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# Effect of binary blended of Portland cement and fly ash to the Strength and Surface Absorption of Concrete

Omar Darwesh[a], *Otman M.M. Elbasir[b], Manssour Bin Miskeen[c]

[a]Azzaytuna university School of civil engineering
[b]High Institute Of Science and Technology -Qaser Bin Gahsear
[c]Department of Architecture and Urban Planning, Faculty of Engineering Science and Technology, Sabha University

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**ABSTRACT**

The main objective of this paper is to determine the effect of fly ash on the workability, compressive strength , and initial surface absorption test of cement concrete using Portland cement and fly ash as partial replacements for Portland cement at 0%, 5%, 10%, 15% , 20% and 25% for a water-cement ratios(0.38) , the cement concretes have higher initial surface absorption values than Portland cement and fly ash concrete at 28 days and the disparity reduced due to improved pozzolanic reactivity of the supplementary cements with increasing curing age. However, Portland cement and fly ash concrete performed better than Portland cement concrete due to their higher fineness, improved particle packing and higher pozzolanic reactivity. The results showed that the compressive strength of 25% fly ash replacement resulted in concrete with a 28-day maximum strength of 48.25 MPa. and the result showed sample which contained Fly ash has less initial surface absorption and it's also showed that the concrete containing 5%,10% and 15% of fly ash had less initial surface absorption than other cubes 20% and 25% fly ash.

## تأثير مزيج ثنائي من الأسمنت البورتلاندي والرماد المتطاير على قوة وامتصاص سطح الخرسانة

عمر درويش[1] و *عثمان البصير[2] و منصور ابوهديمه بن مسكين[3]

[1]جامعة الزيتونة، كلية الهندسية- قسم الهندسية المدنية ، ترهونة - ليبيا
[2]المعهد العالي للعلوم والتقنية قصر بن غشير - ليبيا
[3]قسم الهندسية المعمارية والتخطيط المدن، كلية الهندسية العلوم والتقنية ، جامعة سبها – ليبيا

**الكلمات المفتاحية:**
قوة الضغط
قابلية التشغيل
الرماد المتطاير
اختبار امتصاص السطح الأولي

**الملخص**

الهدف الرئيسي من هذا البحث هو تحديد تأثير الرماد المتطاير على قابلية التشغيل وقوة الانضغاط واختبار امتصاص السطح الأولي للخرسانة باستخدام الأسمنت البورتلاندي والرماد المتطاير كبدائل جزئية للأسمنت البورتلاندي بنسبة 0٪ ، 5٪ ، 10٪ ، 15٪ ، 20٪ و 25٪ نسبة الماء للأسمنت (0.38) ، خرسانة الأسمنت (0٪ رماد متطاير) لها قيم امتصاص سطحية أولية أعلى من الخرسانة الأسمنت البورتلاندي والرماد المتطاير في 28 يومًا وتقليل التفاوت بسبب تحسين التفاعل البوزولاني من الأسمنت التكميلي مع زيادة عمر المعالجة. ومع ذلك ، فإن أداء خرسانة الأسمنت البورتلاندي والرماد المتطاير كان أفضل من الخرسانة الأسمنتية البورتلاندي نظرًا لدقتها العالية ، وتعبئة الجسيمات المحسنة وزيادة تفاعل البوزولاني. أظهرت النتائج أن مقاومة الانضغاط لاستبدال الرماد المتطاير بنسبة 25٪ نتج عنها مقاومة قصوى لمدة 28 يومًا تبلغ 48.25 ميجا باسكال. وأظهرت النتائج أن العينة التي تحتوي على الرماد المتطاير لديها امتصاص أولي أقل للسطح ، كما أظهرت أن الخرسانة المحتوية على 5٪ و 10٪ و 15٪ من الرماد المتطاير لديها امتصاص سطحي ابتدائي أقل من المكعبات الأخرى 20٪ و 25٪ رماد متطاير.

*Corresponding author:
E-mail addresses: ohtmanelbasir@hinstitute-bcv.edu.ly ,(O. Darwesh) Omar Darwesh@gmail.com , (M. Bin Miskeen) mans.binmiskeen@sebhau.edul.ly

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**Introduction**

Concrete is that. The most generally used construction material within the contemporary world. the sturdiness of concrete may be a major consideration in its application in aggressive environments for long service life. Concrete incorporates an oversized number of natural resources as aggregates and cement with water. Cement production consumes huge energy and causes about 7% of total greenhouse emission within the world [1]. Fly ash is composited of inorganic, incombustible matter present within the coal that has been fused during combustion into a glassy, amorphous structure. Coal can zero in ash content from 2%-30%, and of this around 85% becomes ash. It can replace up to 50% by mass of cement [2]. On the other hand,The world has a large output of fly ash. Although it has been applied in the fields such as building materials, its second utilization rate is still at a low level [3,4]. It is generally understood that combining cement with fly ash or other supplemental cementing ingredients enhances both the geological and technical qualities of the concrete mix. [5-7]. Depending on the type and amount of fly ash adding, the compressive strength-developing behavior of concrete with fly ash differs dramatically from that of concrete without fly ash [8–10]. To increase the permeation resistance of its concrete [11, 12]. As a consequence, binary blended of Portland cement with fly ash would reduce the water demand and superplasticizer dosage associated with fly ash, as well as compensate for the slow rates of fly ash reactions at early ages, to enhance both early and later age concrete performance [13, 14, 15-17]. Furthermore, while concrete in practice is specified on the compressive strength, most researches in literature were conducted at different water/cement ratios with Portland cement, and silica fume or fly ash. Hence, this paper investigated the ISAT 10 of Portland cement concrete, binary cement concretes containing fly ash as partial replacements for Portland cement concretes containing Portland cement, fly ash at equal water/cement ratios and strengths.

**2. Materials and Mix Proportions**

The cementations materials used in this study were Portland cement (OPC) type I. Fly ash is a fine, such as glass powder - recovered from the gases resulting from the coal and electric power generation. meets the "ASTM C 1240-93 (1993). The chemical properties of these materials are given in table (1). Specification were used". Aggregates volume rough user in the analysis of Alkrani 20 mm, in accordance with the procedures described in (812 BS part 103:1985).Normal mining sand used in this research. (Bs 812, 1984) and describes the methods of determining the size distribution of sample from the rubble and filling out Sieve analysis. After screening the raw materials (the rubble rough and soft ), after validation and compliance to the specification, design is the work of mixing concrete for the appointment of the quantity of each of the articles required for mixing concrete by working conditions. For the investigation of mixing of all materials were accurately weighed mixing was done in machine mixer and the preparation of the materials by weight. were added into the mixer in the following sequence of cement, coarse aggregate, fine aggregate, water, and fly ash. To investigate the effect of fly ash inclusion (as part replacement of cement), The cement was replaced by fly ash at the rate of 0% (as control mix) 5%, 10%, 15%, 20%, and 25% (by weight from cement). The water/cement ratio was 0.38. Consequently, The slump of control changed due to the effect of the different levels of fly ash. The size of cubes 100*100*100 mm were cast and cured under a layer of damp hessian covered with polythene for 20-24 hours, demoulded , and cured in water tanks maintained at about 20°C until the tests dates. The Preparation mix of materials as shown in
table ( 2).

**Table 1. Chemical composition for cement and fly ash**

| Oxides (%) | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $SO_3$ | $Na_2O$ |
|---|---|---|---|---|---|---|---|---|
| Cement | 20.25 | 5.0 | 3.16 | 63.61 | 4.56 | 0.51 | 1.42 | 0.26 |
| FA | 49.053 | 23.516 | 6.422 | 5.080 | 0.698 | 1.309 | 0.475 | 0.2102 |

**Table 2.** Preparation of concrete mixtures

| Samples | Percentage of (FA%) | OPC ($kg/m^3$) | Fly ash ($kg/m^3$) | Fine Agg ($kg/m^3$) | Coarse Agg ($kg/m^3$) | Water ($kg/m^3$) |
|---|---|---|---|---|---|---|
| M1 | 0 | 592 | 0 | 534 | 871 | 225 |
| M 2 | 5 | 562.40 | 29.60 | 534 | 871 | 225 |
| M 3 | 10 | 532.80 | 59.20 | 534 | 871 | 225 |
| M 4 | 15 | 503.20 | 88.80 | 534 | 871 | 225 |
| M 5 | 20 | 473.60 | 118.40 | 534 | 871 | 225 |
| M 6 | 25 | 444.00 | 148.00 | 534 | 871 | 225 |

**3. Results and Discussions**

**3.1. Workability of fresh concrete**

The effect of the addition of fly ash on concrete. The workability of reference and all other concrete mixes as we can conclude that the values of the falling in the fresh concrete relatively increased as the proportion of the Fly Ash, this stems from the substance qualities, which are the workability and the operation speed for the fresh concrete. That is because of the intrusion of the Fly Ash atoms to the spaces of the concrete mixture and its ability to replace whatever the concrete need to fill like water supply. By providing the needed water, the operation speed (workability) increases. At the proportions of the Fly Ash, the slump tests were relatively bigger than 0% (as a control mix).

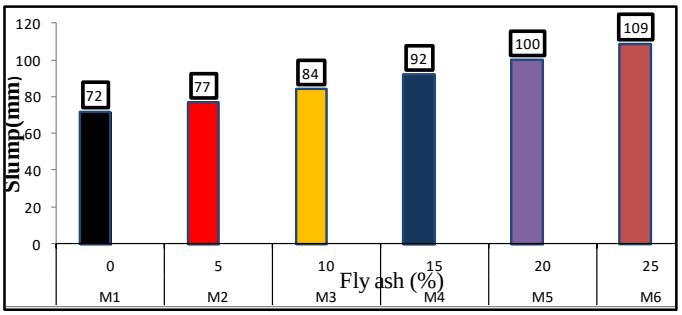


**Figure 1.** Relationship between Fly ash content and workability

**3.2. Compressive strength**

Figure 2 depicts the impact of curing time on the compressive strength of all concrete mixtures (M1, M2, M3, M4, M5, and M6). The specimens of concrete were tested for compressive strength after the times of 3, 7, 14 and 28 days, dependent on the ASTM C109 (ASTM, 1999).The compressive strength of concrete with various percentages of Fly ash was investigated. The specimens' concrete had control of 100 % cement, whereas the specimens' concrete had 5 %, 10 %, 15 %, 20 %, and 25 %Fly ash. The analysis of the compressive strength development of the various concretes, the study was done using 3, 7, 14, and 28 days of curing time. The compressive strength of the concrete was observed as high strength when the curing time was extended. In the control mix, the 3-day compressive strength was 33.67 MPa (M 1). Because of the addition of 5%, 10%, 15%, 20%, and 25% of Fly ash to concrete, it grew by 6.67 %, 13.05 %, 21.87 %, 22.46 %, and 24.45 %, respectively. In the case of the high-strength control mix (M1), around 36.25 percent of the 28-day strength was acquired in three days, whereas 25% fly ash replacement resulted in concrete with a 28-day maximum strength of 48.25 MPa. Early strength growth was rapid, with a difference of 28.46 % between 3-day and 28-day strength. Fly ash utilized as a 50% by weight cement component in concrete, with the potential for exceptionally strong and brittle concrete. It increases the water demand in a concrete mix. The reason for this stability is that the material homogenizes with the ingredients of fresh concrete as well as the cement percentage. The most significant of all is the water

percentage in the mixture, which aids workability and the ability to retain a specific quantity of water since it passes through the cement's blank spaces and interacts well with it, a Fly Ash characteristic. As a result, contact with the cement improves the quality and workability of the concrete mixture.

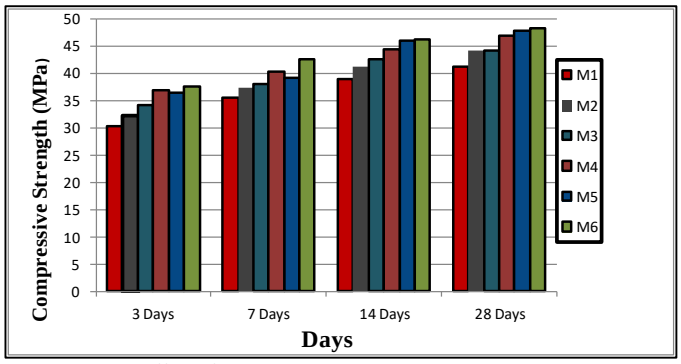


**Figure 2**: Effect of Fly ash on the Concrete compressive strength

**Initial Surface Absorption Test (ISAT)**

The ISAT is the test procedure developed by the British standards in accordance to (British Standards BS 1881-5, 1970) and (British Standards BS 1881-208, 1996). According to BS 1881, [18] the test investigates the porosity and water penetration via capillary suction through a specified unit area. This test is vital as the surface of a structure needs to be impermeable so that water would not be absorbed into the specimen and corrode reinforcement inside. A summary data at aged 28 days is shown from Fig (3). From the results attained, it is evident that the concrete cube sample which contained Fly ash has less initial surface absorption and it's also showed that the concrete containing 5%,10% and 15% of fly ash had less initial surface absorption than other cubes.This also showed that there was a marked increase in FA surface absorption (20% to 25%), a situation which did not occur in specimens containing 5%, 10% and 15% FA. it is considered that concrete has high permeability when surface absorption is greater than 0.20 (ml/ m2s), medium in the 0.15 to 0.07 (ml/m2s) range and low if less than 0.07 (ml/m2s) for 60 minutes' testing. Based on the average absorption values reported for each sample, all concretes had good performance, the 30% FA specimen had medium permeability and the remaining mixtures low permeability[22].The initial surface absorption is simply the number of scale units moved in 1 minute. the useing of fly ash improved the properties of concrete. The distribution of pore size and pore shape of concrete [19]. Ann et al., emphasizes the influence of pozzolanic properties of fly ash for enhancement of durability properties of concrete. Pozzolanic materials produce a dense insoluble calcium silicate hydrate gel in the cement matrix due to the reaction between siliceous oxide and the free calcium oxide in concrete pore water.[20]. This pozzolanic reaction is a slow process which is responsible for the delayed strength gain of concrete mixes (Neville, 1995)[21].

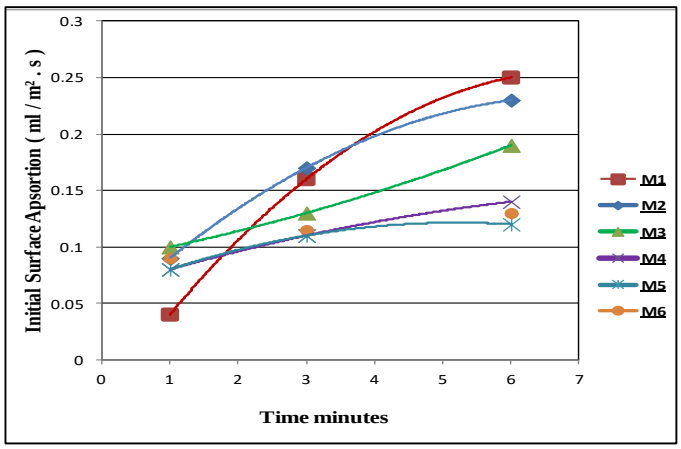


**Figure 3**: Initial Surface Absorption Test (ISAT) at 28 days (Fly ash 0%, 5%, 10%, 15%, 20%,25%)

**Conclusion**

From the results, it is concluded that the effect of binary blended of Portland cement and fly ash on compressive, Surface Absorption of Concrete. The fly ash is a better replacement of cement. The rate of strength gain in binary blended of Portland cement and fly ash concrete is high. After performing all the tests and analyzing their result, the following conclusions can be derived:

1- The values of the falling in the fresh concrete relatively increased as the proportion of the Fly Ash, this stems from the substance qualities, which are the workability and the operation speed for the fresh concrete. That is because of the intrusion of the Fly Ash atoms to the spaces of the concrete mixture and its ability to replace whatever the concrete need to fill like water supply.

2- The compressive strength development of the various concretes, by addition of 5%, 10%, 15%, 20%, and 25% of Fly ash to concrete, the case of the high-strength control mix 0% (M1), around 36.25 % of the 28-day strength was acquired in three days, whereas 25% fly ash replacement resulted in concrete with a 28-day maximum strength of 48.25 MPa. Early strength growth was rapid, with a difference of 28.46 % between 3-day and 28-day strength.

3- Addition of fly ash improves the resistance to water penetration. Sample which contained Fly ash has less initial surface absorption and it's also showed that the concrete containing 5%,10% and 15% of fly ash had less initial surface absorption than other cubes 20% and 25% fly ash.

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**References**

[1]- Malhotra VM (2002). Introduction: sustainable development and concrete technology. Concrete International, 24(7), July.

[2]- Hewlett, Peter (1998). Lea's Chemistry of Cement and Concrete, Elsevier Butterworth Heinemann.

[3]- Wang, B.M.; Zhang, Y.; Han, Y. On Comprehensive Utilization of Fly Ash. Res. Appl. Build. Mater. 2011, 10, 10–13..

[4]- Harmaji, A.; Sunendar, B. Utilization of Fly Ash, Red Mud, and Electric Arc Furnace Dust Slag for Geopolymer. Mater. Sci. Forum 2016, 841, 157–161.

[5]- URBAN, M. Properties of hardened self-compacting concrete with fly ash. In Proc of 3rd International Scientific Conference Quality and Reliability in Building Industry, Levoca, 22–24 Oct 2003, p. 533–538.

[6]- FELDMAN, R. F.; CARETTE, G. G. and MALHOTRA, V. M. Studies on mechanism of development of physical and mechanical properties of high-volume fly ash-cement pastes. Cement and Concrete Composites, 1990, 12(4), p. 245–251.

[7]- ANTIOHOS, S.; MAGANARI, K. and TSIMAS S. Evaluation of blends of high and low calcium fly ashes for use as supplementary cementing materials. Cement and Concrete Composites, 2005, 27(3), p. 349–356.

[8]- GOLDMAN, A. and BENTUR, A. The influence of microfiller on enhancement of concrete strength. Cement and Concrete Research, 1993, 23(4), p. 962–972.

[9]- SENGUL, O.; TASDEMIR, C.; YUCEER, Z.; ERBAYDAR, M. and TASDEMIR, M. A. Mechanical behaviour of high strength concretes with high-volume fly ash. In Proc of the 6th International Symposium on High Strength/High Performance Concrete, Leipzig, 16–20 June 2002, p. 1407–1420.

[10]- ONER, A.; AKYUZ, S. and YILDIZ, R. An experimental study on strength development of concrete containing fly ash and optimum usage of fly ash in concrete. Cement and Concrete Research, 2005, 35(6), p. 1165–1171

[11]- T. R. Naik, S. Singh, and B. Ramme, "Mechanical properties and durability of concrete made with blended fly ash," ACI Material Journal, vol. 95, no. 4, pp. 454-462, 1998.

[12]- R. K. Dhir and M. R. Jones, "Development of chloride-resisting concrete using fly ash," Fuel, vol. 78, no. 2, pp. 137-142, 1999.

[13]- M. D. A. Thomas, M. H. Shehata, S. G. Shashiprakash, D. S. Hopkins, and K. Cail, "Use of ternary cementitious systems containing silica fume and fly ash in concrete," Cement and Concrete Research, vol. 29, no. 8, pp. 1207-1214, 1999.

[14]- L. Lam, Y. L. Wong, and C. S. Poon, "Effect of fly ash and silica fume on compressive and fracture behaviours of concrete," Cement and Concrete Research, vol. 28, no. 2, pp. 271-283, 1998
[15]- P. K. Mehta and O. E. Gjorv, "Properties of Portland cement concrete containing fly ash and condensed silica fume," Cement and Concrete Research, vol. 12, no. 5, pp. 587-595, 1982.
[16]- M. I. Khan, C. J. Lynsdale, and P. Waldron, "Porosity and strength of PFA/SF/OPC ternary blended paste," Cement and Concrete Research, vol. 30, no. 8, pp. 1225-1229, 2000.
[17]- M. I. Khan and C. J. Lynsdale, "Strength, permeability and carbonation of high-performance concrete," Cement and Concrete Research, vol. 32, no. 1, pp. 123-131, 2002.
[18]- BS 1881-part 208-1996 – Testing concrete. Recommendations for the determination of the initial surface absorption of concrete.
[19]- Ali Mardani-Aghabaglou, Murat Tuyan and Kambiz Ramyar, "Mechanical and Durability Performance of Concrete Incorporating Fine Recycled Concrete and Glass Aggregates" - Springer Materials and Structures, August 2015, Volume 48, Issue 8, pp: 2629–2640
[20]- Ann, K.Y., Moonb, H.Y., Kimb, Y.B. and Ryoub, J. (2008). "Durability of recycled aggregate concrete using pozzolanic materials." Elsevier Waste Management Volume 28, Issue 6, 2008, pp:993–999
[21]- Neville, A.M., 1995. Properties of Concrete, fourth edition. Longman group Ltd
[22]- Chindaprasirt, P., Rukzon, S., Strength, porosity and corrosion resistance of ternary blend Portland cement, rice husk ash and fly ash mortar., Construction and Building Materials, Vol. 22, 2008, pp. 1601-1606.