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# Effect of Jaggery on the Properties of Concrete

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***Abstract:*** ***Concrete is a composite material used because all imaginable design structures are made of concrete. The report emphasizes that using locally available materials such as jaggery may improve concrete features. The test was completed to test the quality properties of the concrete using Jaggery as a mixer in the creation of the concrete. These types of blends are often used as part of unusual cases such as large wharves and long piles. Four different levels of admixtures (Jaggery) were selected for testing as 0.5%, 1%, 2%, 2.5%, 3%, 3.5%, 4%, 4.5% and 5% by weight of cement by M25 grade, mix design concrete. Finally, it was thought that the performance and compressive strength of the concrete were improved when Jaggery mixtures were applied to the concrete mix.***

***Keywords: Jaggery, Concrete, Consistency, Setting Time, Slump Value., Compaction Factor, Compression, Scanning Electron Microscopy***

## I. INTRODUCTION

Cement concrete is the utilized material nowadays and in effect broadly utilized as a part of more prominent amounts than some other man-made materials of development in the field of Civil Engineering. The times of incredible Engineering advancement and the expected request of future social orders have required the need to use the mechanical waste and results to accomplish a high economy. Next to each other some methods for the safe transfer of such a material which can cause natural contamination is found. Understanding that the waste and side-effect of the sugar industry may found a reasonable admixture with cement and other restricting materials. It can substantiate itself in the field of development material examination, especially for the main sugar delivering countries of the third world like India, Ghana, and so forth. In such nations, sugar ventures are broadly conveyed all through the length and expansiveness making the crude material effectively accessible. Perceiving the need, a progression of investigations were led to think about the impact of Molasses on concrete, which is one of the four sorts of misuse by the sugar industry. Retarders are utilized as a part of the concrete piece to enhance the setting time and to expand the temperature of the creation with various sorts of admixtures. Utilization of these admixtures will diminish the isolation and dying. Sugar is a starch, a substance made out of carbon, oxygen, and hydrogen. Jaggery is produced using the result of a sugar stick. In this way, both are valuable to include as an admixture in the concrete creation.

### *A. The Objective of this Project is as Follows*

The purpose of this study is to determine how jaggery affects visual structures. To improve concrete features such as performance and compressive strength a mixture such as a jaggery is added to the concrete. Jaggery increases efficiency, durability, and compression strength as your volume in the concrete mix increases. After adding jaggery to the concrete the hydration process is reduced and therefore the drying time of the concrete is increased. The hydration process is an exothermic process in which heat is extracted from concrete mixed with concrete sets. This hydration process takes games between water and other concrete ingredients. Cement plays a very important role in concrete. Consumption of cement in all fields is increasing day by day. The main purpose of this paper is to improve the current concrete structures by adding jaggery as a mixture to the concrete in part. As jaggery is readily available and natural materials that make buildings more environmentally friendly and environmentally friendly. Jaggery does not produce a negative effect on the environment and keeps the environment clean and healthy. Water in concrete helps to improve the performance of concrete but its strength is reduced. That is why it is necessary to use mixtures that increase the performance of concrete but do not reduce the strength of concrete. Under normal weather conditions, the cement lays and hardens when water is added to it. To get the right concrete strength you need to set it right by taking the right time to drain the water. Sometimes due to weather conditions, the concrete mix gets delayed in its drainage process and arrives late, and does not get the proper power so that cracks and other problems can occur in the buildings. So that there is a need to use retarders in the concrete to lay the concrete properly and to get the right strength.

 

A well-known natural compound found in a jug-like environment is used to improve the performance and strength of concrete as shown in Fig.1. Jaggery is used as a concrete cutter that enhances its hydration environment and concrete sets at the right time and gets its proper strength. When used in very small quantities jaggery affects the setting time of the concrete. Jaggery helps during concrete setting as a retarder in the following ways.

*1)* The hydrolysis process begins slowly due to the formation of a protective skin of the compound that returns to the surface of the cement particles.

*2)* Increased melting and production of calcium hydroxide nuclei are impaired due to the formation of calcium ion complexes.

## II. LITERATURE REVIEW

TABLE I
LITERATURE REVIEW

| Sr. No. | Title of Paper | Name of Journal & Issue | Author Details | Findings | Remark |
|---|---|---|---|---|---|
| 1. | Effect of Sugar and Jaggery on Strength Properties of Concrete | The International Journal Of Engineering And Science (IJES) 2(10).,2013 | V. Giridhar et al., (2013) | Deterioration value, compaction factor, and compressive strength have a high value in 0.1% sugar and jaggery. | Excellent performance and compelling power are available. |
| 2. | Effect of Sugar, Jaggery & Sugar Cane Ash on Properties of Concrete | International Journal of Scientific Engineering and Technology Research 4(51),2015 | A. V. Pavan kumar et al., (2015) | The fall is observed at a dose of 0.1%. The highest rate of dehydration, compaction factor, and the set time is found in a dose of 0.125% sugar and jaggery. The maximum amount of stress-energy is achieved in 0.075% sugar and jaggery. | With the rise of the mix, the structures are also improved. Falling deterioration is evident. |
| 3. | Study on Strength of Concrete by Adding Jaggery | IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 14(5)., (2017) | Fouziya Qureshi et al., (2017) | Good consistency, drop rate, binding factor, and compressive strength are obtained with a dose of 0.4% jaggery. The highest values of flexural & split tensile are obtained with a volume of 0.1% jaggery. | Fall falls are observed, performance and pressure forces increase and the separation is small. |
| 4. | Effect of sugar and jaggery on workability and compressive strength of concrete | International Journal of Advanced Research in Science & Engineering 07 (03)., 2018 | Shah et al., (2018) | At a 1% dose of jaggery, the amount of dehydration and stress on day 7 and day 28 is found to be higher than 1% sugar. | Jaggery can be used as a retarder to extend the laying time of concrete. |
| 5. | The behavior of a New Concrete Composition with Jaggery as Admixture | International Journal of Innovative Technology and Exploring Engineering (IJITEE) 08 (10)., (2019) | International Journal of Innovative Technology and Exploring Engineering (IJITEE) 08 | Deterioration value and compact factor high in 0.75% jaggery volume. Flexible and shear strength is most commonly obtained with a 0% dose of jaggery. | The performance and strength of concrete are improved. The setting also increases and the separation is also smaller. |

| | | | | | |
|---|---|---|---|---|---|
| | | | (10)., (2019) | | |
| 6. | Effect of sugar on setting time of cement and compressive strength of concrete | Proceedings of 2nd International Conference on Research and Innovation in Civil Engineering (ICRICE) ( 2020) | A. K. Azad et al., (2020) | It is noteworthy that up to 0.08% of sugar both in the first and last set of growth gradually increases over that set time increases significantly. The compression strength of the concrete was found to increase satisfactorily at 0.08% sugar. | Setting time gradually increases to 0.08% of sugar. The depressant energy grows satisfactorily throughout the entire healing period among all the percentages of sugar consumed. |
| 7. | Effect of sugar and jaggery on properties of concrete | International Research Journal of Modernization in Engineering Technology and Science 3 (6)., (2021) | Ahsan Aziz (2021) | With the desired results the processes of mixing sugar and jaggery with concrete, the amount of water-cement, the percentage of the mixture, etc. are modified in this study and research compared to previous research on the same topic and similar items. | This paper discusses the impact of Sugar and Jaggery on concrete materials. |

*A. Research gap*

*1)* Adding the 0.5, 1, 2, 2.5, 3, 3.5, 4, 4.5, 5 percentage of jaggery by the percentage of cement as an admixture.
*2)* All other previous studies added the jaggery by various percentages except these.
*3)* Various researchers added the admixtures like sugar, jaggery, and sugarcane bagasse ash in combination but in this investigation, only jaggery is used as an admixture.
*4)* Using only jaggery as an admixture will give great results as compared to adding a combination of sugar-jaggery, sugar-jaggery-bagasse ash, or only sugar or only bagasse ash as an admixture.
*5)* In this project the Scanning electron microscopy test is also performed to investigate the internal structure of the concrete.

## III. MATERIALS AND METHODOLOGY

*A. General*

The purpose of this study is how jaggery affects concrete structures. The admixture & design mix volumes are determined by performing specific tests; all these tests and procedures are discussed in this chapter. The quality of the cement, the absorption capacity of the aggregates, the sand area, the density of the aggregate, and the excess moisture of the aggregate all these properties are given prominence in this investigation.

Subsequent tests were performed to determine the concrete properties.

*1) Consistency test of cement*
*2) Setting time of cement*
*3) Slump cone test*
*4) Compaction factor test*
*5) Compressive test*
*6) Scanning Electron Microscopy test (SEM)*

*B. Materials*

The materials used in this project are good ratings, standard Portland cement, wage rates, mixes, and water.

*1) Portland Standard Cement:* Portland Standard 53 General Cement compliant with IS: 12269 used. Cement has a binding surface for use in making concrete. Cement is the most important part of concrete.
*2) Fine Aggregates:* Fine aggregates mean natural sand or crushed sand. Natural sand is found after digging into a river that is easily accessible. The cost of sand is high due to the cost of transportation so especially nearby sand is popular. A filter over 4.75 mm IS is taken from this function. Fine aggregates help to fill the gaps in concrete so that the empty is filled with fine aggregates.
*3) Coarse Aggregate:* Ground aggregates are known as coarse aggregates. The volume of concrete depends on the volume of aggregate salts taken from the mixture.

4) *Water:* Clean portable water should be used for mixing concrete. Water is the most important ingredient in concrete. Water used for concrete should be clean and portable and free of acids. The hydration process is an exothermic process that occurs as a result of water mixing with other concrete ingredients. Cement water is an important element in the mixing of concrete. As the water level rises the performance of the concrete increases but the strength of the concrete decreases.
5) *Jaggery:* Local jaggery will be used as a mixture in concrete. Jaggery should be added to the concrete to some extent to improve the concrete structures which lead to quality construction and require a minimal cost. Jaggery has a good binding area. Jaggery is an admixture is used to improve concrete structures. Jaggery is a natural product made from sugarcane that helps maintain a friendly climate. This product does not harm the environment and does not cause any pollution. So this project uses these natural products to keep the construction level at a very low cost.

Fig. 1 Jaggery (Admixture)

*C. The Impact of Ambient Atmospheric Conditions on Changing Physico-Chemical Structures of Stored Jaggery*

Moisture changes in stored jaggery. The degree of stored jaggery depends on the presence of moisture that allows for the variability and development of different types of fungi and bacteria leading to change in color due to the formation of organic acids and complex decay of jaggery. -5 and below, in addition to this moisture micro-organisms begin to work leading to rapid decay. At the end of the day, jaggery contains a moisture content of 12 percent (d.b) and gradually decreases to about 5 percent by the end of 90 DAS under laboratory conditions throughout treatment. The moisture of the jaggery was kept open, engraved with relatively high humidity (>5 according to cent) on the stop of ninety DAS. Probably due to the direct contact of the area of jaggery kept open with the surrounding air and the Effect of Ambient Atmospheric that allowed the absorption of moisture from the environment. The moisture content of the jaggery was directly proportional to its location, the difference in the vapor content of the jaggery, the surrounding atmosphere, and the time when the jaggery was exposed to such air.

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*D. Change the hardness of the stored jaggery*

The strength of the jaggery depends largely on the humidity levels. High humidity jaggery softens and deteriorates quickly.

*a. Details:-*

Mix Proportion = M25 (1: 1: 2)
Type of cement = OPC 53 Grades (Confirmation at IS 8112)
Partial change type = Jaggery
Some gravity strength of cement = 3.15 (Test - IS: 2720)
Fine gravitational fine aggregates = 2.74 (Test - IS 2386)
Some coarse aggregates = 2.74 (Test - IS 2386)
Direct gravitational force for jaggery = 1.33 - 2.97
Combined water absorption = 0.5% (Test - IS 2386)
Water absorption of good mix = 1% (Test - IS 2386)
Size limit measurements = 20mm
pH for jaggery = 6.8
Moisture content of jaggery= 11.2 %
Minimum amount of cement = 300 kg (Table 5-IS456)
Maximum cement capacity = 450 kg (In terms of clause 8.2.4.2)
Maximum W / C = 0.5 (Table 5-IS456)
Sieve Analysis (Test-IS 2386)
Solid integration (Verification in Table 2-IS383)
Fine aggregate-zone II (Confirmation in Table 4-IS383)
Accepted water content = 190 L
Needed cement = Water content
W / C rating
= 190 / 0.5 = 380 kg
Coarse aggregate rate = 0.62
Final fine aggregate ratio = 0.38

*b. M25 concrete figures:*

A. Capacity of concrete = 1 m3
B. Total cement volume = Cement / (S.G. * 1000)
=380 / (3.15 * 1000)
= 0.121 cu.m
C. Water volume = 0.190 cu.m
D. Total demand value = 0.689 cu.m
E. Solid weight = 1171 kg

F. Good amount = 717 kg
G. Weight = 0.190 * 103
= 190 L (In terms of clause 4.2)
H. Weight of cement = 380 kg (In terms of clause 4.2)
Block size = 150 * 150 * 150 mm
= 0.003375 m3
Weight of cement = 1.28 kg
Weight of solid aggregate = 3.952 kg
Fine weight aggregate = 2.42 kg
Water weight = 0.64 L

*E. Tests on properties of concrete*

*1) Slump Cone Test*


Fig. 2 Slump cone test

*2) Compaction Factor test*


Fig. 3 Compaction factor test

*3) Compressive Strength of Concrete*


Fig. 4 Freshly prepared concrete blocks

Fig. 5 Compression test on hardened blocks

*4) Scanning Electron Microscopy test (SEM)*

Fig. 6 Samples for SEM test

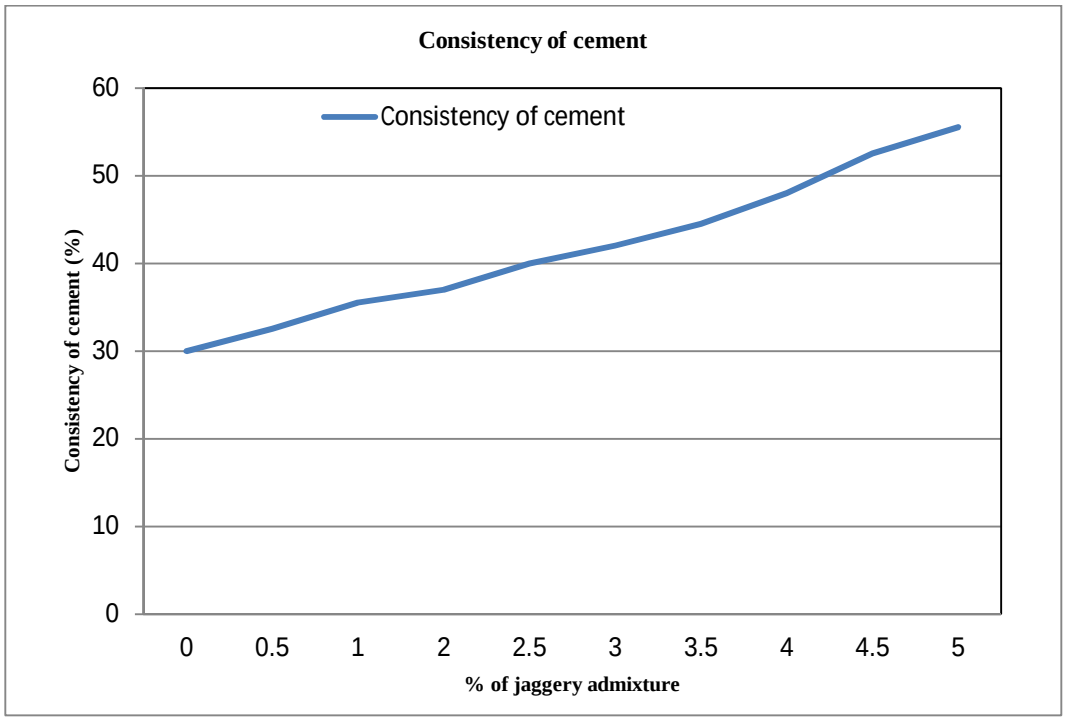
## IV. RESULT DISCUSSION

*A. Discussions On Results Of Consistency Of The Cement Containing Jaggery*

It is noteworthy that the average water level in cement for general consistency is between 26% and 34%. The pastes used as a mixture of 0.5%, 1%, 2%, 2.5%, 3%, 3.5%, 4%, 4.5%, 5% of jaggery as an admixture showed an increase in consistency as compared to normal consistency.

Table II
Consistency Of Cement Containing Jaggery

| Sr. No. | Percentage of Jaggery | Consistency % |
|---|---|---|
| 1 | 0 | 30 |
| 2 | 0.5 | 32.5 |
| 3 | 1 | 35.5 |
| 4 | 2 | 37 |
| 5 | 2.5 | 40 |
| 6 | 3 | 42 |
| 7 | 3.5 | 44.5 |
| 8 | 4 | 48 |
| 9 | 4.5 | 52.5 |
| 10 | 5 | 55.5 |



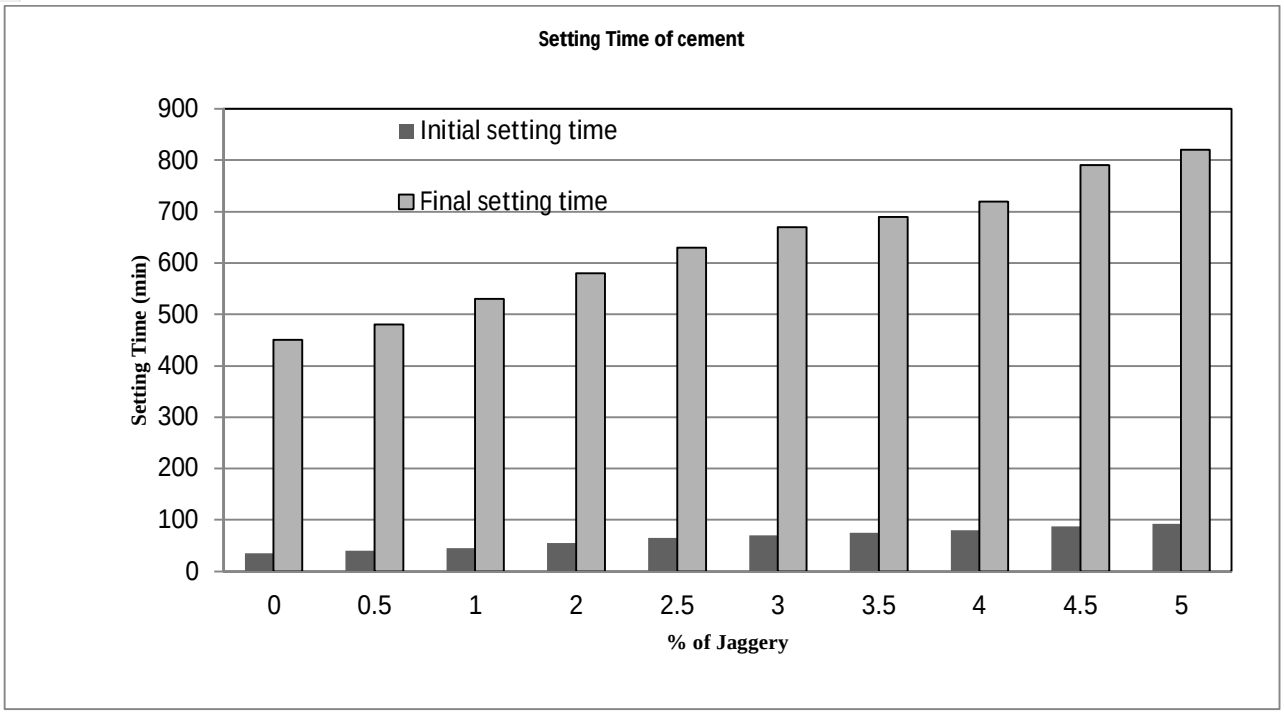

Graph 1: % of jaggery as an admixture vs. consistency of cement graph

*B. Discussions on Results of initial and final setting time of the cement containing jaggery*

The Indian standard limits the initial set time of concrete to not less than 30 minutes and the final set time not to exceed 10 hours. The results of the set time in Table.5 showed that the increase of jaggery affected the preparation; however, this obstacle was within the intersections as indicated by the Indian standard. As the content of the jaggery is extended the set time showed an add-on pattern which means as the percentage of the jaggery admixture increased in the concrete mix the initial and final setting time of the cement also increased gradually.

Table III
Initial And Final Setting Time Of Cement Containing Jaggery

| Sr. No. | % of Jaggery | Initial Setting Time (min) | Final Setting Time (min) |
|---|---|---|---|
| 1 | 0 | 35 | 450 |
| 2 | 0.5 | 40 | 480 |
| 3 | 1 | 45 | 530 |
| 4 | 2 | 55 | 580 |
| 5 | 2.5 | 65 | 630 |
| 6 | 3 | 70 | 670 |
| 7 | 3.5 | 75 | 690 |
| 8 | 4 | 80 | 720 |
| 9 | 4.5 | 88 | 790 |
| 10 | 5 | 92 | 820 |




Graph 2: % of jaggery vs. setting time of cement

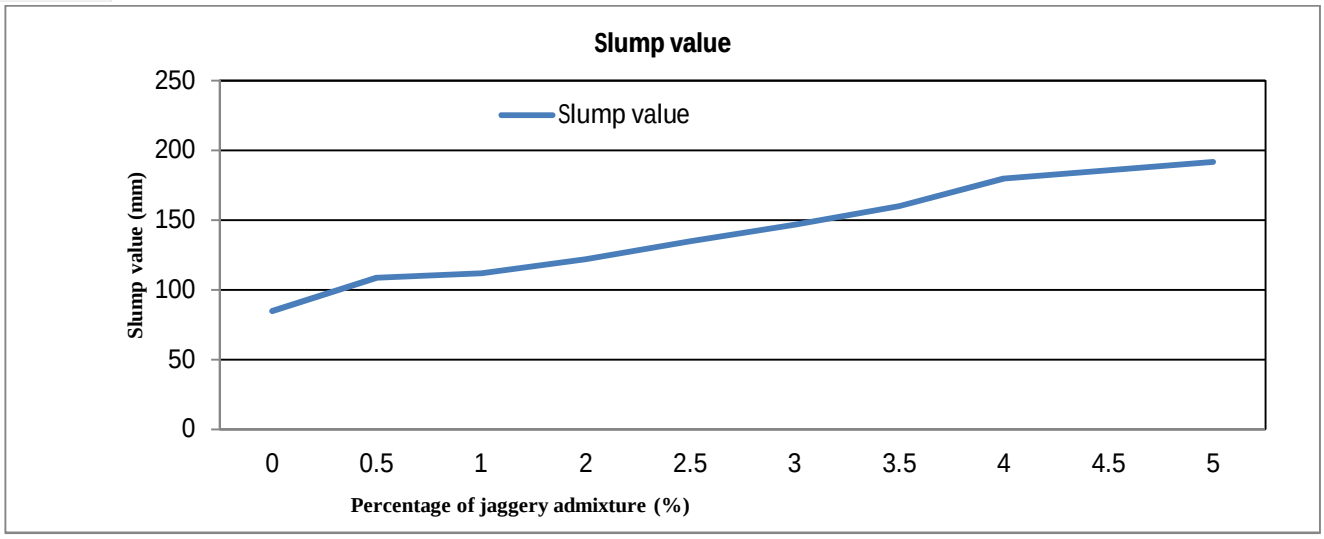
*C. Discussions On The Performance Of Concrete In Slump Cone Test & Compaction Factor Test Using Jaggery As An Admixture*

Jaggery is used as an admixture to put together concrete in nine specific doses such as 0.5%, 1%, 2%, 2.5%, 3%, 3.5%, 4%, 4.5%, and 5%. The slump and compaction factor increase as admixture levels increase depending on the test results. The time frame is strongly influenced by the addition of jaggery to the presence and the clear correction of the deterioration found during the test. It is difficult for cube specimens to be placed after 24 hours. Adding jaggery as an admixture there is an increase in the value of decay as the percentage of jaggery in the concrete mix increases. As the percentage of jaggery increases in the concrete mix, the drying time increases, and since the jaggery particles form a gelatinous layer on the concrete surface so the hydration process is reduced so and the cementing element is improved

.

Table IV
Slump Value Of Concrete Having The Different Composition Of Jaggery

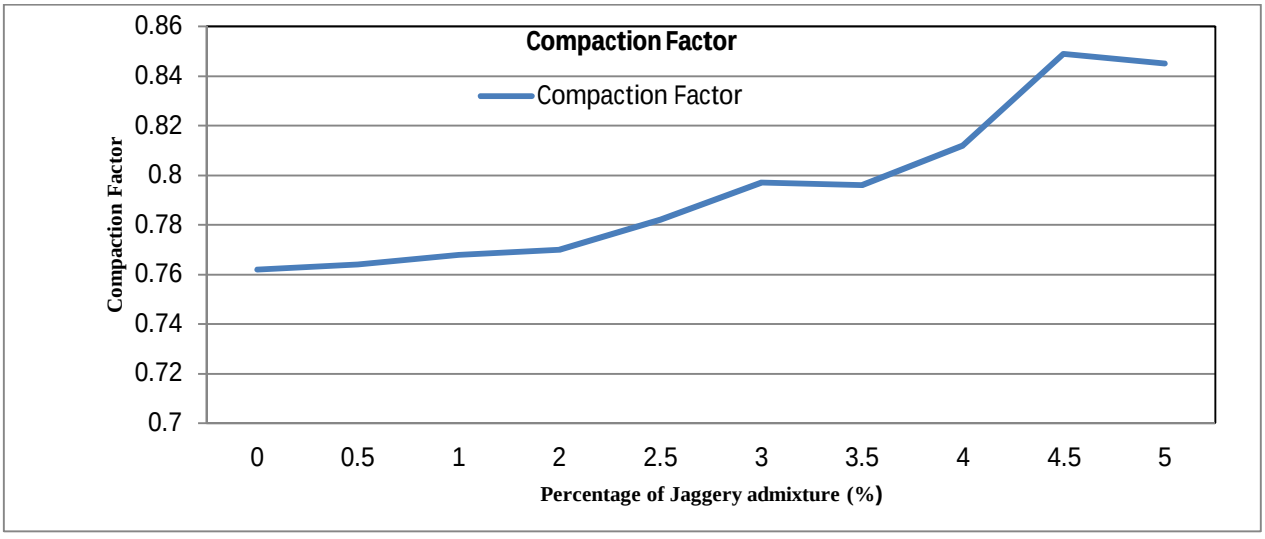
| Sr. No. | % of Jaggery | Slump Value (mm) |
|---|---|---|
| 1 | 0 | 85 |
| 2 | 0.5 | 109 |
| 3 | 1 | 112 |
| 4 | 2 | 122 |
| 5 | 2.5 | 135 |
| 6 | 3 | `47 |
| 7 | 3.5 | 160 |
| 8 | 4 | 180 |
| 9 | 4.5 | 186 |
| 10 | 5 | 192 |




Graph 3: % of Jaggery vs. Slump value

Table V
Compaction Factor Of Concrete Having The Different Composition Of Jaggery

| Sr. No. | % of Jaggery | Compaction Factor |
|---|---|---|
| 1 | 0 | 0.762 |
| 2 | 0.5 | 0.764 |
| 3 | 1 | 0.768 |
| 4 | 2 | 0.770 |
| 5 | 2.5 | 0.782 |
| 6 | 3 | 0.797 |
| 7 | 3.5 | 0.796 |
| 8 | 4 | 0.812 |
| 9 | 4.5 | 0.849 |
| 10 | 5 | 0.845 |



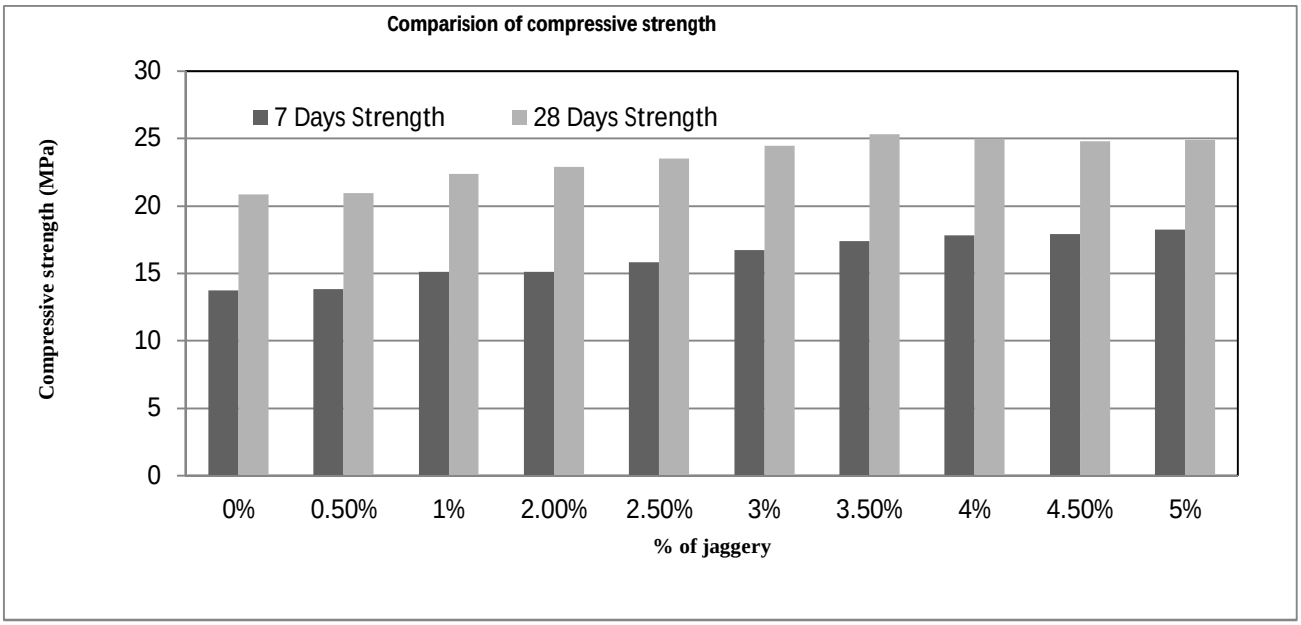

Graph 4: % of Jaggery vs. Compaction Factor

*D. Discussions On The Results Of Compressive Strength Of Concrete By Adding Jaggery As An Admixture*

The test results are given in Table No.7 and are represented on the graph. The pressure force increases slightly as the percentage of jaggery increases. As the volumes of jaggery increase, the compressive strength of the concrete also increases. When jaggery is added to cement as an admixture it forms a thin layer on the cement particles and slows down the cement-drying action which is why the drying time required for cement increases. It is seen that the compressive strength of the concrete block increases as the jaggery percentage in concrete up to some point after some limit it is observed that the compressive strength is decreased in a little manner. Up to 3.5%, the compressive strength increased in a significant manner than at 4%, 4.5%, and 5% it is decreased a little bit.

Table VI
COMPRESSIVE STRENGTH OF CONCRETE ON 7TH AND 28TH DAY BY ADDING JAGGERY AS AN ADMIXTURE

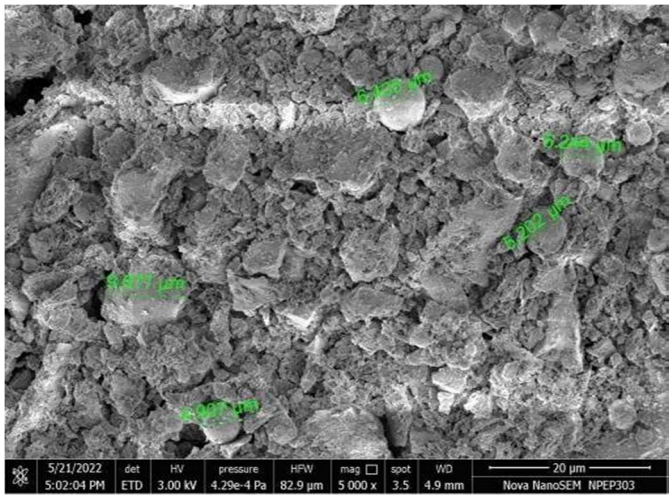
| Sr. No. | % of Jaggery | Compressive Strength of 7 day (MPa) | Compressive Strength of 28 days (MPa) |
|---|---|---|---|
| 1 | 0 | 13.76 | 20.84 |
| 2 | 0.5 | 13.84 | 20.97 |
| 3 | 1 | 15.10 | 22.37 |
| 4 | 2 | 15.12 | 22.89 |
| 5 | 2.5 | 15.83 | 23.50 |
| 6 | 3 | 16.71 | 24.45 |
| 7 | 3.5 | 17.39 | 25.32 |
| 8 | 4 | 17.82 | 24.97 |
| 9 | 4.5 | 17.90 | 24.80 |
| 10 | 5 | 18.25 | 24.89 |



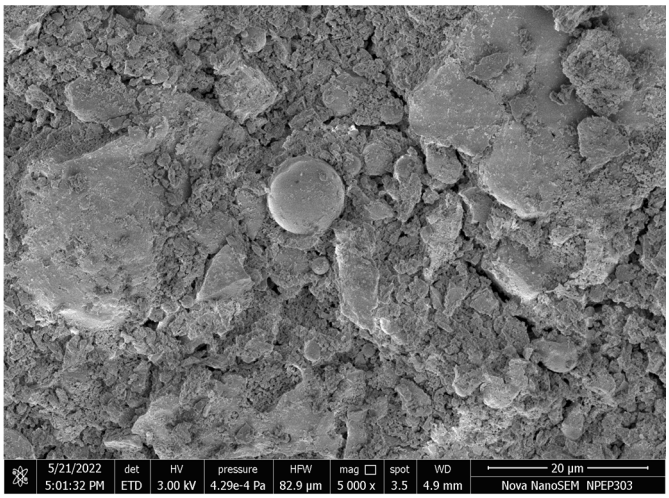

Graph 5: % of Jaggery vs. Compressive strength

*E. Discussions On The Results Of Scanning Electron Microscopy (SEM) Cement Containing Jaggery*

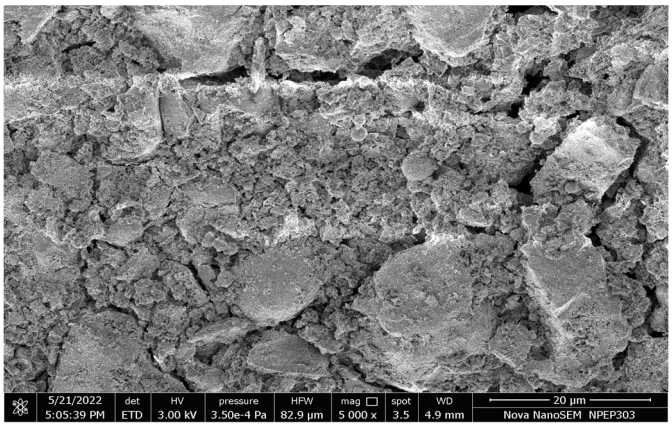
From the images, it can be seen that a cohesive bond between jaggery granules and concrete materials is formed which is good for the development of concrete structures. The complete bond grows between the granules and the cement material; the resulting concrete will work properly. Jaggery granules completely blended with the concrete material in concrete cover the width of the crack that forms and closes as it tries to grow and open. From these images of the SEM test, we can see that the cracks are formed which can be neglected. So from these results, this can be said that jaggery can be used as an admixture in concrete to build the commercial structure with high quality and high performance.




(a)




(b)




(c)

Fig. 7 (a), (b), (c) Images under scanning electron microscope

## V. CONCLUSION

*1)* Due to the use of this admixture (Jaggery) the separation and bleeding were significantly reduced.

*2)* As the volume of the mixture increases the efficiency increases. The average water level in the cement for general consistency is between 26% and 34%. Inconsistency test it is observed that at the normal water level the consistency observed is 30% and after that as the percentage of the jaggery in the concrete mix increases the consistency is also increased gradually and at the last at the 5% the consistency has been increased up to 55.5%.

*3)* The Indian Standard limits the initial set time of concrete to not less than 30 minutes and the final set time not to exceed 10 hours. From the results, it is observed that as the percentage of the jaggery admixture increased cement has been increased. When jaggery is added to the concrete as an admixture it forms a thin layer on the cement particles and slows down the cement-drying action which is why the drying time required for cement increases. At the normal proportion, the initial setting time was reported as 35 minutes and its final setting time observes was 450 minutes i.e. 7.5 hours. As the percentage of jaggery increased in the concrete mix the initial and final setting time of the concrete also increased.

4) Jaggery is used as an admixture to put together concrete in nine specific doses such as 0.5%, 1%, 2%, 2.5%, 3%, 3.5%, 4%, 4.5%, and 5%. The slump and compaction factor increase as admixture levels increase depending on the test results. At the normal proportion i.e. at the 0% of jaggery slump value observed is 85mm and as the percentage of the jaggery increased in the concrete mix the slump value increased at the last at 5% jaggery the slump value reported was highest i.e. 192mm. Similarly, the compaction factor observed was also increased as the percentage of jaggery in the concrete mix increased. At the 0% jaggery compaction factor observed was 0.762 and it went on increasing gradually and at the last, at 5% it is reported as 0.845.

5) As the volume of the jaggery increases the compressive strength of the concrete also increases. It is seen that the compressive strength of the concrete block increases as the jaggery percentage in concrete up to some point after some limit it is observed that the compressive strength is decreased in a little manner. Up to 3.5%, the compressive strength increased in a significant manner than at 4%, 4.5%, and 5% it is decreased a little bit. That means at 0% jaggery 7 days compressive strength observed is 13.76 MPa and 28 days compressive strength for the same is observed as 20.84 MPa. Then as the percentage of the jaggery increased in the concrete mix the compressive strength also increased up to 3.5% of jaggery then after that at 4%, 4.5% and 5% the compressive strength decreased in a significant manner. At the last at 5% of jaggery 7 days compressive strength observed was 18.25 MPa and 28 days compressive strength observed was 24.89 MPa. Higher long-term compressive strength is achieved by adding the jaggery in the concrete as an admixture.

6) From the images it can be seen that a cohesive bond between jaggery granules and concrete materials is formed which is good for the development of concrete structures. The complete bond grows between the granules and the cement material; the resulting concrete will work properly. Jaggery granules completely blended with the concrete material in concrete cover the width of the crack that forms and closes as it tries to grow and open. From these images of the SEM test, we can see that the cracks are formed which can be neglected. So from these results, this can be said that jaggery can be used as an admixture in concrete to build the commercial structure with high quality and high performance.

## VI. FUTURE SCOPE OF THE STUDY

1) The present investigation has been made to suggest the environment-friendly and eco-friendly solution for the quality structure development which is locally available material jaggery which has been used as an admixture in the present project.

2) This project is targeting the improvement of consistency, initial and final setting time, workability, and increase in compressive strength of concrete by adding the jaggery as an admixture in 0.5%, 1%, 2%, 2.5%, 3%, 3.5%, 4%, 4.5%, and 5%.

3) The factors responsible for the enhancement of the properties of the concrete by adding jaggery as an admixture are studied by the various tests like consistency test of cement, initial and final setting time of cement, slump cone test, compaction factor test, compressive strength test, and scanning electron microscopy test.

4) For the further investigation of the behavior of the concrete after adding the jaggery as an admixture in various proportions the tests like flexural strength test, split tensile strength test and shear strength test can be performed and the values and changes in the behavior of the concrete can be reported.

## VII. ACKNOWLEDGMENT

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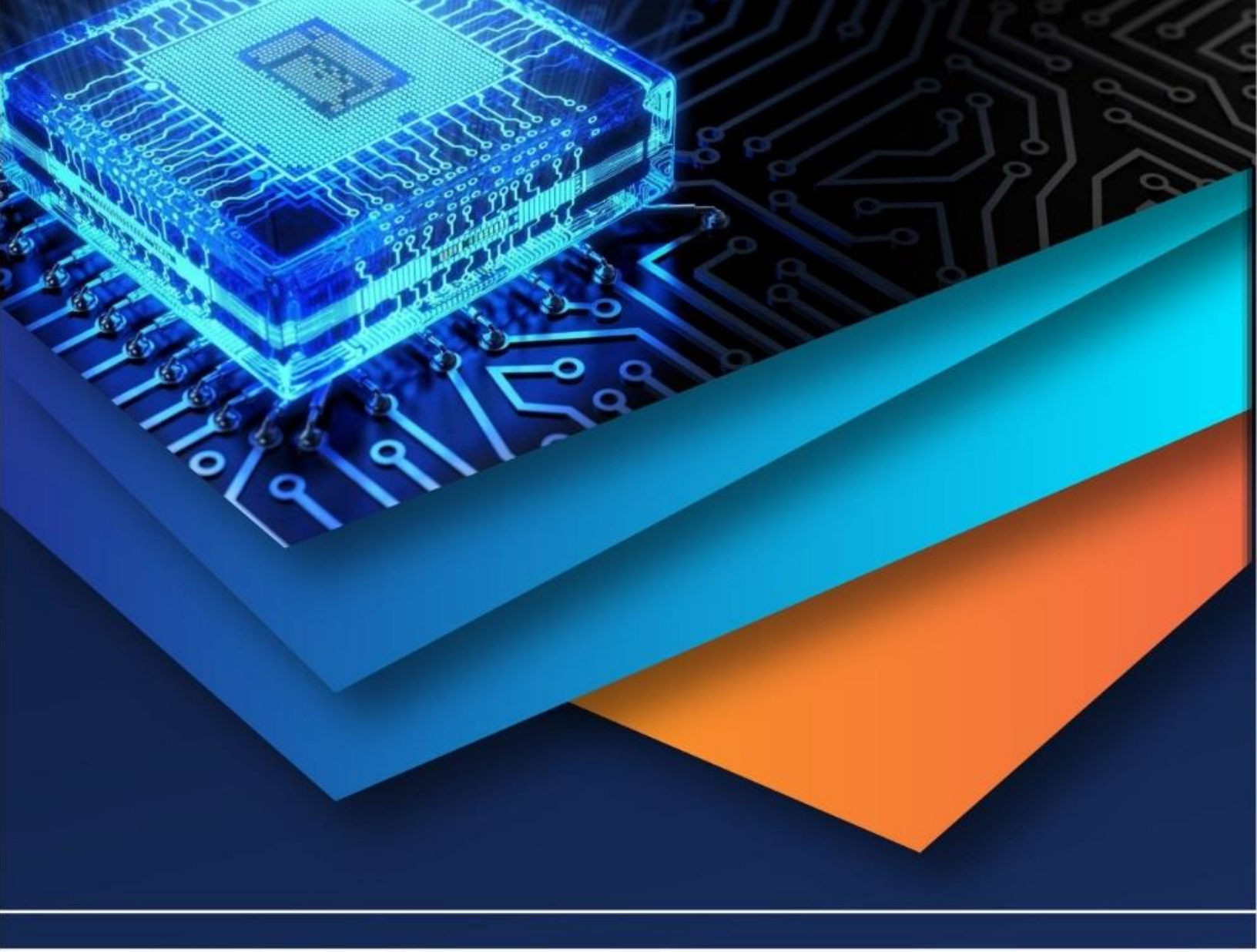

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