: residential and office buildings, hospitals, schools, bridges and others. Then in May 2007, Lebanon has been again subjected to another type of war. It was the fight between the Lebanese Army and the organization of "Fateh Al Islam". As a consequence, all the region of "Nahr El Bared" camp was destroyed.
Immediately after these wars, the government had to find a quick issue for the huge amount of the concrete waste. Also, if in Lebanon it was urgent to establish some recommendation guidelines for recycling concrete in order to get rid quickly of the demolished constructions

without increasing the harms on economy and environment, it is also important for all other countries, and especially of the Middle East Region, like Palestine and Iraq, and even Turkey and Iran when subjected to seismic catastrophes, to have their proper norms on recycled concrete.

INTRODUCTION

The ultimate goal of recycling is to process building materials or construction elements, which are at a given moment in time not able to fulfill their primary task anymore, in such a way that they can be used again in the original application, without quality loss [1]. Different researches made in the domain of Concrete Recycling have shown its importance on economy and environment [2,3,4]. Minimizing the construction waste management spending was the principal target of Germany. Therefore, it was the first country which had established its national guideline about Recycled Concrete [5].

Directly after the war of July 2006, some studies have been undertaken by our team using, as Recycled Aggregates, those obtained from the South Suburb of Beirut [6]. Different types of original concrete have been treated. Some of them were completely or partially burned; and others were safe. Also comparisons between old and new Recycled Concretes and between calcareous and silica-calcareous Recycled Aggregates have been shown [7]. The influence study of the percentage of Recycled Aggregates was also a target. Our previous results have demonstrated that the behavior of the new concrete depends on the origin of Recycled Aggregates, and that no difference appears when using, in the new compositions of Recycled Concrete, exactly 20% of old or new, safe or burned Recycled Aggregates.

All the previous researches have shown that the strength, the durability and the workability of a new concrete are decreasing when using Recycled Aggregates [8]. The porosity, in opposite, was increasing. In fact, the tests have shown that Recycled Aggregates absorb a higher amount of moisture than ordinary concrete. Also the angularity of the crushed material contributes to a higher water requirement [9]. Therefore, when the water/cement ratio increases, it is known that the characteristics of the concrete will be badly affected. We can exclude the workability of this rule but if this last can increase when adding water, both of strength and durability will decrease.

However, and since the principal responsible of the Recycled Concrete deficiency is the addition of water, our goal was to substitute the added water by plasticizers. Also the present paper presents the influence of using one type of plasticizers, while manufacturing new concrete from Recycled Aggregates, on the concrete strength. The percentage of the plasticizer has been varied in order to determine its limit corresponding to a workable and sustainable concrete. Also some tests have been done by adding 10 % of cement. The results have shown that the original values of the concrete strength can be recuperated.

MANUFACTURING OF SPECIMENS

Our previous studies based on calcareous recycled aggregates obtained from the “South Suburbs of Beirut” have shown that no difference appears in the new concrete when using 20% of Recycled Aggregates, either the original concrete constituting the Recycled Aggregates was new or old, and burned or safe. But for other percentages, the difference was significant [7]. Also we recommended using old concrete, as Recycled Aggregates, when making the normalization tests, especially because it will be the reality after wars or natural catastrophes.

In this work, the Recycled Aggregates used in the experimental tests were obtained from the demolition of “Nahr El Bared” Camp. The concrete pieces have been chosen randomly: some of them were safe, partially or completely burned, and the original aggregates were of different

types: some of them were calcareous, siliceous and silica-calcareous. However, for all manufactured specimens, only 20% of Recycled Aggregates has been considered. So the natural gravels constitute 80% of the total quantity of aggregates. These last have been obtained from the calcareous mountains of Lebanon.

RECYCLED CONCRETE COMPOSITION

At first, the apparent densities of natural gravels and sand were searched: for gravels (between 4 and 16mm diameter), the apparent density is 1400 kg/m^3 and for sand it is 1700 kg/m^3. The ratio 800 liters of gravels over 400 liters of sand was considered [10]. Finally, the composition of 1 m^3 of the considered Recycled Concrete is as follow:
For all types of 4/16 gravels: 0.8 m^3 x 1400 kg/m^3 = 1120 kg;
Normal sand: 0.4 m^3 x 1700 kg/m^3 = 680 kg;
Cement (7 bags): 350 kg;
Water: 200 Kg.
So the resulted 1 m^3 of Recycled Concrete has 2350 kg, which is an acceptable value. Meanwhile the gravels have been divided into 80% of natural aggregates and 20% of Recycled Aggregates. Also the Recycled Aggregates have been washed and dried.

EFFECTS OF PLASTICIZER ON NORMAL CONCRETE

The considered plasticizer in this research corresponds to water reducer. These products are retained by adsorption on the cement surface. They provoke grains deflocculating and mortar lubrication. This process permits either the amelioration of workability without adding water, or a decrease in the W/C ratio, so an increase in the concrete strength without modifying workability [10]. Also we can adopt both of these ways to determine the adequate strength and workability.
The used plasticizer in our tests has the limit of 1.5% of the cement weight, as indicated by the manufacturer. In fact, when overcoming this value it will also play the role of hardening delaying. However, we should sometimes overcome this value in order to determine the adequate limit for Recycled Concrete, because it has been demonstrated that the Recycled Aggregates absorb more quantity of water.

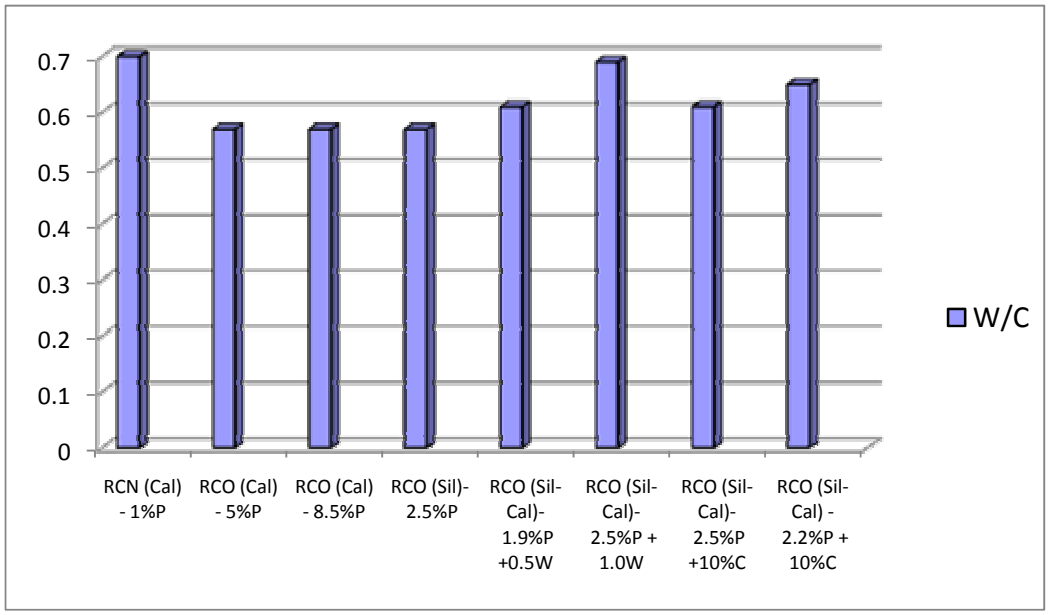
NOMENCLATURE

N: New concrete (manufactured for less than 1 year).
O: Old concrete (obtained from old demolished constructions and aged for more than one year: The mean age value is 10 years).
RCN (Cal) - 1%P: Recycled Concrete – New – Calcareous Recycled Aggregates + 1% Plasticizer.
RCO (Cal) - 5%P: Recycled Concrete - Old – Calcareous Recycled Aggregates + 5% Plasticizer.
RCO (Cal) - 8.5% P: Recycled Concrete – Old – Calcareous Recycled Aggregates + 8.5% Plasticizer.
RCO (Sil) - 2.5%P: Recycled Concrete – Old – Siliceous Recycled Aggregates + 2.5% Plasticizer.
RCO (Sil-Cal) - 1.9%P+ 0.5W: Recycled Concrete - Old – Silica-Calcareous Recycled Aggregates + 1.9% Plasticizer + 0.5 kg Water.
RCO (Sil-Cal) - 2.5%P+ 1.0W: Recycled Concrete - Old – Silica-Calcareous Recycled Aggregates + 2.5% Plasticizer + 1 kg Water.

RCO (Sil-Cal) - 2.5%P+ 10%C: Recycled Concrete - Old – Silica-Calcareous Recycled Aggregates + 2.5% Plasticizer + 10% Cement.
RCO (Sil-Cal) - 2.2%P+ 10%C: Recycled Concrete - Old – Silica-Calcareous Recycled Aggregates + 2.2% Plasticizer + 10% Cement.

EXPERIMENTAL TESTS

The principal target of this research is to determine the Recycled Concrete strength when using plasticizers. The W/C ratio and the workability of concrete have been examined in order to insure a workable concrete with an acceptable ratio Water over Cement. The strength value is obtained using a concrete press machine, and the workability using slump-test. The original value of the concrete strength was obtained using a Schmit-Hammer on many surfaces of the concrete pieces got from the demolished regions. The mean value was 23 MPa.
All strength results presented in this paper correspond to the mean value of 4 specimens (cylinders of 30 cm height and 15 cm diameter). The tests have been made after, at least, 28 days from the date of manufacturing. The quantity of plasticizer, being the variable, was noted for every test. Also some tests have been done by adding 10% of cement, because many previous studies have indicated the benefice of this addition quantity [11].
The first test RCN (Cal) – 1%P has been done to respect the limit value of the plasticizer percentage, relatively to cement quantity, indicated by the manufacturer of the product for normal concrete. When examining the W/C ratio values, given in figure 1, we remarked that for 1% plasticizer of the cement quantity, we should add water to insure an acceptable workability. And as the W/C ratio was not significantly affected by this value of plasticizer, we thought about fixing the value of W/C to the normal value of concrete (W/C= 0.57) and searching the corresponding value of plasticizer content, workability and strength of the Recycled Concrete (figures 2 and 3). Therefore, the tests corresponding to RCO (cal) – 5%P, RCO (Cal) – 8.5%P and RCO (Sil) – 2.5%P have been done. Then other tests have been carried out using Silica-Calcareous Recycled Aggregates. Herein two alternatives have been considered to insure adequate values for workability and W/C ratio. These alternatives correspond to the addition of water or 10% of cement.


0.7
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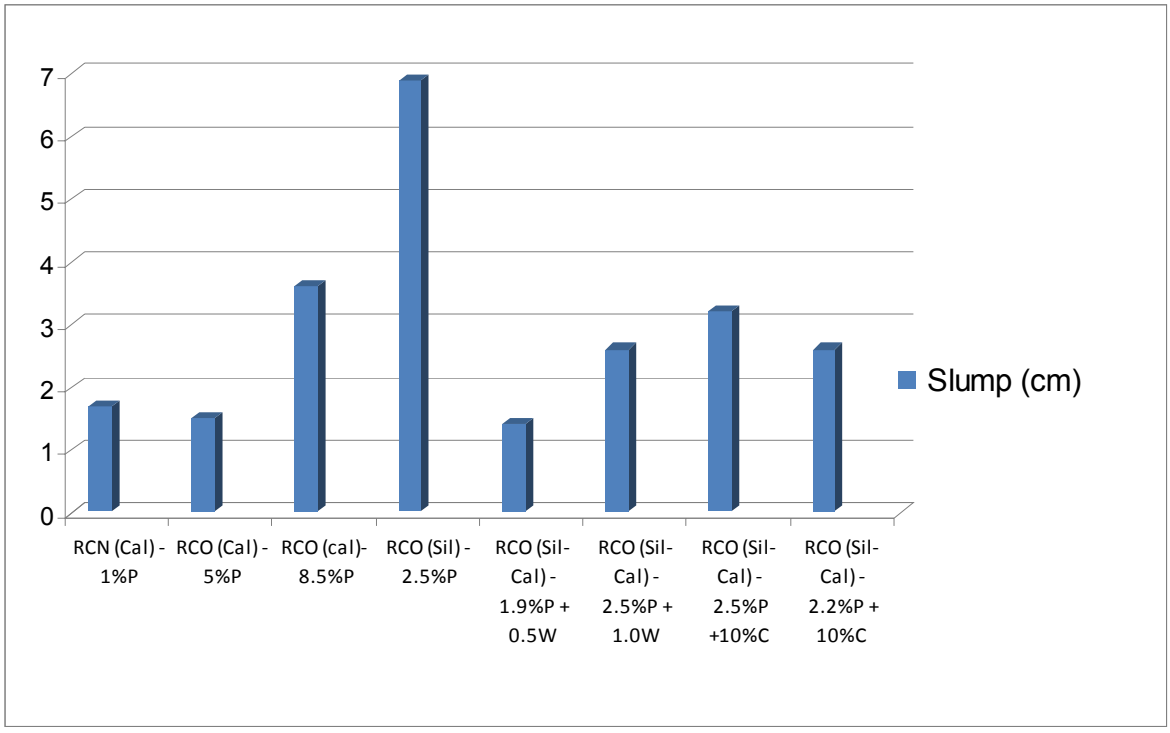
RCN (Cal) - 1%P
RCO (Cal) - 5%P
RCO (Cal) - 8.5%P
RCO (Sil)- 2.5%P
RCO (Sil-Cal)- 1.9%P +0.5W
RCO (Sil-Cal)- 2.5%P + 1.0W
RCO (Sil-Cal)- 2.5%P +10%C
RCO (Sil-Cal) - 2.2%P + 10%C
W/C

Fig. 1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RCN (Cal) - 1%P
RCO (Cal) - 5%P
RCO (cal)- 8.5%P
RCO (Sil) - 2.5%P
RCO (Sil-Cal) - 1.9%P + 0.5W
RCO (Sil-Cal) - 2.5%P + 1.0W
RCO (Sil-Cal) - 2.5%P +10%C
RCO (Sil-Cal) - 2.2%P + 10%C
Slump (cm)

Fig. 2

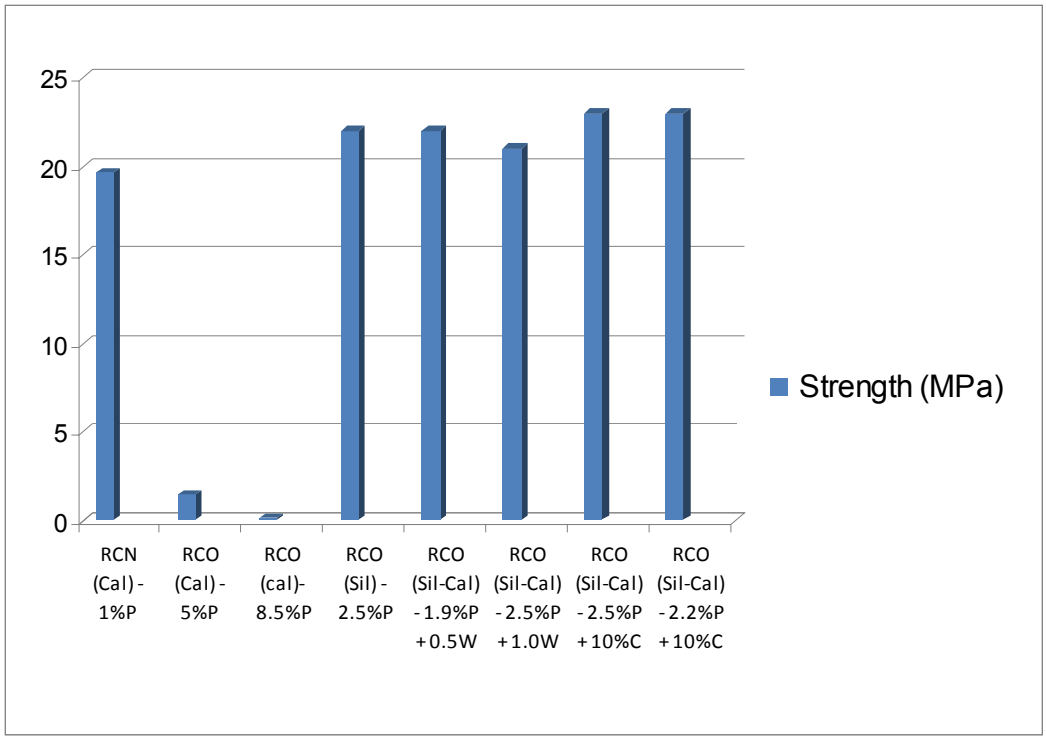

Fig. 3

RESULTS ANALYSIS

THE EXAMINATION OF FIGURE 1 SHOWS:

1- A big difference between the values of the plasticizer percentage when using Calcareous Recycled Aggregates (RCO - 5% and 8.5%P) and Siliceous Recycled Aggregates (RCO – 2.5%P). For the same W/C ratio, the percentage of plasticizer for the Siliceous Recycled Aggregates was more acceptable.

2- The second alternative mentioned above and which corresponds to the addition of 10% Cement gave better results for W/C ratio than the first alternative corresponding to the addition of water alone.

3- For the Silica-Calcareous Recycled Aggregates, the W/C ratio had increased by comparison to the Siliceous Recycled Aggregates. It is normal because the Calcareous Aggregates absorb more water. This confirms again our previous results on the influence of the nature of original aggregates on the behavior of the Recycled Concrete [7].

The examination of figure 2 shows:

1- The workability of Recycled Concrete when using Siliceous Recycled Aggregates is good, and is better for a smaller quantity of plasticizer than Calcareous Recycled Aggregates.

2- The workability diminishes when using a mix of Siliceous and Calcareous Recycled Aggregates. This phenomenon is also attributed to the absorption of water by the Calcareous Aggregates. However, the addition of 10% Cement has shown better workability than adding water alone.

The examination of figure 3 shows:

1- For 1% plasticizer and for Calcareous Recycled Aggregates, the strength is acceptable even the concrete is hard to be workable.

2- For 5% plasticizer the strength is negligible and no strength exists for 8.5% plasticizer. This proves that the limit value of plasticizer content has been overcome. In addition the visual examination has shown that the plasticizer had played also the role of delaying the hardening of the concrete.
3- For the Siliceous Recycled aggregates, the original value of strength has been approximately recapitulated when using 2.5 % plasticizer even without adding water or cement.
4- For the mix of Siliceous and Calcareous Recycled Aggregates, the strength has been also approximately recuperated for 2.5% plasticizer but with addition of water (comparison between RCO (Sil)-2.5%P and RCO (Sil-Cal) – 2.5%P+1.0W).
5- When adding 10% more cement and for an added quantity of plasticizer between 2.2 and 2.5%, the original value of normal concrete has been obtained. It is equal to 23 MPa.

CONCLUSIONS

The original strength of concrete can be re-obtained in the new Recycled Concrete when using plasticizers, and certainly recuperated when adding plasticizer and 10% more of cement. The best results concerning the strength and the workability of Recycled Concrete correspond to Siliceous Recycled Aggregates. The pure Calcareous Recycled Aggregates are the worst. For a mix of Silica-Calcareous Recycled Aggregates, acceptable values can be obtained for strength and slump. The limit value for the quantity of plasticizers can reach 2.2% of the cement weight when manufacturing Recycled Concrete.

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