

The Electrical and Setting Properties for Different Blended Cement with Styrene Butadiene Rubber mixtures

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ABSTRACT

The effect of polymer- modified cement mortars were studied by prepared a varying polymer/ cement mass ratio at constant water/ cement mass ratio of 0.25. The studying was revealed the effect of styrene- butadiene rubber (SBR) emulsion on the electrical and setting properties at different curing time and frequencies for the dielectric behavior for the different matrix blended cement. This effect may related to the polymer films formation in the modified surfaces of polymer- cement matrix (i.e.) the reduction in the capillary porosity of the matrix system leading to the pore volume peak in the pore size distribution to shift towards the finer pore size range, that is leading to changes in the electrical properties (σ , ϵ). This change in the electrical properties leading to changes in the setting parameters, which is contributed to the abrupt diminution of the amount of macroscopic capillary pores. Also the effect of frequency on the electrical properties could be explained on account of the slowing down of the polarization process leading to changes in the (σ , ϵ), and that might be related to the ionic movements accompanying the local changes in the (σ , ϵ) and accompanied by a changes in the relaxation times in the different modified- polymer cement matrix.

Key words: Polymer, blended Cement, styrene- butadiene rubber

Introduction:

Polymer modified cement pastes are a class of composite materials which includes a broad group of originally bound and inorganic bound in cement, each with its own distinctive properties. The resins used as binders for the formation of the modified polymer cement matrix are monomers or polymer/ monomer solution that are mixed or combined with Portland cement at the time of mixing, the organic polymer that are dispersed in the water of mixing. The polymer families most commonly used for the preparation of modified polymer cement mortars. These properties include improved bond strength, increased flexibility and impact resistance, improved resistance to penetration by water and by dissolved salts, and improved resistance to frost action (Yasin and Qureshi, 1989; Wang *et al.*, 1999 and Stancato *et al.*, 2005). In recent years, the research and application of polymer latex blends have become a very active area of science work in order to meet the special requirement. In the area of coatings, the traditional methods to achieve the good property of film forming. The polymer latex modification for the cement mortars is governed by both cement hydration and polymer film formation processes in their binder phase (i.e.) the general polymer modified mortar properties depend significantly on the polymer content rather than w/c, when compared to ordinary cement mortars (Silva *et al.*, 2001 and Tang *et al.*, 1999). Styrene- butadiene rubber emulsion is widely used to modify the cement mortars matrix (latex), because the mortars constituents in the modified polymer mortars are compactly joined with each other due to the presence of interweaving polymer film thereby forming a monolithic structure the durability of the characteristic of the polymer modified cement matrix (Shiyum and Zhiyuan, 2002 and Ru Wang *et al.*, 2006). This study investigated the effect of SBR on the electrical and setting properties during the hydration processes as a function of the curing time for the hydration mechanism and the effect of the frequency of the applied field on the different modified- polymer matrix.

Experimental technique:

The cement paste samples were first prepared by mixing Ordinary Portland Cement (OPC), with styrene butadiene rubber (latex) in the form of suspension in ratio 0.1, 0.2, 0.3, 0.4, 0.5 SBR by weight from the weight of water which represents 0.25 (W/C). After mixing with the water, latex the cement paste was casted in cylinders with the dimension of 1cm diameter and 1.5cm height.

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For measuring the electrical conductivity, the test cell was of co-axial type [including concentric inner and outer electrodes mounted on an insulated base plate. The electrodes were polished before and the experiment and cement pastes were polished before the experiment. The cell was kept in desiccators at 100% relative humidity during the test period. The measurement began exactly, three minutes after the first contact with water, this the zero time of test. Electrodes were hooked to an automatic R-L-C bridge, PM 6304 PHILIPS for resistance, and capacitance measurements between the electrodes over the hydration stages of setting and hardening.

Results and Discussion

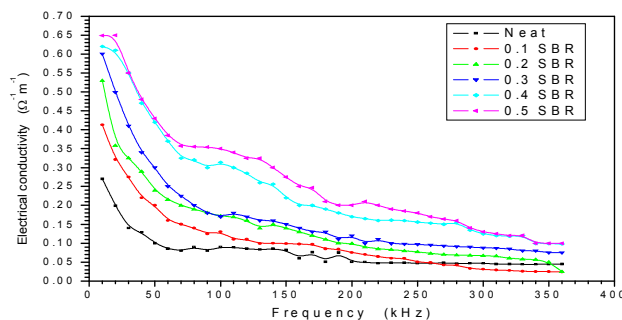


Fig. 1: The variation of the electrical conductivity (σ) in the polymer cement system with the curing time at different P/C ratio

In Fig (1) we show that the electrical conductivity (σ) as a function in the p/c ratio for the different blended cement admixture at W/C = 0.25. From this we can easily shows that the electrical conductivity is increased with increasing the P/C ratio. These results are mainly attributed to an increase the rate of hydration of cement in the latex modified cement progresses through the curing time period of hydration, because of their excellent water retention capillary due to the polymer film formation and the contribution of the ionic super plasticizer to the conductivity mechanism, which is related to the polyelectrolyte effect of SBR and its super plasticizer content (Joao *et al.*, 2002).

The dielectric properties of the blended material determine the response of this material when placed in an electric field. These properties are always presented relative the dielectric constant of the vacuum.

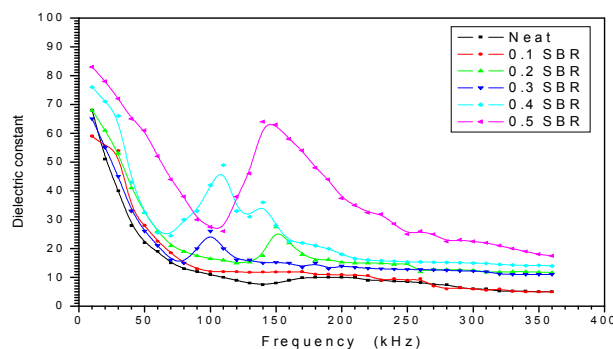


Fig. 2: The variation of the dielectric constant (ϵ) in the polymer cement system with the curing time at different P/C ratio

Fig (2) shows the effect of the P/C ratio of SBR on the dielectric constant (ϵ) behavior for the latex modified mortar system as a function in the curing time (min.). At the P/C > 0.1, there are an initial increase in the behavior of the (ϵ), and the associated peak appearance, during the behavior of (ϵ). The shape and position of this peak are clearly depending on the P/C ratio, and that is due to the effect of polymer thickness formation as in the case of the electrical conductivity (σ). The high values of (ϵ) at the beginning of hydration for each sample is due to the drift mobility of the ionic concentration, the origination of the double electric layers, which are located at the electrodes forming (electrode polarization), and the increase in the dielectric dipoles (polarization) which are produced from the bounded charges on the surface for each sample due to the effect of the alternating electric field (200 KHz) (Al- Salami *et al.*, 2007).

The decrease in (ϵ), after the initial high values in the mixed samples may be related to the formation of a thin layer of hydration products, and the continuous formation of the polymer film inside this matrix system, this creates an envelope around the anhydrated cement grains, leading to decrease in both of the number of ions and their mobility, and the increases in the peak value at $P/C > 0.1$ are mainly related to the reason of the progresses the hydration mechanism through a considerable long period, because of their excellent water retention capacity due to the increase polymer film formation (Soroka,1979).

Finally, the decrease in (ϵ) of all samples with the increase of the curing time of hydration can be ascribed to three phenomena; these are (i) modification of the chemical nature of the constituents, (ii) change of the relative amount of individual phases and (iii) variation of local topology (Soroka,1979).

The setting time is a physical property occurs during the process of the hydration mechanism in the mortar cement pastes, and it is used to describe the stiffening of the different samples.

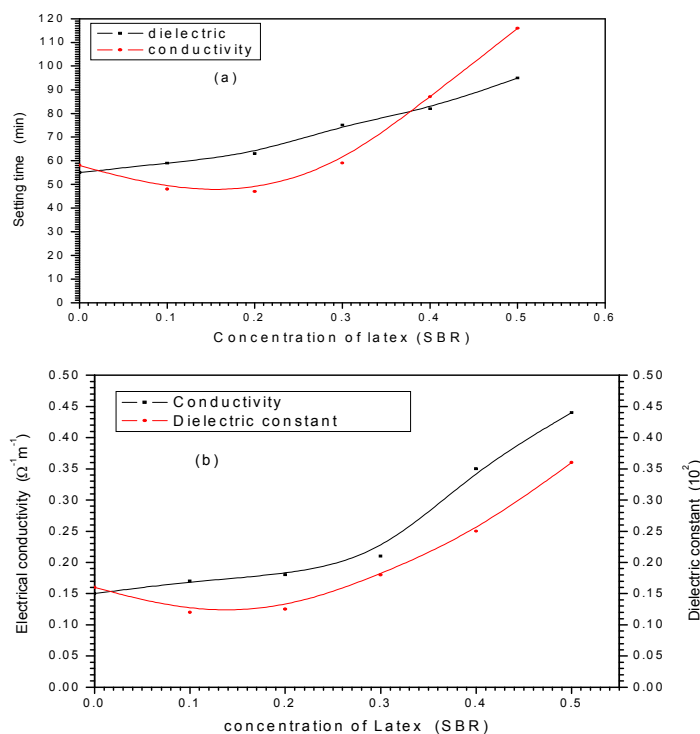


Fig. 3-a & b: The variation of the setting time with P/C ratio in both (σ) & (ϵ) in the cement polymer system

Fig (3a) shows the variation of setting for the electrical conductivity (σ) and the dielectric constant (ϵ) behavior with the concentration of P/C in the different samples. One can observe that the setting times for (σ) and (ϵ) are increased to higher values after the concentration $P/C \sim 0.3$, but before this critical ratio of P/C, the variation in the setting time for (σ) & (ϵ), may be considered as a small systematic change. The increase in the setting time at this critical ratio ($P/C \sim 0.3$), may be related to the increase of the polymer film formation and the increase of the adsorption of the surfactants on the binder surface, due to the inhibition of the hydration mechanism inside the sample (Joao *et al.*, 2002).

Fig (3b) represents the behavior of (σ) & (ϵ) at the setting time with concentration of P/C ratio. This figure supports the last fig (3a), which indicated to the critical ratio $P/C \sim 0.3$. Also fig (3b) shows a nearly steady state in the (σ) & (ϵ) before $P/C \sim 0.3$, but after this critical point, there are clear changes in both (σ) & (ϵ). That is related to the increase of the water redistribution between gel pores or between gel pores and interlayer positions, and the effect of the local electric field, both gel pore structure and the interlayer spacing are increased due to the increase in the local swelling (electro-osmotic pressure effects).

The small variation in the setting time before $P/C \sim 0.3$ for the variation of (ϵ) & (σ), fig (3a) can be contributed to the parallel increase of pore size and the decrease in the gel layer thickness of CSH hydrated phase, but the systematic changes in the (σ) & (ϵ) after the $P/C \sim 0.3$ is increasing by increasing P/C in the matrix system, that is due to the water retention of the latex-modified mortars is most helpful to inhibit dry-out-phenomenon (Sihai and Chung,2001).

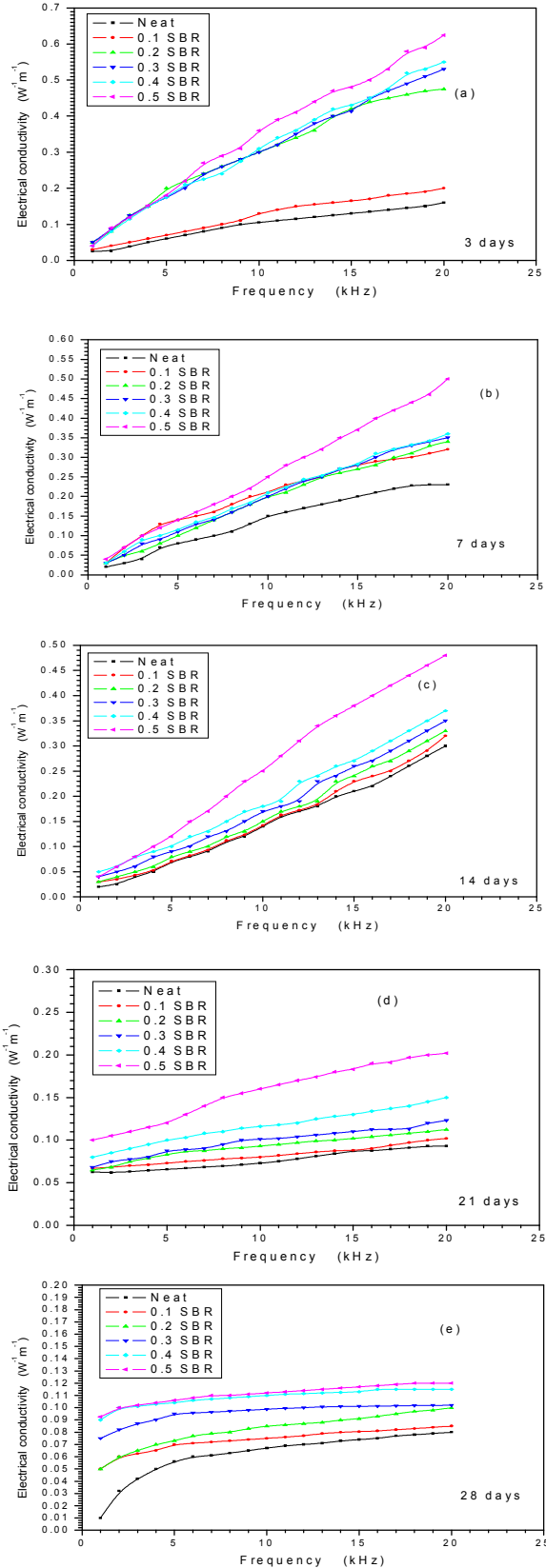


Fig. 4 a-e: The variation of the conductivity with frequency at different P/C ratio at hydration time 3, 7, 14, 21&28 days

In general, the behavior of (σ) with frequency at curing time (3, 7, 14, 21, and 28 days). In Fig's (4a-c) indicates that there is an increase in the values of (σ) with the P/C ratio inside the mortar- latex for the different samples. This refers to an increase in the water retention with rising P/C ratio, this water retention in the latex modified mortars is the most helpful or effective to inhibit dry- out phenomena, and that is leading to the progresses of the hydration mechanism inside these samples, due to the polymer film formation.

The effect of frequency on the electrical properties (σ) for the different samples in fig, s (4a-e) is clearly increases with increases of frequency. That is related to the increase in the rate of hydration process, due to the decreasing of the free water inside the samples and the increase of the volume solid phase with increasing the curing time (Rhim and Buyuozturk, 1998). Also the rate of decreasing in (σ) with curing time, for all latex-modified cement samples, are mainly due to the formation of a crystal bonding with a strong crystalline network in the mortar pastes with the progressive hydration, this due to the increase of bulk density and decrease of porosity (El. Alfi, 2006).

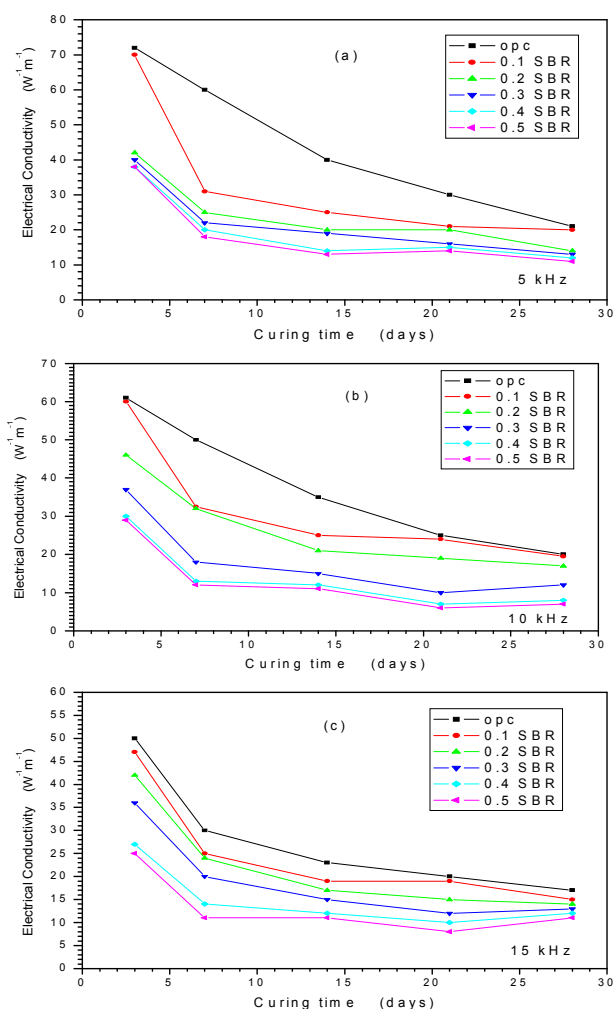


Fig. 5 a-c: The variation of the conductivity in the polymer cement system with the curing time T different frequencies (a) 5 KHz (b) 10 KHz and (c) 15 KHz

The frequency dependence of the (σ) for all samples is clearly observed in fig (5a-c) at selected frequency 5, 10, and 15 KHz. With increasing frequency of the applied electric field, that is accompanied by a high rate of changes in (σ), this is due to the decrease in the pore size as a result of the increase in the layer thickness of the CSH hydrate phase, and the increase in the ionic movement, which is associated to the increase in the local conductivity, which is leading to a large relaxation times (Coverdale *et al.*, 1994).

The critical ratio for the P/C value inside the latex cement matrix is occurring at $P/C \geq 0.2$ as shown in fig (5a-c), that is may be due to the increase in the accessibility of SBR molecules to increase the formation of the polymer film inside the pore system (i.e.) increase the electrical conductivity (Rhim and Buyuozturk, 1998).

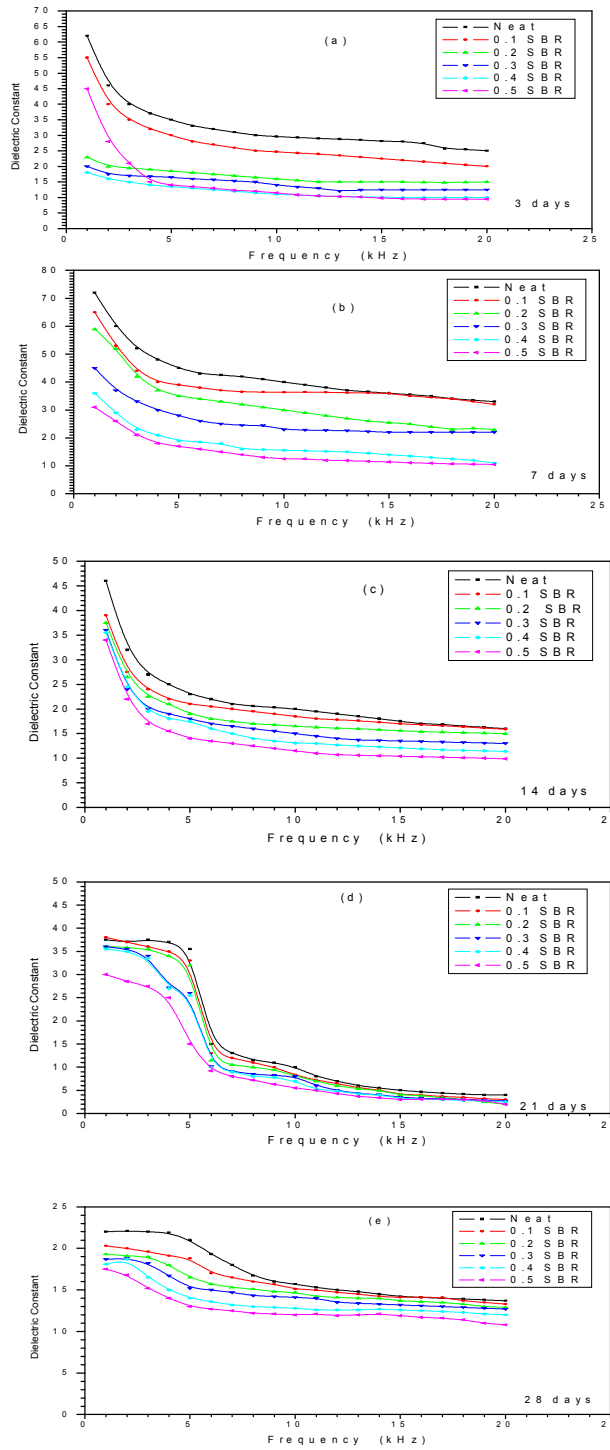


Fig. 6a-e: shows the variation of (ϵ) with frequency at different curing time (3, 7, 14, 21, and 28 days).

The general behavior for all samples (ϵ) is decreasing with increasing frequency that is attributed to the effect of the frequency on the dielectric amplification, due to the decrease of the interfacial polarization, and or the decrease of space charge polarization mechanism (Joao *et al.*, 2002).

With increasing the curing time (ϵ) decrease as shown in fig (6a-e). At thereby age of hydration the flexibility of the mortar cement improves the strength of the samples up to 21 days. This is mainly related to the rate of the hydration mechanism, which governs the development of the microstructure of the latex- modified,

while SBR latex, hardly affects the microstructure, due to its insufficient solidification. So that with increasing the curing time the variation in (ϵ) tends to relatively small trend, see fig (6e) (Ohama, 1995).

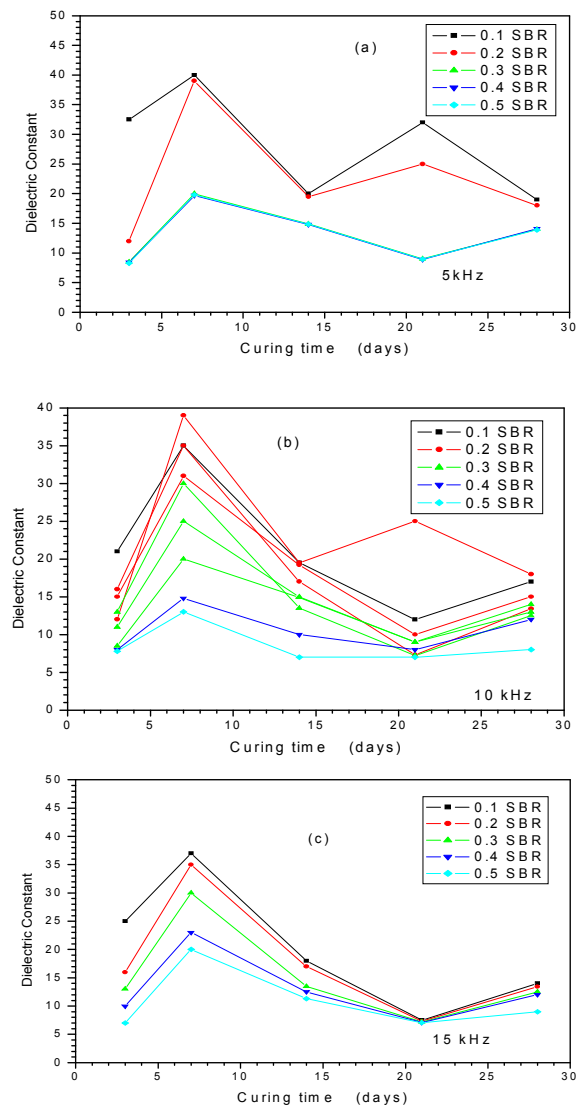


Fig. 7a-c: shows the variation of the (ϵ) as a function of curing time at different frequencies

It is obvious that the increase of (ϵ) between curing time 3 and 7 days is related to the hydration mechanism of the mortar samples, which becomes very pronounced, during this hydration stage, the clinker constituents have a high contribution to the hydraulic properties decrease the flexibility and decrease the strength, due to the continuous formation of the polymer film inside the cement matrix with increase the curing time of hydration (7 to 21 days) (ϵ) decrease at all frequencies. This may be attributed to the decrease in the amount of free water in the latex cement and the effect of polymer film on the W/C ratio, and that is leading to change the nature of water from a free to an absorbed state, which results in a reduction the ionic polarization (i.e. decrease in ϵ). At the curing time periodic (21 up to 28 days), the variation in ϵ becomes small, that is can be attributed to some hydration reaction of the unhydrate parts of cement grains inside the samples during this range of hydration (i.e.) thus making it difficult for the movement of the free ionized water remaining in the latex- modified (Al- Salami *et al.*, 2007 and Sihai, 2001).

Conclusions:

From this study it can be concluded that the electrical and setting properties of the polymer modified mortars are influenced by the polymer film, cement hydration rate and the combined structure between the

organic and inorganic phases. The rate of changes in the electrical properties in the latex SBR modified cement matrix mainly contributes to the reduction of water absorption. This reduction in the capillary porosity of the matrix system leading to the pore volume peak in the pore size distribution to shift towards the finer pore size range, so that the electrical properties (σ & ϵ) show a significant correspondence to consolidation (setting) of the matrix system, which could be attributed to the abrupt diminution of the amount of macroscopic capillary pores. The increase in the setting time (retardation processes) in the different modified polymers- cement matrix, may be related to the retardation of the hydration mechanism of the hydrated phases. This behavior does not cause inconvenience in practical applications because this trend depends on the polymer type and polymer/ cement (P/C) ratio. The effect of the frequency on the electrical properties (σ & ϵ) for the modified latex (SBR) cement matrix could be explained an account of the slowing down of the polarization process leading to a decrease in the value of (ϵ) and an increase in (σ), which might be probably due to ionic movements accompanying the local increase of the conductivity and finally leads to large relaxation times.

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