Effecting the addition of the Plastic waste and Rubber on the constructions materials properties

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Abstract. Effecting addition certain rubber is Styrene Butadiene Rubber (SBR) has been selected for study and plastic waste used in this work is recycled high density polyethylene on the cement ratio was kept constant at 50%. Three sand / cement ratios of (1:3) were adopted. Rubber / cement ratios were varied as 5%, 10%, 15% and 20%. The effect of (SBR, PE) on OPC was studied and compared with control mortar properties (consistency, flow, density, hardness, compressive strength, water absorption, SEM, Ultrasonic Pulse Velocity and XRD). At (7, 14, 28) days. The resulting of the test indicated that, there is probability to yield plastic new cement from PE plus OPC by (5, 10, 15, 20) %. The compressive strength amounts of all plastic waste mortar mixture tends to digress under the amounts for the mortar reference mix with increasing the plastic proportion of waste of whole ages. But workability improve their density was decreased this leading to produce materials of lightweight. The compressive strength value of SBR tends to less but SBR had improved to produce mortar modified by mortar.

1. Introduction
The uses of materials of plastic and their compounds are still rapidly growing due to their depressed cost and manufacture facility. Thus, rise plastic waste quantity being added which creating significant challenges for their removal. Waste plastic recycling in concrete or mortar has features as it is widely used and has a tall serving life, which means that wastes were removed from the waste flow for a long period of time. Also, utilize of post – consumer waste plastic in the construction materials will not only be its protected removal process but may increase the properties of concrete such as shrinkage of drying strength of the chemical tensile strength and creep on shortened and tall term basis [1]. The use98e again of the waste is very important from various viewpoints. It helps to conserve and validity of normal resources which are not replenish, it lowering the toxic waste of the ambience and it also helps to conserve and reuse power manufacture operation. Waste and manufacturing by product will be measured as potentially valued resources only await suitable enforcement and treatment. Waste of the plastic are between these wastes, their behavior has damaging influence on the environment payable to their long biodegradability age. And thence one of logical ways for drop of their negative influences is the application of these substances in other businesses [3]. The uses of the product of waste material stand for a means of alleviating some of the solid waste problems management [2]. Concrete or mortars plays an important part in the helpful utilize of this construction substance. Although some of these substances can be usefully of integrated in concrete, both as partition of the cement as aggregate is or binder phase important to realize that not all waste substance are appropriate for such use [4]. The liquid rubber SBR is the most usually used for utilize adjust OPC mortar. Figure1. Shows the Chemical compassion of Styrene butadiene Rubber liquids. Rubber made by reaction of two different monomers such as butadiene with Styrene (SBR), are set of big -volume
artificial rubbers [5]. Height connections happen among the rubber movie that formed and cement hydrates. This work gives less strain compare to normal concrete and develops the material goods of concrete such as compressive and flexural strengths with high stability [6].

![Chemical structure of SBR rubber latexes](image_url)

Figure 1. Chemical structure of SBR rubber latexes [5]

The rubbers liquids are blended with fresh OPC mortar or concrete, the rubbers are uniformly sprinkled in the cement dough phase. In the rubber- cement dough, cement gel is progressively made by the cement moisturizing and the stage of the water is saturating with calcium hydroxide through the moisturizing, while the rubber precipitation partly on the surface of the cement gel-anhydrate cement mix. It is possible that the Ca(OH)₂ in the stage of the water interact with a silica surface of the aggregate to shape calcium [6]. Rubbers have been applied in concrete for a few centuries. There are three kinds of rubber concrete, which are rubber adjusted concrete, rubber concrete and rubber soaked concrete. Rubber concrete can be meaning as a composite substance with its binder prepared of artificial organic rubber, through the rubber adjusted concrete involves of the blending of cement and rubber in specific amount as binder [7]. The rubber modified concrete benefits and mortar comprise excellent properties, little labor cost and small power requirements [7]. The objective of this work involve the influence of styrene butadiene rubber and plastic waste of polyethylene on the mechanical and physical properties of OPC mortar with various ratios from rubber and waste of the plastic. The application of rubber in civil engineering playing field is expanding, the applications is benefits are reported from the degraded reinforced concrete repair system arrangements, reinforcement and rearrangement of existing reinforced concrete structures, adhesive or bonding factors for delamination way, liquid- membrane insulation system applied and high score re dispersible rubber powders [8].

2. The Work of the empirical

2.1 Materials

2.1.1 Ordinary Portland cement (c)

OPC was used in this study commercially known as (AL-Mass) and its fineness due to ASTM C204 – 05 [10] 3914 cm²/g. keep the cement in dry place to reduce the influence of environmental moisture. The physical and chemical properties of OPC are given in Table 1 which adjusted to IQS 5/1984[9]. As well as ASTM C150 [11].

| Item                | Test result | IQS No. 5/1984 | Item  | Content % | IQS No. 5/1984 |
|---------------------|-------------|----------------|-------|-----------|----------------|
| Fineness(m²/kg)     | 391.4       | 230            | SiO₂  | 14.75     |                |
| Autoclave exp       | 0.24        | 0.80%          | Al₂O₃ | 3.149     |                |
Compressive Strength (MPa) 17.6 15 Fe$_2$O$_3$ 2.857 - 3-days age 7-days age 26 23 Cao 63.23 - mgO 2.36 2.8% ≥ SO$_3$ 1.746 5% ≥ Time of setting Initial (min) 144min. 45 L.O.I. 3.04 4% ≥ Final (min) 396 10 max L.S.F 0.95 0.66-1.02 I.R. 0.64 1.5 ≥

* Physical and chemical properties done at National center for Laboratory and Structural Research

2.1.2 Sand
The used sand is within zone (2) according to the requirements of IQS 45/1984 [12].

Table 2. Chemical test results for sand.

| Specification | Result of test | IQS No.45 /1984 |
|---------------|----------------|-----------------|
| Modules of finesse % | 2.43 | |
| So$_3$ % | 0.11 | 0.5% ≥ |
| Specific gravity | 2.63 | |
| The finesse mat. Pass the sieve 200 % | 4.5% | 5% ≥ |
| Density kg /m$^3$ | 1765 | |
| Water adsorption % | 2% | |

*National center for Laboratory and Structural Research

2.1.3 Rubber
SBR liquid used in this study from Henkel Poly Bit Company [13]. The physical properties of SBR are shown in table 3.

Table 3. General properties of SBR.

| PROPERTIES | VALUES |
|------------|--------|
| Color $ \&$ Appearance | White milky liquid |
| PH | 8.5 ± 0.05 |
| Density [g/cc] | 1.0 ± 0.05 |
| Solid content, [%] | 40±3 |
| SBR Modified Mix[W/C: 0.45 and 350 kg cement | |
| Compressive strength, [N/mm$^2$] | > 40 |
| Flexural strength, [N/mm$^2$] | > 12 |
| Tensile strength, [N/mm$^2$] | > 6 |
| Shear Bond strength [N/mm$^2$] | > 5 |
| Application temp, [°C] | 5 to 45 |
| Service temp, [°C] | -5 to 45 |

All values provided are subject to tolerance of 5-10%
2.1.4 Plastic waste
The plastic waste used in this work recycled high density polyethylene from plastic factory in Aden Square as shown below in plastic recycling machine:

![Styrene–Butadiene Rubber (SBR)](image)

**Figure 2.** Styrene–Butadiene Rubber (SBR)

![Recycling of plastic waste](image)

**Figure 3.** Recycling of plastic waste (a.) machine, (b), recovery of the plastic waste (c), heat treatment and cooling (d. crushing, (e. )End product
2.1.5 Water w
Water of the tap was used in this study for all mortar mixes and also for the specimens in casting and curing. Constant ratio of the amount of water added to the mix is shown in the table 4.

Table 4. Chemical test of tap water.

| Ions   | Concentration, Mg/L |
|--------|----------------------|
| CaCO₃  | 380                  |
| Ca⁺⁺   | 130                  |
| Mg⁺⁺   | 85                   |
| SO₄⁻⁻  | 350                  |
| Cl⁻    | 0.25                 |

3. Result and dissection

3.1 compression test
The strength of the compressive a carried out by using 5cm cubes according to ASTM C109/190M – 02 [14]. The samples were demoded after 1 day then cured allowing to ASTM C511 – 03 [15]. This test was executed at age of 3, 7 and 28 days.

The resulted of this test of mortar samples containing Portland cement as partial replacement by SBR or / and HDPE at ages of 7, 14 and 28 days.

The compressive of strength of rubber adjust mortars with several P/C ratios in Figure 4. When the rate of styrene butadiene rubber rise from 0% to 20% the compressive of the strength of mortar rise to for all analysis age achievement to maximum value in 28 days at 20% SBR content [17]

![Figure 4](image_url)

**Figure 4. The strength of the compressive with different ratio of rubber / cement**

The result of the compressive of strength exams for the waste plastic, mortar mix is show in figure 5. By growing the plastic waste ratio (HDPE) the strength of compressive values of tendency to reduction under the normal mix at each curing age. This direction can be referring to reduce in adhesive strength among the surfaces of plastic of the waste and cement paste. Plastic in considered to be hydrophobic material so this characteristic can intercept the water necessary for cement hydration from entering through the structure of mortar samples through the curing period all of the compressive
of the strength are higher than low compressive strength wanted for the structure of materials. These results are consistent with results Marzouk et al.(2007)[16] and Pizziet et al.[17]

![Figure 5](image1)

**Figure 5.** The strength of the compressive with different ratio of HDPE

The highest strength of compressive can be obtained from the mortar which containing of 5% from (SBR and HDPE) as shown that in Figure 6.

![Figure 6](image2)

**Figure 6.** The strength of the compressive with different ratio of SBR and HDPE

3.2 *Scanning Electron Micro Scope (SEM) analyses of mortar*

The microstructure analysis of samples of mortars (cement mortar(C), SBR mortar (S), PE mortar (P) and (PS mortar)).
Figure 7. Microstructure of OPC mortar by Scanning Electron Microscope (SEM).
Figure 8. Microstructure of PE mortar by Scanning Electron Microscope (SEM).
Figure 9. Microstructure of SBR mortar by Scanning Electron Microscope (SEM).
**Figure 10.** Microstructure of SBR and PE mortar by Scanning Electron Microscope (SEM).

**Table 4.** The results of SEM test of mortars

| Name of Sample | Space         | Intensive                  | Crystal          |
|----------------|---------------|----------------------------|------------------|
| C              | Large space   | Not intensive              | Large crystal    |
| S              | Few space     | Good intensive with few clot | Good compact    |
| P              | Not uniform   | Have clot                  | Forming voids   |
| SP             | Uniform       | Better intensive           | Crystal medium and compact |
3.3. X – Ray diffraction (XRD) analysis

Mineralogy composition of mortars have been determined on few grams of the sample using diffractometer with CuKα1.54056Å° radiation generated at 40 KV and 30 mA in (shimadzu Lab X xrd – 6000 X – Ray diffractometer).

![XRD analysis](image1)

**Figure 11.** XRD analysis for cement mortar

![XRD analysis](image2)

**Figure 12.** XRD analysis for PE mortar

![XRD analysis](image3)

**Figure 13.** XRD analysis for SBR mortar
4. Conclusion

The rate of styrene butadiene rubber rise from 0% to 20% the compressive of the strength of mortar rise to for all analysis age reaching to maximum value in 28 days at 20% SBR content, which equal to 74.4 MPa. By growing the plastic waste ratio (HDPE) the strength of compressive values of tendency to reduction under the normal mix at each curing age. The highest strength of the compressive can be obtained from the mortar which contain of 5% from (SBR and HDPE). The results of SEM test of mortars show good intensive good compact and uniform medium.

References

1) Ganesh Tapkire, Satish Parihar, Pramod Patil, and Hemraj R. Kumavat, 2014 Recycling plastic used in concrete paver block, Intern. J. of research in engineering and technol., Vol. 3, issue 9 pp. 33-35.
2) Davis, M.L., Cornwell, D.A., 1998. Introduction to Environmental Engineering, third ed. WCB, McGraw-Hill.de Assunçao, R.M.N., Royer, B., Oliveira, J.S., Filho, G.R., Castro Motta, L.A., 2004. Synthesis, characterization and application of the sodium poly (styrenesulfonate) produced from waste polystyrene cups as an admixture in concrete. Journal of Applied Rubber Science 96,1534–1538.
3) Hassani, A., Ganjidoust, H., Maghanaki, A.A., 2005. Use of plastic waste (poly-ethylene terephthalate) in asphalt concrete mixture as aggregate replacement. Waste Management & Research 23, 322–327. Hınıslıoğlu, S., Agar, E., 2004. Use of waste density polyethylene as bitumen modifier in asphalt concrete mix. Materials Letters 58, 267–271.
4) McCrum, N.G., Buckley.C.P. and Bucknali.C.B. 1997 Principles of Rubber Engineering " Oxf ord University Press. 2Ed. pp. 447.
5) Ohama, Y 1998 Rubber-Based Admixtures." Cement and Concrete Composites J. 20, pp. 189-212.
6) Ohama, Y. 1987 Principle of Latex Modification and Some Typical Properties of Latex-Modified Mortars and Concretes ACI Materials Journal, Vol.84, No.6, November- December, pp511-518.
7) Figovsky O and D. Belin, 2014 Advanced rubber concretes and compounds, CRC Press, Taylor & Francis Group, Boca Raton.
8) M.A. R.Bhatta M A R and Ohama Y Recent status of research and development of concrete rubber composites in Japan, Concrete Research Letters, (4), 125-130, (2010).
9) IQS 5/1984, "Portland Cement," Iraqi Organization for Standards and Specifications. Baghdad, Iraq, 1984.
10) ASTM C204-05,"standard test methods for fineness of hydraulic cement by air – permeability".
11) ASTM C150/C150M–12," standard specification for Portland cement".
12) IQS 45/1984 "Aggregate From Natural Sources for Concrete," Iraqi Organization for Standards and Specifications. Baghdad, Iraq, 1984.
13) http://www.henkelpolybit.com/en/retail/retail-products/waterproofing/acrylic-coatings/polyflex-10.html
14) ASTM C109-02, "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)". Annual Book of ASTM Standard, Vol.04-01, 2002.
15) ASTM C 511-03, "Standard Specification for Moist Cabinets, Moist Room, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concrete", Annual Book of ASTM Standard, Vol.04-01, 2003.
16) Marzouk, O.Y., Dheilly, R.M., Queneudec, M., 2007. Valorization of post-consumer waste plastic in cementations concrete composites. Waste Management 27, 310–318.
17) Pezzi, L., De Lice, P., Vuono, D., Chiappetta, F., Nastro, A., 2006. Concrete products with waste’s material (bottle, glass, plate). Materials Science Forum, 1753–1757.