The influence of salt concentrations and power of hydrogen values on polymer cement mortar compressive strength

Hyman Jafar Meerza Al Jaaf, Rand Salih Al-Jadiri and Manolia Abed Al-wahab Ali

Materials Engineering Department, College of Engineering, Mustansiriyah University, Baghdad -Iraq.

Abstract. The objective of this study is to investigate the influence of adding recycled rubber with different weight (5, 10 and 15 gm.) on the cement mortar compressive strength. It was found from the obtained results, the best compressive strength is obtained at (10) gm. After that, the effect of two factors was studied. The first factor was different power of hydrogen values (pH) and how they affect the compressive strength test on cement mortar samples. The second factor was different salt concentrations solutions were used as curing water for the samples to immerse. The salt that used was sodium chloride (NaCl) with different weight percentage (5%, 10%). From the results, It is noticed that, the pH with (7) value gives the optimum compressive strength for cement mortar. Also, the average of compressive strength values for the samples immersed in salted water was higher at (5%) weight percent of salt than (10%). On the other hand, the longer the immersion of the samples in the salted water, the greater the compressive strength values of cement mortar.

Keywords. Salt concentrations, power of Hydrogen, polymer cement mortar, butadiene rubber, compressive strength

1. Introduction
The applied particle that used to fix building units together is called Cement Mortar. It is cheaper to use in repairing treatments of aggregate structure. It is prepared by mixing cement, sand and weight ratio of water. There are somekinds of cement mortars such as Portland cent mortar and polymer cement mortar[1,2]. Adding Polymers in mortar havetaken in considerable over (25) past years. Polymer-impregnated concrete. The first mortar polymer compound to obtainin marketing was (PIC). PIC has stability properties anexceptional strength, but it has limitedmarketablesubmissions. Polymer concrete (PC) becomesrecognized in the 1970’s and it is used for reparation of thin edges for molded components, floors and bridges. Polymer-modified mortar (PMM) has been recycledmainly for overlays and reparation. There are many recent and forthcoming uses for these materials because of their exclusive properties. Improvements of repair methods inconstituents’ replacements for metals structural applications will demonstrate to be general uses of mortar -polymer materials. The efficiencycost of surface impregnation of concrete to erosion abrasion is uncertain since the negligible depths being filled may erode too rapidly. Using polymer-Portland cement mortar may be inexpensive than surface penetration due to deepness of supplies and use of known construction procedures [3, 4]. The power of hydrogen is a measure to recognize a solution if it is acidic or basic. Also, it is called pH value in chemistry consequences. Its values are between(1-14) as standard principles, a solution with
pH a lesser amount of (7) is acidic; whereas, with pH greater amount than (7) is Basic. Pure water is impartial and its pH is (7) at (25 °C). PH values are measured by using a device that has glass conductor indicator called (pH meter) [5, 6]. Styrene-Butadiene rubber (SBR) is an artificial rubber that molded from styrene and butadiene. It is useful in strong alteration for natural rubber. In addition, it is a combination of about (75) percent butadiene (CH2=CH=CH2) and (25) percent styrene (CH2=CHC6H5) as shown in figure 1. Both these chemical substances are polymerized as a chain to apply in postponement development [3, 7, 8].

![Figure 1. Structure of Styrene Butadiene](image)

Adding the polymers to the cement mortar can progress some mechanical properties such as compression strength of mortar. It is used in concrete and mortar to rise durability, confrontation to water diffusion and improve scrape resistance [3, 6, 7]. Compressive Strength is the ability of a construction to struggle loads to shrink bulk. Furthermore, it is conflicts hardness of a substance. Some supplies disruption at a limit compression on its strength; whereas, others curvature forever, so at satisfied quantity of alteration can be the boundary for compression capacity. The compressive strength can be considered abasic rate for the structure project [6, 9].

2. Literature Review
LI H., Xiao H.G. and Yuan J. (2004) considered absorbency of chloride and the structure of cement mortar that modified by styrene–butadiene rubber (SBR). SBR established the dispersion of chloride conflict with common ionic porosity of the mortar, even though growing its ionic confrontation and reducing the electronic capacity. From the data, it is establish that SBR assisted the construction of calcium aluminate thiosulfate hydrate stages and permitted chloride obligating [10]. Zenan Z, Deyu K, and Rong S.C (2007) examined decay technique of Poly (dl-lactase-co-glycolic acid)-methoxypoly(ethylene glycol) (PLGA-mPEG) elements at diverse settings of pH values. Methotrexate (MTX) was applied as the drug sample. In dissimilar intermediate, the Polymer conformation was responsible for the uncommon deprivation performance. The microelements presented rapid mass loss; whereas, molecular weight reduced at pH (10.08). At pH (7.4), the particles assumed different loose declination. While, at pH (1.2), it obtained wildest molecular weight reduction but gentlest weight drop and achieved regular dilapidation [11]. P. Suganthy et al., (2013) considered crushed plastic submission, which produced from high-density polyethylene to substitute the aggregate in cement with diverse fractions. They replaced the normal sand by destroyed plastic sand. Five mixes of mortar were molded from materials exchanged by aggregate (sand) with (0, 25, 50, 75 and 100%) correspondingly to training the experimental results of some mortar assets. The results displayed that increasing the replacement of sand with plastic gives best decline of mortar, which is 90mm with growing in (water/cement) proportion. From the results, it is noticed that the decreasing in strength of specimen for plastic sand by up to 25% is fast which provides appropriate replacement up to 25% of sand with plastic crumbled sand [12]. Prashanth, V P et al, (2017) presented that the Geo-polymer mortar (GPM) is organized from obtainable fly ash and GGBSF which will be fixable at sundry curing condition. The influence of water-to-Alkaline ratio on workability in terms of flow and compressive strength tested for the specimen cured in sundry curing condition and conventional method of curing. Motivated solution to binder ratio of 0.5 and 0.4 for 1:3 and 0.8 and 1 for 1:6 by mass was preserved.
constant based on past research. Sodium silicate solution of 4-mole concentration and sodium hydroxide solution were applied as alkaline activators. When the water-to-alkaline binder ratio increases, the Stability of GM increases too, but in the way that affect inversely with compressive strength. FA and GGBFS based GPM suggestions early strength of order 5-12 MPa. for three days sundry curing. (1:6) mortars of alkaline to binder ration 1 and water to the alkaline ratio of 0.23 proposals good inflow and strength, which adversely proven through block masonry triplet study [5].

3. Experimental methods
Mortar samples preparation: Samples are prepared by mixing the materials [Sand, Cement and Rubber(Styrene Butadiene)] with some mixing ratio of three to one and adding a certain percentage of water to the mixture.

Materials and tools: Sand, cement, rubber (Styrene Butadiene), mold (5*5*5 cm), Sieve (Size=1.20 mm), NaOH solution (0.1N), HCl (0.1 N) solution, NaCl solution (at different weight percentage).

Steps of Preparation: In this stage, (6) samples were prepared and left in water for (7 and 28 days). Other (6) samples were prepared by adding (5, 10 and 15gm.) of styrene butadiene rubber respectively for each three samples and then left in water for (7 and 28 days). As follows:
- Materials mixture [sand, cement and rubber(Styrene Butadiene)]
(1: 3 According to the Iraqi standard) as shown in (Figure 2)

Figure 2 Styrene Butadiene, Materials mixture

-Pour the combination inside the mold.
-Disuse the mold for twenty-four hours to dry the samples.
-Carry out the specimens from the mold.
-Put the specimens in a water for a week.
-Pick up the samples from the water.
-Apply the compression test on the specimens.[13](Figure 3)

Figure 3. Samples of mortar
**pH test**
The samples were placed in solutions with different pH values, the solutions were conducted to pH test to determine the nature of each solution (alkaline, neutral, and acidic) and how can each solution effect the compressive strength of each sample. Figure (4) Shown the pH device [6,14]:

![Figure 4. pH Device](image)

Also, the samples were curing in different salt concentrations (NaCl) solutions for 7, 28 days respectively. Then, the samples were tested by compressive strength device to know how can effected by using different salt concentration solutions [14]. As shown in figure (5):

![Figure 5. Samples of mortar curing in water](image)

**Compressive Strength Test:**
The compression apparatus progresses the values of the maximum load applies on the specimens which is about (100 KN) as shown in figure (6) to calculate the compressive strength depending on equation (1) bellow [13]:

![Figure 6. Compressive strength Device](image)

After preparing each sample for the test by putting it on the base of the device, each sample conducted to measure the maximum load of the device on it. Then, the compressive strength of each sample can calculated by using the below eq.(1):
Compressive strength = Ultimate load (N) / cross sectional area (mm$^2$) …………………(1)
The totally cubic specimens have the similar cross syllabic area that is (50 mm x 50 mm = 2500 mm$^2$). The compressive strength unity is to be N/mm$^2$. To convert it to (KN/m$^2$), divide it on (0.001). Then, divide the result on (1000) to convert to (MPa) [15,16]. Mega pascal (MPa) equals 1,000 kiloNewtons (kN/m$^2$).

4. Results
The test of compressive strength for six samples immeressed in water (three for 7 days and other three for 28 days) showed the results in tables 1,2 repectivily[17]:

| Sample No. | Load Applied (KN) | Compressi ve strength (MPa) |
|------------|-------------------|-----------------------------|
| 1          | 30.10             | 12.04                       |
| 2          | 32.35             | 12.94                       |
| 3          | 29.96             | 11.98                       |

So, the average of three samples (7 days) compressive strength is (12.32 MPa)

| Sample No. | Load Applied (KN) | Compressive Strength (MPa) |
|------------|-------------------|-----------------------------|
| 4          | 53.20             | 21.28                       |
| 5          | 55.73             | 22.29                       |
| 6          | 52.42             | 20.96                       |

The average of three samples (28 days) compressive strength is (21.51 MPa).

After adding different weights of rubber (Styrene Butadiene) instead of sand, which was (5,10 and 15 gm). The samples were prepared and immersed for (7) and (28) days. Then, the samples conducted to compressive strength test to give the below results. Tables (3, 4) and figure 7 showed the results of compressive strength test at different rubber weight for 7 and 28 days.

| Sample No. | Rubber Wt. (gm.) | Load Applied (KN) | Compressiv e strength (MPa) |
|------------|-------------------|-------------------|-----------------------------|
| 1          | 5                 | 32.72             | 13.08                       |
| 2          | 10                | 36.82             | 14.72                       |
| 3          | 15                | 28.85             | 11.54                       |
Table 4. Compressive Strength of (28 Days) Samples

| Sample No. | Rubber Wt. (gm.) | Load Applied (KN) | Compressive Strength (MPa) |
|------------|------------------|-------------------|-----------------------------|
| 4          | 5                | 61.53             | 24.61                       |
| 5          | 10               | 65.67             | 26.26                       |
| 6          | 15               | 58.12             | 23.24                       |

The average of (7 days) samples compressive strength is (13.11 MPa) and for (28 days) samples is (24.70 MPa). So, the best value of compressive strength at (7 and 28 days) samples is by adding (10 gm.) by weight rubber as shown in figure 7:

![Figure 7. The relationship between rubber wt. and compressive strength of 7 and 28 Days](image)

The results of compressive strength mortar samples after adding them in curing water with different pH values (alkaline, neutral, and acidic) were as given in tables (5,6) and fig. (8):

Table 5. Samples at Acidic, Neutral, Alkaline Water (7 Days)

| Sample No. | pH value | Load Applied (KN) | Compressive Strength (MPa) |
|------------|----------|-------------------|-----------------------------|
| 1          | 3        | 25.85             | 10.34                       |
| 2          | 7        | 32.79             | 13.11                       |
| 3          | 11       | 31.21             | 12.48                       |

Table 6. Samples at Acidic, Neutral, Alkaline Water (28 Days)

| Sample No. | pH value | Load Applied (KN) | Compressive Strength (MPa) |
|------------|----------|-------------------|-----------------------------|
| 4          | 3        | 22.89             | 9.15                        |
| 5          | 7        | 54.43             | 21.77                       |
| 6          | 11       | 48.59             | 19.43                       |
Figure 8. The relationship between pH Values and compressive strength of 7 and 28 Days

The best compressive strength mortar samples value is at neutral curing water at (pH=7); whereas, it decreases at acidic and alkaline solutions but it is higher at alkaline than acidic for both (7 and 28 days). After adding (10 gm.) weight of rubber (Styrene Butadiene) to (6) samples. They were immersed in curing water has (5% of NaCl solution) at (7) and (28) days. Then, the specimens conducted to compressive strength test to give the below results. The compressive strength results of (7 and 28 days) samples immersed in (5% NaCl) curing water are expressed in tables (7,8) and figure (9):

Table 7. Compressive strength at 7 days samples (5% NaCl)

| Sample No. | Rubber Wt. (gm.) | Load Applied (KN) | Compressive strength (MPa) |
|------------|------------------|-------------------|---------------------------|
| 1          | 10               | 28.03             | 11.21                     |
| 2          | 10               | 30.32             | 12.12                     |
| 3          | 10               | 27.95             | 11.18                     |

The average of three samples (7 days) compressive strength is (11.50 MPa)

Table 8. Compressive strength at 28 days samples (5% NaCl)

| Sample No. | Rubber Wt. (gm.) | Load Applied (KN) | Compressive strength (MPa) |
|------------|------------------|-------------------|---------------------------|
| 4          | 10               | 50.72             | 20.28                     |
| 5          | 10               | 52.54             | 21.01                     |
| 6          | 10               | 49.98             | 19.99                     |

The average of three samples (28 days) compressive strength is (20.42 MPa)

Figure 9. The relationship between 5% NaCl and compressive strength of 7 and 28 Days
After adding (10 gm.) weight of rubber (Styrene Butadiene) to (6) samples. They were immersed in curing water has (10% of NaCl solution) at (7) and (28) days. Then, the specimens conducted to compressive strength test to give the results.

The compressive strength results of (7 and 28 days) samples immersed in (10% NaCl) curing water are stated in tables 9, 10 and figure 10:

**Table 9. compressive strength of 7 days samples (10% NaCl)**

| Sample No. | Rubber Wt. (gm.) | Load Applied (KN) | Compressive strength (MPa) |
|------------|------------------|-------------------|---------------------------|
| 1          | 10               | 24.40             | 9.76                      |
| 2          | 10               | 23.81             | 9.52                      |
| 3          | 10               | 22.21             | 8.88                      |

The average of three samples (7 days) compressive strength is (9.38 MPa)

**Table 10. compressive strength of 28 days samples (10% NaCl)**

| Sample No. | Rubber Wt. (gm.) | Load Applied (KN) | Compressive strength (MPa) |
|------------|------------------|-------------------|---------------------------|
| 4          | 10               | 43.02             | 17.20                     |
| 5          | 10               | 44.11             | 17.64                     |
| 6          | 10               | 40.34             | 16.13                     |

The average of three samples (28 days) compressive strength is (16.99 MPa)

**Figure 10.** The relationship between 10% NaCl and compressive strength of 7 and 28 Days

5. **Conclusion**

The objective of this research is to investigate effect of addition rubber (Styrene Butadiene) by different weights (5, 10, 15 gm.) on mortar’s compressive strength, and then the effect of different salt concentrations and pH values solutions on the same test. The results showed:-

1) Six samples of mortar prepared and left in curing water for (7, 28) days. Then, compressive strength was verified for all specimens to depend it as a standard value.

2) After preparing (6) mortar specimens by putting diverse weights of rubber (5, 10, 15 gm.) and left Three of them in curing water for (7) days and the three others for (28) days. The test of compression was measured on the six samples. The (10 gm.) weight of waste rubber sample had
the maximum compressive strength rate associating with other specimens for (7 and 28) days. For the other samples, the compressive strength decreased with decreasing or increased rubber weight.

3) Six samples of mortar with (10 gm.) rubber weight were prepared. These specimens preserved with dissimilar (PH) solutions (Acidic, neutral, alkaline) and left for (7) and (28) days respectively. Compressive strength was confirmed for six specimens. The samples with neutral pH solution had highest compressive strength than the acidic and alkaline solutions. It reduced with rising acidity and alkalinity but samples treated with alkaline solution had highest values of compressive strength than that treated with acidic solutions.

4) The results of six mortar samples immersed in curing water with (5% or 10% NaCl solutions) showed that the (5% salt solution) did not affect the compressive strength values comparing with (10% salt solution) which decreased their values.

5) Compressive strength results showed that compressive strength of polymer cement mortar decreased with increasing rubber weight upper than (10 gm.) which was the perfect weight to add. Also, it had the best value at neutral solution (PH = 7) and decreased with increasing acidity and alkalinity. In addition, The compressive strength had better value for the samples immersed in solutions of (5% NaCl) salt concentrations than (10% NaCl).

6) In addition, the compressive strength of samples which left in water for (28) days had upper values comparing with (7) days samples which meant the longer left in water , the best compressive strength reached for all tested samples.

Acknowledgment
The authors gratefully acknowledge support from Mustansiriyah University (www.uomustansiriyah.edu.iq). This work is supported by the Structure Laboratory, Automated Testing Laboratory and Chemistry Laboratory in College of engineering/ Mustansiriyah University-Baghdad-Iraq.

References
[1] Kong, F.K. and Evans R.H. “Reinforced and Prestressed Concrete”, Pitman Publishers, London, UK. (1987).
[2] I. Burnet “High-strength concrete in Melbourne Australia concrete”, concrete International , vol.11, issue 4, (1 April, 1989).
[3] H. Wang,Y. Du, D. Wang ,B. Qin.“Recent Progress in Polymer-Containing Soft Mattersfor Safe Mining of Coal”,MDPI publisher, polymers, vol.11, issue 10(2019). DOI: 10.3390/polym11101706
[4] Neville, A.M. (1981). “Properties of Concrete” (Third Edition) Longman Group Ltd. London, UK
[5] P. V P. M. Lakshmaiah, M. Kumar , “Study on influence of alkalis on the consistent and other properties of sun-dry cured geo polymer mortar”, International Conference on Composite Materials and Structures- ICCMS 2017 Hyderabad,India, 27-29th December (2017).
[6] H. J. Al Jaaf, M. A. Ali, R. S. Al-Jadiri “Effect of pH Solutions on Using Waste Marble powder to Enhance Mortar Compressive Strength”, ICMSMT 2019, IOP Conf. Series: Materials Science and Engineering 561 (2019) 012130.DOI:10.1088/1757-899X/561/1/012130.
[7] S. Aydin, H. Yazici, B. Baradan. “High temperature resistance of normal strength and autoclaved high strength mortars incorporated polypropylene and steel fibers”, Construction and Building Materials, 2008, 22, 504-512.DOI: 10.1016/j.conbuildmat.2006.11.003
[8] H. Toutanji, S. McNeil, Z. Bayasi,“Chloride permeability and impact resistance of polypropylene-fiber. Mortar”, Cement and Concrete Research, 28(7), 961-968. (1998).
[9] M. Jemimah Carmichael, G. Prince Arulraj. “Influence of setting time and compressive strength of cement mortar”, Engineering Science and Technology: An International Journal (ESTIJ), ISSN: 2250-3498, Vol.2, No.1. (2012)
[10] H. Li, H.G. Xiao, J. Yuan, J. Ou, “Microstructure of cement mortar with Composite”, 2004, 35(B), 185-189.(2004)
[11] Z. Zenan, K. Deyu, S.C. Rong “Influence of cement paste as compared with Construction and Building Materials”, 21, 539-545. (2007)
[12] P. Suganthy, D. Chandrasekar, S. Chathish Kumar. P. K. “Utilization of pulverized plastic in cement concrete as fine aggregate”, IJRET: International Journal of Research in Engineering and Technology ISSN: 2319-1163, Volume: 02 Issue: 06 | June(2013),DOI: 10.15623/ijret.2013.0206018
[13] R. Farhan, N. Rahma, K. Eweed, Producing a new type of cement by adding Zirconium Oxide, IOP Conference Series: Materials Science and Engineering 454(1) pp: 012149. (2018)
[14] A.O. Emmanuel, F. A. Oladipo, O. Olabode E.(2012), “Investigation of Salinity Effect on Compressive Strength of Reinforced Concrete”, Journal of Sustainable Development; Vol. 5, No. 6; 2012, ISSN 1913-9063 E-ISSN 1913-9071, Published by Canadian Center of Science and Education. DOI:10.5539/jsd.v5n6p74
[15] B.W. Jo, C.H. Kim, J.B. Park. “Characteristics of cement mortar, Construction and Building Materials”, 2007, 21, 1351-1355. (2007)
[16] K. M. Eweed, I. A. Atiyah, R. S. Al-jadiri, “Predicting The Effect Of Adding The Nanoalumina On The Characterization Of Asphalt Base Composite ” International Journal of Civil Engineering and Technology (IJCIET), vol.10, issue 1, Jan.2019.
[17] K.L. Lin, D.F. Lin, H.L. Luo, M.C. Tsai, “Effects of cement mortar”, Journal of Environmental Management M(2007).doi:10.1016/j.jenvman.2007.03.036