USING OF LIBYAN CALCINED CLAY AS REPLACEMENT CEMENT IN CONCRETE

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***Abstract* : An extensive research work has been carried out in the past years by the industrial research center on the natural raw materials in the south region of Libya. The investigation shows that there are many raw materials that can be used in the building material industry, one of that materials was natural pozzolan . From that point we start thinking to carry out a wide range investigation for the possibility of using the natural pozzolans as replacement cement material in concrete. Pozzolana is a siliceous material which whilst itself possesses no cementitious properties, either processed or unprocessed and in finely divided form, reacts in the presence of water with lime at normal temperatures to form compounds of low solubility having cementitious properties. Pozzolanas may be natural or artificial, fly ash being the best known in the latter category. These were used with lime to make concrete before the advent of cement. Currently their principal use is to replace a proportion of cement when making concrete. The advantages gained are economy, improvement in workability of the mix with reduction of bleeding and segregation. Other advantages are greater imperviousness, to freezing and thawing and to attack by sulphates and natural waters. In addition, the disruptive effects of alkali-aggregate reaction and heat of hydration are reduced. It is generally held that the additions of natural pozzolanas reduces the leaching of soluble compounds from concrete and contribute to the permeability of the concrete at later ages. When mixed with cement the silica of the pozzolana combines with the free lime released during the hydration. Silicas of amorphous from react with lime readily compared to those of crystalline form and this constitutes the difference between active pozzolanas and materials of similar chemical composition which exhibit little pozzolanic activity. It is commonly thought that lime-silica reaction is the main or the only one that takes place, but recent information indicates that alumina and iron if present also take part in the chemical reaction. This study were undertaken to produce reactive pozzolana i.e. calcined clay from five different places. The calcined clay produce from these places were grinding to pass 150 micrometer sieve and calcined at 800 C° for 2 hrs The effect of addition calcined clays 10%, 15%, 20% as replacement with Portland cement was investigated by various tests.**

Keywords:Metakaolin.calcined clay. pozzolana concrete.

I. : INTRODUCTION :

An extensive research work has been carried out in the past years by the Libyan industrial research center on the natural raw materials in the south region of Libya. The investigation shows that there are many raw materials that can be used in the building material industry, one of that materials was natural pozzolan (kaolinite) [1]. From that point we start thinking to carry out a wide range investigation for the posibility of using the kaolinite in the form of metakaolinite as replacement cement material in concrete. Metakaolinite is obtained by heating kaolinite at 700-850 C°. It is a poorly crystalline transition phase which behaves as highly reactive artificial pozzolan. Nowadays, the properties of calcined clays are widely discussed in cement literature for their pozzolanic properties. Metakaolinite reacts with calcium hydroxide and water to yield hydrated compounds of Ca and Al silicates. Pozzolanic activity of metakaolinite is related to the cristallinity of the original kaolinite. Pozzolana is a siliceous material which whilst itself possesses no cementitious properties, either processed or unprocessed and in finely divided form, reacts in the presence of water with lime at normal temperatures to form compounds of low solubility having cementitious properties. Pozzolanas may be natural or artificial, When mixed with cement the silica of the pozzolana combines with the free lime released during the hydration. Silicas of amorphous from react with lime readily compared to those of crystalline form and this constitutes the difference between active pozzolanas and materials of similar chemical composition which exhibit little pozzolanic activity. It is commonly thought that lime-silica reaction is the main or the only one that takes place, but recent information indicates that alumina and iron if present also take part in the chemical reaction [2]. This paper deals with the influence of south Libya metakaolin as partially replacement of ordinary Portland cement on the compressive strength of concrete mortar, for that reason, calcined clay from five different places in the south of Libya, the clays were collected as shown in table (1) & Figure (1). The calcined clay produce from these places were grinding to pass 150 micrometer sieve and calcined at 800 C° for 2 hrs. The effect of addition calcined clays 10%, 15%, 20% as partially replacement of Portland cement was investigated by various tests.

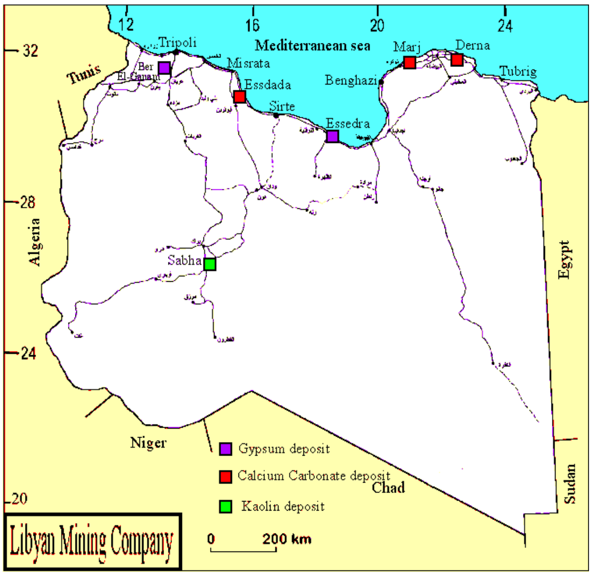


Figure 1: Kaolin clay deposits in Libya.

Table1: Location of clays.

Symbol of Site	Location	Clay Mineral (%)
A	10 km from Sebha	Kaolinite 95%, Quartz 5%.
B	10 km from Temenhint_Sebha	Kaolinite 50%, Quartz 50%.
C	Alafya_Brack	Kaolinite 54%, Quartz 46%.
D	Agar_ Wadi Shatti	Kaolinite 90%, Quartz, Illite.
E	Tarout _ Wadi Shatti	Kaolinite 30%, Quartz 70%.

II. MATERIALS AND METHODS

The materials that used in this investigation were as follows:

- *Cement;* the Portland cement type I have been obtained from Alburg manufactory (Ziliten). The type I Portland cement used in this study complies with the specifications defined by the ASTM C150 standard and Libyan standard specifications 340/97.

- *Fine Aggregate;* The standard sand is silica sand, composed almost entirely of naturally rounded grains of nearly pure quartz, used for preparing mortars for mechanical tests. The sand that used in making test specimens for mechanical tests was natural silica sand from Zellaf desert 30 km from Brack city. The grade of original sand was out of the grade limits of ASTM C778-03, to conform to the requirements for standard sand, it was modified. The graded Sand was used for compressive strength test according to ASTM C109-03.

- *Clays;* Five clay soils as shown in Table (1) were brought from different sites at Sebha and Brack cities regions, the Clay minerals proportion was obtained by XRD (X-Ray Diffraction Method). The samples were excavated with shovels from the sides of natural slopes. They were generally dry with blocky structure and in order to perform laboratory tests the samples were crushed to the size of 0.25 to 0.5in. and calcined at 800 C° for a period of 2.0 h to produce fired clay bricks. The chemical analysis results of the selected samples are shown in table (2).

Table2: Chemical analysis of studied samples.

	Sebha (A)	Temenhint (B)	Alafya ('C)	Agar (D)	Tarout (E)
SiO2	82.75	67.39	56.73	53.41	54.52
TiO2	0.52	1.43	1.05	1.25	1.30
Al2O3	10.65	22.16	20.73	30.07	24.89
Fe2O3	0.89	0.99	8.90	2.10	2.50
Mn3O4	0.03	0.02	0.05	0.02	0.03
MgO	0.20	0.14	0.55	0.20	0.29
CaO	<0.004	<0.004	0.01	0.05	0.58
Na2O	0.25	0.01	0.09	<0.009	0.83
K2O	0.53	0.34	2.76	1.35	1.14
P2O5	0.15	0.04	0.16	0.12	0.50
SO3	0.03	0.02	0.09	0.04	0.51
V2O5	0.01	0.02	0.04	0.02	0.03
Cr2O3	0.02	0.03	0.02	0.03	0.03
SrO	0.02	0.01	0.02	0.02	0.03
ZrO2	0.06	0.07	0.05	0.04	0.05
BaO	<0.006	<0.006	0.04	0.02	0.02
NiO	<0.002	<0.002	<0.002	<0.002	<0.002
CuO	<0.002	0.00	0.01	0.01	0.00
ZnO	<0.001	<0.001	0.02	0.00	0.00
PbO	0.02	0.02	0.02	0.02	0.01
HfO2	0.01	<0.004	0.01	0.00	0.01
SiO2	82.75	67.39	56.73	53.41	54.52

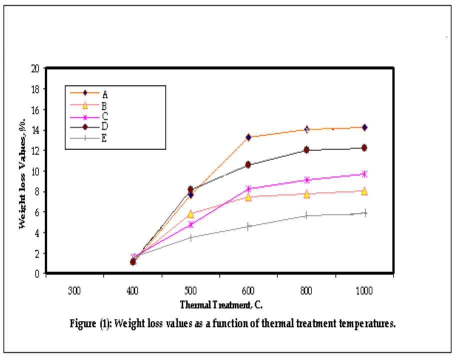
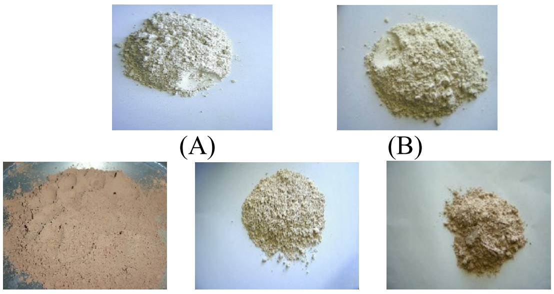


Figure2: Weight loss of samples



(A) (B)
(C) (D) (E)

Figure 3: Calcined clay

A. Mix Proportion

Three different proportions of blended cement paste and mortar mixes were prepared. For each type OPC replacing with three different amount of calcined clay in dry condition, the mixtures were thoroughly homogenized and kept in polythene bottles until the test.

B. Consistency and setting time of blended cement

Water consistency of blended cements was determined in accordance with IS 4031 (Part 4)-1995. The pastes having normal consistency as shown in fig.(4) which were used to determine the initial and final setting time in accordance with ASTM C187-04 as shown in (figure 5) .

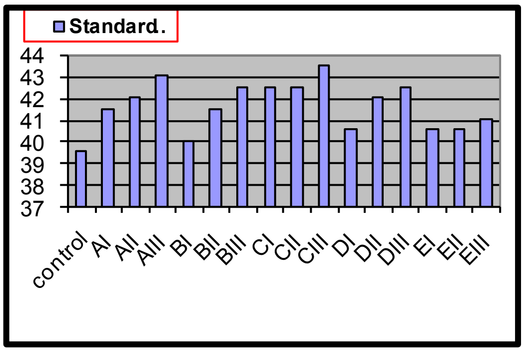


Figure 4: Water consistency of blended cements

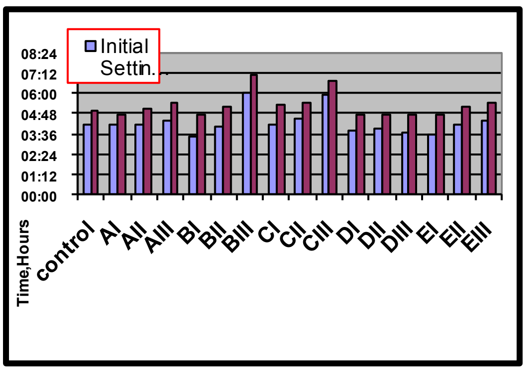


Figure 5: Initial and final setting time

C. Expansion of Blended Cement

The expansion of blended cement was measured by Le Chatelier test that was done by 300 grams of blended cement weighted carefully and added to water needed for preparing paste of standard consistency . The cylinder was placed on a glass plate and fill it with the blended cement paste, covered it with an other glass plate and 80 gm weight is placed on this covering plate. Immersed the whole assembly in water again at the temperature of 23C° ±2C° and kept for 24 hours. At the end of this period we measured the distance between the indicators points and submerge the whole assembly in water at temperature at 22 C°±2C°. After that the heat of water was raised up to that water start boiling within 30 min±5min. kept the mould assembly in boiling water for one hour. After boiling for one hour , the assembly is taken out of water and allowed to cool . After cooling , the distance between the indicators is measured again. The increase in distance represent the expansion of the cement as shown in (fig. 6).

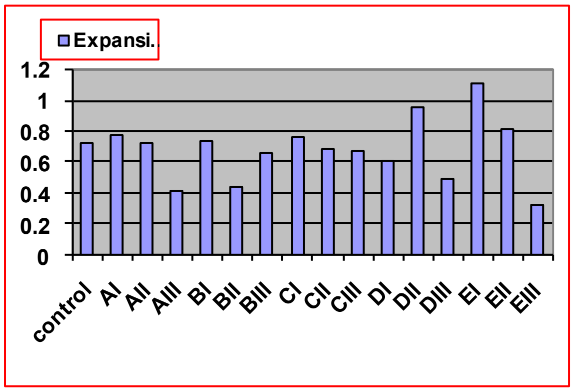


Figure 6: expansion of the cement

D. Compressive Strength

The control mixture was prepared with w/c ratio equal to 0.459, cement: standard graded sand equal to1: 2.75 . The mortar mix were prepared using ELE (UK) Automatic Mortar Mixer in accordance with ASTM C 305-99. Fifty-millimeter cubes were cast in two equal layers and compacted as per ASTM C109 After 24 h of initial curing in a moist room (23±2 C°) with relative humidity not less than 95%, the specimens were demoulded and cured in water until the age of testing. . For all blended cement mixes The water/ blended cement ratio (w/bc) was maintained constant.

III. RESULTS

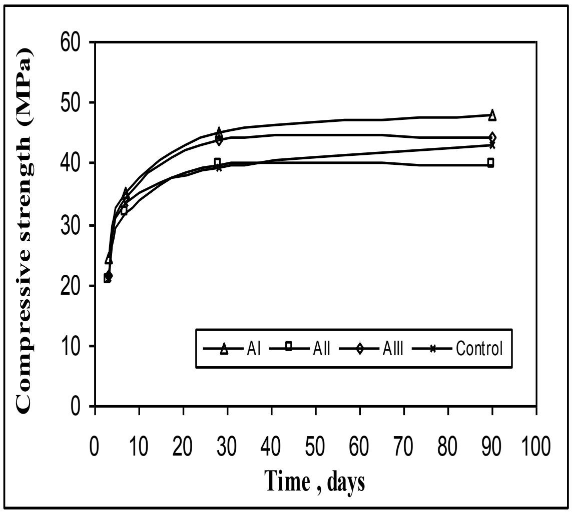
The average compressive & relative compressive strength of the mortar cubes after 3,7,28 days of mixing was shown in Fig. (7)a , b. Relative compressive strength (RS) at the different curing times for MK mortar is plotted in Fig (7.b). The RS is the strength of MK mortar divided by the strength of the control (i.e. 0% MK) at the same curing time. At 3 and 7 days of curing AII mortar seems to be slightly reduce the compressive strength resulting in RS value of less than one. However, beyond 7 days of curing, the RS of AII mortar increases and reaches a maximum at 28 days of curing. The optimum percentage of MK that results in higher strength is around 10%. BI and BIII mortars seem to increase the compressive strength resulting in RS value of more than one for most curing time and reaches a maximum in BI except at 7 days where compressive strength of BIII mortar less than control. Moreover the maximum contribution of BI occurs at 90 days of curing where more than 18% increase in strength is obtained. CI and CII mortars seem to increase the compressive strength resulting in RS value of more than one for most curing time and reaches a maximum in CII except at 10 days where compressive strength of CI mortar less than control. Moreover the maximum contribution of CII occurs at 3 and 90 days of curing where more than 20% and 12% increase in strength is obtained. DI and DII mortars seem to increase the compressive strength resulting in RS value of more than one most curing time and reaches a maximum in DI, except at 7 days where compressive strength of DII mortar less than control. Moreover the maximum contribution of DI occurs at 3 and 90 days of curing where more than 25% and 15% increase in strength is obtained**.** At all time of curing all E mortars seems to increase the compressive strength resulting in RS value of more than one and reaches a maximum in EI. Moreover the maximum contribution of EI occurs at 3 and 28 days of curing where more than 25% and 18% increase in strength is obtained (i.e. RS > 1.25 and >1.18) due to pozzolanic reaction. The optimum percentage of MK that results in higher strength is around 10%.

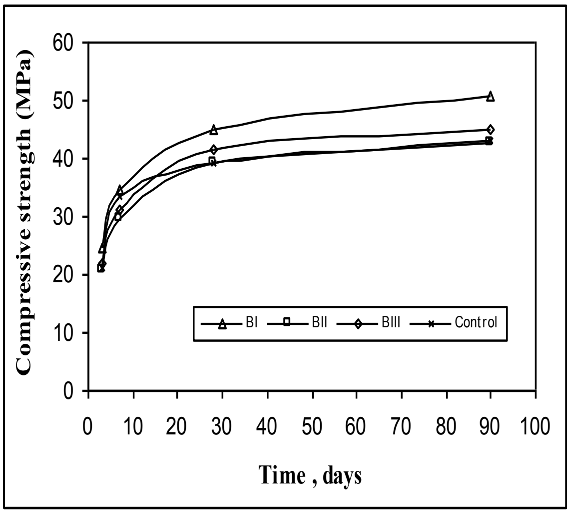
IV. CONCLUSION

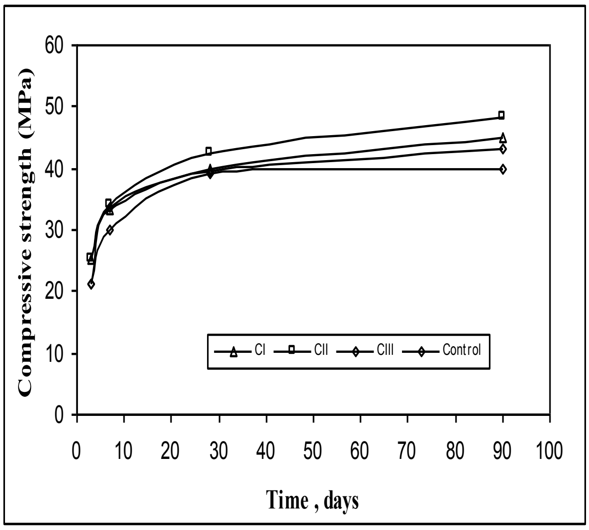
This paper present the results for the effect of south Libya MK replacement of cement on the concrete mortar compressive strength. Based on the results obtained from this study, the following conclusion may be drown:

1. The using metakaolin material effectively improving the compressive strength, for example the compressive of AI and DI mortar has been increased by 11% and 16% respectively, and all replacement level of C and B mortar samples were improved the strength, specially BI and BII.

2. In all samples the optimum percentage of MK that results in higher strength is around 10%, except C sample where the optimum percentage was 15%.







(a)
Figure7: Compressive Strength

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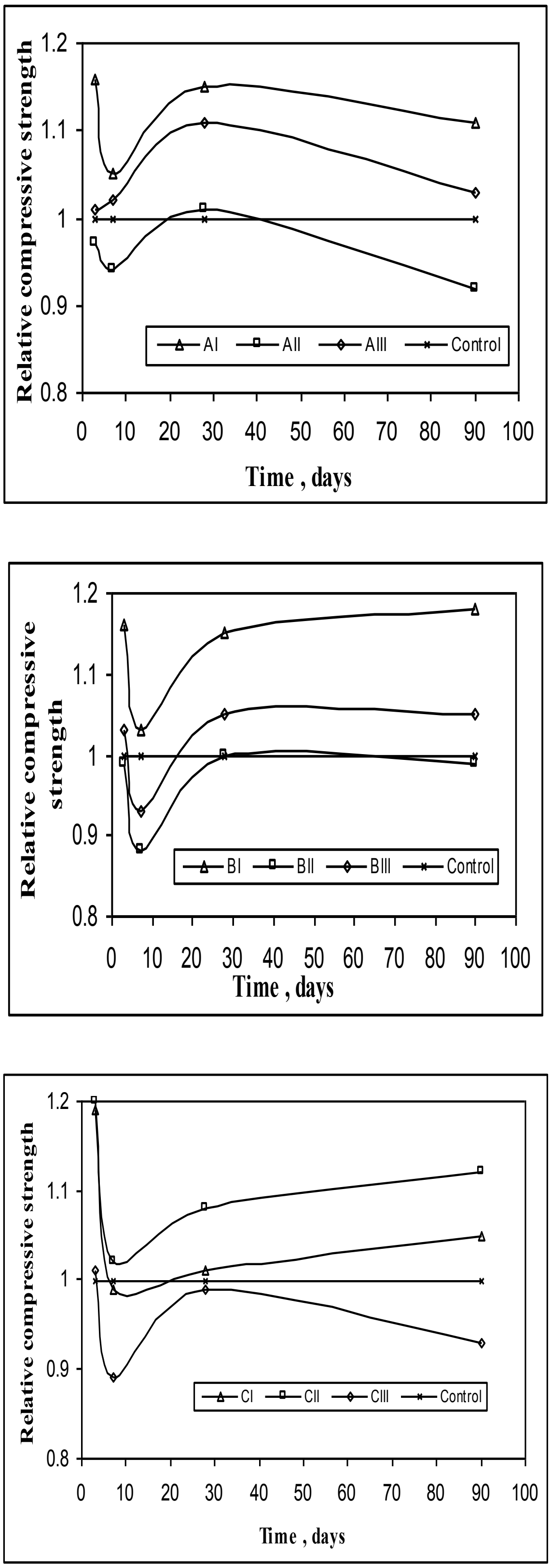
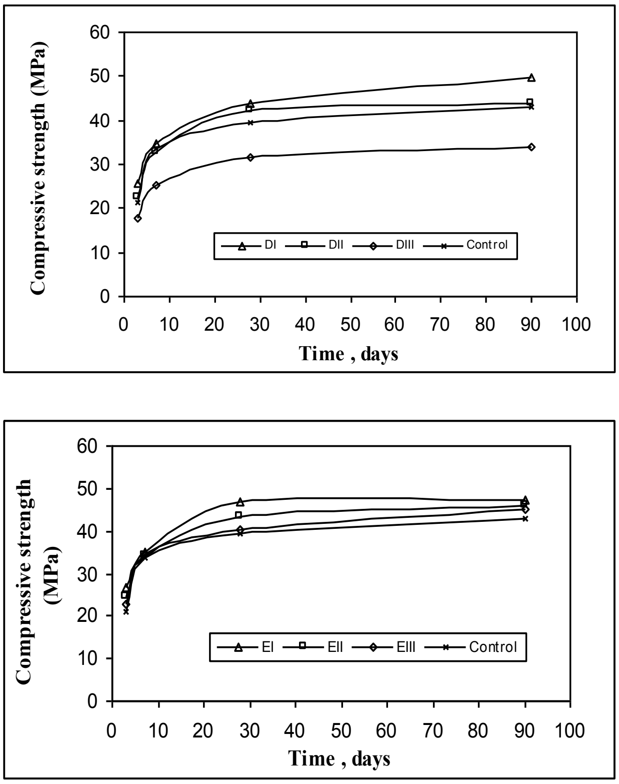


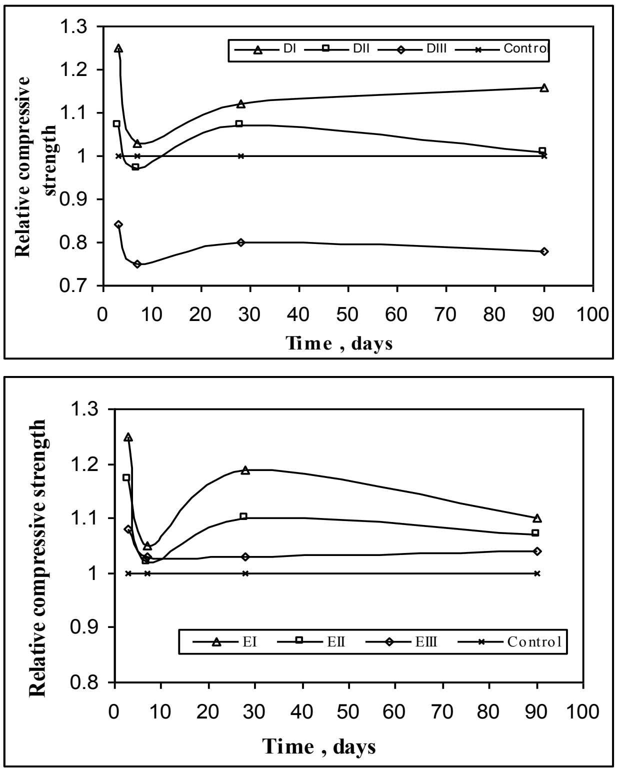
(b)

Figure7: Relative Compressive Strength



(a)

Figure7: Compressive Strength(cont..)



(b)

Figure7: Relative Compressive strength(cont..)