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Original Article

Experimental Investigation on the Best Method of Reactivating a False/Flash Set Wet Concrete and Its Effects on the Hardened Phase

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Abstract - *Concrete that sets too fast or incorrectly needs reactivation to meet its original strength requirements. The research intends to determine the corrective means of reactivating a false/flash-set concrete to retain its properties in wet and hardened phases. The methodology involved the experimental design of concrete mix using CP 110 to calculate the target strength parameter and determine various quantities of material components required to achieve the designed strength. However, the quantifications and combination of material components until an even mix was obtained, the concrete mix matrix was divided into 4 portions. The first portion was used to mould 12 cubes, while the other 3 portions were allowed to set falsely for 3 hours before experimentation continued. The second portion was reactivated by remixing only with a mixer, and the third portion was reactivated by adding 10% of the initial amount of water. In comparison, the fourth portion was reactivated by adding 10% of the initial amounts of water and cement, respectively. The 48 concrete cubes were cured and tested at ages 7, 14, 21, and 28 days. The results indicated that water addition reduces the design strength by 44.32%. The best technique of reactivating false/flash-set wet concrete is either by adding exact water and cement (WCG) amounts, with a mean strength value of 29.48N/mm^2 or by remixing in a mixer without water (NWG), with a mean strength value 29.19N/mm^2. The research recommends further study to determine the exact water and cement amounts to be added to maintain the water/cement contents in the concrete mix design.*

Keywords - *Concrete mix matrix, Flash/false set concrete, Material component, Reactivating agent, Wet and hardened concrete.*

1. Introduction

According to [1], concrete could possibly be described as a construction material composed of carefully proportioned mixtures of cement, sand, gravel, and/or other aggregate materials combined with water, which hardens into a durable, shaped object suitable for various structural applications. The fresh form of concrete is well-defined by [2] as a newly produced material that can take any dimension and form. Characteristics of the newly formed concrete in its wet and/or hardened phase could be controlled by the quantities and qualities of different components materials used in its production, which include the following: cement types and grading, aggregates' particle sizes, shapes, and textures, water and any other admixture ("if necessary") [3, 4, 2, and 5]. Other factors that influence concrete characteristics in its wet and solid states include the consistency/evenness of the mixed material component matrix, the environmental condition of the mixtures in terms of moisture content, coldness and/or hotness of climate, starting from the time water reacts with cement till the completion of compaction and solidifications [2, and 5]. [6] highlighted that when the mix temperature of concrete is elevated, the mixing, placing, consolidating, and finishing of the concrete becomes difficult in hot weather.

1.1. Statement of Problem for the Research

During the construction of structures, wet concrete is often produced by batching and mixing the various constituent materials at a given proportion, then transported to the site or to where it will be transferred into the prepared formworks after which it will be compacted. The time frame from the moment of mixing (cement with water) to the time of full compaction might have caused the wet concrete to start setting (false or flash set) with respect to other surrounding conditions (humidity and temperature). To reactivate the fluidity and mobility of the false or flash-set wet concrete at the site, water is usually added for remixing, which could negatively influence the concrete's properties in the fresh and/or solid phase. This research aims to determine how adding water and cement (as reactivating agents) to reactivate false or flash-set concrete affects their properties, such as strength at the hardened phase.

1.2. The Research Aim

The study aims to determine the corrective means of reactivating a false or flash-set concrete without altering or affecting the properties of wet and hardened concrete or maintaining the mixed concrete's initial water/cement balance.

1.3. The Research Objectives include to

- Determine the consistency/workability and concrete's strength (in compression) made with normal design mix proportion of given characteristic strength value.
- Evaluate the consistency/workability and concrete's strength (in compression) that was allowed to set falsely or have a flash set for about 3 hours (after the initial mixing of the concrete), then reactivated by agitating or remixing with mixer only, no addition of an extra amount of water to it.
- Assess the consistency/workability and concrete's strength (in compression) that was allowed to set falsely or have a flash set for about 3 hours (after initially mixing the concrete), then reactivated by remixing with the addition of a predetermined amount of water as a reactivating agent.
- Measure the consistency/workability and concrete's strength (in compression) that was allowed to set falsely or have a flash set for about 3 hours (after initial mixing), then reactivated by remixing with the addition of a given quantity of cement and water as reactivating agent.
- Compare the results obtained from the objectives.

1.4. Limitations of the Study

The study is limited to reactivation of freshly batched concrete mix matrix that was allowed to set for 3 hours falsely/flashy before given treatments by remixing with a mixer (without adding extra water), with the addition of the given amount of water, and with the addition of given amounts of water plus cement. The cement is 42.5 grade produced by BUA cement (Nigeria), sand is from Ekulu Riverbed, and coarse aggregate is granite from Abakaliki, Ebonyi state, Nigeria.

A newly batched concrete mix matrix made up of various material components in given design mix ratios is transported, transferred, and compacted into prepared formwork during concreting work. However, the difference in time between the initial cement and water hydration and achieving full compaction might have caused the mixed concrete matrix to lose plasticity, leading to a false set triggered by environmental factors, including humidity, temperature, and weather conditions. Likewise, insufficient gypsum amount in cement can trigger the mixed concrete matrix to set quickly, leading to a flash set. This research investigates the optimal effective approaches for reactivating false or flash-set concrete by considering remixing or agitating with a mixer, addition of extra water, and addition of extra water plus cement as reactivation agents. The reactivation is focused on maintaining the concrete's properties, including workability, strength, and durability. Through the identification of the best techniques for reactivating false or flash set concrete, the research will offer construction industries and professionals valued comprehension on how to reenergise a concrete mix matrix that lost its plasticity or set more quickly than normal, thereby improving the production of concrete structures more with optimal performance in strength and durability.

2. Wet and Hardened Concrete Properties

The variations in the quantifications of the various material constituents consequently change the behavior and characteristics of the concrete, leading to various concretes in the solid phase. The chosen materials in concrete production determine the strength of such structure, and quantifying them should be specified in the standard format. The workability of fresh concrete is a multifaceted property encompassing three key characteristics: consistency, mobility, and compatibility [7 and 8]. By optimizing these three characteristics, concrete suppliers can deliver fresh concrete that is easier to handle, place, and finish, ultimately facilitating improved constructability and structural integrity. [9] highlighted that false set concrete is characterized by a rapid loss of workability shortly after mixing. Fortunately, further mixing without adding water can often restore its plasticity. [10] False set is typically more noticeable in concrete briefly mixed in stationary mixers and then transported to the formworks at the site in non-agitating equipment or when concrete is produced in a small on-site batch plant. However, in cases where concrete mixing continues for an extended period, such as mixing while in transit or remixed before placement or transport, as is common in concrete pumping operations, excessive early stiffening in the cement is less likely to cause problems. Meanwhile, quick or flash setting can be caused by inadequate or defective gypsum in Portland cement or an improper chemical composition of the clinker [10]. A significant heat release accompanies this type of setting and cannot be reversed by simply remixing the paste [9]. Nonetheless, the research focuses on the reenergizing of this flash set concrete mix matrix with the aim of reactivating its initial mix consistency, strengths in compression, and durability properties. [6] acknowledged that quickly mixed concrete for a short duration and not remixed before placing may become stiff, a phenomenon known as a brief mix set. Additionally, delays in placing the concrete, long transportation times, or holding the concrete mix matrix for extended periods can also lead to loss of workability. Furthermore, interactions between the various components of the concrete can also contribute to this loss of workability of freshly prepared concrete.

The climate conditions and moisture content for the curing duration dictate strength gain and govern the development of strength when Portland cement types are used in concrete production [11]. Aggregates (fine or coarse) comprise the largest proportion of the material's constituent parts. Cement's reaction with water gives an interactive chemical binder that bonds these aggregates together as a solid entity [1]. However, the presence of more water other than the initially determined quantities into the fresh concrete mix matrix is essential to enhance the fluidity and mobility of the concrete to be placed within the formwork and to cover the reinforcements placed in it before changing into the hardened phase. [1 and 2] further revealed that extra water addition to the concrete mix increases the concrete's workability for easy compaction at the site. The effects of common practices at sites during concreting work on the durability and compressive strength properties of fresh and hardened concrete cannot be overemphasized. It is worth mentioning that the level of supervision concerning the inspection of construction works and the carefulness taken in building them echoes the structural integrity and strength of the project.

Wrongful placement of reinforcements, inaccuracy in measuring dimensions of members, and inadequate placing and compaction of concrete introduce defects like voids and honeycombs ('bee hives'), which directly or indirectly affect the durability of such structures [1]. Porosity induced in concrete reduces its Mass and density. Long-term performance and durability depend on the environmental conditions, particularly moisture and temperature, during the critical hydration process. These conditions can impact the formation of hydrated compounds, porous structure, and, ultimately, the hardened properties of concrete, such as compressive strength, permeability, and resistance to degradation [12]. The temperature and moisture levels in the course of hydration are crucial to ensure the production of durable and long-lasting concrete structures. Despite its inherent durability, concrete exhibits a notable decline in fatigue resistance when exposed to water. The concrete's fatigue resistance is significantly compromised when tested underwater content, compared to testing in the absence of moisture [13].

This is primarily attributed to the concrete's pore structure, which accelerates degradation mechanisms such as chemical reactions, erosion, and crack propagation. As a result, the concrete's capability to endure repetitive loadings and stress cycles is compromised, ultimately leading to premature failure. This highlights the importance of considering environmental conditions, particularly moisture exposure and the content of samples when assessing the fatigue behavior and overall durability of concrete structures. In other words, testing conditions are critical.

[14] emphasized that strengths gained at the stage and attained at more or less in the future age under typical curing, together with the materials constituting the concrete, are associated, which could be assumed to have linear and logarithmic development index. The rate of development in concrete strength with known component materials and mix-proportions, placed in a conducive environment, absolutely increases with age in months tough at a reduced rate. Concrete workability is proportional to water content, as increasing water amounts facilitates easier mixing, placement, and finishing. However, the excessive water content can be detrimental, leading to a loss of cohesion and stability within the concrete matrix [6**]**. This can manifest as bleeding (water emerging on the surface) and segregation, where aggregate particles separate from the cement paste. Such phenomena can compromise the concrete's structural integrity, durability, and aesthetic appeal. Therefore, a precise balance between ensuring adequate workability and minimizing the risks associated with excessive water content must be met. However, for specifications, the 28th day is usually adopted by many codes [7], but a higher design strength may be necessary for some conditions where loads are not permitted to be on the concrete until they have reached a certain strength beyond 28 days [12]. According to [16] on 'design of normal concrete mix' [now 17, and 18], the strength development of concrete at various ages of testing is as listed below. It is presumed that at the expiration of each testing age (in days), the concrete structure might have gained some percentage in strength as presented: 40 – 50% of the ultimate design strength value on the 7th day, 60- 70% of the design strength value on the 14th day, 80 – 90% of the ultimate design strength value on the 21st day, and 100% of the ultimate design strength value on the 28th day. However, it is noteworthy to state clearly that [16] prediction values are more or less approximate. The true strength gains of concrete may perhaps be influenced by many factors, which include but are not limited to; 'mix design proportions, curing conditions and procedures, qualities and gradation of aggregates, water-cement content, testing method and cross section' [16, 2, and 5]. The percentage concrete's strength gains at which the mix design is a prerequisite to attain target strength in structures for various ages, according to [19], are as follows:

- 1 day-16%,
- 3 days -40%,
- 7 days-65%,
- 14 days -90% and
- 28 days – 99%.

A moderate quantity of water beyond that disbursed in the chemical hydration of water and cement yields voids within the pastes of cement. Nevertheless, the hardened cement paste strengths reduce, inversely a proportional manner, to the division of the total volume introduced in the pores. However, only the hardened part of the cement matrix offers resistance to subjected stresses, and there is a direct increase in strength since pores do not contribute to a stress-resisting mechanism. This is the main reason cement-paste strength relies on the initial water-cement fraction but reduces with an increase in water-cement fraction [1].

[20] examined how false set formation affects the properties of fresh cement paste mixtures that contain a high range of waterreducing admixtures. Two type s of cement from separate manufacturers were used, and the mixtures were formed by utilizing varying mixing times to observe the effects concerning false sets on their properties. The results showed that prolonging the mixing time had a positive impact on the rheological performance of the mixtures that were affected by false set formation. [9] emphasized that for concrete to be workable, the cement paste must stay fluid for a sufficient amount of time to facilitate adequate placement and finishing. [21] evaluated the intrinsic setting properties of cement for 3D printing, using normal concrete mix without making use of viable accelerators, to enhance surface finish, 'pumpability', and buildability. The findings revealed that flash setting boosts early strength gain; however, it decreases compressive strength in the long term. These effects become more intensified with higher OPC substitution rates with sodium aluminate.

3. Material and Research Methodology

The research approach taken in this study involved the experimental design of a standard concrete mix with a given target characteristic strength, as well as material constituents.

3.1. The Research Design

The experiment resolved to determine the best technique for reactivating a false or flash-set wet concrete matrix to prevent alteration of the initially designed concrete mix strength obtained from the mix design.

3.2. Constituent Materials: Cement, Sand, Granite, and Water

3.2.1. Cement

The type of cement used is Ordinary Portland Cement of 42.5 grade produced by BUA cement in Nigeria.

3.2.2. Sand

The fine aggregate was a mixture of medium and coarser particles obtained from the Riverbed (Ekulu River sharp sand). The fine aggregate was characterized to evaluate the particle size distributions, gradation and zoning, fineness modulus, 'specific gravity, and bulk density'.

3.2.3. Coarse Aggregate

The coarse-aggregated material utilized in the experiment was obtained from crushed granite stones of sizes 20mm and below. The crushed granite was characterized to determine its particle size analysis and gradation, rate of water absorption, and specific gravity.

3.2.4. Water

The water used was obtained from municipal water supply/ tap water that is portable and free from impurities.

3.2.5. Experimental Procedure

The standard concrete mix design was done using [13] code: The characteristic concrete strength value of 25 N/mm^2 was arrayed, while the calculated target means strength was obtained as 38 N/mm^2. The free-water content was 190kg/mm^3, and a water/cement ratio value of 0.52 was obtained. The slump value of range 10 – 30 mm was assumed, and the cement content value of 365.385kg/mm^3, fine aggregate content value of 599.23kg/mm^3, and coarse aggregate content value of 1273.38kg/mm^3 were calculated. The proportion of the mixed component materials of cement-fine aggregate (sand)-coarse aggregate is 1:1.64:3.49. The quantities of various selected constituent materials were obtained with respect to the total volume of concrete cubes that were moulded. The component materials were measured by weight, and the required quantities were thoroughly mixed until a consistent/uniform mixture was achieved. Then, slump tests were done on the wet concrete immediately after mixing. The wet concrete matrix was divided into four (4) portions for further experimentation. The first portion was used to form concrete cubes immediately after initial mixing for the first group. In contrast, the other three (3) portions were delayed and allowed to set falsely or have a flash set for about 3 hours before given reactivating treatments (remixing with no water, with a given quantity of water, and with water plus cement) for groups 2 to 4 sets of concrete cube specimens.

3.2.6. The Control (CT) Group

Group 1 is termed control group 1 (CT). From the first portion of the mixed concrete matrix immediately after blending, the slump tests were repeated three times, and the mean value was taken. The CT group was the first set of concrete cube samples to be moulded immediately after mixing the concrete mix matrix with the ratio of cement: sand: granite = 1:1.64:3.49. Twelve (12) sample concrete cubes were produced with square moulds of dimensions 150mm*150mm*150mm, and three (3) cubes were cured (by total immersion in water) and tested after the "7, 14, 21, and 28 days of curing" respectively.

3.2.7. The No-Water (NW) Group 2

The second group, termed NW, after 3 hours of false/ flash set of the wet concrete, the concrete matrix was given treatment by reactivating without adding anything to the matrix, just remixed/agitating with a mixer. The relative quantities of the component materials remain the same (1:1.64:3.49 and water-cement ratio of 0.52 initial value) as mixed before the false or flash set occurred. Slump testing was estimated three (3) times, and the average value was taken. Then, twelve (12) concrete cube samples were produced with steel square moulds of dimensions

150*150*150mm, and three (3) cubes were cured and tested respectively after the 7, 14, 21, and 28 days.

3.2.8. The With-Water (WW) Group 3

The third group, termed WW, after 3 hours of false or flash set of the wet concrete, the concrete matrix was given treatment by reactivating with a controlled amount of water (10% of the initial water content) into the concrete matrix, then remixed with a mixer. The component materials ratios remain the same (1:1.64:3.49) except for water content, which increased by 19kg/mm^3 (from 0.52 to 0.572), representing 10% of the initial water content.

This ratio decreases the amount of cement in this group (from the initial value of 365.385 to 209kg/mm^3). Slump testing was performed three (3) times, and the average value was determined. Then, twelve (12) cubes of concrete samples were formed with square moulds of dimensions 150mm*150mm*150mm, and three (3) cubes were tested respectively after "7, 14, 21, and 28 curing days" by immersing in a water tank at about 30^{o}C state.

3.2.9. The Water and Cement (WC) group 4

The fourth group, termed WC, after 3 hours of false/ flash set of the wet concrete, the concrete matrix was given treatment by reactivating with known cement and water amounts (10% of the initial water and cement contents respectively) into the matrix, then remixed with mixer. The cement weight increased by 36.53kg/mm^3 while the water content increased by 19kg/mm^3, representing 10% of their respective initial quantities.

The mix ratio becomes 1:1.49:3.17 while the ratio of water-cement is 0.572). Slump testing was conducted three (3) times, and the average value was taken. Then, the twelve (12) concrete cube samples were produced with steel square moulds of dimension 150mm*150mm*150mm, and three cubes were tested respectively after the following days of curing in the water tank: 7, 14, 21, and 28.

Curing Method

The 48 concrete cube specimens were cured by total immersion in the water curing tank for the respective testing days at a room temperature of 30^{o}C.

Testing Conditions of the Sample Concrete Cubes

The concrete cube samples were weighed immediately after removal from the curing tank and allowed to dry off (at room temperature of about 30^{o}C) for a day; they were reweighed before testing with a universal testing machine (UTM) of 1000B capacity, to determine their compressive strengths at their respective testing ages of "7, 14, 21, and 28 days".

The concrete cube samples were tested in dry conditions at a temperature of about 32^{0}C, and humidity value of 60%.

Figure 1 below presents the experimental design setup for a better understanding of how each group was reactivated.

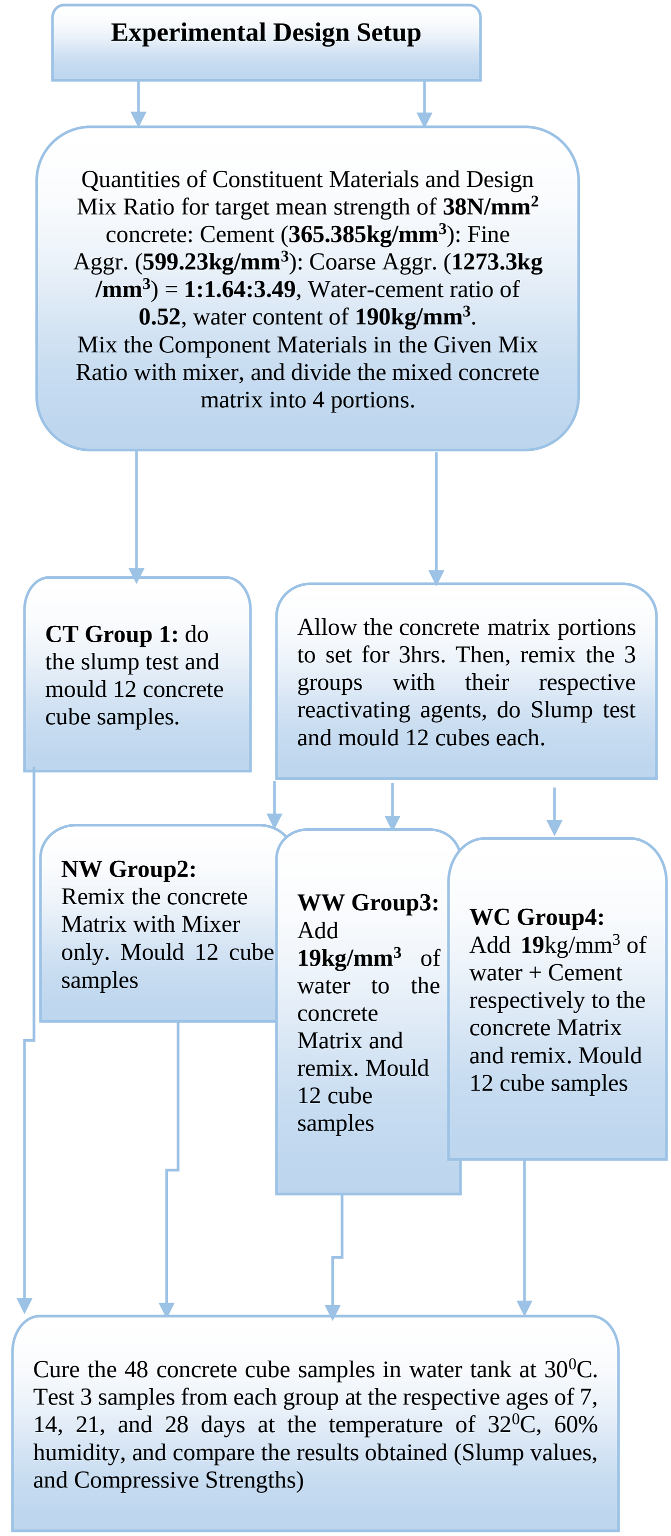

Fig. 1 Experimental procedure on how each group of the concrete mixed matrix was reactivated in the study

Method of Data Collection

The data observed from the experimental setup were collected from the following:

Characterizations of the fine and coarse aggregates used in the concrete mix design to determine their "particle size distributions, zoning and gradations, fineness modulus, wet and dry density, specific gravity, and water absorption rate".

The slump tests of various wet concrete mix matrix reactivating groups were taken immediately after remixing or reactivation to evaluate their consistencies/uniformity.

The weight of various concrete cube samples from the 4 groups was determined immediately after removal from the curing tank and reweighed 24 hours before crushing. The values were used for water absorption analysis of the concrete samples in solid form to evaluate their durability. The compressive strengths of the concrete samples were obtained/observed after crushing with UTM for the respective testing days of 7, 14, 21, and 28, as stated before.

Method of Data Analysis and Validation

Statistical techniques were applied to test and validate the collected data. ANOVA-Test was used to compare results observed from various reactivation groups/methods and likewise test the formulated hypothesis for significant difference at 95%.

4. Results Presentation and Discussions

The following results were observed from the experiments on the best method of reactivating flash/false set concrete.

Table 1. Characteristics and Experimental Results of the sample groups and age of testing

		Failure Loads (kN) (With respect to testing age, 'day')				Mean Weight of samples (Kg)	Mean Density of samples (Kg/m^3)
Groups	**Age (days)**	**7**	**14**	**21**	**28**		
CT.g1		498.7	711	765.6	830	8.9997	2666.5778
		476.1	680	736.8	790		
		499.6	719	779.8	840		
NW.g2		350.2	497	540.6	580	8.4347	2499.1704
		393.5	563	598	650		
		443.6	635	690.2	740		
WW.g3		249.8	365	388.8	420	8.5893	2544.9778
		234.8	336	349.9	380		
		299	447	460	500		
WC.g4		399.5	577	617.2	660	8.647	2562.074
		362.4	520	498.4	580		
		452.8	645	699.5	750		

Table 1 above presents the results (loads at failure, weight, and density of the concrete sample cubes) of experiments conducted on the best method of reactivating a flash/false set wet concrete using different techniques as reactivating agents at respective testing ages (in days). From the table, the control group (CT. g1) gave the maximum values of the failure load at every testing age, followed by WC. g4 and NW. g2 group. The CT. g1 has a mean weight value of 8.9997kg and a mean density of 2666.578kg/m^3.

The sample group reactivated with water and cement group (WC. g4) has a mean weight of 8.647kg and a mean density of 2562.074kg/m^3. The sample group reactivated with No-water (NW. g2) (remixed with mixer only) has a mean weight value of 8.4347kg and a mean density of 2499.17kg/m^3. The sample group reactivated with water (WW. g3) has a mean weight of 8.5893kg and a mean density of 22544.98kg/m^{3,} which gave the lowest load values at failure at every stage of the testing age. The results imply that introducing water only to a false or flash-set wet concrete as a reactivating agent reduces the capacity of concrete to resist stresses and load-bearing ability. The strength properties of hardened phased concrete at every stage of strength development were negatively influenced by water addition. The use of water alone in reactivating false or flash-set concrete should be discouraged during concreting / construction work as it reduces the load-bearing capabilities of concrete. Nevertheless, the WC. g4 and NW. g2 groups gave values that were within the same range. The results indicated that either of the two techniques could best reactivate flash/false set concrete. However, the actual amounts of water and the equivalent quantities of cement to be added during reactivation must be determined through further research for optimal values.

Table 2. Results of the slump and compressive strength test values of the concrete samples after curing and testing for the respective ages.

S/N	Compressive Strength (N/mm^2) (With respect to testing age, 'day')				Average Slump value (mm)
Age of test (days)	**7**	**14**	**21**	**28**	
CT. g1	22.1644	31.6	34.0267	36.8889	21
	21.2922	30.2222	32.7467	35.1111	
	22.2044	31.9556	34.6578	37.3333	
Mean:	21.887	31.2593	33.8104	36.4444	
Standard Dev.:	0.298	0.529	0.562	0.679	
NW. g2	15.5644	22.0889	24.0267	25.7778	5
	17.4889	25.0222	26.5778	28.8889	
	19.7156	28.2222	30.6755	32.8889	
Mean:	17.5896	25.1111	27.0933	29.1852	
Standard Dev.:	1.199	1.77	1.94	2.06	
WW. g3	11.1022	16.2222	17.28	18.6667	48
	10.4356	14.9333	15.5511	16.8889	
	13.2889	19.8667	20.4444	22.2222	
Mean:	11.6089	17.0074	17.7585	19.2593	
Standard Dev.:	0.86	1.48	1.43	1.57	
WC. g4	17.7556	25.6444	27.4311	29.3333	28
	16.1067	23.1111	22.1511	25.7778	
	20.1244	28.6667	31.0889	33.3333	
Mean:	17.9956	25.8074	26.89	29.4815	
Standard Dev.:	1.17	1.61	2.59	2.18	

Table 3. Results of the corresponding percentage gain in the strength development at various testing ages of the concrete samples in the solid phase.

Groups	% gain in strength (with respect to testing age (days))				% Difference between CT.1 and others at 28 days	% difference between WW. g3 and NW. g2, WC. g4 at 28 days
Age of test	**7**	**14**	**21**	**28**	**% loss in strength**	**WW. g3 - NW. g2, WW. g3 - WC. g4.**
CT.g1	57.6	82.26	88.97	95	-	-
NW.g2	46	66	71	76.8	18.2	+26.12
WW.g3	30.55	44.76	46.73	50.68	44.32	-
WC.g4	47.36	67.91	70.76	77.59	17.41	+26.91

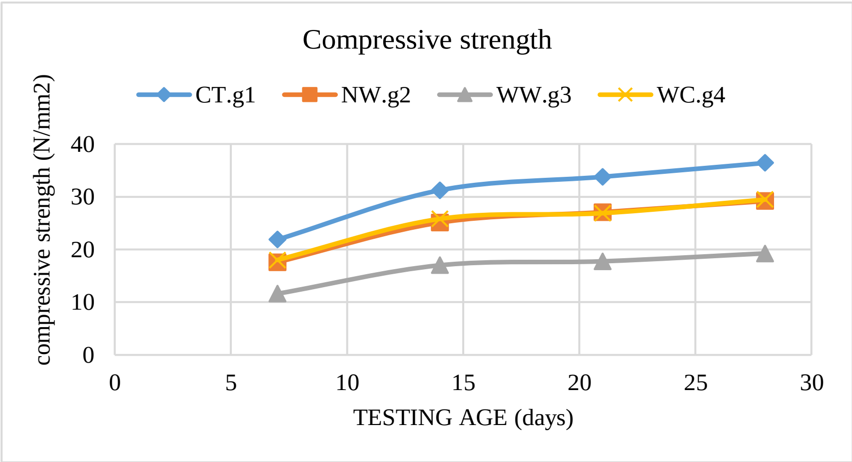

Fig. 2 The Concretes compressive strength development with age

Table 2 above shows the compressive strength test results, with the slump test values of various reactivation groups obtained from the experimental design on the best methods of reactivating a false/flash set wet concrete matrix. From the table, control group CT. g1 gave the maximum compressive strength value at all the stages of testing age, while the with-water group (WW. g3) yielded the lowest strength value in compression. These results indicated an interactive influence between the increase in free-water content in the concrete mix matrix and the strength properties of the hardened concrete. This increase in water content decreases the concrete structure's strength. Nevertheless, the augmentation in water with an equivalent increase in cement content improved positively on the concrete's strength in the hardened phase as demonstrated in the Water and Cement group (WC. g4). The values of the slump test indicated that the Control group (CT. g1) and the Water-Cement group (WC. g4) wet concrete mix matrix have a true-slump characteristic of values 21mm and 28 mm, respectively. The With-Water group (WW. g3) have a collapsed-shaped slump characteristic of value 48mm while the No-Water group (NW. g2) has a shear/harsh slump characteristic value of 5mm, indicating loss of mobility.

Tables 2 and 3 above contain the mean strength in compression and percentage gain in strengths at various testing ages of the concrete sample cubes for different reactivation groups. Table 2 revealed that the control group CT. g1, on the 7^{th} day, the concrete cubes obtained an average mean compressive strength of 21.887 N/mm^2, which signifies about 57.6 percent of the initially designed target mean characteristic strength from the normal mix design, as presented in Table 3. The standard deviation value is 0.298. On the 14^{th} day test, the concrete samples developed mean compressive strength values of 31.2593 N/mm^2, representing 82.26 percent of the initial target mean strength, standard deviation (SD) value of 0.529. On the 21^{st} day test, the concrete samples developed mean compressive strength values of 33.8104 N/mm^{2,} representing 88.97 percent of the initial target mean strength and an SD value of 0.562. At the 28-day test, the mean strength in compression was 36.4444N/mm^{2,} representing 95% of the initial target mean strength and an SD value of 0.679.

Tables 2 and 3 also indicated that the No-Water group (NW. g2) at the 7th-day test gave an average mean compressive strength value of 17.5896 N/mm^2, representing 46 % of the initial target mean strength and an SD value of 1.199. The 14th-day test gave an average mean strength value of 25.1111 N/mm^2, representing 66% of the initial target mean strength and an SD value of 1.77. On the 21^{st} day test, the average mean strength value was 27.0933 N/mm^2, representing 71% of the initial strength with an SD of 1.94. Results of the 28th-day test predicted that the average mean strength of concrete in compression was 29.1852 N/mm^2, representing 76.8% of concrete's initial characteristic design strength and an SD value of 2.06.

From Tables 2 and 3 above, it was demonstrated that the With-Water group (WW. g3) at the 7th-day test gave an average mean compressive strength value of 11.6089 N/mm^2, representing 30.55 % of the initial target mean strength and SD value of 0.86. The 14th-day test gave an average mean strength value of 17.0074 N/mm^2, representing 44.76 % of the initial target mean strength, with an SD of 1.48. At the 21st-day test, the average strength value was 17.7585N/mm^2, representing 46.73% of the initial strength and an SD value of 1.43. The 28th-day test predicted that the average mean strength of concrete was 19.2593 N/mm^2, representing 50.68 % of the initial characteristic designed strength of concrete with an SD value of 1.57. Furthermore, Figure 2 above displays a pictorial view of the compressive strengths of concrete cube samples against the various testing ages from the treatment groups for better comprehension, comparison, and appraisal.

Likewise, in Tables 2 and 3 above, the Water-Cement group (WC. g4) at the 7th-day test gave an average mean compressive strength value of 17.9956 N/mm^2, representing 47.36 % of the initial target mean strength with an SD value of 1.17. The 14th-day test gave an average mean strength value of 25.8074 N/mm^2, representing 67.91 % of the initial target mean strength with an SD value of 1.61. At the 21st-day test, the average mean strength value was 26.89 N/mm^2, representing 70.76% of the initial strength, with a value of SD 2.59. In contrast, the 28th-day test predicted that the average mean strength of concrete was 29.4815 N/mm^2, representing 77.58 % of the initial design strength, with a value of SD 2.18. However, the ANOVA Test was used to test for significance at 0.05 level of significance, and the results were observed using the 4 different techniques of reactivating false or flash set concrete at various testing ages, respectively. For the 7th-day test results, the mean compressive strength of concretes indicated a significant variation: F-Cal (19.8)>F-Crit (4.066), P-value 0.000462. The 14^{th} and 21^{st} day tests likewise demonstrated a substantial difference in their mean strength values observed from the 4 techniques/groups used in reactivating the false or flash-set concrete, as indicated with ANOVA F-Test results:

F_{Cal} (16.88)>F_{Crit} (4.066), P- value 0.0008022, 14^{th} day,
F_{Cal} (13.5)>F_{Crit} (4.066), P- value 0.0001688, the 21^{st} day respectively. From the 28th-day test, a statistically notable difference existed in the mean compressive strength values observed from the groups, as revealed by the ANOVA Test: F_{Cal} (16.77)>F_{Crit} (4.066), P- value 0.000822 on 28^{th} day.

The presented results in Table 3 specified that adding extra amounts of water as a reactivating agent reduces the designed strength by about 44.32% while adding extra amounts of water with the equivalent quantity of cement and remixing with a mixer as a reactivating agent improves the design strength by about 26.12%. The result conforms to the [8] report that excess water in the concrete damages its properties at the hardened stage. The results observed align with the reports by [19] on the range of percentage gain concerning testing ages in all the groups, except the group reenergized with water only, which is below the specified percentage ranges stipulated. However, more research is needed to evaluate the water and cement quantities to be added to obtain optimum quality concrete mix. The results indicated that exposing a wet concrete matrix to set falsely or flashy for 3 hours reduces the strength. Still, reenergizing/remixing with water further decreases the performance and longevity (though with increased workability). The result is in accord with findings by [21] that flash set decreases the concrete’s strength in the long term. Nevertheless, reenergizing the false or flash set wet concrete with no water (just remix with a mixer) and with cement and water (given amount of cement and water) improved the strength to about 26.12% and 26.91%, respectively, compared with values obtained when reactivated with water alone at the testing age of 28 days. This result is consistent with findings obtained by [20] that prolonging the agitation or mixing time had a beneficial effect on the rheological characteristics of the mixtures that were affected by false set formation. The properties were amply enhanced concerning consistency and strength.

The practical implication of the results for construction practice is that a delay in the placement of wet concrete for about 3 hours will negatively affect the concrete’s properties in its wet and hardened phases, including consistency / workability, strength, and durability. This delay leads to a loss of workability, affecting the ease of placing and achieving full concrete compaction. It induces voids, which decreases the hardened concrete’s durability. Using water alone as the reactivating agent for false or flash-set concrete should be discouraged during construction as it decreases the performance and resilience of the hardened concrete. Though it enhances its workability, the reduction in strength and durability properties of concrete is enormous. However, since remixing or agitating a false set of concrete improves the workability and strength of the concrete, construction practices should adopt the transportation of freshly batched concrete mix in a mixer that can remix or agitate the wet concrete before placing it inside formworks or moulds. Nevertheless, flash set concrete, according to the results obtained, can best be reactivated by remixing the concrete mix matrix with given amounts of cement and water, which improves the workability, strength development, and quality of the concrete at both wet and solid phases.

The outcome of this study can be improved upon through further research by evaluating the precise cement and water or (admixture) amounts to be added into a flash or false set concrete for reactivation and optimal performance and production of high-quality concrete structures.

5. Conclusion and Recommendations

The following conclusions and recommendations were drawn from the results presented and discussed on the best techniques of reactivating a false or flash set wet concrete using water, no water, and water plus cement as reactivating agents.

5.1. Conclusion

The results of this research showed that a delay in the placement and compaction of the wet concrete mixed matrix for 3 hours leads to a loss in plasticity and reductions in strength and durability properties at the hardened phase.

The strength properties of concrete (in its hardened phase) at every stage of strength development were negatively influenced by adding extra water. Using water as a reactivating agent in false/flash set wet concrete decreases its ability to withstand applied stresses and loads.

A flash/false set of concrete could be best reactivated by either remixing with a mixer only (no water is added) or by adding exact amounts of water and cement content into the concrete mix matrix as the ultimate technique. However, the actual amounts of water and the equivalent quantities of cement to be added during reactivation must be determined through further research for optimal results.

The results specified an interaction effect between the increased free-water content in the concrete mix matrix and the strength properties in its hardened phase. From the observed results, allowing a wet concrete matrix to set falsely or flashy for about 3 hours decreases its strength at the hardened stage.

The results also established that adding extra amounts of water as a reactivating agent reduced the designed strength by about 44.32% at the 28 days, while adding an extra amount of water together with the equivalent quantity of cement as an agent of reactivation boosts the design strength at every testing age. Likewise, remixing, agitating or reactivating with neither water nor cement boosts the designed strength, although with lost plasticity/workability.

5.2. Recommendation

The research recommends two ultimate approaches for reactivating flash or false set concrete: (1) adding specific quantities of water and cement and/or (2) remixing/reactivating or agitating the mix with a mixer only.

The study, conversely recommends further research on determining the actual amounts of water and the equivalent quantities of cement to be added during reactivation for optimal quality of concrete mix design during construction.

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