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Improvement some mechanical &physical properties cement with ceramics materials

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ABSTRACT

The importance of cement usage as construction materials and as bonding materials to fixated the ceramics tiles, those using as swimming tanks or spicily medical applications, which could be exposed to different environmental conditions have acidic natures or salts natures, so in this research study the adhesive property in cement through study the mechanical (compressive strength, Schmidt hammer) and some physical properties (density, porosity, thermal conductivity)and estimated compressive strength by using ultrasonic pulse velocity. This study has been accomplished after adding ceramics materials to cement and manufacturing samples and tested during immersed to attacked solution (salts solution, acidic solution) with 0.5 N along duration 28 day ,the results obtained higher compressive strength values when adding of adhesive materials percent 10 % more from the other percents (20,30 %) , the same results illustrated with Schmidt hammer test and density except the porosity results ,because of the voids and causes of presences of adhesive materials . and the salt solution ,acidic solution has more harmed aggressive solutions more immersed with ordinary water .

Key words: cement, compressive strength and Schmidt hammer, density, porosity, thermal conductivity.

1.INTRODUCTION

Mortars based on mineral binders like lime, cement, or gypsum has been used for more than 8000 years in the construction of buildings. These mortars have mainly been used for laying stones and bricks (masonry mortars) and for coating walls (rendering mortars). Until the 1950s cement-based mineral mortars were exclusively produced and applied by so called job-site mixing technology. Job-site mixing means transportation of the individual raw materials to the job-site and their mixing on site in the appropriate ratio. Thus cement, the most common mineral binder, is mixed with fillers (sand) before water is added to create the wet mortar for application. Similar to the way in which job-site-mixed

Concrete was substituted by the economically and ecologically more favorable ready-mix concrete, job-site mixing technology for masonry and rendering mortars was replaced by factory-mixed dry mortars, also called dry mix mortars. Dry-mix mortars or dry mortars are produced in specially designed dry-mix mortar plants in which mineral binder(s) and aggregates (sand) are mixed together in the appropriate way. This factory-based process also allows different additives and admixes to be added to these dry mortars to improve significantly their technical performance. Based on this technology individual dry mortars for specific applications can be produced according to formulations developed and pretested in the laboratory. The factory-mixed dry mortars are delivered to the construction site in bags or in special silos and need only be mixed with water prior to use. Together with the appropriate equipment for efficient transport, mixing with water, and machine application of the wet mortar, this dry-mix mortar technology led to a drastic improvement in productivity in the application of high volume products like masonry and rendering mortars. The possibility of adding specific dry additives or admixes in a well defined ratio to the dry mix during the production also

Led to the development of high quality mineral mortars with well-defined and specific technical properties. These highly specialized mortars corresponding to the requirements of the modern building industry cannot be produced with jobsite mortar technology. Consequently, high-quality, additive - and admix modified mineral mortars are today widely used in the building industry and have largely substituted other building materials such as ready-to-use paste compounds and liquid admixes used in combination with mineral mortars.[1]

2.LITERATURE REVIEW

In (2006) A. Alexandra P. Mansur and Herman S. Mansur ,study Adherence between glass tiles and cement mortars is crucial to the stability of tile systems and, based on chemical features, only the weak Vander Waals forces and hydrophilic interactions may be expected to develop between glass tiles and Portland cement mortar and they resulted The adherence results varied in a broad range reflecting the overall balance of silane and cement features including reactive organ functional group, hydrophobic/hydrophilic features, kind of interactions developed between silane and cement[2].

At (2007) Dale P. Bentz and et.al. study X-ray absorption measurements have been applied to studying film formation at the exposed surface during the drying of cementitious tile adhesive mortars as a function of ingredients and mixture proportions. Preliminary observations suggested that in addition to a drying front, concurrently, a densification front is observed proceeding from the exterior of the specimens inward. Due to the extremely high viscosity of the pore ‘‘solution’’ in these mortars, an analysis based on Stokes equation actually suggests that some of the smaller cement particles will be ‘‘carried’’ along with the drying pore solution to the top surface of the specimen where they are sequentially deposited. [3].

At (2008) J. Khadem zadehYeganeh, M.Sadeghi, H.Kourki, study For reducing its waste and decreasing environmental problems we can use it (HIPS) in modification of cement mortar. Cement mortar was modified using recycled high impact poly styrene (HIPS) in powder form.

Mixtures with polymer–cement ratios of 10, 15, and 20 wt. % were investigated for changes in compressive properties and adhesion to steel rebar. Compressive tests indicated an increase in Young’s modulus for samples with 10% and 15% HIPS. Adhesion strength to the steel rebar decreased on adding the HIPS. However, when the HIPS were treated with Maleic anhydride, an increase in adhesion strength was obtained. The decrease in adhesion of the untreated HIPS-modified cement to steel was attributed to the disruption of the interface between the cement mortar and steel rebar. Addition of 5% nano clay increased both compressive Young’s modulus and adhesion strength to the steel rebar [4].

At (2009) Alexandra Ancelmo and et al, they study Adhesion between tiles and mortars is of paramount importance to the overall stability of ceramic tile systems. In this sense, from the chemical perspective, weak forces such as van der Waals forces and hydrophilic interactions are expected to occur preferably at the tiles and polymer-modified Portland cement mortar interfaces. Thus, the main goal of this study was to chemically modify the ceramic tile surface through organosilanes aiming to improve adhesion with polymer-modified mortars (PMMs). Glass tile surfaces were treated with five silane derivatives bearing specific functionalities. Fourier transform infrared spectroscopy and contact angle measurements were used for characterizing the novel surfaces produced as the chemical moieties were immobilized onto them. In addition, pull-off tests were conducted to assess the effect on adhesion properties between tile and poly(ethylene-co-vinyl acetate) modified mortar. The bond strength results have given strong evidence of the improvement on adherence at the tile–PMM interface, reflecting the whole balance of silane, cement, and polymer interactions[5].

At (2012) Liang Chen , Byoung In Suh ,show that all-ceramic materials, especially silica-based lithium disilicate and nonsilicate- based Zirconia, has become a topic of interest in the field of dentistry. It is still difficult to achieve a strong and durable resin-ceramic adhesion, especially resin-Zirconia bonding. Approach: The article reviews the current literature published in the past 5 years, focusing on the latest resin bonding techniques (including surface treatment, priming and cementation). The preferred protocol for Zirconia-resin bonding is the combination of surface roughness such as air-abrasion and treatment with a phosphate-containing Zirconia primer followed by cementation with a non-phosphate-containing resin cement [6].

3. METHODOLOGY

The purpose of this work is to study the adhesive property of cement, by adding powder materials (mixture natural ceramics materials) to cement past, we obtiend of optiumaizing percent with haigh value of strength for this materials, then expouser the samples after curing time (28 day) in harsh solutions as (salt and acidic) solutions have (0.5 normality) .This chapter includes the description of materials used, mix proportions, the experimental work details and the measurements.

3.1 Materials

Ordinary Portland cement manufactured by (Tasloga factory \ trademark AL_jeser) cement factory was used throughout this investigation. It was stored in a dry place (air- tight plastic containers) to reduce the effect of humidity and temperature..The used cement conforms to the Iraqi specification No.5/1984[12].

3.2 Testing

3.2.1 Compressive Strength

The compressive strength test was determined according to BS1881: part 116:1989[13]. This test was measured on 100 mm cubes using an electrical testing machine with a capacity of 2000 kN, at loading rate of 5 MPa per minute. The average of three cubes was adopted for each test. The test was conducted at age of 28 days after curing with tap water, and at ages exposure to aggressive solution. **Compression =force / area . . . . . (3.1)**

Compression: [MPa]. Force: [N]. Area: [mm²].

3.2.2 3Schmidt hammer test

The test was carried out according to ASTM C 805 [15]. Cubic and cylindrical specimen with dimension of (100 mm) and (100* 200mm) were used in this test. Testing the compressive strength of concrete using the Schmidt hammer is considered a non-destructive test, the main principle of this test is that it measures the rebound of an elastic mass when it collides with the sample surface under the test, this rebound depends on the hardness of cement mortar samples and on the energy it absorbs from the collision. The tested sample has to be smooth and firmly supported. The hammer is pressed against the samples, and then the mass inside the hammer is rebounded from the plunger and gives a reading on the scale. This reading is called rebound number which is the distance traveled by the mass expressed as a percentage of the initial extension of the spring. The rebound number depends on energy stored in the spring and on the size of the mass. Finally each device was combined with a graph with contained calibrating curves relating the rebound number with the compressive strength.

3.2.3 Ultrasonic pulse velocity test

The test was carried out according to ASTM C597-02[16] *using* apparatus shown in Fig (3.5). Cubic and cylindrical specimen with dimension of (100 mm) and (100*200 mm)were used in this test. The accuracy of the dial measurement was checked against a calibration circuit. The faces of the transducers were pressed against the sides of the test specimens after establishing contact through coupling medium. Wetting the test specimen with grease was made to exclude entrapped air between the contact surfaces of the transducer and the surface of test specimen. By moving the transducers, the average time interval was conducted. The test was conducted at ages *of 30, 60 and 90 days* of exposure to oil products after 28 days water curing. Finally the velocity of ultrasonic waves passing through the concrete is calculated by:

V (km/s) = L/T. . . . . (3.2)

Where : V: ultrasonic pulse velocity (km/sec)L: length of specimen (mm)

T: effective transient time (μ sec), After that the compressive strength is obtained by using the equation: □ **= 2.8 Exp [0.53 * V]. . . . . (3.3)**[17]

Where □: compressive strength (N/mm^2),V: velocity of ultrasonic waves (km/sec)

Fig (3.5) shows the ultra-sonic pulse apparatus.

3.3.5 Thermal conductivity test:

Lee's disc manufactured by (Griffen and George Company/ England) Lee's disc instrument is used to calculate thermal conductivity of the samples under test Fig.(3-6), this instrument consists of three discs of brass and heater. The heat transfers from the heater to the next two disc then to the third disc across the samples. The temperatures of the discs (T_A, Y_B, T_C) can be measured with the thermometers which are located in them. The surfaces of these discs should be clean and well touched to obtain the optimum heat transfer through them. After supplying (6volt) by the power supply to the heater, the current value through the electrical circuit is about (0.25A), and then the temperatures of the discs are recorded after reaching the thermal equilibrium (nearly after 45 min).

$$IV=\pi r^2 e(T_A+T_B)+2\pi re[d_A T_A+d_S(\frac{1}{2})(T_A+T_B)+d_B T_B+d_C T_C] \quad \textbf{(3-4)}$$

Where: I: Is the current value through the electrical circuit.

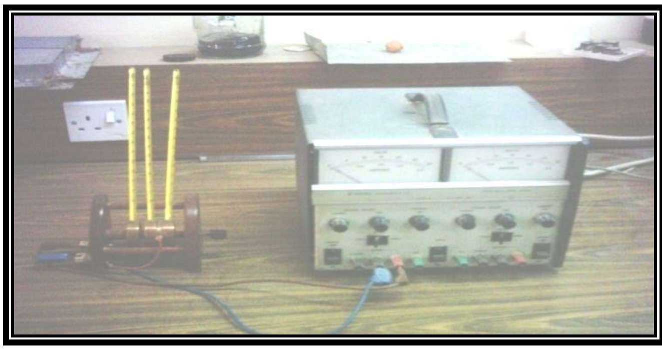
V: supplied voltage (volute) , r: radius of disc (mm)

T_A, T_B& T_C: temperatures of the brass disk A, B & C respectively.

d_A, d_B & d_C: thicknesses of the brass discs A, B & C respectively d_s is the thickness of the specimen. From the equation (3-4), the value of (e) is calculated which represents the quality of heat flows through the cross sectional area of the specimen per unit time (W/ m^2C^0).

$$k(\frac{T_B - T_A}{d_S}) = e[T_A + \frac{2}{r}(d_A(\frac{1}{4}d_S))T_A + (\frac{1}{2r})d_S T_B] \quad \textbf{(3-5)}$$

Where: k :the thermal conductivity coefficient (W/ $m.C^o$).Fig.(3-5) shows Lee's disc instrument.



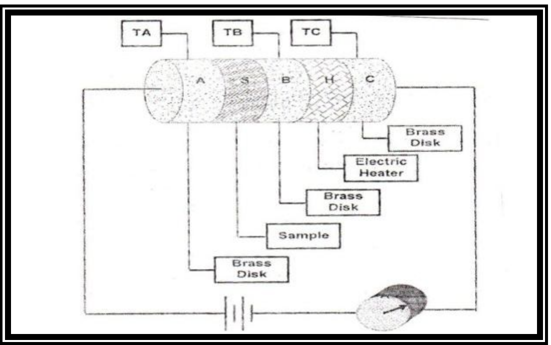


Fig.(3-5): Lee's disc instrument[18].

4. Results and discussion

In this section the results are presented and discussed for all the experimental work which is described in detail in chapter three. The properties of cements mortar samples (compressive strength, and Schmidt hammer test and some physical properties like density and porosity) after the continuous exposure to different solutions with (0.5 N), salts and acidic solutions also using ordinary water at age (28 day).

4.2 Mechanical properties

4.2.1Compressive strength

Compressive strength is the most important property of concrete since the first consideration in structural design is that the structural elements must be capable of carrying the imposed loads. Also with cement mortar represent as guide for higher adhesion of mortar samples. figure (4.1) illustrate the compressive strength values of mortar samples when exposure to three conditions as noted above ,the compressive strength have higher value when added 10% from the adhesive materials than all ratios in all conditions because of the continuous Chemical reactions between water and cement which forms a new hydration product increases the bond between cement paste and aggregate which satisfied with Alharbi [18]. and the little percent of adhesive materials the type of reactions is exothermal and it make cement need more humidity ,so no longer effect of attacked solution on the samples ,whiel the (20,30 and 100%)ratios show more effected with those solutions

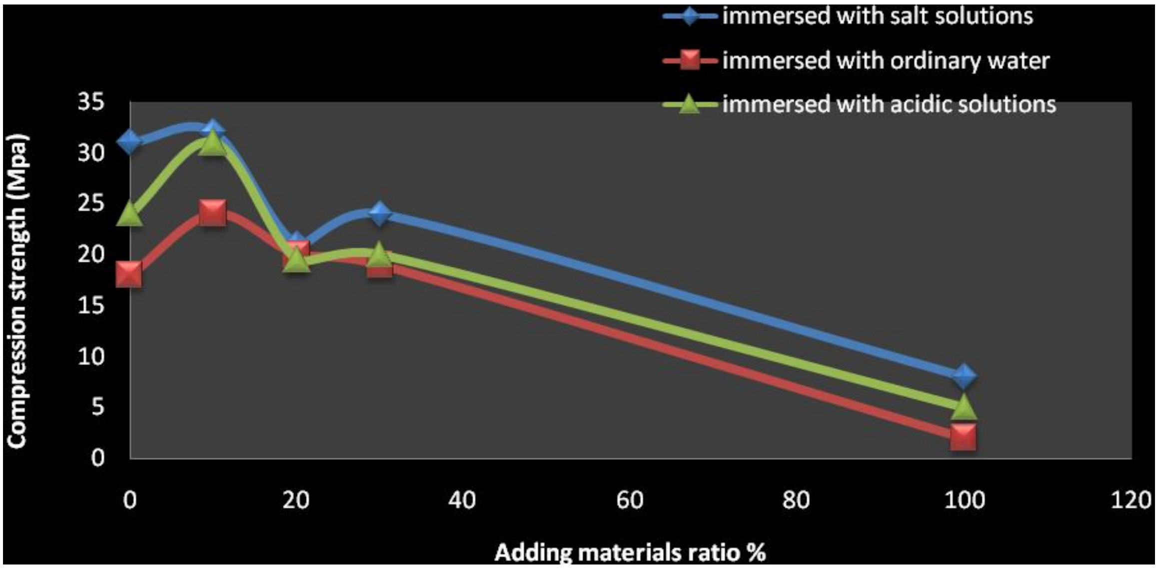


fig.(4.1) relationships between compression strength and adding adhesive materials ratio.

4.2.2 Schmidt hammer test

Rebound surface hardness testing of concrete is one of the most widespread NDT methods for in situ strength estimation of concrete structures. Hardness test methods are indirect methods of determining the strength of concrete, i.e. compressive strength of concrete is determined from the calibration relationship between parameter of nondestructive testing and strength of concrete.

Fig (4.2) illustrate the effect of attacked solution like salts solutions and acidic solutions after using adhesive materials with cement mortar. In addition, the reaction between the aggressive solution and hydration products may lead to a certain strength losswhichit is caused by the effect of the following:-

- Test area treatment- Surface texture has an important effect on the accuracy of the test results, when a test is performed on a rough textured surface, the plunger tip causes excessive crushing and a reduced rebound number is measured. Mahmood[19]. Test results show that the hammer rebound values for specimens which were have ratio

10% of adding adhesive materials increase slightly with increase in age up to 28 day, this increase is because of the progress of hydration which decreases the void space within the concrete mass. when soaked in water and tested in the saturated surface-dried condition, show rebound readings 5 points lower than when tested dry.

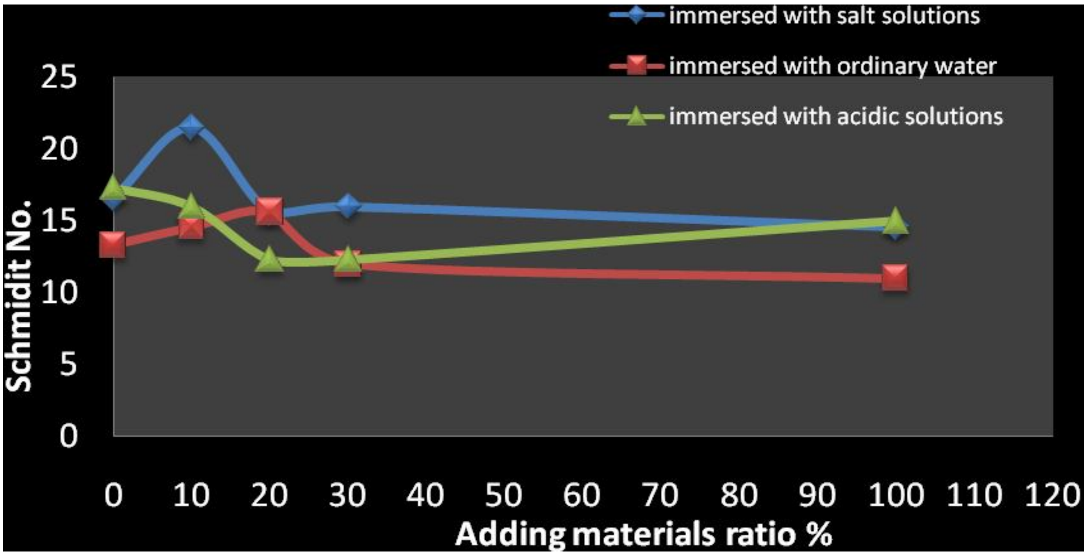


fig.(4.2) relationships between Schmidt hammer rebounded and adding adhesive materials ratio.

4.3 physical properties

4.3.1 Density:

The density of hardened samples is a function of the densities of the initial ingredients, mix proportions, initial and final water content, air content, degree of consolidation, degree of hydration, volume changes, and subsequent gain or loss of water, among other factors. Dependence on these factors makes density an effective indicator of the uniformity of raw materials, mixing, batching, placing, sampling, and testing.fig (4.3) the relationship between the density and the ratio of adding adhesive materials, the density of samples immersed with ordinary water higher values than that immersed with salts and acidic solutions, because of the effect of salt and acidic materials. The decrease in bulk density is due to the difference in adhesive ratio in mixes.

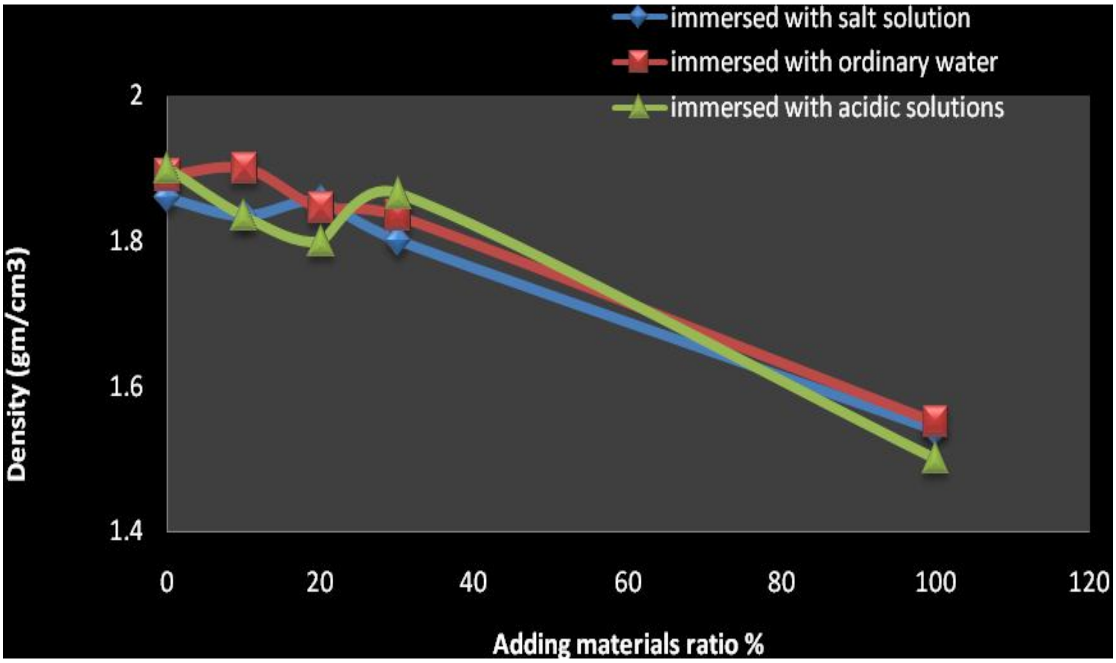


Fig.(4.3) relationships between density and the adding adhesive materials ratio .

4.3.2 Porosity

The value of porosity percent related directly with density and voids formation when adding adhesive materials with different ratio ,so when the mixing process occurred handling there are a large number of porosity formed as noticed when examined along 28 day when immersed with attacked solutions . as show in fig.(4.4)

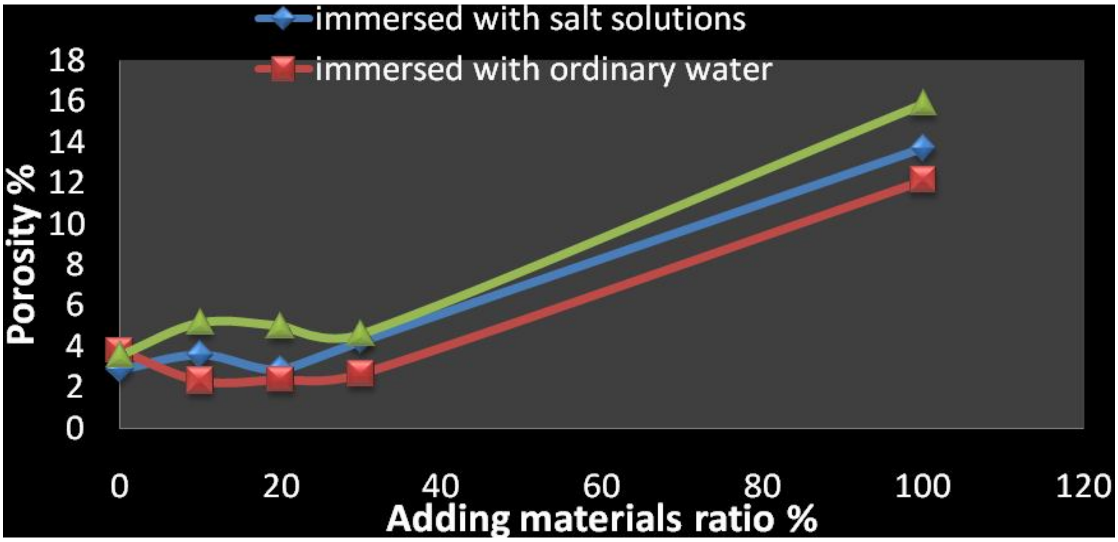


Fig.(4.4) relationships between porosity and the adding adhesive materials ratio .

4.3.3 Thermal conductivity:

Thermal conductivity is the ability of a material to conduct heat. This quantity represents the rate of heat flow per unit time in homogenous material under steady conditions, per unit area, per unit temperature gradient in a direction perpendicular to area. The results were represented in the Figures (4-5) it can be noticed that the average of the thermal conductivity of those samples is less than (0.009 w/m.c^0) which reflects the high resistance of those materials to heat transfer, which means their suitability to be used as thermal insulators. This low thermal conductivity is because ceramics and cement have no free electrons and low phonon velocity. So can be using as good insulators.

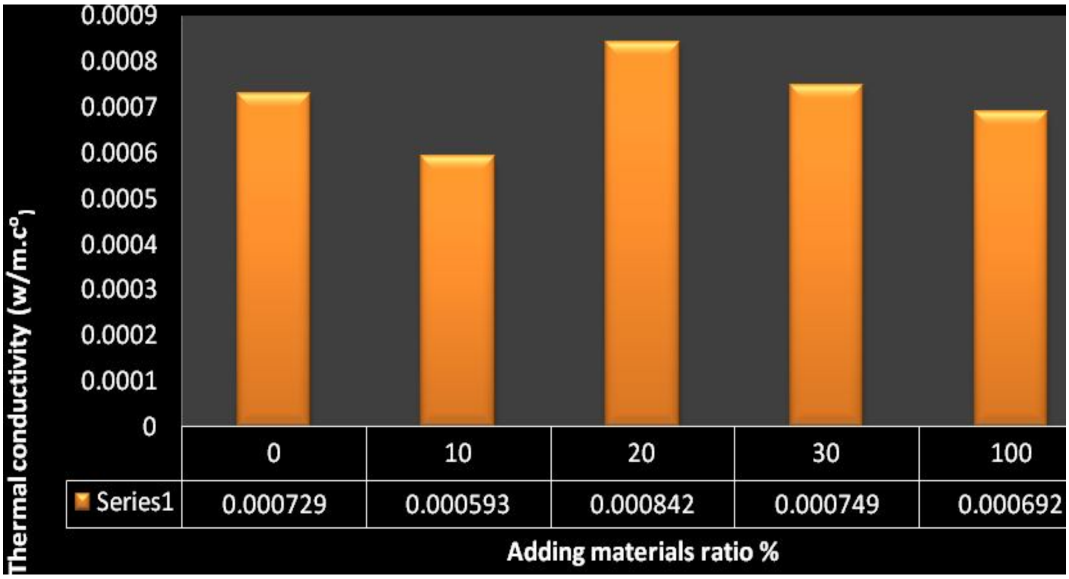
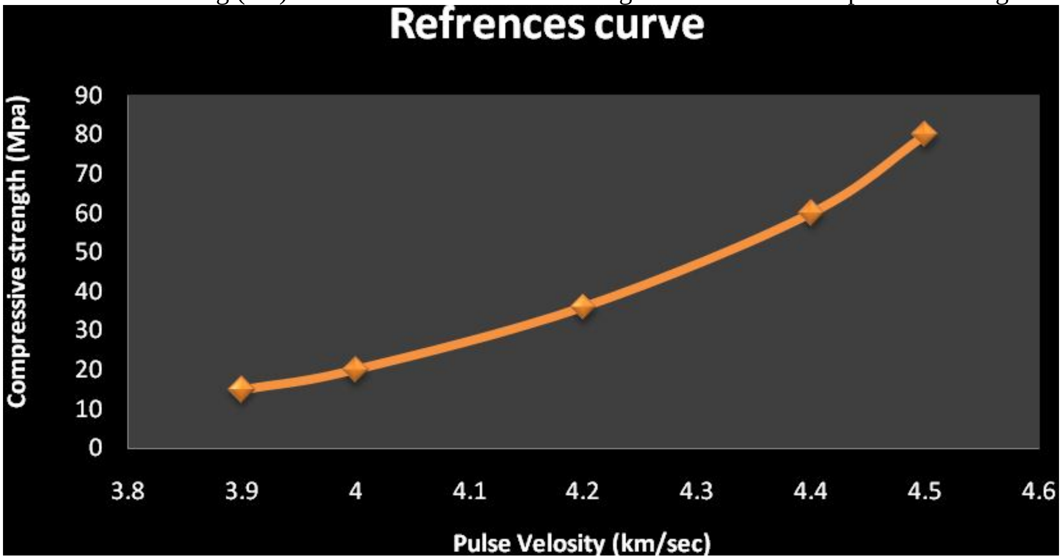


Fig.(4.5) thermal conductivity of samples (cement and adhesive materials).

4.4Ultrasonic pulse velocity (UPV)

Ultrasonic measurements are used in structural engineering to determine material properties, detect defects, and assess deterioration. A reference property value, such as ultrasonic pulse velocity (UPV), is determined using laboratory specimens. Field measurements are compared with the reference property value to assess the condition of the material. The ratio of field UPVs to the reference UPV indicates the level of material deterioration. As in compressive strength results the UPV for specimens exposed to salt and acid solutions decreases as the exposures periods increases, this is due to the deterioration of samples exposed to oil products and the effect of bond between aggregate and cement paste due to increase in micro cracks in the microstructure of concrete specimens which satisfied with Faiyadth [21]. In some cases it can be seen that the ultrasonic pulse velocities increase and then decrease continuously with exposure period. This behaviors because of the formation of new compounds within the samples mass which fill the porous as result of the reaction between the salt and acidic solutions and the cement samples ingredients, after that the expansion of these compounds leads to form voids within the samples mass. Also this is due to the aggressively of the salts and acidic solutions .as shown in fig.(4.6) with the references curve using to detected the compressive strength [22].



Fig(4.6) references curve [21].

But, here we can using pulse velocity of ultrasonic to detected the density and porosity and compressive strength, according the value of pulse velocity decreased when the density is higher than porosity of samples, and this aim of estimated method

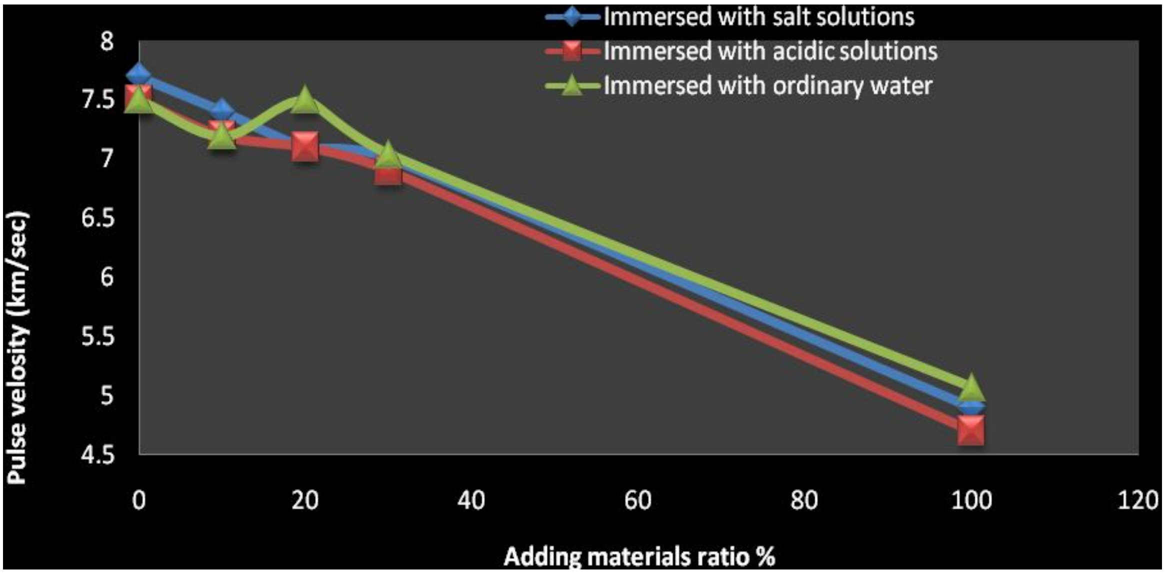


Fig.(4.6) Relationships between adding materials ratio and pulse velocity of ultrasonic.

5. Conclusions

1. Adding adhesive materials improve ability of cement adhesive property with ratio 10% according the values of compressive strength and Schmidt hammer.
2. Increased the adding materials ratio more than 10% leads to decreased all mechanical properties values.
3. The attacked solutions more affected with salts solutions and acidic solutions.

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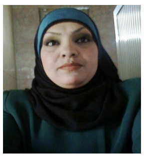

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