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# The Effect of Calcium Chloride Admixture on the Compressive Strength of Concrete Blocks

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## Abstract

Calcium chloride admixture is used as an accelerator in the hydration process of cement, leading to increased rate of setting and substantial compressive strength development. Taking advantage of this admixture is paramount for maximizing its utility value in the construction industry, since compressive strength is considered as an integral property of concrete blocks in the construction and building fraternity. An experiment was conducted to determine the effect of calcium chloride admixture on the compressive strength of concrete blocks. It utilized a mix design of 1:5 (Cement: sand) which was the standard mix design used in the construction industry within the country. The mix design manipulation resulted in five treatments, which were the calcium chloride admixtures at proportions of $T_1$ (0%), $T_2$ (1%), $T_3$ (2%) and $T_4$ (3%) and $T_5$ (4%) including the control ($T_1$, 0%) on weight basis of the cement, with four replications. All concrete block specimen were cured for 28 days. Data analysis was conducted using one-way ANOVA in SPSS version 2.0 computer software. The results reflected that the optimum compressive strength (2.98 N/mm$^2$) of the calcium chloride blended concrete blocks was achieved with 4% addition of calcium chloride. The compressive strength under $T_5$ (4% of $CaCl_2$) was 1.62 N/mm$^2$, 2.07 N/mm$^2$, 2.14 N/mm$^2$ and 2.98 N/mm$^2$ after 7, 14, 21 and 28 days, respectively. Treatment 4 (3% of $CaCl_2$), had the highest water absorption value (12.8%), while the control Treatment ($T_1$) had the lowest water absorption value (11.06%). It was concluded that an increase in the proportion of the calcium chloride added to the concrete mix design led to an increase in the compressive strength of the concrete blocks. It was also concluded that there was an increase in compressive strength of all the calcium chloride blended concrete blocks with an increase in the curing period, while it was concluded that there was an increase in the amount of water absorbed with an increase in the proportion of calcium chloride admixture in the specimen.

## Keywords

Calcium Chloride, Admixture, Compressive Strength, Concrete Blocks

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## 1. Introduction

Concrete is a common material used in the construction industry. It is obtained by mixing cement, water, fine and coarse aggregates and sometimes admixtures in required proportions. While admixtures, unlike cement, aggregate and water, are not essential components of the concrete mix, they are an important and increasingly widespread component: in many countries, a mix which contains no admixtures is nowadays an exception. The reason for the large growth in the use of admixtures is that they are capable of imparting considerable physical and economic benefits with respect to concrete [8]. These benefits include the use of concrete under circumstances where previously there existed considerable, or even insuperable, difficulties. They also make possible the

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use of a wider range of ingredients in the mix.

Chemical admixtures are materials in the form of powder or fluid that is added to concrete to give it certain characteristics, not obtainable with plain concrete mixes [11]. Chemical admixtures are added to concrete in very small amounts mainly for air entrainment, reduction of water or cement content plasticization of fresh concrete mixtures, or control of setting time. Admixtures, although not always cheap, do not necessarily represent additional expenditure because their use can result in concomitant savings, for example, in the cost of labour required to effect compaction, or in improving durability without the use of additional measures. However, it was concluded that chemical admixtures reduce the cost of construction, modify properties of hardened concrete, ensure quality of concrete during mixing/transporting/placing/curing, and overcome certain emergencies during concrete operations. Chemical admixtures fall into the following categories: air entrainers, water reducers, set retarders, set accelerators, super plasticizers and specialty admixtures [7].

Calcium Chloride ($CaCl_2$) is an accelerator type of chemical admixture and a by-product of the Solvay process in the manufacturing of sodium carbonate. Accelerators increase the initial rate of chemical reaction between the cement and the water so that the concrete stiffens, hardens, and develops strength more rapidly. As an accelerator, Calcium Chloride increases the hardening rate of the concrete and it is available in two forms: (i) regular flake Calcium Chloride and (ii) concentrated flake, pellet, or granular Calcium Chloride [6]. The latter form of Calcium Chloride was used in the experiment. In normal use, Calcium Chloride admixture dosages are less than 5% by mass of cement and are added to concrete at the time of batching/mixing [2, 9].

Calcium Chloride as an accelerating admixture has been used in concrete since 1885 and finds application mainly in cold weather, when it allows the strength gain to approach that of concrete cured under normal curing temperatures. In normal conditions, Calcium Chloride is used to speed up the setting and hardening process for earlier finishing or mould turnaround. Besides affecting setting time, Calcium Chloride has a minor effect on fresh concrete properties. It has been observed that the addition of Calcium Chloride slightly increases the workability and reduces the water required to produce a given slump and reduces bleeding. On the other hand it was reported that the initial and final setting times of concrete are significantly reduced by using Calcium Chloride [5, 10].

Admixtures such as Calcium Chloride confer certain beneficial effects of concrete, including; reduced water requirements, increased workability, controlled setting and hardening, improved strength and durability. Calcium Chloride is considered the most efficient and economical admixture, which is categorized under accelerators [4, 1]. The use of these chemical admixtures should be encouraged and embraced in the construction industry since they increase the strength and improve the properties of concrete and enhances and increase the life span of structures [3]. In the kingdom of Eswatini, the use of admixtures such as Calcium Chloride to reap the above benefits, was not exploited in concrete block production and by extension in the construction industry, hence this study. The objectives of the study were (i) to determine the effect of Calcium Chloride admixture on the compressive strength of concrete blocks; (ii) to determine the effect of the curing period on the compressive strength of concrete blocks blended with Calcium Chloride and (iii) to assess the water absorption of the calcium blended concrete blocks.

# 2. Methodology

## 2.1. Research Design

This study was an experiment, with five treatments (T), including the control (0% $CaCl_2$). There were four replications in each treatment. The concrete mix design was 1:5 (cement: sand), as this was the standard mix used in the country. The mix design was manipulated by adding Calcium Chloride in proportions of 1%, 2%, 3%, and 4% by weight of cement (Table 1).

**Table 1.** Concrete mix design.

| Treatment | Calcium Chloride % | Mix-Cement: Sand |
|---|---|---|
| $T_1$(control) | 0 | 1:5 |
| $T_2$ | 1 | 1:5 |
| $T_3$ | 2 | 1:5 |
| $T_4$ | 3 | 1:5 |
| $T_5$ | 4 | 1:5 |

## 2.2. Fabrication of Blocks

Prior to concrete mixing the sand was sieved using a 10 mm test sieve to ensure uniformity of its aggregates and removal of twigs. The load bearing concrete 6 inch blocks were fabricated using a block mould. The fabrication of the blocks was conducted on a clean concrete slab to minimize debris. The curing period for each sample in each treatment were 7 days, 14 days, 21 days and 28 days.

## 2.3. Compressive Strength Test

The failure load was conducted using the ProIkon cube load testing machine. Equation 1 was used for calculating the compressive strength of the Calcium Chloride blended concrete blocks.

$$\sigma c = \frac{F}{A} \quad (1)$$

Where: σc - Compressive strength ($N/mm^2$)

F - Failure load (N)

A - Area of bed face ($mm^2$)

## 2.4. Water Absorption

The absorption of water was conducted for all the block sets including the control. Sample block sets assumed to be representative of the unit population were tested for water absorption. The sample blocks were oven dried for 24 hours at a temperature of 100 -105°C until the mass was constant and the dry weights ($W_1$) were measured. The same blocks were immersed in water for 24 hours and the wet weights ($W_2$) were measured. The proportion of water absorption of the Calcium Chloride blended concrete blocks was determined using equation 2.

$$\text{Water Absorption} = \frac{W_2 - W_1}{W_1} \text{ X } 100\% \quad (2)$$

Where: $W_1$ - Oven dry weight.

$W_2$ - Wet weight.

## 2.5. Data Analysis

The data was analysed using IBM Statistical package of Social Science version 20 and Microsoft excel. The analysis of variance (ANOVA) and paired T test were used for the analysis.

# 3. Results and Discussion

## 3.1. Effect of Calcium Chloride on Compressive Strength Results

The results in Table 2 reflected that the optimum compressive strength (2.98 $N/mm^2$) of the Calcium Chloride blended concrete blocks was achieved with 4% addition of Calcium Chloride. The compressive strength was 1.62 $N/mm^2$, 2.07 $N/mm^2$, 2.14 $N/mm^2$ and 2.98 $N/mm^2$ after 7, 14, 21 and 28 days, respectively.

**Table 2.** Mean compressive strength of Calcium Chloride blended concrete blocks.

| Calcium Chloride (%) | Compressive strength at 7 days ($N/mm^2$) | Compressive strength at 14 days $N/mm^2$) | Compressive strength at 21days $N/mm^2$) | Compressive strength at 28 days ($N/mm^2$) |
|---|---|---|---|---|
| 0 ($T_1$) | 1.08 | 1.24 | 1.71 | 2.10 |
| 1 ($T_2$) | 1.31 | 1.52 | 1.75 | 2.23 |
| 2 ($T_3$) | 1.42 | 1.73 | 1.92 | 2.34 |
| 3 ($T_4$) | 1.59 | 2.01 | 2.09 | 2.53 |
| 4 ($T_5$) | 1.62 | 2.07 | 2.14 | 2.98 |

The results indicated that there was a direct relationship between the compressive strength and the Calcium Chloride proportion of the Calcium Chloride blended concrete blocks. This implied that an increase in the proportion of Calcium Chloride, which was expressed on weight basis of cement in the mix, led to an increase in the compressive strength of the concrete blocks. This was attributed to the acceleration effect caused by Calcium Chloride and the reduction in the porosity of the pastes due to the formation of more hydration products which causes an increase in compressive strength. The highest compressive strength (2.98 $N/mm^2$) was achieved with 4% Calcium Chloride, while the lowest compressive strength (1.08 $N/mm^2$) was achieved with no calcium (control).

The concrete blocks without Calcium Chloride (control) had lower compressive strength throughout (1.08 $N/mm^2$, 1.24$N/mm^2$, 1.71 $N/mm^2$ and 2.1 $N/mm^2$ after 7 days, 14 days, 21 days, and 28 days of curing). The strength also increased as the percentage of the Calcium Chloride admixture was increased. As an example, the mean compressive strength for the control treatment ($T_1$) after 28 days of curing was 2.1 $N/mm^2$, whereas the mean compressive strength for the blocks containing 1% Calcium Chloride was 2.23 $N/mm^2$. The addition of Calcium Chloride admixture led to an early development of strength in concrete, and that was observed from the results in Table 2 since they reflected a substantial increase in the compressive strength at the 7$^{th}$ day.

The mean separation results showed that all the treatments were significantly different ($P<0.05$) from the control (Table 3). It is worth noting that this was also the case between treatments i.e. they were significantly different ($P>0.05$). This meant that the Calcium Chloride admixture in the concrete mix, affected the compressive strength of the concrete blocks fabricated. The optimum compressive strength (2.98 $N/mm^2$) was achieved at 4% Calcium Chloride. This reflected a gradual integrated increase in the compressive strength, curing days and the proportion of the Calcium Chloride admixture. The mean difference in compressive strengths of the different treatments ($T_2$-$T_5$) from the control ($T_1$), were found to be 0.13 $N/mm^2$, 0.24 $N/mm^2$, 0.43 $N/mm^2$ and 0.88 $N/mm^2$, respectively after 28 days of specimen aging. The variation of compressive strengths could be attributed to the percentage of Calcium Chloride present in the five respective concrete mix batches.

**Table 3.** Mean compressive strength treatments analysis of variance (ANOVA).

| (I) Treatment | Treatment | Std. Error | Sig. |
|---|---|---|---|
| | $T_2$ | 0.91287 | 0.001* |
| | $T_3$ | 0.91287 | 0.000* |
| $T_1$ | $T_4$ | 0.91287 | 0.000* |
| | $T_5$ | 0.91287 | 0.000* |
| | $T_1$ | 0.91287 | 0.001* |
| $T_2$ | $T_3$ | 0.91287 | 0.001* |
| | $T_4$ | 0.91287 | 0.000* |
| | $T_5$ | 0.91287 | 0.000* |
| | $T_1$ | 0.91287 | 0.000* |
| $T_3$ | $T_2$ | 0.91287 | 0.001* |
| | $T_4$ | 0.91287 | 0.001* |
| | $T_5$ | 0.91287 | 0.000* |
| $T_4$ | $T_1$ | 0.91287 | 0.000* |
| | $T_2$ | 0.91287 | 0.000* |
| | $T_3$ | 0.91287 | 0.001* |
| | $T_5$ | 0.91287 | 0.001* |
| | $T_1$ | 0.91287 | 0.000* |
| $T_5$ | $T_2$ | 0.91287 | 0.000* |
| | $T_3$ | 0.91287 | 0.000* |
| | $T_4$ | 0.91287 | 0.001* |

*. The mean difference is significant at the 0.05 level.

The mean compressive strength results for each treatment reflected that there was a relationship between the increase in the amount of Calcium Chloride and compressive strength of the Calcium Chloride blended concrete blocks. The compressive strengths for the $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ were 1.53 N/mm$^2$, 1.7 N/mm$^2$, 1.85 N/mm$^2$ and 2.2 N/mm$^2$, respectively (Figure 1). The analysis of variance showed that, there was also a significant difference ($P<0.05$) between the control treatment; $T_1$; (0% $CaCl_2$) and $T_5$ (4% $CaCl_2$), which was the treatment that had the highest proportion of Calcium Chloride. This was the case between treatments as well i.e. they were significantly different ($P<0.05$).

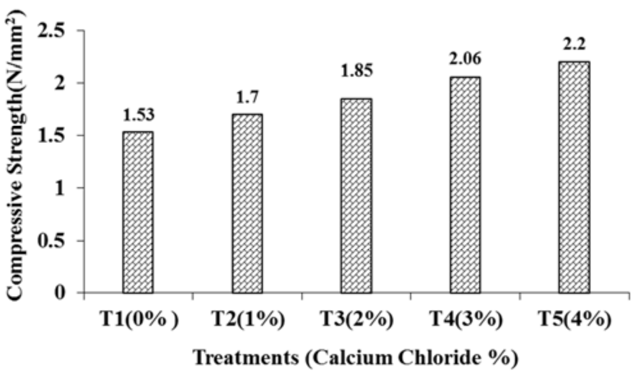


**Figure 1.** Mean compressive strength of Calcium blended concrete blocks.

## 3.2. Effect of Curing Period on Compressive Strength Results

Proper curing procedures, which entails the control of temperature and moisture environment of the concrete, are essential for high-quality concrete. The amount of time it takes for the concrete blocks to be cured has a huge influence on the final compressive strength. A one week curing period yields low compressive strength because at this point the load bearing concrete blocks are still undergoing the hardening state.

The results indicated that as expected, the compressive strength increased with increasing curing time in all the treatments in question (Figure 2). The highest compressive strengths were achieved after 28 days of curing as reflected by the block compressive strengths of 2.1 N/mm$^2$, 2.23 N/mm$^2$, 2.34 N/mm$^2$, 2.52 N/mm$^2$ and 2.98 N/mm$^2$ for $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$, respectively.

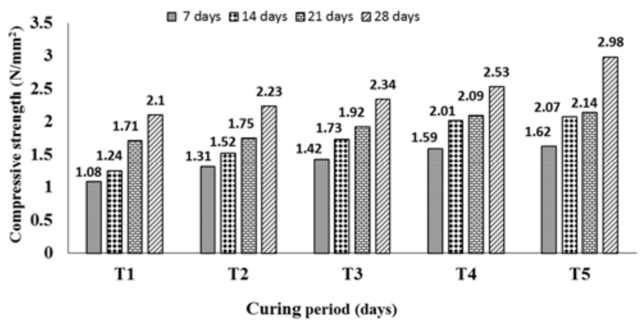


**Figure 2.** Effect of curing period on compressive strength.

The mean values of all the Calcium Chloride blended concrete blocks that were cured for 28 days were all significantly different ($P<0.05$) from each other as reflected in Table 4.

**Table 4.** Compressive strength analysis of variance for curing ages.

| Curing Age (Days) | Curing Age (Days) | Std. Error | Sig. |
|---|---|---|---|
| | 14 | 1.03441 | 0.000* |
| 7 | 21 | 1.03441 | 0.000* |
| | 28 | 1.03441 | 0.000* |
| | 7 | 1.03441 | 0.000* |
| 14 | 21 | 1.03441 | 0.000* |
| | 28 | 1.03441 | 0.000* |
| | 7 | 1.03441 | 0.000* |
| 21 | 14 | 1.03441 | 0.000* |
| | 28 | 1.03441 | 0.000* |
| | 7 | 1.03441 | 0.000* |
| 28 | 14 | 1.03441 | 0.000* |
| | 21 | 1.03441 | 0.000* |

*. The mean difference is significant at the 0.05 level.

The results in Table 5 indicated that the mean compressive strength between the curing periods were significantly different ($P<0.05$). The paired sample T-test was then carried out to determine the effect of the curing periods on the mean compressive strength of the Calcium Chloride blended concrete blocks under each treatment. The paired curing period categories included 7 and 14 days, 7 and 21 days, 7 and 28 days, 14 and 21 days, as well as 21 and 28 days.

**Table 5.** Mean compressive strength of concrete blocks.

| Curing period (days) | Compressive Strength (N/mm²) | | | | |
|---|---|---|---|---|---|
| | 0% ($T_1$) | 1% ($T_2$) | 2% ($T_3$) | 3% ($T_4$) | 4%($T_5$) |
| 7 and 14 | 1.08 | 1.32 | 1.42 | $1.59_{ab}$ | 1.62 |
| | 1.24 | 1.52 | 1.73 | $2.01_{ab}$ | 2.07 |
| 7 and 21 | 1.08 | 1.31 | 1.42 | $1.59_{ad}$ | 1.62 |
| | 1.79 | 1.75 | 1.92 | $2.09_{ad}$ | 2.14 |
| 7 and 28 | 1.08 | $1.31_{bc}$ | $1.42_{bd}$ | $1.59_{cb}$ | $1.62_{cd}$ |
| | 2.1 | $2.23_{bc}$ | $2.34_{bd}$ | $2.53_{cb}$ | $2.98_{cd}$ |
| 14 and 21 | 1.24 | $1.52_{abcde}$ | 1.73 | 2.01 | 2.07 |
| | 1.71 | $1.75_{abcde}$ | 1.92 | 2.09 | 2.14 |
| 21 and 28 | 1.71 | $1.75_{de}$ | $1.92_{ae}$ | $2.09_{be}$ | $2.14_{ce}$ |
| | 2.1 | $2.23_{de}$ | $2.34_{ae}$ | $2.53_{be}$ | $2.98_{ce}$ |

[abcde] — Columns with pairs having same alphabets display that means were significantly different (P < 0.05).

In a generic sense the results reflected that in all treatments the compressive strength increased with an increase in the curing period of the block specimen. This was due to the ongoing hydration process that occurred as the concrete blocks were hardening. When comparing 7 and 14 days of curing, the results showed that the mean differences between the 3% Calcium Chloride blended concrete blocks were significantly different (P<0.05), while all the remaining pairs under this pair were not significantly different (P>0.05). When pairing the mean compressive strengths for the 7 and 21 days of curing; the results reflected that at $T_4$ (3% $CaCl_2$) they were significantly different (P<0.05); while the other treatments were not significantly different (P>0.05).

The results reflected that significant values of the mean compressive strength of the Calcium Chloride blended concrete blocks was developed in the control treatment (0% $CaCl_2$) of the blocks that were cured for 7 and 28 days. These were not significantly different (P> 0.05), while all the other compressive strength means of the other treatments in the pair of 7 and 28 days of curing were significantly differently (P<0.05). On the other hand when comparing the mean compressive strengths that were developed after 14 days and 21 days of curing, the results reflected that the concrete blocks containing 1% Calcium Chloride admixture was significantly different (P<0.05), meanwhile the other treatments were not significantly different (P>0.05). The results from the last pair (21 and 28 curing days) reflected that the control treatments (without Calcium Chloride admixture) were not significantly different (P>0.05), albeit all the concrete blocks blended with Calcium Chloride under this pair were significantly different (P<0.05).

The variation in the change of the compressive strength cannot be huge but the overall difference was significantly different (P<0.05), hence the increase in the curing period caused a substantial increase in compressive strength of the Calcium Chloride blended concrete blocks.

## 3.3. Effect of Calcium Chloride on Water Absorption Results

Water absorption is a measure of water absorbed by the Calcium Chloride blended concrete blocks. While this parameter is influenced by a lot of factors, at the same time it can be a significant indicator reflecting and predicting many qualities of concrete blocks. Table 6 indicated the water absorption test results of the Calcium blended concrete blocks in question.

**Table 6.** Water absorption percentage on Calcium Chloride blended concrete blocks.

| Calcium Chloride (%) | Dry-Weight (kg) | Wet-Weight (kg) | Water absorption (%) |
|---|---|---|---|
| 0 ($T_1$) | 19.17 | 21.29 | 11.06 |
| 1 ($T_2$) | 18.70 | 20.93 | 11.93 |
| 2 ($T_3$) | 19.28 | 21.70 | 12.55 |
| 3 ($T_4$) | 18.60 | 20.98 | 12.80 |
| 4 ($T_5$) | 18.92 | 21.3 | 12.58 |

The water absorption was found to be 11.06%, 11.93%, 12.55%, 12.80% and 12.58% for treatments 1, 2, 3, 4 and 5, respectively. The results indicated that the concrete blocks with Calcium Chloride admixture had higher water absorption than the control specimen. The direct relationship between the Calcium Chloride admixture content and water absorption can be attributed to the fact that Calcium Chloride's presence causes the hydration process of the concrete to be rapid and this results in an increase in the water absorption rate of the Calcium Chloride blended concrete blocks.

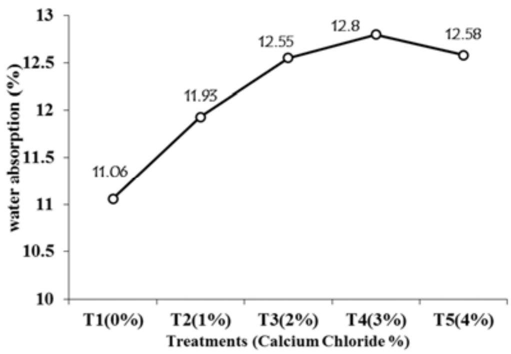


**Figure 3.** Effect of adding Calcium Chloride on water absorption.

The results in Figure 3 indicated that Treatment 4 (3% $CaCl_2$), had the highest water absorption (12.8%), while the control Treatment 1 (0% $CaCl_2$) had the lowest water absorption (11.06%). Depending on the cement properties, in most cases the cement particles in the mixture results in the rapid development of very strong bonds and very low porosity. Observing the penetration height of the dry specimen it was evident that the surface water absorption was higher than the internal water absorption. This was due to the fact that the external surface of the concrete blocks was more exposed to evaporation, which created the absorption gradient to be high on the surface.

## 4. Conclusions

The results reflected that all the investigated Calcium blended concrete blocks showed higher values of compressive strength than those of the control samples. The optimum compressive strength (2.98 $N/mm^2$) of the Calcium Chloride blended concrete blocks was achieved with 4% addition of Calcium Chloride. The compressive strength under $T_5$ (4% of $CaCl_2$) was 1.62 $N/mm^2$, 2.07 $N/mm^2$, 2.14 $N/mm^2$ and 2.98 $N/mm^2$ after 7, 14, 21 and 28 days, respectively. The mean separation results from SPSS showed that all the treatments were significantly different ($P<0.05$) from the control. It was therefore concluded that the Calcium Chloride admixture had a positive effect on the compressive strength development of the concrete blocks blended with Calcium Chloride.

There was an increase in compressive strength of all the Calcium Chloride blended concrete blocks with an increase in the curing period. The results showed an increase in compressive strength with an increase in the curing period. The concrete blocks under treatment 5 which were cured for 28 days recorded the highest value of compressive strength (2.98 $N/mm^2$), while the concrete blocks cured for 7 days under the same treatment reflected a compressive strength of 1.62 $N/mm^2$. Based on the significant variation of the compressive strengths under each different curing age; it was concluded that the curing period had a huge effect on the final compressive strength of the load bearing Calcium Chloride blended concrete blocks.

There was a relationship that was established from the study between water absorption and the proportion of Calcium Chloride admixture in the specimen. Treatment 4 (3% of $CaCl_2$), had the highest water absorption (12.8%), while the control Treatment ($T_1$) had the lowest water absorption (11.06%). The results indicated a clear trend that; the combined water contents absorbed by the concrete blocks increased with the Calcium Chloride content at all the hydration ages. This was attributed to the acceleration effect of Calcium Chloride on the hydration process of concrete.

## References

[1] Bentz, D. P.; Zunino, F. and Lootens, D. (2016). Chemical vs. Physical Acceleration of Cement Hydration. *Mater. Struct.* 38 (11): 37-44. https:www.ncbi.nlm.nih.gov. Accessed October, 2020.

[2] Camapanale, C.; Massarelli, C.; Savino, I., Locaputo, V. and Uricchio, V. F. (2020). Effects of Different Mineral Admixtures on the Properties of Fresh Concrete. *International. Journal of Environmental Research and Public Health* 2020, 17, 1212; 2-26. Accessed November, 2020.

[3] Legeto, C. K. (2018). Analysis of chemical admixture use on the quality of concrete. Thesis, jomo kenyatta university of agriculture and technology. Nairobi, Kenya.

[4] Kothari, A.; Habermehl-Cwwirzen, K.; Hedlund, H. and Cwirzen, A. (2020). A Review of the Mechanical Properties and Durability of Ecological Concretes in a Cold Climate in Comparison to Standard Ordinary Portland Cement-Based Concrete. *Materials* 2020, 13, 3467; doi: 10.3390/ma13163467. 2 -32.

[5] Maryoto, A.; Setijadi, R.; Widyaningrum, A. and Waluyo, S. (2020). Drying Shrinkage of Concrete Containing Calcium Stearate, (Ca(C18H35O2)2), with Ordinary Portland Cement (OPC) as a Binder: Experimental and Modelling Studies. Molecules Molecules 2020, 25, 4880; doi: 10.3390/molecules25214880. 2-32.

[6] Meagher, T.; Shanahan, N.; Buidens, D.; Riding, K. A., and Zayed, A. (2015). Effects of chloride and chloride-free accelerators combined with typical admixtures on the early-age cracking risk of concrete repair slabs. *Construction and building materials*, *94*, 270-279.

[7] Mohammed, T. U.; Ahmed, T.; Apurbo, S. M.; Mallick, T. A.; Shahriar, F.; Munim, A. and Awal, M. A. (2017). Influence of chemical admixtures on fresh and hardened properties of prolonged mixed concrete. *Advances in Materials Science and Engineering*, *2017*. https://www.hindawi.com/journals/amse/2017/9187627/. Accessed August, 2020.

[8] Odeyemi, S. O.; Anifowose, M. A.; Oyeleke, M. O.; Adeyemi, A. O. and Bakare, S. B.(2015) Effect of Calcium Chloride on the Compressive Strength of Concrete Produced from Three Brands of Nigerian Cement. *American Journal of Civil Engineering*. Vol. 3, No. 2-3: pp. 1-5.

[9] Prasath, K. S., Tamilselvan, T., & Manobala, R. (2019). Experimental Investigation On Mechanical And Durability Properties Of Concrete Incorporated With Quarry Dust. *International Research Journal of Engineering and Technology (IRJET)*, *6* (1), 1610-1614.

[10] Rahman, F. U. (2019). Role of calcium chloride in concrete. https://theconstructor.org. Accessed October, 2020.

[11] Williams, C. K.; Al Hatali, E. M. A. M. and Al Ajmi, N. S. (2020). A Study on the Mechanical Properties of Concrete by Partial Replacement of Cement with Calcium Chloride. *International Research Journal of Engineering and Technology (IRJET)*. Volume: 07 Issue: 08. 160-164. https://www.irjet.net/archives/V7/i8/IRJET-V71825.pdf. Accessed November, 2020.