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# Performance of Concrete Floor Slabs Using Different Concrete Mixes

**Esraa Emam Ali[1], Naglaa Kamal Rashwan[2]**
[1]Building Material Research And Quality Control Insitute, Housing and Building N.R.C., Giza, Egypt
[2]Department of Civil Eng. Dept., Industrial Education College, Beni-Suef, Egypt
And Mandated to El Minia High Institute of Engineering and Technology (H.I.E.T) , El Minia, Egypt
. Email: esraa_emam@yahoo.com, nmkrash@yahoo.com

***Abstract : The quality of a concrete floor or slab is highly dependent on achieving a hard and durable surface that is flat, relatively free of cracks, and at the proper grade and elevation. The objective of this study is to investigate the performance of different concrete mixes containing "Nano clay, Basalt and Dry shake". To achieve the main aim, an experimental program consisted of fabricating and testing concrete slab 3x3 $m^2$ with thickness 15 cm divided into four quarters, each quarter had a specific concrete mix proportions (Nano clay, Basalt, Dry shake and control). The laboratory tests used included compressive strength, abrasion resistance and Pull off resistance. The results showed that Basalt concrete mix had low water absorption, high abrasion resistance and high compressive strength and Pull off strength as compared to control concrete mix and almost follow it Dry shake mix and Nano clay mix in their performance. In conclusion, the studied concrete mixes had favorable performance and properties compared to the control mix and the most beneficial results was recorded in Basalt mix.***

**Keywords:** Performance, Concrete, Basalt, Nano clay, Dry shake.

## INTRODUCTION

***(guide for concrete slab 302 1R-96 )***The quality of a concrete floor or slab is highly dependent on achieving a hard and durable surface that is flat, relatively free of cracks, and at the proper grade and elevation. Properties of the surface are determined by the mixture proportions and the quality of the concreting and jointing operations. The timing of concreting operations especially finishing and jointing is critical. Failure to address this issue can contribute to undesirable characteristics in the wearing surface such as cracking, low resistance to wear, dusting, scaling, high or low spots, and poor drainage, as well as increasing the potential for curling.

Concrete is the leading material in structural applications that demand high strength and stiffness with an important view to the cost dimension, concrete has been broadly used for rigid pavements, since the first road of concrete pavement was prefaced in 1893 because it is capable of providing a highly durable, serviceable and attractive surface ***(Zeman, 2010)***.

Several types materials are added to the concrete for the purpose of improving its performance to face such environmental loading include high temperatures, wetting and drying ,freezing and thawing, the attack of sulphate and other types of natural attacks ***(Benjamin et al., 2015)***. Nowadays, there is a rich research area for the application of nanotechnology in civil engineering generally and specially in concrete pavements, from these applications (self-healing materials, crack-preventive materials, self-cleaning materials, shape alloy (SMA) materials and Alkali-silicate reaction "ASR" gels) ***(Faruqi et al., 2015)***. Nano clay is extensively used in the modification of polymer matrices for improving mechanical, thermal, and barrier properties ***(You et al., 2010)***. Nano clay could help to modify concrete properties in both plastic and hardened stages and this consequently increased the durability of the concrete and also, improves the performance of concrete ***(Brightson et al., 2013)***. Also, it has been reported that the addition of nano clay by 3.0% of the concrete improved its compressive and flexural strength, reduced porosity and water absorption, increased density, fracture toughness, impact strength, hardness and thermal stability ***(Hakamy et al., 2015)***.

Basalt is a hard and dense volcanic igneous rock, found in most countries globally. Due to it is very high abrasion resistance, Basalt was used extensively in casting process for making slabs for architectural applications. Also, Basalt is used in highway and airfield pavement constructions in several countries because of its proven good characteristics like high abrasion and excellent UV resistance, its aggregate is free of moisture, higher specific gravity, good mechanical characteristics, high elastic modulus, high thermal and chemical stability, good sound insulation and electrical characteristics and lower abrasion loss values ***(Ayub et al., 2014)***. Dry shakes are mix of cement, aggregates, admixtures and pigments "differed is their composition" which applied on to the concrete surface during construction. It is characterized by improving the abrasion resistance and durability and also can be used for improving the surface quality steel fibres consisted concrete ***(Garcia et al., 2008)***.

The main objective of this research is to investigate the performance of different concrete mixes containing "Nano clay, Basalt and Dry shake" for using them improving the surface of concrete floor slabs.

## EXPERIMENTAL PROGRAM

To achieve the main aim of the current study, an experimental program consisted of fabricating and testing concrete slab 3x3 $m^2$ with thickness 15 cm divided into four quarters, each quarter had a specific concrete mix proportions as shown in Figure (1), in order to investigate the performance of concrete mixes to improve floor's resistance to wear.

### 1. Materials and concrete mixes.

Four concrete mixes were used in the current research. Two mixes of them (mix No. 1 (control mix) and mix 2 (dry shake) possessed the same proportions, while the other two mixes (mixes No. 3(nano clay) and mix 4 (basalt) possessed different proportions.

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Table (1) shows the details of these four mixes. The used cement was Ordinary Portland Cement type CEM I – 42.5 complies with the Egyptian Standard (ES: 4756-1/ 2009) the properties of the used cement are presented in Table (2). In mixes 1, 2 and 3 local dolomite crushed stone size 10 mm, and natural sand were used as coarse and fine aggregates, respectively, the physical properties of crushed stone and sand are presented in Table (3 and 4). While basalt size 5 mm was used as coarse aggregate in mix 4.the physical properties are presented in Table (5). Silica fume having a silicon dioxide content of 96.5%, a specific gravity of 2.15 and specific surface area of 20000 $cm^2$/gm was used as a partial replacement to the cement. Silica fume was added to replace 10% of the cement content in mix 3 and mix 4. Nano clay also used as partial replacement o f cement, nano clay was added to replace 10% of the cement content in mix 3. Nano metakaolin was brought from (Senaa desert-Egypt) with the help of Middle East

Mining Investments Company MEMCO. According to previous investigation NMK was calcinations for reactivation clay. The calcinations temperature and the time of calcinations at that temperature adopted in this study were 750$^{o}$Ċ and 2 hr. respectively. The materials used in this study were nano-clay of Blaine surface area ≈ 480000 cm2/g and of average dimensions of 200*100*20 nm. Table (6) gives the chemical composition of NMK.

In addition, a liquid-based, sulphonated naphthalene-based high-range water-reducing admixture (HRWR) was used at a constant dosages of 2% by mass of cement to enhance workability confirming to C 494 was used in the designed mixes for achieving considerable workability. The used dosage of the admixture is 1.5% of the binder materials. It worth to mention that the amounts of water listed in Table (1) include the absorbed water by the coarse and fine aggregates. Also the consistencies of the designed four mixes were adjusted to be maintained at the same level of workability, i.e. slump values equal 70 + 5 mm.

Dry shakes are often specified for the sole purpose of enhancing wear resistance. Although it vary greatly in their effect on wear resistance but it considered the most common material used to enhance concrete floors surfaces, its chemical base was blend of high grade mineral aggregates mixed with cement, admixtures and pigments and density 1.70 kg/l (bulk density). It is used as a surface layer with thickness 3 cm in mix 2. Also a helicopter was used in order to achieve a smooth surface of concrete slab as shown in figure (2).

**Table (1): Proportions of different concrete mixes.**

| Mix No. | Type of Concrete | Cement (Kg/m$^3$) | Silica Fume (Kg/m$^3$) | Nano clay (Kg/m$^3$) | Silica Fume (Kg/m$^3$) | Coarse Agg. (Kg/m$^3$) | | Fine Agg. (Kg/m$^3$) | Water (Lit/m$^3$) | Admix. (Kg/m$^3$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Dolomite | Bazalt | Sand | | |
| 1 | **Control** | 350 | --- | --- | --- | 1224 | --- | 612 | 175 | 3.5 |
| 2 | **Dry shake** | 350 | --- | --- | --- | 1224 | --- | 612 | 175 | 3.5 |
| 3 | **Nano clay** | 690 | 69 | 34.5 | 69 | --- | 690 | 690 | 276 | 3.5 |
| 4 | **Bazalt** | 690 | 69 | --- | 69 | --- | 690 | 690 | 276 | 3.5 |

**Table (2): Properties of Cement Type (CEM I 42.5 N)**

| Properties | | Measured Values | Limits of the E.S.S* |
|---|---|---|---|
| **Fineness (cm2/gm)** | | 3290 | |
| **Specific Gravity** | | 3.15 | |
| **Expansion (mm)** | | 1.2 | Not more than 10 |
| **Initial Setting Time ( min)** | | 180 | Not less than 60 min |
| **Final Setting Time ( min)** | | 230 | |
| **Compressive Strength (N/mm2)** | **2 days** | 22.4 | Not less than 10 |
| | **7 days** | 33.7 | - |
| | **28 days** | 56.8 | Not less than 42.5 and not more than 62.5 |
| **Chemical Compositions** | **SiO2** | 20.36 % | |
| | **Al2O3** | 5.12 % | |
| | **Fe2O3** | 3.64 % | |

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| | | | |
|---|---|---|---|
| | **CaO** | 63.39 % | |
| | **MgO** | 1.03 % | |
| | **SO3** | 2.21 % | |
| | **Loss ignition %** | 1.3 % | |

** Egyptian Standard no: 4756-1 /2009*

**Table (3): Physical Properties of the used crushed stone**

| Test | Results | Specification Limit * |
|---|---|---|
| **Specific gravity** | 2.61 | - |
| **Unit Weight** | 1.65 | - |
| **Materials Finer than no 200 Sieve** | 1.38 | Less than 4 % |
| **Absorption %** | 2.15 | - |
| **Abrasion (Los Anglos)** | 14.84 | Less than 25 % |
| **Crushing Value** | 17.55 | Less than 30 %** |
| **Impact** | 9.20 | Less than 30 % |

**Egyptian Standard no: 1109/2002*
*** Egyptian Code of Practice for Reinforced Concrete Construction, E.C.P.203- 2007.*

**Table (4): Physical Properties of the used Sand**

| Test | Results | Specification Limit * |
|---|---|---|
| **1. Specific Gravity** | 2.63 | - |
| **2. Unit Weight** | 1.70 | - |
| **3. Materials Finer than no 200 Sieve** | 1.36 | Less than 3 % |

**Egyptian Standard no: 1109 / 2002*

**Table (5): Physical Properties of the used bazalt**

| Test | Results | Specification Limit * |
|---|---|---|
| **Specific gravity** | 2.68 | - |
| **Unit Weight** | 1.62 | - |
| **Materials Finer than no 200 Sieve** | 1.26 | Less than 4 % |
| **Absorption %** | 1.87 | - |
| **Abrasion (Los Anglos)** | 12.45 | Less than 25 % |
| **Crushing Value** | 15.82 | Less than 30 %** |
| **Impact** | 8.63 | Less than 30 % |

**Egyptian Standard no: 1109/2002*
*** Egyptian Code of Practice for Reinforced Concrete Construction, E.C.P.203- 2007.*

**Table (5): Chemical Properties of NMK**

| Chemical content | % |
|---|---|
| **SiO2** | 45.5 |
| **Al2O3** | 37 |
| **Fe2O3** | 0.2 |
| **TiO2** | 1.5 |
| **CaO** | 0.01 |
| **MgO** | 0.02 |
| **Na2O** | 0.03 |
| **K2O** | 0.07 |
| **L.O.I** | 12.5 |

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**Figure (1): preparation of concrete mixes.**

**Figure (2): Helicopter to achieve a smooth surface**

**Figure (3): Pull Off test**

**RESULT AND DISCUSSION:**

**1. Absorption.**

The results revealed that Basalt concrete mix had the lowest percentage of absorption (3.23%) follow it dry shake concrete mix with (3.56%) and the control mix (3.88%) while, nano clay concrete had the highest absorption (4.43%), (Table, 6). In line with our findings, it has been reported that the increase in Basalt percentage in concrete mix decreases water absorption due to its higher density and durability ***(Ayub et al., 2014 &Siva et al., 2015)***.

**2. Abrasion resistance.**

Table (7) shows the results of abrasion resistance test of studied concrete mixes. Control concrete mix recorded (1.11 mm) abrasion thickness loss. Dry shake concrete mix had the highest loss of thickness (4.79 mm), however, Bazalt concrete mix had recorded the lowest abrasion thickness loss (0.66 mm) and Nano clay mix recorded (0.98 mm). Similarly, ***Ayub et al., (2014)*** reported that Basalt had higher specific gravity and abrasion loss values. However, ***Garcia et al., (2008)*** found that dry shaking improved abrasion resistance of concrete floor's. Furthermore, ***Al-Baijat, (2008)*** found that basalt aggregates had high specific gravity, hardness, strength, tight grained structure and this consequently resulted in high abrasion resistance and low abrasion loss values. ***Yazici and Sezer, (2007)*** reported similar results. It was well reported that the abrasion of the concrete pavement is caused by the continues movement of wheels on the concrete surface ***(García et al., 2012)***. Several factors is associated with abrasion resistance of concrete such as: concrete strength, binder content and type, aggregate characteristics, air content and porosity, and surface treatment, the finishing method of concrete surface and type of hardeners or toppings ***(Papenfus, 2003)***.

**3. Compressive strength.**

The results of compressive strength test revealed that the three experimented concrete mixes (Nano clay, Basalt and dry shake) had higher compressive strength than the control mix. Basalt concrete mix had the higher compressive strength of all concrete mixes (FCU=345.5 kg/cm2), follow it dry Shake concrete mix (FCU=35.5 kg/cm$^2$) and finally Nano clay concrete mix (FCU=288.7 kg/cm2), (table, 8). The increase in basalt percentage in the concrete mix enhances the concrete mix strength and this may be is due to the fact that basalt is denser and more durable and less water absorbing ***(Siva et al., 2015)***. Also, ***Hakamy et al., (2015)*** reported that the addition of nano clay by 3.0% of the concrete mix could increase compressive and flexural strength, reduced porosity increased density, fracture toughness, impact strength, hardness and thermal stability. Similarly, ***AL-Salami et al., (2013)*** reported that nano clay increases the strength and durability, reduces the pore size and porosity of the cement matrix and also reduces pollution of cementitious composites. In addition, ***Gopalakrishnan, (2016)*** found that the compressive strength of the cement mortars with nano clay were higher than plain cement mortar alone. ***Naik et al. (1994)*** reported a linear relationship between the compressive strength and abrasion resistance.

**4. Pull Off strength test.**

The results of Pull Off strength test indicated that Basalt concrete mix had highest Pull Off strength (16.37 kg/cm$^2$) and in contrary Nano clay mix had the lowest value (9.31 kg/cm$^2$),

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Pull Off strength was increased in dry shake concrete mix (13.25 kg/cm$^2$) than control mix (12.48 kg/cm$^2$). These results are almost in line with those of comprehensive strength test (table, 9 and fig. 3). These results were expected regarding Basalt concrete mix because of its higher compressive strength increased Pull Off strength of the concrete mix.

and abrasion resistance. As it was reported by ***Pereira and de Medeiros, (2012)*** who reported that Pull Off test results had high correlation ($R^2$> 0.93) with the concrete strength. These results are in accordance also with ***Wlodarczyka and Jedrzejewskia, (2016)*** who confirmed that Using Basalt

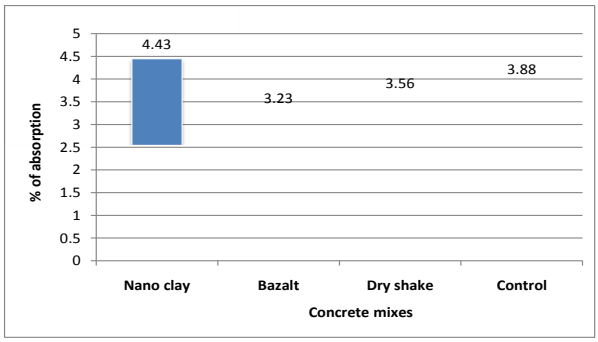


**Figure (8): Percentage of absorption among different concrete mixes.**

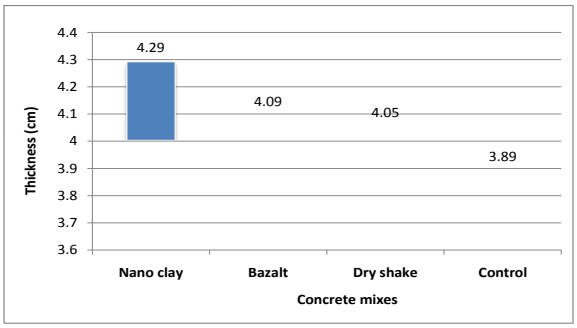


**Figure (9): Thickness of different type of concrete mixes.**

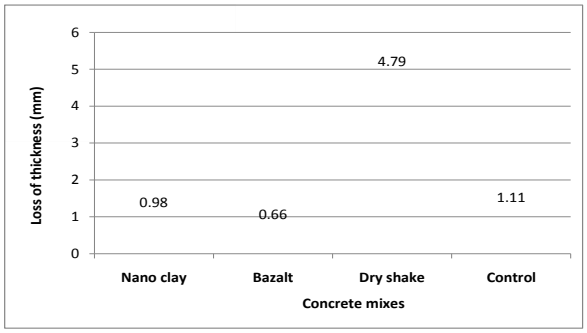


**Figure (10): Loss of abrasion thickness of different concrete mixes.**

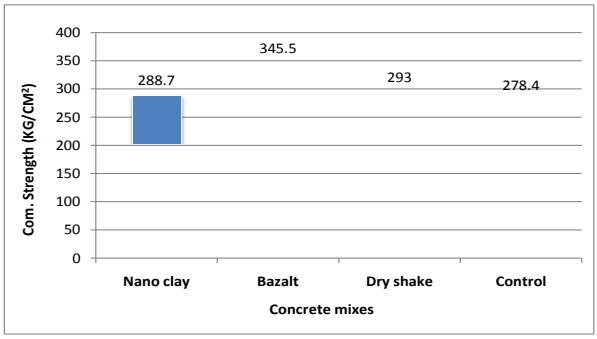


**Figure (11): Compressive strength among different concrete mixes.**

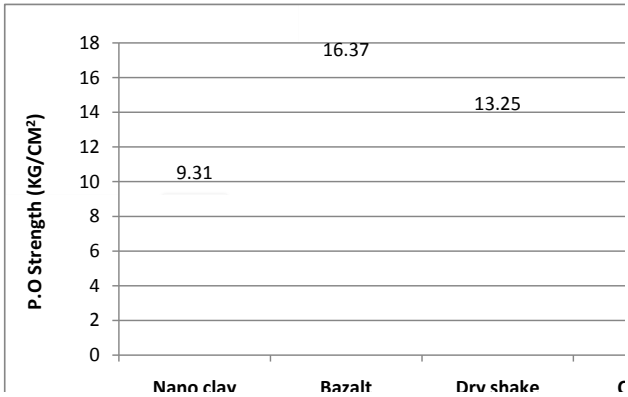


**Figure (12): Pull off strength among different concrete mixes.**

**CONCLUSION:**

From the previous results of the experimental tests, it can be concluded that Basalt concrete mix was the best concrete mix of all studied ones, by providing low water absorption, high compressive strength and high abrasion resistance with a special view to its economics and relatively low cost, follow it dry shake and nano clay mixes compared to control mix. Much more work is needed to evaluate concrete mixes that provide specific characteristics and could be used for rigid pavements.

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