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"Experimental Investigation to Evaluate the Properties of Bricks by using Hypo Sludge"

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Abstract - *Bricks have been one of the most important parts of any constructional project. With the advancements of the present construction industry, there is a great need to incorporate the use of industrial and agricultural bi-products & waste products along with the traditional construction materials. In the present research work, an attempt has been made to evaluate the use of industrial waste obtained from the paper industry commonly known as Hypo sludge by partial replacement with the ingredients of bricks. As the strength of bricks is very much essential as these are the load bearing members hence; in this research work various properties of the manufactured bricks are taken into consideration such as the compressive strength, water absorption, density of bricks, etc.*

The research work finally concludes that the partial use of hypo sludge in bricks can be done without affecting the properties of bricks. Thus the problem of decomposing the hypo sludge can also be solved to a great extent. The results of this research work conclude that after 7 days the highest compressive strength was obtained when 20% of hypo sludge was used with 50% fly ash. Whereas in the case of compressive strength after 14 days and 21 days, the highest compressive strength was obtained when 25% hypo sludge was used with 40% fly ash. During the hardness test, no impressions were created on the surface of bricks which is also an important aspect. The water absorption test showed that when 15%, 20% and 30% hypo sludge was used in bricks, the water absorption was less as compared to the bricks made with 10% hypo sludge.

Key Words*: *Hypo sludge, Water absorption, Pozzolana, Compressive strength, Eco-friendly, Lightweight.

1. INTRODUCTION

For any masonry work, the brick is most widely used manmade material used for construction purpose and in some other construction work. It is a composition of clay earth mass, and various chemical constituent also. Rapid development along with time; its manufacturing process has been modified. Through the basis of manufacturing, it is characterized in two ways either it can be fired or maybe non-fired. . Recent development of using raw materials for brick, manufacturing has taken the place of clay earth mass. Now the advancement of cement based technology the manufacturing of bricks has become better. Previous history shows that burnt and sun-dried bricks both were used during Indus-valley civilization.

The bricks prepared from mud falls under the category of sun-dried bricks. They are not subjected to heating. Nomenclature of bricks depends upon various factors, some of the important factors are uses, shape and size, mode of origin and the type of materials used. Today we are focusing on sustainable development therefore the research is being done in order to use different industrial and agricultural waste products in the construction industry. Thus the use of waste material is quite justified and an attempt has been made to utilize the industrial waste known as hypo-sludge in the manufacturing process of bricks. The extensive research work done in the previous time categorizes the building material on the basis of manufacturing process as well as the type of replacement material used.

In manufacturing of clay bricks, the organic matter should be very less because it increases the water absorption and ultimately decreases the strength. The manufacturing of clay brick production varies according to the amount of composition. The main ingredients of bricks include silica, alumina, lime iron-oxide and magnesia whose proportion varies to some extent while composing the clay content.

1.1. Hypo-sludge bricks

The waste product from paper manufacturing industries that is hypo sludge is comparatively a new cementitious material which is actually an artificial pozzolana. The primary waste product that is hypo sludge contains calcium in lower amount, thus it has been used to prepare bricks. The different sludge obtained during paper manufacturing process are hypo sludge; ETP sludge and De linking sludge. In the present research we are trying to utilize the waste product in the manufacturing process of bricks and trying to find the suitability of this hypo sludge waste in the construction industry to reduce the environmental pollution.

Figure 1 - Sample of casted Hypo-Sludge Bricks.

2. LITERATURE SURVEY

A. Kulkarni, S. Raje et. Al. **(2013) [1],** experimented on fly ash bricks by partial replacement of hypo sludge by weight with lime with a permutation of (5%, 10%, 15% and 20%) for performing their experiments to determine compressive strength and to make economical and green bricks to avoid a problem such as ash disposal and unbalanced environment. Till 10% replacement the compressive strength was under desired limits. But as the percentage replacement was increased the values of compressive strength started declining.

Apurva K., Mamta Rajgor et. Al. (2014) [2] used hypo sludge and fly ash to manufacture bricks in the Indian context. The replacement of hypo sludge was done from 5% to 20% with an increment of 5% at every time. These bricks turned out to be green bricks. The compressive strength increased when 5% and 10% hypo sludge was used but as the percentage replacement increased up to 15% and 20% gradually the strength started decreasing. The cost of these bricks was also less as compared to the conventional bricks. The test performed proves that these bricks are suitable in terms of construction works at appropriate places.

B. Navaneetha, S. Manjula et. Al. (2019) [3] utilized hypo sludge and sugarcane waste in fly ash bricks. They investigated by replacing these waste products in 2.5%, 5% and 7.5% content with the nominal contents. At 2.5% and 5% replacements the compressive strength at 21 days increased but on increasing the content up to 7.5% and 10% the compressive strength started decreasing gradually. It was also noticed that the water absorption percentage started decreasing when the replacement percentage was increased uniformly.

D. Shaktivel, L. Kartikeyan et. Al. (2019) [4] used sludge and pulp production residue to manufacture the bricks. They investigated that when these waste were replaced by 5% and 10% respectively the compressive strength was under the desired limit, but when 15% replacement of waste products was done the compressive strength decreased rapidly. All the tests specified in the IS codes have been done to find out the characteristics of the bricks. These bricks proved to be economical and eco friendly in terms of environmental pollution control.

IS 3812 [9], It gives us the specification for fly ash for use as pozzolana and admixture. This code has given specifications for use of fly ash in construction materials and ways of collecting the fly ash. The various physical and chemical requirements of fly ash for use as a replacement material in construction industry have been given in this I.S. code. According to this IS code the fly ash has been categorized in two grades Grade I and Grade II.

IS 1077: 1992 [10], gives detailing of common burnt clay building bricks. The various dimensions and tolerances of bricks has been shown in this IS code. The classes of bricks as per the compressive strength have been specified in this code. The various tests to be performed on bricks like compressive strength, water absorption, Efflorescence etc have been explained. The standard results by which the obtained results needs to be compared are also provided in the IS codes according to the classification of the bricks.

Rohit Kumar Arya, Rajeev Kansal et. Al. (2016) [11], determined the weight, compressive strength, water absorption capacity, fire resistance, hardness etc. of papercrete brick by utilization of waste papers (newspapers, invitation cards, magazines etc.) in order to determine their aptness for use as a building construction material. While using paper pulp with cement and sand it was found that the weight of the brick was approximately 50% lesser than conventional clay brick. Therefore papercrete bricks will decrease the dead weight of the structure in a significant amount. So it can change our design and building cost as in an economical point of view.

R. Kumar, V. Patyal et. Al. (2014) [12], fly ash is mainly used as a replacement of Ordinary Portland Cement, in general, 25% of replacement of Portland cement but high volume mixed in under research. Some successful enterprise report where fly ash was incorporated in the mixture in the ranges 20% to 50%. Fly ash bricks are comparatively lighter in weight and stronger than conventional clay bricks. Fly ash can be carried as waste material in large quantity from the thermal power plant and creating serious environmental pollution, it can be utilized as the main raw material in the manufacture of bricks. Manufacturing fly ash bricks create an opportunity to help the environment by reducing pollution around the power plant areas as well as the economical use of the material.

2.1. Objective of Study:

Determine the compressive strength, economy and viability of green bricks to avoid; problems such as ash disposal and unbalanced environment. To accesses the costs of these modified bricks minimize cost as compared to the conventional bricks. The test performed to find proves that these bricks are suitable in terms of construction works at appropriate places. It shall be checked about that the water absorption percentage when the replacement percentage was increased or decreases uniformly.

3. EXPERIMENTAL SETUPS

Brick is one of the important building units used for masonry work in the building construction which make up walls and columns after adjoining a great number of bricks by the help of mortar paste. On the basis of raw materials used for manufacturing of bricks, they are usually classified into three categories as clay bricks, fly ash bricks and hypo sludge bricks. They can also be typically categorized in the form of graded class i.e. first class, second class, third class and fourth class bricks. Different categorized bricks have dissimilar strength, color, appearances and applications according to anxiety in construction. Generally, the modular size of brick is (190×90×90) mm and non-modular size of brick varies as length (210-250 mm), width (100-130 mm) and height (70-75 mm). Its maximum weight is approximately 3 to 3.5 kg. These bricks are obtained by hand molding or machine molding.

As bricks are light in weight and having uniform shape and size, they can be properly arranged and due to these reasons brick has now replaced the use of stones in most of the construction work. In this proposed study manufacturing of hypo sludge brick is targeted as; because now a days bi-products & waste material like fly ash, quarry dust, hypo sludge, coal dust based bricks are being made over conventional bricks. So; the waste materials can be profitably utilized for making eco-friendly constructional bricks, sustainable to the environment with optimaization in mechanical strength and behaviour.

3.1. Mix proportioning of bricks

Mix Proportioning can be defined as "The technique of selection of the appropriate composition of materials" for manufacturing of bricks. In the current research work, hypo sludge has been used in varying percentages of its weight w.r.t. weight of brick moulded. A good brick earth constitutes mineral proportioning consisting of alumina, silica, lime, oxides of iron and magnesia where silica (sand) provides a body of brick and is coarser than other materials.

Therefore, in order to use hypo sludge and fly ash in bulk, all ingredients have been replaced by cement, lime, hypo sludge and fly ash and bricks are completely made up of these materials only and in our research is enriched of clay and silica mass due to the use of alluvial type of soil, having fines silica particles. 10 to 30% hypo sludge is further added and varied the amount of fly ash in all the proportions for making non-conventional brick. The percentage of fly ash is varying from 70% to 30% whereas hypo sludge and cement are varying in the range from 10% to 30% in the different samples prepared.

Sample bricks were prepared by varying the percentage composition of hypo sludge, fly ash and cement in the brick and keeping the percentage of lime constant. Different samples prepared are tabulated below:

Table No.- 1, Proposed Mix Proportioning for Hypo sludge brick

S. No	Notation of Sample	No. of Bricks	Lime (%)	Cement (%)	Flyash (%)	Hypo - Sludge (%)
1	Type A (M1)	9	10	10	70	10
2	Type B (M2)	9	10	15	60	15
3	Type C (M3)	9	10	20	50	20
4	Type D (M4)	9	10	25	40	25
5	Type E (M5)	9	10	30	30	30

4. RESULTS & OBSERVATIONS

4.1. Measurement of brick dimensions

Based on Clause 5.2.1, IS 12894:2002. The bricks were placed in contact with each other in a straight line upon a level surface. The method of arranging the bricks depended on which dimension to be measured; length, width or height. The dimension result obtained from dimension test present in table 2.

Table No. - 2, Dimensions value of different composition of bricks

Mix Composition (Wt. %)	Dimensions (cm)			Average Value of dimensions (cm)		
	Length	Width	Height	Length	Width	Height
Type- A Brick (10% Hypo sludge, 10% cement, 10% lime & 70% fly-ash)	20	10	10	20	10	10
	20	10	10			
	20	10	10			
Type- B Brick (15% Hypo sludge, 15% cement, 10% lime & 60% fly-ash)	20	10	10	20	10	10
	20	10	10			
	20	10	10			
Type- C Brick (20% Hypo sludge, 20% cement, 10% lime & 50% fly-ash)	20	10	10	20	10	10
	20	10	10			
	20	10	10			
Type- D Brick (25% Hypo	20	10	10	20	10	10

sludge, 25% cement, 10% lime & 40% fly-ash)	20	10	10			
	20	10	10			
Type- E Brick (30% Hypo sludge, 30% cement, 10% lime & 30% fly-ash)	20	10	10	20	10	10
	20	10	10			
	20	10	10			

4.2. Initial Rate of Absorption

Initial Rate of Absorption test conducted on each composition for 2 number of sample and the result is shown in table no. -3.

Table No. - 3, Percentage (%) initial water absorbed by bricks having various FA and HS contents.

Mix Composition (Wt. %)	Weight (Kg)		Initial Rate of Absorption (%)	Average Initial Rate of Absorption Value (%)
	Dry	Wet		
Type- A Brick (10% Hypo sludge, 10% cement, 10% lime & 70% fly-ash)	3.286	3.390	3.16	3.04
	3.284	3.380	2.92	
Type- B Brick (15% Hypo sludge, 15% cement, 10% lime & 60% fly-ash)	3.284	3.382	2.97	2.94
	3.284	3.379	2.89	
Type- C Brick (20% Hypo sludge, 20% cement, 10% lime & 50% fly-ash)	3.286	3.381	2.89	2.98
	3.287	3.388	3.07	
Type- D Brick (25% Hypo sludge, 25% cement, 10% lime & 40% fly-ash)	3.290	3.395	3.19	3.15
	3.293	3.396	3.12	
Type- E Brick (30% Hypo sludge, 30% cement, 10% lime & 30% fly-ash)	3.310	3.410	3.02	2.99
	3.330	3.429	2.97	

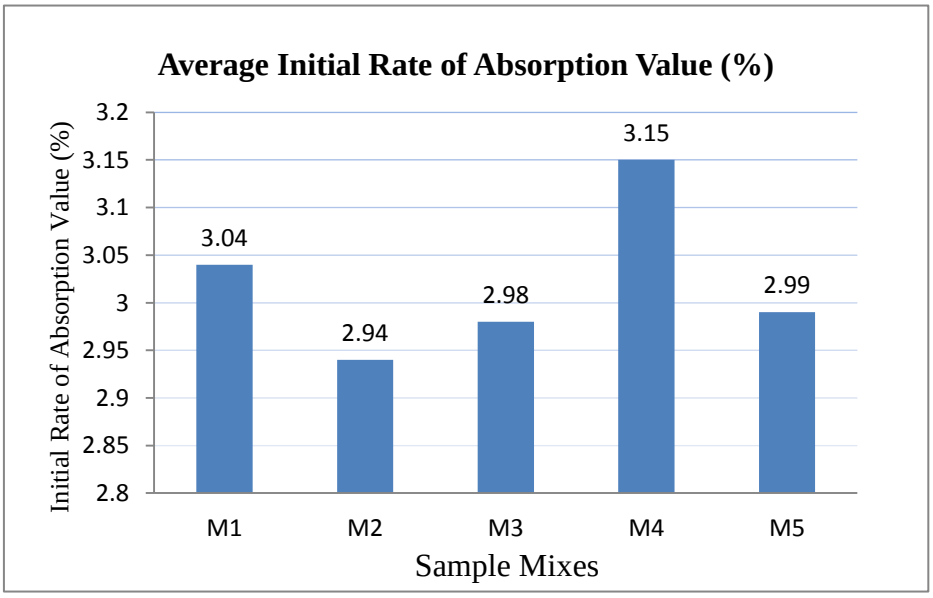

Figure 2- Graph showing Initial Rate of Absorption for Different Mixes

4.3. Water Absorption Test

Table No. - 4 shows the amount of water absorbed corresponding to different Fly-Ash and Hypo-Sludge composition. The water absorption values of Fly-Ash and Hypo-Sludge composites lies in the range of 14.5% to 16.25%. It can be seen that the entire composition meet the absorption criteria set by IS code specification. IS code permits the maximum of 20% water absorption when compacts are immersed for 24 hours.

Table No. – 4, Details of standard prisms used for experimentation.

Mix Proportion (Wt. %)	Weight (Kg)		Water Absorption (%)	Average Water Absorption Value (%)
	Dry	Wet		
Type- A Brick (10% Hypo sludge, 10% cement, 10% lime & 70% fly-ash)	3.286	3.778	15	14.5
	3.284	3.744	14	
Type- B Brick (15% Hypo sludge, 15% cement, 10% lime & 60% fly-ash)	3.284	3.898	16	15.75
	3.284	3.793	15.5	
Type- C Brick (20% Hypo sludge, 20% cement, 10% lime & 50% fly-ash)	3.286	3.828	16.5	16.25
	3.287	3.813	16.1	
Type- D Brick (25% Hypo sludge, 25% cement, 10% lime & 40% fly-ash)	3.290	3.790	15.2	15.45
	3.293	3.810	15.7	
Type- E Brick (30% Hypo sludge, 30% cement, 10% lime & 30% fly-ash)	3.310	3.846	16.2	15.8
	3.330	3.843	15.4	

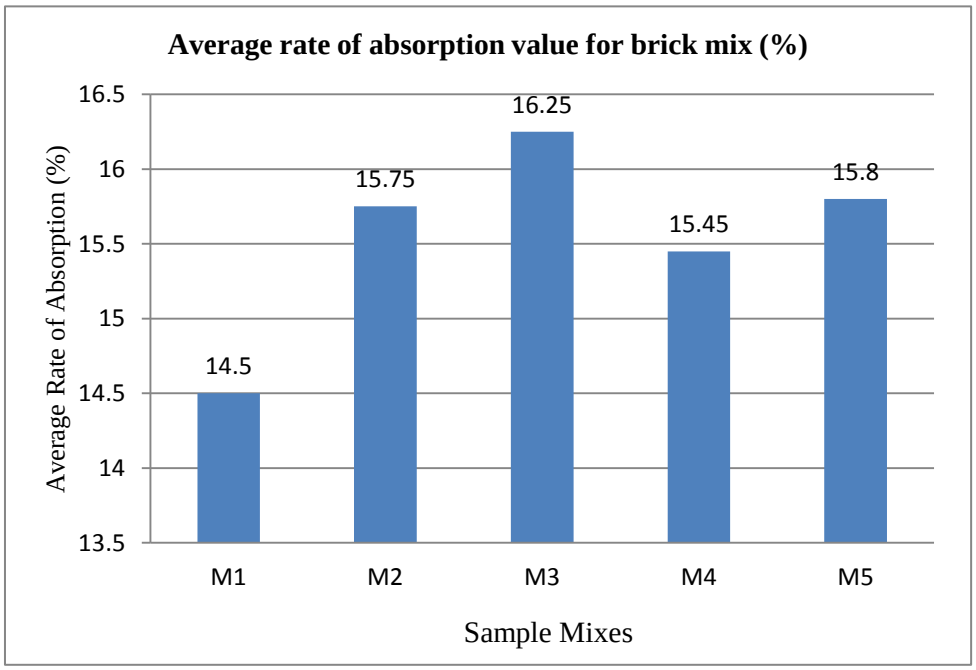

Figure 3- Graph showing water absorption test results for different mixes

4.4. Efflorescence test results

Percentage of efflorescence was calculated by using butter and graph paper. The liability efflorescence of all tested samples with different parameters is reported as slight. Approximately 10% of the exposed area of the brick was enclosed with a lean deposit of salts. Low deposition of salt is attributed to the fact that fly-ash and cement used were having very less salt content in their composition. Only hypo-sludge & lime that was used for research contains little salt. But fly-ash and cement form the bulk of brick. Hence only a little efflorescence is observed in the bricks that too because of lime content.

Table No. 5- Results of Efflorescence Test

S.No.	Specimen	Observations
1	Type A (M 1)	Slight
2	Type B (M 2)	Slight
3	Type C (M 3)	Slight
4	Type D (M 4)	Slight
5	Type E (M 5)	Slight

4.5. Compressive strength of casted hypo-sludge bricks.

The table no. - 6. below shows that; the consolidated test results of the compressive strength obtained from the prepared bricks in different durations that are 7 days, 14 days and 21 days respectively. The M5 proportion bricks are giving the best compressive strength test results for all 7 days, 14 days and 21 days.

Table No. 6 - Consolidated Compressive strength of different samples

Proportions	7 days (N/mm²)	14 days (N/mm²)	21 days (N/mm²)
M1	1.22	2.41	5.43
M2	1.44	3.05	5.88
M3	1.81	3.34	6.76
M4	1.68	3.66	6.88
M5	1.98	3.84	7.1

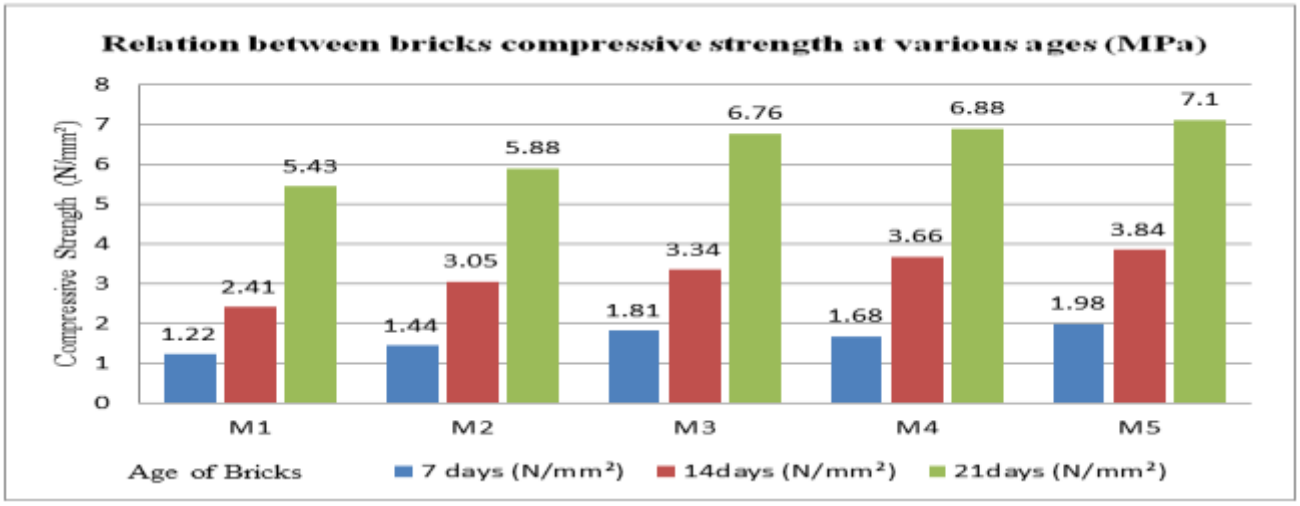

Fig. 4.8- Graph of Comparison of compressive strength for different days sample

5. CONCLUSIONS

The following are the conclusions made from this experimental investigation.

1) As the increase in the content of hypo sludge and with the decrease in the amount of fly-ash, then it is noted that average initial rate of absorption is decreasing in 15%, 20% and 30% hypo sludge content, but for the 10% and 25% quantity of hypo sludge, it was increased.
2) The density of brick masonry got reduced on using hypo sludge. Density is varying between 1880 to 1922.5 kg/m3 for the 10%, 15%, 20%, 25% and 30% hypo sludge respectively
3) In case of hardness test, there is a little or no impression was observed on hypo sludge brick surface as it indicates the proper hardness of brick.
4) The increments in the value of compressive strength have been observed when percentage of hypo sludge was increased from 10% to 30% uniformly and simultaneously the fly ash content was decreased.
5) Compressive strength is varying between 1.22 to 1.98 MPa for 10%, 15%, 20%, 25% and 30% hypo sludge respectively but it is seen that it is more for 20% & 30% hypo sludge and 50% & 30% fly-ash content and least was for 10% hypo sludge and 70% fly-ash content for 7 days.
6) Compressive strength is varying between 2.41 to 3.84 MPa for 10%, 15%, 20%, 25% and 30%, hypo sludge respectively but it is seen that it is more for 25% & 30% hypo sludge and 40% & 30% fly-ash content and least was for 10% and 70% fly-ash content for 14 days. In the case of 21 days strength, the trend is similar, it varies from 5.43 to 7.10 MPa .
7) When it is compared between the various ages of bricks, it was found that the brick sample mix M5 gives the good compressive strength than other sample mix bricks when it was tested for 7 days, 14 days and 21 days.
8) The soundness value is best for 25% and 30% hypo sludge content and it produces good metallic sound without breaking of brick when they struck to each other.
9) The efflorescence of moulded hypo-sludge bricks are under considerable variance, as it contains dissolved chemicals.
10) These bricks are eco-friendly and thus solving the consistent problem of environmental issues like disposing off hypo-sludge waste from paper industries which pollutes the land and air.

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