International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

Influence of Surkhi on Various Properties of Concrete Bricks

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***Abstract*—This paper investigates the influence of surkhi on properties of concrete bricks. In this topic surkhi which is considered as a waste material is used as a replacement of fine aggregates. The various tests pertaining to bricks are conducted on bricks in which fine aggregate is replaced by surkhi. The results are then studied at various replacements of fine aggregate by surkhi. Due to the fact that surkhi is a waste material which has pozzolanic properties can be used to produce concrete bricks of better quality. Due to the properties of surkhi there is a gradual increase in compressive strength in earlier stages and gradual decrease of compressive strength is obtained in later stages, this may be attributed to high bleeding and shrinkage properties of surkhi. Not only the compressive strength of the bricks but also the other properties like efflorescence, soundness, hardness, structure and other properties of bricks are effected considerably. In general these properties get better and the quality of bricks is increased. Also the fine aggregate used in this experimental method is stone dust but not sand, because stone dust has some better properties than sand such as it is finer than sand. Since surkhi is a pozzolanic waste material, it not only makes the brick economical but also increases the compressive strength of the brick to a considerable extent.**

Keyword—Concrete bricks; Surkhi; Compressive Strength; Water Absorption; Efflorescence and Soundness.

I. INTRODUCTION

The use of economic and environmental friendly materials has been a big achievement in the construction industry. The use of waste products in the construction industry is also of great concern. Many waste materials have been used in the construction industry and better results have been obtained than conventional methods. Many waste materials such as sawdust, Fly ash, rice husk, surkhi are used in manufacturing concrete. Keeping in mind the above points the attention has been focused on low cost and environmental friendly building materials. Bricks are the most important type of building materials used all over the world. Conventional bricks are masonry units made of inorganic, non-metallic materials which are sundried or burnt. Burnt bricks have better properties than sundried bricks. But with the advancements in the construction industry bricks composed of other materials have been also manufactured such as concrete bricks, Fly ash bricks etc. these bricks which are composed of other materials are not only economical but also have better properties as compared to conventional bricks

Concrete bricks are strong, durable and attractive than clay bricks. Concrete brick has more benefits than its striking visual qualities. They are more fire resistant, reduce noise and have better thermal properties. Concrete bricks are manufactured using cement, fine aggregate and coarse aggregate and mixing them in proper proportions. Surkhi is used as a substitute for fine aggregates in mortar.

Surkhi has almost the same function as that of sand but it imparts strength and better hydraulic properties to the concrete. Surkhi is an artificial pozzolanic material made by powdering bricks or burnt clay balls. Pozzolanic materials are those materials which in themselves possess little or no cementitious value but they attain cementitious value when they come in contact with water because they chemically react with calcium hydroxide liberated on hydration. Surkhi is used for making waterproof cement mortars and concrete. They also make the concrete more resistant to alkalis and salt solutions. The addition of surkhi is accompanied by slight reduction in initial strength as it attains its full strength after a long period of time.

Higher shrinkage than ordinary concrete is another property of surkhi concrete. Surkhi is not standardized product and its properties vary widely. Surkhi is also used for reduction of temperature rise during hydration in the mass of concrete and it is also used to reduce cracking in concrete. Concrete which is made by adding surkhi is more plastic, bleeds less and segregates less as compared to ordinary concrete.

Taking into consideration the above properties of surkhi, in this paper the strength and other properties of bricks made by replacing fine aggregate by surkhi will be determined.

II. EXPERIMENTAL MATERIALS

A. Surkhi

Surkhi is an artificial pozzolanic material made by powdering bricks or burnt clay balls. Surkhi is used for making waterproof cement mortars and concrete. They also make the concrete more resistant to alkalis and salt solutions. The addition of surkhi is accompanied by slight reduction in strength as it attains its full strength after a long period of time. Higher shrinkage than ordinary concrete is another property of surkhi concrete. Surkhi is

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not standardized product and its properties vary widely. Surkhi is also used for reduction of temperature rise during hydration in the mass of concrete and it is also used to reduce cracking in concrete. Concrete which is made by adding surkhi is more plastic, bleeds less and segregates less as compared to ordinary concrete. We have used surkhi as a substitute for sand in our experimental work. We used locally available surkhi.

Fig. 1. Surkhi

B. Stone dust

Stone dust may be defines as the pulverized form of stones. Stone dust is a by-product of stone crushing operations. It is generally used to fill the voids between gravel and paving stones. But it also imparts certain good properties to the concrete such as it increases the strength, decreases permeability, increases durability and increases the water absorption of concrete. These properties of stone dust provide enough significance to stone dust to be used as a replacement for fine aggregate. The stone dust obtained from local crushers was used to carry out the experiments.

Fig. 2. Stone dust

TABLE I. PHYSICAL PROPERTIES OF STONE DUST

Property	Stone dust	Method
Specific gravity	2.50-2.67	IS 2386 (Part III) 1963
Bulk relative density (kg/m^3)	16900-1850	IS 2386 (Part III) 1963
Absorption (%)	1.26-1.49	IS 2386 (Part III) 1963
Moisture content (%)	7	IS 2386 (Part III) 1963
Fine particles less than 0.075mm (%)	13-17	IS 2386 (Part I) 1963
Sieve analysis	Zone II	IS 383 – 1970

C. Cement

Cement in general is a binding material used to bind various materials together. Ordinary Portland Cement (43 Grade) with 28 percent normal consistency Conforming to IS: 8112-1989 was used.

D. Aggregate

Since aggregate is an important constituent of concrete because it gives body to concrete, reduces shrinkage and effects economy. We have used crushed stone aggregates which are produced by mining and then breaking down the rock to desired size. Crushed stone aggregate available from local source has been used. The size of coarse aggregate is between 4.75mm and 10mm.The specific gravity of the aggregate is 2.68.

E. Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Generally if water is fit for drinking it is fit for making concrete. This does not appear to be a true statement for all conditions. Some waters containing a small amount of sugar are fit for drinking but not for mixing concrete and conversely water suitable for making concrete may not necessarily be fit for drinking. The pH of the water used for making concrete should be in the range of 6 and 8. Hence the water used for making concrete should be free from any impurities which may impart undesired properties to the concrete.

The content of water affects the workability of concrete. Water content in a given volume of concrete will have a significant influence on the workability. The higher the water content per cubic meter of concrete, the higher will be the fluidity of concrete which is one of the important factors affecting workability. It should be noted that from the desired point of view, increase of water content is the last resource to be taken for improving workability even in the case of uncontrolled concrete. More water can be added, provided a corresponding higher quantity of cement is also added to keep the water/cement ratio constant, so that the strength remains the same.

II. MOULDING AND CASTING

Moulds for manufacturing of bricks were made of wood with the standard modular dimensions of common building brick that are 190mm x 90mm x 90mm. The bricks were cast using standard methods as given in the Indian Standard codes. The required quantities of cement, coarse aggregates, stone dust and surkhi are calculated according to the mix proportions. The proportioning of the various materials was done by using weight batching because it is more accurate. The required quantity of water is then added to the mixture and is mixed thoroughly. The mixture is then casted into the moulds and compacted. Then the mold is removed and the specimens are allowed to sun drying for two days. The specimens are also wet cured for a period of 3 days, 7days and 28 days. Curing is very important for these bricks, because if the bricks are not cured properly they will not attain full strength.

Fig. 3. Moulds for manufacturing bricks

IV. TEST PROCEDURE AND TEST RESULTS

In the present paper, the bricks manufactured by replacing fine aggregate with surkhi are subjected to various tests to find their suitability as a structural material. The bricks were cast and then tested according to the Indian Standard codes. The various tests which are to be conducted on bricks are compressive strength test, water absorption test, hardness test, soundness test, shape and size test and structural test. The composition of these bricks is given in the table below:

TABLE II. PERCENTAGE WISE COMPOSITION OF VARIOUS MATERIALS USED.

Specimen number	Cement (%)	Stone dust (%)	Surkhi (%)	Gravel (%)
1	20	55	0	25
2	20	50	5	25
3	20	45	10	25
4	20	40	15	25
5	20	35	20	25
6	20	30	25	25
7	20	25	30	25

Fig. 4. Brick samples

A. *Water absorption test*

This test is used to determine the amount of water absorbed by the brick. When immersed in water for a period of 24 hours it should not, in any case, exceed 20% of weight of dry brick. This test is carried out for all the samples of bricks. The bricks which are to be tested should be oven dried at a temperature of 115 degree centigrade until the brick attains constant weight, cool the brick to room temperature and record the weight as (W 1). Now the dried brick is immersed in clean water for 24 hours at a temperature of 27+ 20 degree Celsius. The brick is then removed and wiped out of any traces of water and weighed immediately and the weight is recorded as (W2).
Lesser the water absorbed by a brick, better is the quality of brick. Good quality bricks don't absorb more than 20% of water.

Water absorption in percentage by weight = (W2-W1/W2) x 100

TABLE III. CALCULATION OF WATER ABSORPTION VALUE.

Specimen number	W1	W2	(W2-W1/W2) x 100
1	3.645	3.747	2.722
2	3.493	3.621	3.534
3	3.497	3.638	3.875
4	3.383	3.594	5.870
5	3.569	3.818	6.521
6	3.450	3.789	8.946
7	3.427	3.815	10.170

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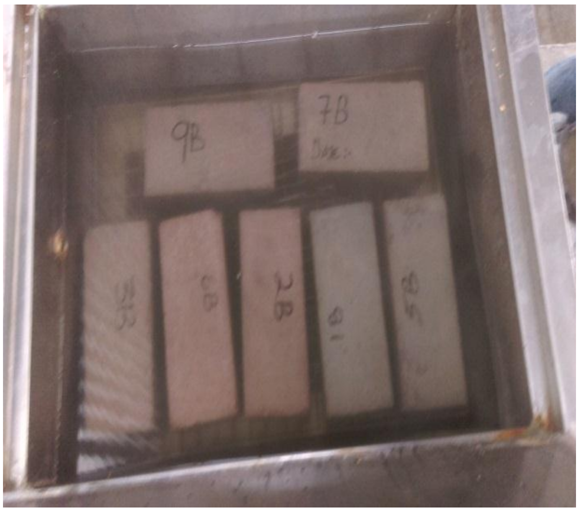

Fig. 5. Brick samples in water for water absorption test

B. *Efflorescence test*

In this type of test, the bricks are placed vertically in water with one end immersed. The bricks are immersed up to 2.5 cm and the whole arrangement is kept in a warm well ventilated room at a temperature of about 30 degree Celsius until all the water evaporates. When the water in the apparatus evaporates place a similar quantity of water again in the dish and allow it to evaporate. The examination of the brick is carried and the percentage of white spots to the surface area of the brick is calculated. If deposition of salts is present it is reported as effloresced. If no difference is noted, it is reported as not effloresced.

The presence of alkalies in bricks is harmful and they form a gray or white layer on brick surface by absorbing moisture.

If the whitish layer is not visible on surface it proofs that absence of alkalis in brick. If the whitish layer visible about 10% of brick surface then the presence of alkalis is in acceptable range. If that is about 50% of surface then it is moderate. If the alkalies presence is over 50% then the brick is severely affected by alkalies.

The efflorescence in each type of brick was less than 10 percent which is within the permissible range.

TABLE IV. EFFLORESCENCE VALUES OF BRICKS

Specimen number	Efflorescence
1	Mild (1.5)
2	Mild (2.9)
3	Mild (3.3)
4	Mild (3.7)
5	Mild (4.3)
6	Mild (5.8)
7	Mild (7.2)

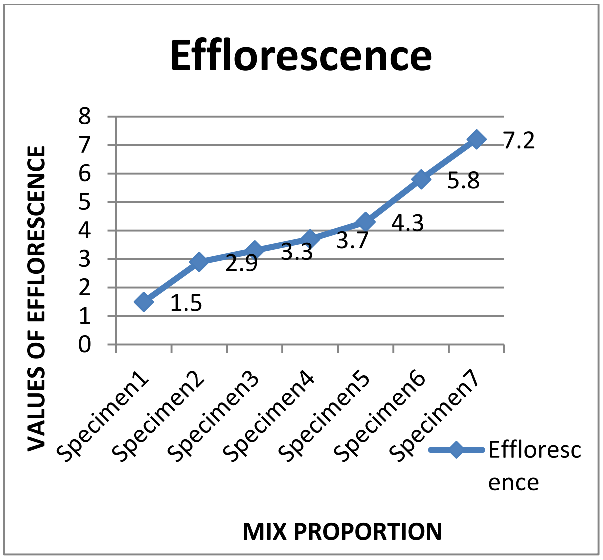

Fig. 6. Variation of efflorescence

C. *Hardness test*

To determine whether a brick is hard or not the hardness test is used. The hardness of a brick can be judged by making an impression on the surface of a brick by a hard substance. The harness of the brick is an important property which determines the durability of a structure. The hardness is then determined by making a scratch and the extent of hardness is determined by assessing the scratches made on the bricks.

If little or no scratch is found then the brick is said to be a good quality brick and if excessive scratches are found then it a bad quality brick.

Fig. 7. Comparison of scratches on bricks

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TABLE V. HARDNESS OF BRICKS

Specimen number	Measurement of hardness
1	No impression after scratching
2	No impression after scratching
3	No impression after scratching
4	No impression after scratching
5	No impression after scratching
6	Mild impression after scratching
7	Mild impression after scratching

D. Soundness test

In this type of test two bricks are stroked against each other if they produce a clear ringing sound and are not broken then the bricks are called as sound bricks. If they do not produce ringing sound and are broken after striking against each other, then the bricks are called as unsound bricks.

Fig. 8. Striking bricks for soundness test

TABLE VI. MEASUREMENT OF SOUNDNESS

Specimen number	Soundness
1	Ringing sound is produced and brick is not broken
2	Ringing sound is produced and brick is not broken
3	Ringing sound is produced and brick is not broken
4	Ringing sound is produced and brick is not broken
5	Ringing sound is produced and brick is not broken
6	Ringing sound is produced and brick is not broken
7	Ringing sound is not produced and brick is not broken

E. Shape and size test

This test is used to closely inspect a brick. The brick should be truly rectangular, should have sharp edges and should be of standard size. This test is done by stacking 20 bricks lengthwise, all blisters and projections should be removed from the bricks, now measure the total length and repeat the measurement three times and takes the mean. Then find the length of one brick by dividing the mean by twenty. Similarly find the height and breadth of the bricks by arranging them breadthwise and height wise. We also observed the edges and color of the bricks and the results are given below in the table.

Fig. 9. Determination of shape and size

TABLE VII. SIZES AND SHAPE OF BRICKS

Specimen number	Size(based on above test) in centimeter			Shape
	Length	*Breadth*	*Height*	
1	9	9	19	cuboidal with perfect edges
2	9	9	18.9	cuboidal with perfect edges
3	9	8.9	18.8	cuboidal with perfect edges
4	9	8.9	18.8	cuboidal with perfect edges
5	9	8.8	19	cuboidal with perfect edges
6	9	8.7	19	cuboidal with blunt edged
7	9	8.6	18.7	cuboidal with blunt edged

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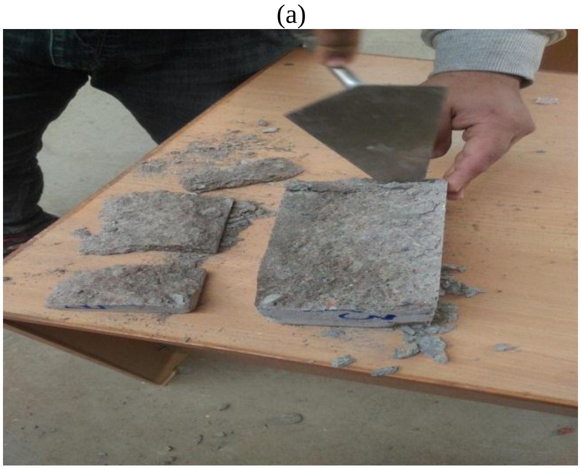
F. *Structural test*

This is a test which is done to determine the internal structure of a brick. In this test, the brick is crushed and the internal structure is analyzed. In this study, all the bricks were crushed and then analyzed. Upon analysis it was found that all the bricks were homogenous, no lumps were formed and voids were seen. This is among one of the parameters to determine the compressive strength of the brick.

(a)



(b)

Fig. 10. Showing internal structure

G. *Compressive strength test*

This is the main test conducted to determine the suitability of brick as a building material. This test is conducted with the help of a compression testing machine. In this test the bricks are first preconditioned, the specimen is then placed with flat surfaces horizontal between two 3mm thick ply sheets and carefully centered between the two plates of the compression testing machine. The load is then applied uniformly at a rate of 14 N/mm square per minute till failure occurs. The compressive strength is then obtained from the maximum load at failure and average area of the bed faces of the specimen, which is given as Compressive strength in N/mm square is equal to maximum load at failure divided by the average area of the bed faces of specimen in millimeter square. The compressive strength of the specimens it determined at 7 days, 14 days and 28 days after the construction of the specimens.

(a)

(b)

(c)

(d)

Fig. 11. Compressive strength test

The bricks were placed in the compression testing machine and the load was gradually applied at a constant rate. Before placing in the compression testing machine the bricks were tested for shape and size, the bricks were cured properly. Also the bricks were cleared with a clean piece of cloth to remove the unwanted materials adhering to the surface of the bricks. The bricks were properly centered on the compression testing machine. After applying the load on the bricks the crack pattern was studied and the application of load was stopped when the cracks started to develop on the bricks. The load at the end was noted and the compressive strength of the bricks was computed from the recorded load and the area of the specimens.

TABLE VIII. VALUE OF COMPRESSIVE STRENGTH

Specimen number	3 days compressive strength in N/mm square	7 days compressive strength in N/mm square	28 days compressive strength in N/mm square
1	9.260	16.828	25.89
2	6.230	9.302	15.85
3	6.987	10.105	16.47
4	8.908	15.094	24.76
5	9.990	18.044	27.76
6	7.988	13.338	22.82
7	5.362	9.125	14.68

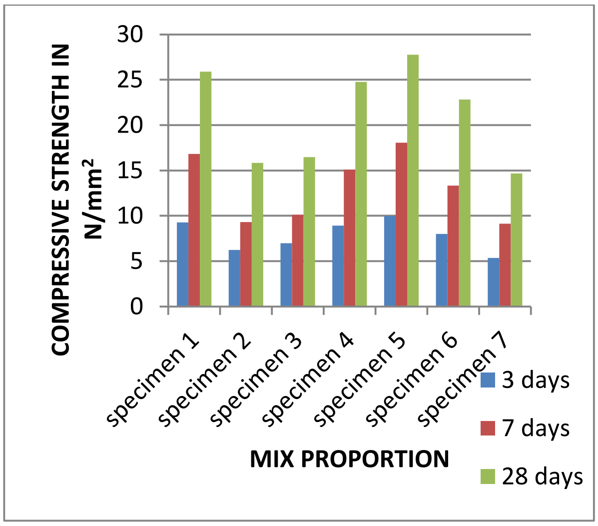


Fig. 12. Variations of 3 days, 7days and 28 day strength of specimens

The strength of specimen 1 is greater than most of the specimens because in specimen 1 the percentage of surkhi used as a fine aggregate is zero. Therefore it acts as a reference for the other specimens because it is just like a conventional concrete brick. The conventional concrete brick has average 28 day strength of 3.5 newton per millimeter square while as class A bricks have strength of 10.5 N/mm^2 and class AA bricks have strength of about 14 newton per millimeter square. Hence from our test results almost all our specimens have strength more than class AA bricks. Also the 3 day and 7 day strength of the bricks is less than usual results; it is because of the influence of surkhi which attains its strength at later age.

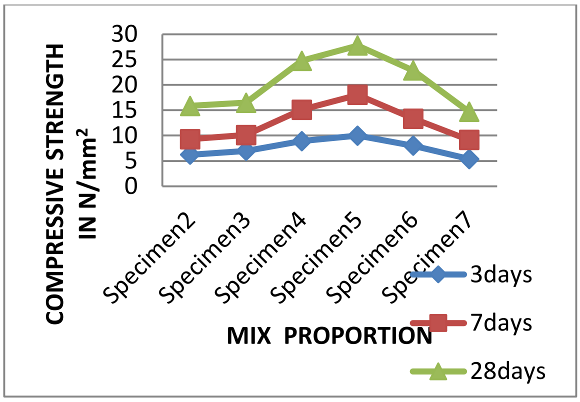


Fig. 13. Graph showing the variation of 28 day strength of bricks in which surkhi is used.

From the above graph it is concluded that the compressive strength of the brick specimens in which surkhi is used as a replacement of fine aggregate goes on increasing up to specimen 5 in which 57 percent of stone dust is replaced by surkhi and it recedes beyond that and is minimum at specimen 7 where 120 percent replacement of stone dust with surkhi is done. This increase and decrease in the strength of the bricks can be attributed to the properties of surkhi such as pozzolanic property, resistance to alkalis, less bleeding and many others.

V. ECONOMY

Economy is one of the most important parameters during construction. Conventional concrete brick costs us more than this brick, as in this brick surkhi is used as an ingredient which is a waste material. By replacing surkhi powder as an ingredient for making brick, the cost of the brick was reduced to some extent without affecting its elastic properties. Therefore the bricks in which surkhi is used as a replacement of fine aggregate are more beneficial not only in terms of strength but also in terms of economy than conventional concrete bricks.

VI. CONCLUSION

From the above studies and test results it is found that the brick in which surkhi was used as fine aggregate had less water absorption value as compared to conventional bricks. Also the bricks were found to be sufficiently hard as the scratches made with fingernails left no impression on the bricks. The efflorescence on the bricks was found to be mild as in each case it was well less than 10. The bricks except the specimen number 7 satisfied the soundness test as all the bricks except specimen 7 produced ringing sounds. The structure of the bricks on breaking was found to be homogenous, no holes or lumps were observed. The compressive strength of all the bricks was greater than class AA brick. The compressive strength of bricks in which surkhi is replacing fine aggregate shows almost a parabolic variation as the compressive strength increases from specimen 2 to specimen 5 and decreases from thereafter. Thus by incorporating surkhi as a replacement of fine aggregate bricks with better properties were produced. Bricks with higher compressive strength, better hardness and better water absorption values, less efflorescence, better soundness and better structure were produced. Thus the bricks could be used to produce better structures owing to their better properties as compared to conventional bricks. Also the bricks produced by above methods were more economic than conventional bricks as surkhi sometimes is considered as a waste product. Thus these bricks have a better scope in the construction industry owing to their economy and better properties.

ACKNOWLEDGEMENT

The work mentioned in this paper was assisted by the help of many generous people. I was fortunate enough to receive assistance from them and I want to thank each and every one of them.
First and foremost, I am indebted to my guide, Er. Ravi Kumar who was very supportive at every stage and I want to thank him for his prestigious advice.
I also want to thank S.K. Sharma, HOD civil engineering who provided his full assistance and encouraged me at every step.
I also want to express my gratitude to all the staff members of civil engineering department, Swami Devi Dayal group of Professional institutions.
Last but not the least, I am grateful to my parents who provided their full support to me at every stage of my life.

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