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INVESTIGATION ON THE EFFECT OF STORAGE TIME DUE TO MOISTURE ABSORPTION OF CEMENT ON THE PROPERTIES OF CONCRETE

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ABSTRACT

Cement is the major ingredient of concrete having adhesive and cohesive properties and when it is combined with water, it forms a paste that is used for attaching and binding the other ingredients of concrete. The property of cement highly affects behavior of the concrete. When cement is stored, it loses its fineness property, which is important in hydration and strength development of concrete. In order to investigate the impact of moisture absorption of cement due to storage time, cements were collected from cement factory and stored for 1 month, 2 months and 3-month time. Then the materials were tested for cement and concrete properties. Laboratory results show that, fineness of the cement which was checked by sieve analysis and the percentage of the residue was 18% which is greater than 10% as recommended by IS standard; setting time of cement increases; slump results were collapse and compressive strength decrease by 22% after 3 months storage of cement. Finally, it was concluded that when the cement was stored for longer time, its properties affected due to moisture in the air.

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INTRODUCTION

Cement is the essential component of concrete, when hydrated, binds the aggregates together to form the hard. Over 95% of the cement used in concrete throughout the world is Portland cement in its various forms. It is by no means a simple material, and its complexities have an impact on the properties and behavior of concrete from mixing right through to the end of its life (Peter *et al*., 2010). Portland cement consists particles with a range of sizes. The overall particle size distribution of cement is called "fineness" The fineness of cement affects heat released and the rate of hydration. Greater cement fineness (smaller particle size) increases the rate at which cement hydrates and thus accelerates strength development. The effects of greater fineness on paste strength are manifested principally during the first seven days (Steven *et al*., 2003). Cement is a moisture-sensitive material; if kept dry, it will retain its quality indefinitely but Cement stored in contact with damp air or moisture sets more slowly and has less strength than cement that is kept dry (Steven *et al*., 2003).

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In spite of all the best precautions taken to store cement, it is found that the cement can be affected and the strength is reduced due to increased storage time. When cements are stored for long time, they may absorb the moisture and begin the hydration process. As a result they form lumps and lose their fineness property that is important for hydration process, setting time and strength development of the concrete. According to association of engineer's civil engineering handbook it is assumed that a cement stored in normal storage (stored in bulk) for 3 month can lose 20 % of its strength. Indian standard specifies that the cement stored in bags in local storage should only be stored for 3 month. Based on the standard, the research is done for storage time of 3 months in normal storage and study the reduction in the properties of cement and concrete.

Storage conditions of cement

All the cements collected were fresh cements and they were stored as stated on Indian and Ethiopian standard. As a reason, the cement bags were stored in the EiABC material laboratory according to the standard. That is 150mm to 200mm above the ground level, without touching any walls or 600mm is left around the walls

and covered with plastic sheet. The temperature of the store was room temperature, which is below 30^0C and stored for three month based on ES 1176-7.

Data processing and analysis

The constituent materials of concrete had been properly stored, sampled and subjected to various tests to investigate their properties towards engineering applications. Before testing the concrete, there were different material tests conducted to investigate the properties of the ingredients and to decide whether they were acceptable or not. The cements were stored to get the required storage time. They were stored from fresh cement up to 3 month with one month difference between each. The mix design was calculated based on weight. First, the trial mix was done to know the property of the concrete to be mixed. After the trial mix, the mixing procedure for each month storage time had been done. Then each bag of cementwere tested based on their storage time.

Experimental works procedure

Coarse aggregate used for this research was crushed aggregate that was brought from the local construction material suppliers. The aggregate was dried in air inside the laboratory room. The size of coarse aggregate used was between 37.5mm-4.75mm diameter aggregate sizes and it has been sieved and stored at dry place in the laboratory room.
Natural sand was used as fine aggregate research, which was collected from the local material suppliers. Since fine aggregates are full of dust and silt, before the material was collected it was tested for its silt content and organic impurity according to Ethiopian standard. Based on the standard maximum silt content should be 6%.

Laboratory test on concrete

Slump test is the simplest and easiest test to measure the workability of fresh concrete and the test was done according to ASTM C-143. In this research,cubes having dimension of 15x15cm were prepared. After the concrete cubes werecured in accordance with the standard, they were tested for the compressive strength. The concrete cubes were tested for 7 day, 14 day and 28 day of compressive strength. In addition, for each day strength 3 samples were prepared based on Ethiopian standard.

RESULTS

Properties of Aggregates Used

The specific gravity and water absorption of aggregates were determined based on ASTM procedure. C-127 was used for coarse aggregate and C-128 for Fine aggregate.

Table 1. Specific gravity for coarse aggregate

Description		Values
Average Values	Specific gravity	2.735
	Apparent specific gravity	2.92
	Water absorption	2.33

Since aggregates take the major part from the constituents of concrete, their gradation plays a major part in the properties of concrete. The fineness modulus was also calculated for the sand. Usually fineness modulus is calculated for fine aggregate rather than the coarse aggregate. The range of fineness modulus for the sand usually lies between 2.3 and 3.1 according to the ASTM C136 standard. The fine aggregate sample taken in this research had the fineness modulus of 2.51, which was in the limits. Based on Ethiopian standard the silt content of sand should be kept less than 6 % and if it is greater than 6 %, it should not be used for construction. The amount of silt content for the sand used in this study was 3.51%.

Table 2. Specific gravity for fine aggregate

Description		Values
Average Values	Specific gravity	2.56
	Apparent specific gravity	2.6
	Water absorption	0.53

Concrete is made with aggregate particles covering a range of sizes that is usually from 10mm up to 50mm which is grading. Since aggregates take the major part from the constituents of concrete their gradation plays a major part in the properties of concrete. Usually fineness modulus is calculated for fine aggregate rather than the coarse aggregate. The sample of the fine aggregates satisfies the grading requirements for fine aggregates (i.e. percentage passing). The range of fineness modulus for the sand usually lies between 2.3 and 3.1 according to the ASTM C136 standard. The fine aggregate sample taken in this study had the fineness modulus of 2.51, which is between the limits. Based on the result, the nominal size of the coarse aggregate is 37.5-4.75.

Properties of Cement

Consistency of the cement, which is used to determine the amount of water needed to form a paste measured with penetration of 10±1 in the Vicat needle apparatus. The amount of water determined in the consistency test was used for other tests like setting time. When the storage time of cement increases, it may lose its fineness property. As a result, the amount of water needed for consistent cement paste was decreased. For most cement pasts the percentage by water of dry cement lies between 26%-33%. As it was shown in the table below, the consistency percentage lies between the limit. However, when the cement loses its fineness the water needed for mixing the cement decreases.

Table 3. consistency of cement samples

Storage time by month	% by water of dry cement	Amount of water	Penetration
Fresh (15 days)	33%	165mm	10.5
1 month	31%	155mm	10
2 month	29%	145mm	9.5
3 month	27.4%	137mm	11

When the cement storage time increases, it loses its fineness property, which in turn affects the setting time of the cement paste. The ASTM standard states that the initial setting time should not be less than 90 min and the final setting time should be less than 10 hrs. As it is shown in the figure below, both the initial and final setting times was at good condition. However, when fineness decrease the hydration process also decrease and this increases the time needed for the cement to set. When the cement is stored for weeks it loses its fineness property and it form lumps that cannot be broken by hand. Fresh cement does not have any lumps and it is very smooth when it is

touched by hand, it is very fine and without any coarser particles. In this research, the fineness property was measured by sieve analysis. Based on IS 4031 the residue percentage in the No 200 sieve should not be greater than 10 for the ordinary Portland cement. The results for each of storage times were shown below. According to the result the percentage of the retained after the 1 month storage is greater than 10% which is greater than the allowed percentage stated in the IS standard.

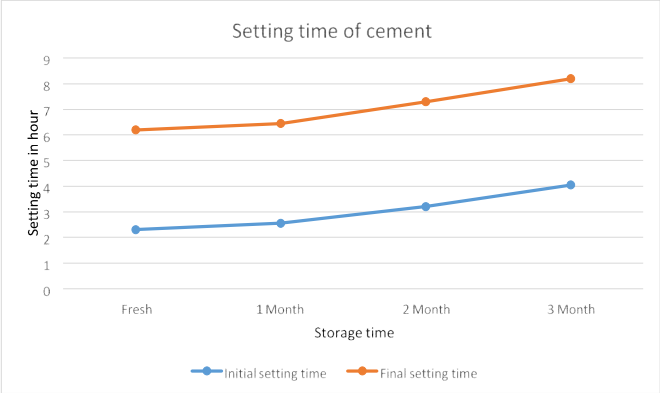

Figure 1. Setting time of cement

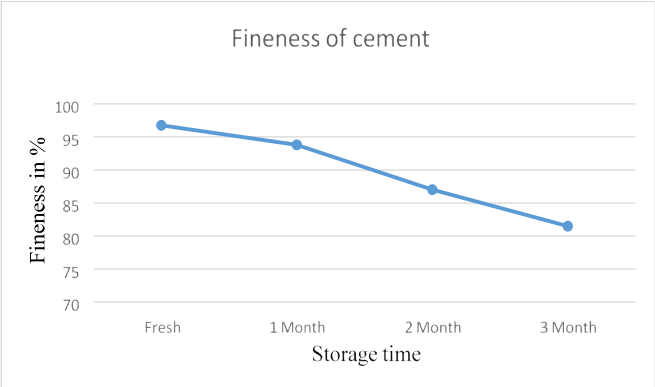

Figure 2. Fineness of cement

Property of Fresh Concrete

One of the common properties of fresh concrete is its workability. Workability is the amount of useful internal work necessary to produce full compaction. Slump test is the common and acceptable method to measure workability. In this study, the mix was done for each storage time and slump test was conducted for each of them. When the cement was stored, it loses its fineness property, which leads in binding of the other ingredients of the concrete mix. As a result, the slump becomes from true slump to shear or collapse slump as the storage time of the cement increase. The other property that was observed in this test was that when the storage time of the cement increase the amount of water needed for the mix decrease. This is because the cement has already began the hydration or setting process and the specific surface area that gets in contact with the water has decreased. The result of this study shows, the mix for the fresh cement is stiff and the mix for the 3 month stored cement is loose. Which means the slump test of the concrete goes from true slump to shear slump, since the cement had lost its binding capacity. The result of test is summarized in the table below.

Table 3. Slump test result

Storage time	Slump in mm	Remark
Fresh cement (15 days)	4.87 cm	True Slump
1 month	8.43 cm	True Slump
2 month	15.31 cm	Shear
3 month	19.35 cm	Collapse

Compressive strength

Compressive strength of the concrete was tested at 7, 14 and 28 days. Generally the result shows, compressive strength of concrete decreases as the cement storage time increases. This is because when the cement is stored, it may absorb moisture. Even if there is no contact with any moisture, the moisture in the air can affect the cement. In addition, when the cement get in contact with any kind of moisture, it begins the hydration process or it forms lumps.

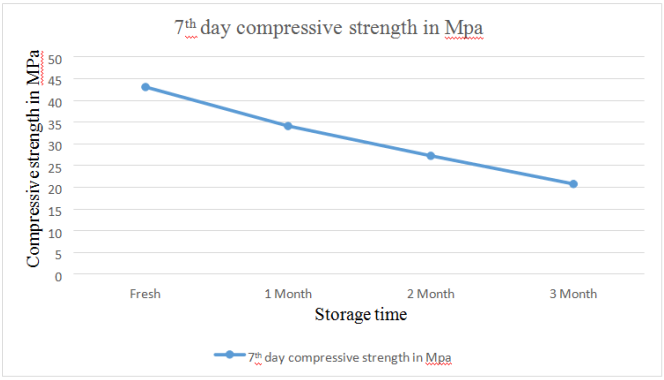

Figure 3. 7th day compressive strength

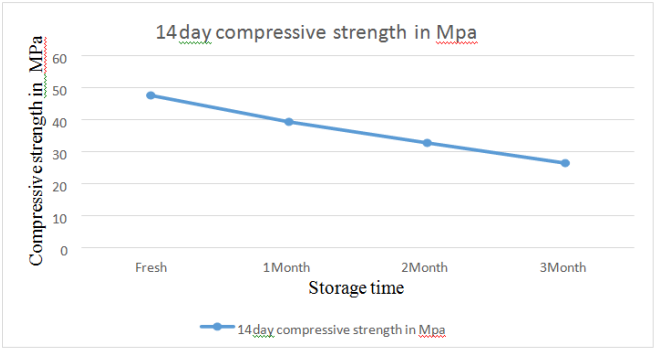

Figure 4. 14th day Compressive Strength

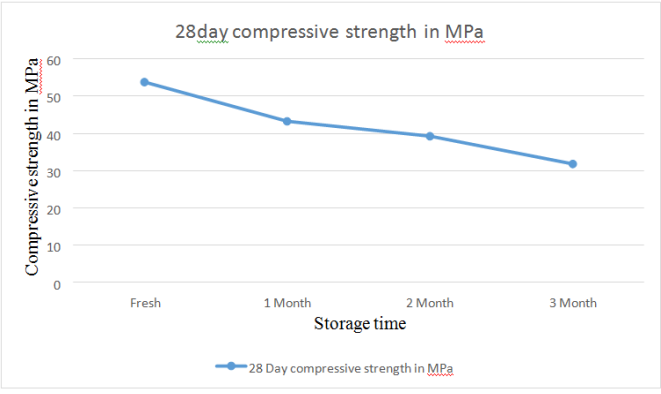

Figure 5. 28th Compressive strength

Because of lump formation, the cement loses its fineness, which is the major property for the cement and uses for

development of hydration process, setting time and early achievement of strength. The bonding ability of the cement paste is also dependent on the cement fineness. In this study, for the 7th day strength, fresh concrete mix have a characteristic strength of 43.1 and after the cement is stored for 3 month, the compressive strength is about 20.8. Which is 22.3% decrease in the characteristic compressive strength of the concrete. Every mix in this study shows, when the storage time increases, the compressive strength decrease due to moisture absorption from air. The result of the study is summarized below in figures.

Conclusion

Based on the laboratory tests conducted on the cement and the observed results, when the cement storage time increase the cement loses its fineness. This is because cement has the ability of absorbing any kind of moisture whether it is dampness of the storage space or moisture in the air. When the cement absorbs moisture, it begins the hydration process and forms lumps. First, the formed lumps can be broken and become fine, but when the storage time increase; the lumps cannot be smashed and hence become rigid. In the IS standard of sieve analysis, if the retained percentage is greater than 10%, it is not acceptable. As shown in the result of sieve analysis, the percentage of retained for the 3 month stored cement is greater than 18%, which is greater than the standard value. The strength of concrete was reduced when the stored cement was used. Based on the analysis and the results, the compressive strength of the concrete was reduced by 22% after 3month. Even 3 month stored cement concrete cube test result was almost equal to the strength recommended on EBCS EN 1992-1-1:2014 (EBCS 2). However, when the safety factors are applied for the design purpose, it becomes less than the recommended standard for the C-25 strength of the concrete. Therefore, it can be concluded that, if stored cement is used in the making of concrete can affect the workability and the strength of the concrete.

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