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Partially Replacement of Clay by S.T.P. Sludge in Brick Manufacturing

Prof.S.S.Razvi [1]
Department of Civil Engineering,
P.E.S. College of Engineering,
BAMU University,
Aurangabad, Maharashtra.

Gopal Bajaj [2]
Department of Civil Engineering,
P.E.S. College of Engineering,
BAMU University,
Aurangabad, Maharashtra.

Vikas Gore[2]
Department of Civil Engineering,
P.E.S. College of Engineering,
BAMU University,
Aurangabad, Maharashtra.

Kalyan Patre[2]
Department of Civil Engineering,
P.E.S. College of Engineering,
BAMU University,
Aurangabad, Maharashtra.

Jyoti Bawaskar[2]
Department of Civil Engineering,
P.E.S. College of Engineering,
BAMU University,
Aurangabad, Maharashtra.

Abstract— In many countries, sludge is a serious problem due to its high treatment costs and the risks to environment and human health. The sludge presents increasingly difficult problem to cities of all sizes because of the scarcity of suitable disposal sites, increasing labour costs, and environmental concerns. The study investigated the use of water treatment sludge incorporated with clay. In this study bricks were produced with sewage sludge additions ranging from 20, 25, 30 and 40% by dry weight respectively and compare produce brick with regular brick. Bricks with a sludge content of up to 40 % were capable of meeting the relevant technical standards. However, if bricks with more than 30 % sludge addition are not recommended for use because they are brittle in nature and easily broken even when handled gently as well as colour is not as per the requirement. Also from this investigation me can solve disposal problem completely and also construct and economical structure with easy designing.

Keywords— STP Sludge, Clay, Crushing strength, Recycling, Environment, Statistical analysis.

1. INTRODUCTION

In many countries, sludge is a serious problem due to its high treatment costs and the risks to environment and human health. The sludge presents increasingly difficult problem to cities of all sizes because of the scarcity of suitable disposal sites, increasing labour costs, and environmental concerns. Sludge generated at water treatment plants should be treated and handled in an environmentally sound manner. Coagulant sludge is generated by water treatment plants, which use metal salts such as aluminium sulphate (alum) or ferric chloride as a coagulant to remove turbidity.

The traditional practice of discharging the sludge directly into a nearby stream is becoming less acceptable because these discharges can violate the allowable stream standards. The discharging of sludge into water body leads to accumulative rise of aluminium concentrations in water, aquatic organisms, and, consequently, in human bodies. Some researchers have linked aluminium's contributory influence to occurrence of Alzheimer's disease, children mental retardation, and the common effects of heavy metals accumulation. The growing demand for waste utilization has made solid wastes like sludge and demolition waste an essential composition of this study. The possibility of reduction of the production costs provides a strong logic for use of this waste.

The most basic building material for construction of houses is the conventional brick. The rapid growth in today's construction industry has obliged the civil engineers in searching for more efficient and durable alternatives far beyond the limitations of the conventional brick production. A number of studies had taken serious steps in manufacturing bricks from several of waste materials. However, the traditional mean of bricks production which has brought hazardous impacts to the context has not yet been changed or replaced by more efficient and sustainable one. If the utilization of the waste like sludge in clay bricks usually has positive effects on the properties such as lightweight bricks with improved shrinkage, porosity, thermal properties, and strength. The lightweight bricks will reduce the transportation and manufactured cost. Moreover, with this waste incorporation it will reduce clay content in the fired clay brick, and then reduce the manufacturing cost and become economical for construction.

2. LITERATURE REVIEWS

In India, out of the total population of 1027 million in the year 2001, about 285 million live in urban areas. The percentage of urban population to the total population of the country, which in the year 1991 was 25.7 percent, stands at 27.8 percent in the year 2001.

The percentage decadal growth of population in rural and urban areas during the decade 1991-2001 was 17.9 and 31.1 percent, respectively. Generate huge amount of sludge containing about 7-10 % hydrocarbon. Disposal of the sludge with the high hydrocarbon content is of environmental concern. Also, Many waste material from various industrial and commercial manufacturing processes has been used to find out an environmental friendly material and method, as well as alternative low cost material for building purposes. Several trials have been reported in Taiwan, UK, USA, Egypt, and other parts of the world to use water treatment sludge in various industrial and commercial manufacturing processes.

In a study that was carried out by Swati Pavagadhi, Divyang Bhargav, Vishal Katariya (2015) they conclude that replacement of soil with this Dry Sludge material reduce the weight of brick. And it's become light weight product. Use of Dry Sludge in brick can save the ferrous and non-ferrous metal industries disposal, land pollution, cost and produces a „greener brick for construction. Another research carried out by Anyakora Nkolika Victoria (May 2013) he conclude that sludge clay burnt bricks can be successfully produced using water treatment plant sludge as supplement for clay under the conditions of firing temperatures, and manufacturing methods used in this study. The proportion of sludge in the mixture and the firing temperature are the two key factors affecting the quality of brick.

In a study that was carried out in Taiwan (Chiang et al. 2009). Novel lightweight bricks have been produced by sintering mixes of dried water treatment sludge and rice husk. Samples containing up to 20 wt.% rice husk have been fired using a heating schedule that allowed effective organic burn-out. Rice husk addition increased the porosity of sintered samples. From the previous researches, it is clearly obvious that water treatment sludge, SF, and RHA could be used in manufacturing of clay brick. The another study which carried out in USA, as a cost-effective technology for arsenic soil remediation (Nagar 2008). The ultimate goal of that study was to evaluate the effectiveness of WTR (Al- and Fe-based) in lowering the human health risk from soil arsenic exposure. A new study was conducted in Taiwan (Lin et al. 2006). In this study, an effort was endeavored to investigate the properties of water permeable bricks made of water treatment sludge and bottom ash. It was concluded that a 20% weight content of bottom ash added to 80% weight content of water treatment sludge under a sintering condition of 1150o C for 360 minutes can generate brick complying with the Chinese standard specifications for first degree brick. Another research carried out in the UK, assessed the potential of incorporating aluminum and ferric coagulant sludge in various manufacturing processes including clay brick making (Godbold et al. 2003). A mixture consists of about 10% of the water treatment sludge and sewage-sludge incinerated-ash was added to about 90% of natural clay to produce the brick.

3. EXPERTIMANTAL ANALYSIs

A. *Material used*

The material uses for this study is sludge and clay.

i. Sludge:

The sludge used for this study is collected from the Municipal Corporation Water Treatment Plant, Aurangabad, Maharashtra.

Table I
MAJOR CONSTITUENTS OF STP SLUDGE

Item	Si02	Fe203	Al203	Ca0	Mg0	Na20	L.o.I
%	43.12	5.26	15.97	5.56	5.56	0.52	26.79

ii. Clay:

The clay used for this study is collected from nearby locally available. And the physical property of that clay is

Table II
MAJOR CONSTITUENTS OF CLAY

Item	SiO2	Fe2O3	Al2O3	CaO	MgO	SO3	Na2O	K2O	TiO2	P2O5	L.O.I
Ratio (%)	65.32	7.51	13.89	1.09	0.95	0.05	2.61	0.75	1.46	0.28	5.87

B. *Sample Preparation*

There are four different series of mixing ratios were tried. However, the batching proportions of raw materials required to produce brick with nominal dimensions of 19x9 X 9 centimetres are shown in Table (iii).

Table III
DIFFERENT PROPORTION RAW MATERIAL

Trail	**Sludge (%)**	**Clay(%)**
A	20	80
B	25	75
C	30	70
D	40	60

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C. Making of Brick

In this paper, two raw materials namely Sludge and clay are as the major ingredients. They are mix with each other in proportion as mention in table (3) to produce brick. The following steps are taken for making brick

1. First of all raw material with required proportion i.e. sludge and clay are mix together and added water with sprinkle. And mixing of material properly it is kept in same manner for 12 to 16 hours.
2. After 12 to 16 hours the mixture is again mixed properly by adding some water. The all the mixing is done manually with hand and feet.
3. After mixing the lump of mix is taken, rolled in sand and slapped into mould. The mould used for this study is metal mould. And this mould is empty at drying area where brick are arranged for dry in sunlight.
4. When brick are kept in sunlight after every two day they are turned over to facilitate uniform drying and prevent from warping.
5. After 8 to 10 days they are ready to be burnt in kiln. The green bricks arranged in kiln and insulation is provided with mud pack. Fire holes are left to ignite the kiln are later sealed to keep the heat inside.
6. This is maintained for week. After a week kiln is disassembled and brick are sorted according to colour. Colour is an indication of the level of burning.

4. TESTING AND RESULT

Following tests are performed on different specimens of brick according to Indian standards code and we compare these specimens of brick with locally available brick in market of Aurangabad, Maharashtra.

A. *Water absorption Test*

1. First of all we note the dry weight of all type of trail made by us and also we note the dry weight of locally available brick.
2. Than we are immersed that all brick in water for 24 hours.
3. After 24 hours we again weight and note wet weight of brick.
4. And from this weight by calculating water absorption by using formula

$$W = \frac{M_2 - M_1}{M_1} X\ 100$$

5. In no case it should be greater than 20% by the requirement specified by IS Code for first class brick.

Table IV
RESULTS OF WATER ABSORPTION TEST

Trail	Proportion	Water absorption (%)
1	Normal brick (100%) clay	10.35
2	Type- A Brick (20% sludge & 80% clay)	14.86
3	Type- B Brick (25% sludge & 75% clay)	16.53
4	Type- C Brick (30% sludge & 70% clay)	11.57
5	Type- D Brick (40% sludge & 60% clay)	17.66

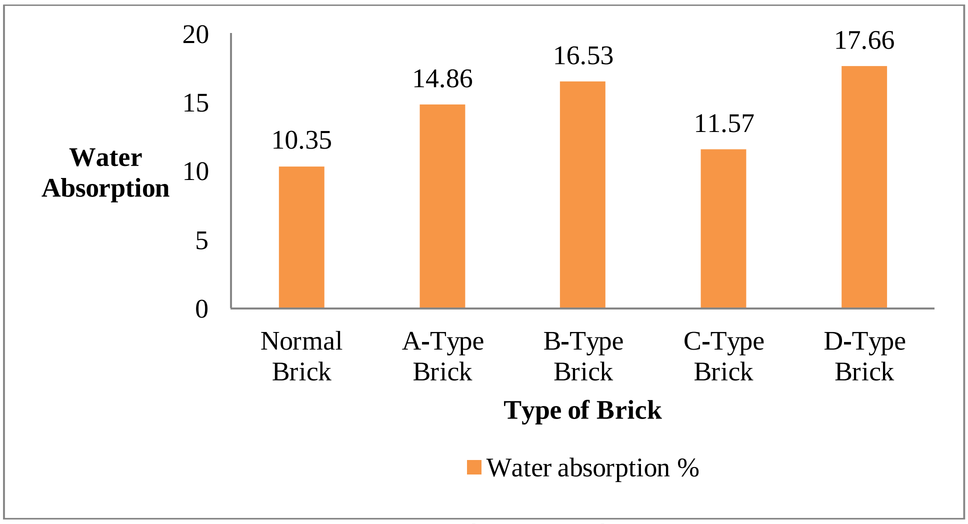

Fig 1.Water absorption Graph

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B. Crushing strength test

1.This test is perform by using IS:3495-PART 1-1992 method.
2. To perform this test we use compressive testing machine.
3. Brick is compressed till crushing of brick occurred, by applying uniform load at rate 14 N/mm².
4. The all the reading occurred on testing machine are measured and noted.
5. According to the reading obtain the crushing strength of all brick are calculated by using formula

Crushing Strength = Maximum load at failure / Avg. area of bed face (mm)

Table V
RESULTS OF CRUSHING STRENGTH TEST

Trail	Proportion	Avg. Crushing strength (N/mm²)
1	Normal brick (100%) clay	3.27
2	Type- A Brick (20% sludge & 80% clay)	2.53
3	Type- B Brick (25% sludge & 75% clay)	2.00
4	Type- C Brick (30% sludge & 70% clay)	1.80
5	Type- D Brick (40% sludge & 60% clay)	1.11

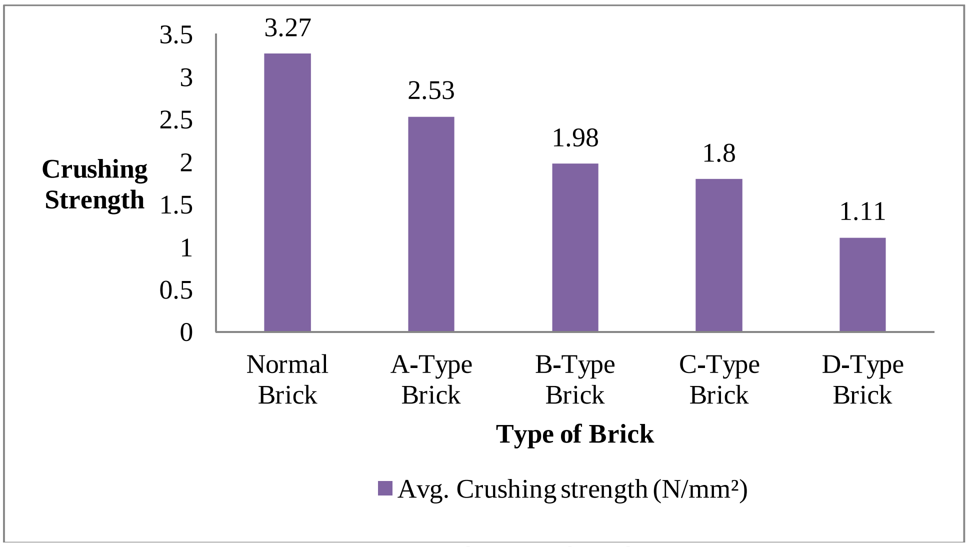
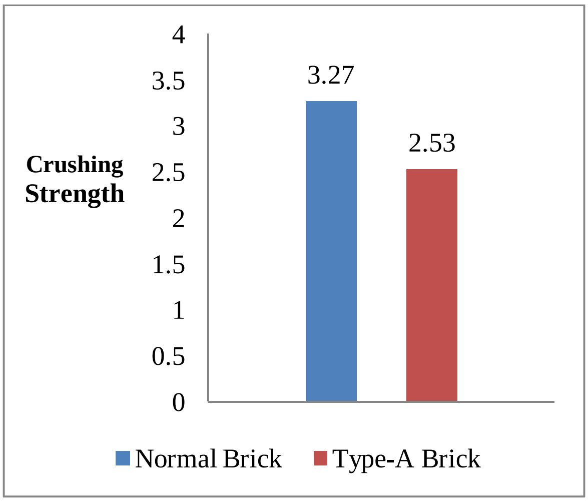


Fig.2 Avg. Crushing strength Graph



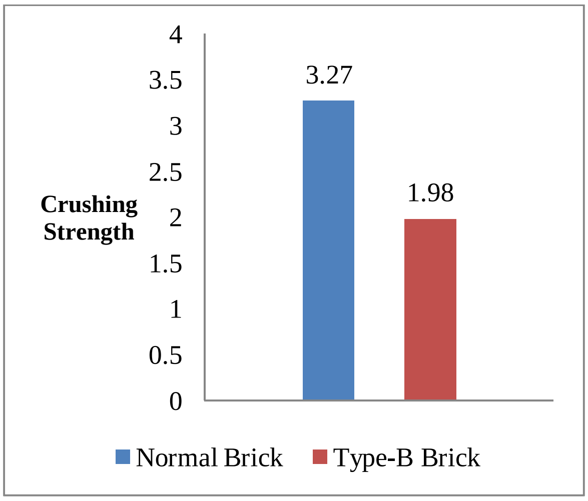


Fig.3 Compare Between Normal &Type- A Brick

Fig.4 Compare Between Normal &Type- B Brick

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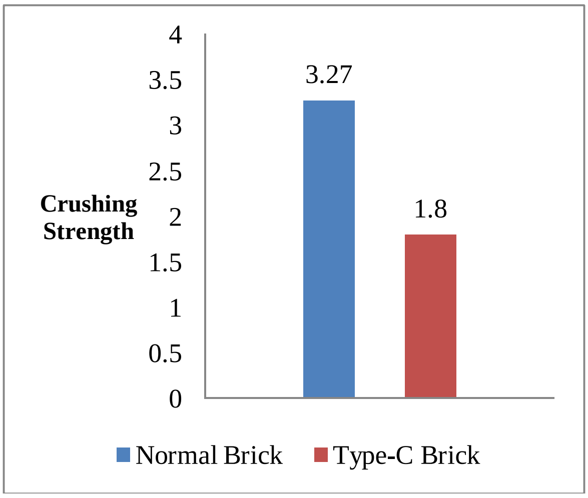


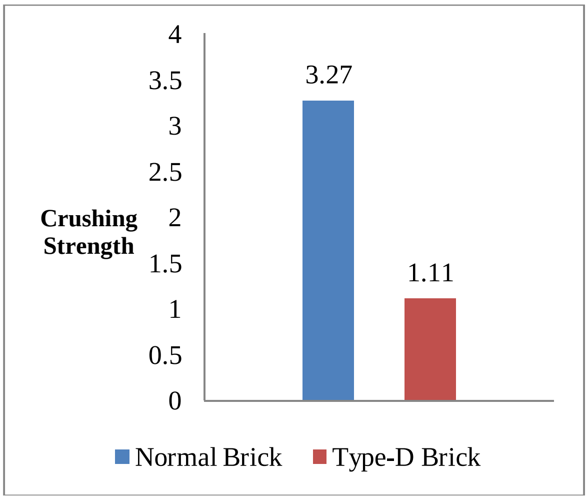


Fig.5 Compare between Normal &Type- C Brick Fig.6 Compare between Normal &Type- D Brick

C. Hardness Test

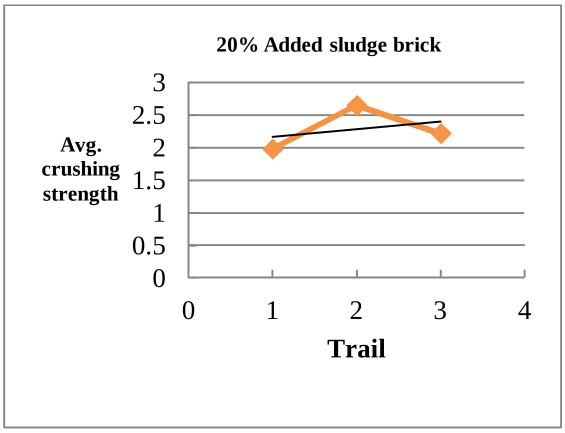
1. Scratch is made on the brick surface with the help of finger nail.
2. If no impression on the surface, the brick is sufficiently hard

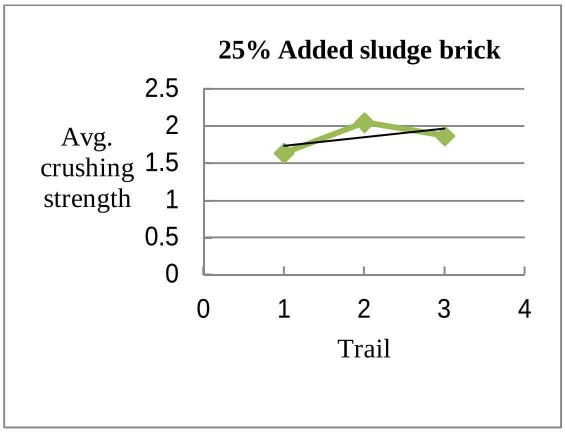
D. Statistical Analysis Result

Accourding to the performance, graph between the trail and crushing strength are prepared. All the trail are calculated statistically to check the result obtain in experiment method.

Table VI
Statistical Equation for different trail

S.No.	Properties	Material	Equation	R^2 value
1	A	Sludge(20%) and Clay (80%)	$y = 0.12x + 2.043$	$R^2 = 0.125$
2	B	Sludge(25%)andClay (75%)	$y = 0.115x + 1.623$	$R^2 = 0.313$
3	C	Sludge(30%)andClay (70%)	$y = 0.175x + 1.25$	$R^2 = 0.942$
4	D	Sludge(40%) and Clay (60%)	$y = 0.205x + 0.696$	$R^2 = 0.933$





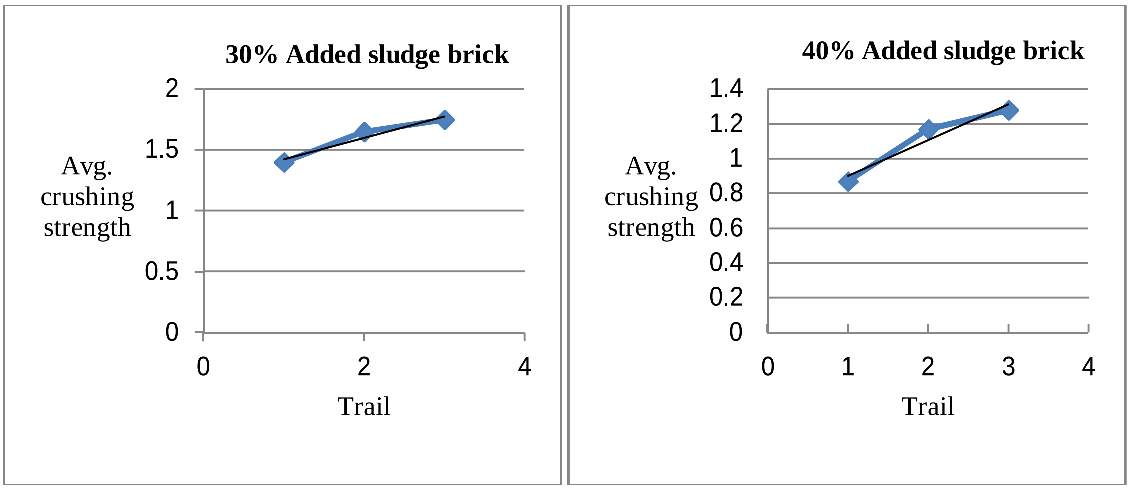


Fig.7 Statistical analysis Result

Justification

In the present study result obtained by experiment and statistical analysis are considered for comparison. There is negligible difference between results obtained from the experimental analysis and statistical analysis; it is due to rounding of the values. The R^2 values shown in table 6 indicate the closeness.

5. COST ESTIMATION

Table VII - Cost Estimation

S.NO.	NORMAL BRICK	TYPE 'A' BRICK (20% SLUDGE)	TYPE 'B' BRICK (25% SLUDGE)	TYPE 'C' BRICK (30% SLUDGE)	TYPE 'D' BRICK (40% SLUDGE)
1	Rs. 3.50	Rs. 2.50	Rs. 1.75	Rs. 1.50	Rs.1.00

A. *Benefit cost ratio Analysis*

Manufacturing cost per Brick = Rs. 2.50
Let Selling price per Brick = Rs. 4.00
Cost Ratio = 4/2.50 = 1.6 > 1 Hence it is very Profitable

B. *Feasibility Analysis*

1) Economic Feasibility:- It utilizes waste material such as sludge whose management leads to expenditure of millions of fund by the Indian government. Since BCR = 1.6 >1 Hence Economically Feasible.
2) Environmental Feasibility:- Sludge harm the environment in number of ways. Such as sludge causes sewage sickness of land, disposal problem. Since this project utilizes use of wastes in making of Brick which is non harmful in nature. Hence Environmentally Feasible.
3) Technical feasibility:- Sludge Bricks can be made just like Clay Bricks i.e. no additional technology is required. Hence Technically Feasible.

6. CONCLUSION

This study suggests that the sludge clay can be effectively used for manufacturing of brick to required shape and size by adopting the proportion of ingredients of Type-A. Merely dumping and disposal problem of sludge will occupy the more space and creates the environmental pollution with in surrounding region. So in order to prevent all the above issues, sludge can be used for manufacturing of brick as a strong material and cost effective. Also, the Type-A brick in this project investigation may prove economical and strength is achieved. Also the water absorption for this brick is in range of 14 to 15% that means its follow the condition requirement of first class brick. Also, if use of this brick can made design easy and dead load which come on structure is control at some level.

A. Future Scope

A long term prospective towards sludge management needs to be drawn out. More imporatntly participating role of the water treatment plant and other technologies are needed on continues basis. The future also posses challenges to scientists,technology and engineers towards sound management of sludge disposal and deposition technologies. This is to ensures that momentum is maintained, more so, since environment issues shall be prime concern during the coming century.

B. Utility and Suggestion

Ifwe used this type of brick which made by us the economy and speedy work may also come at site. Also the saving of Rs.1 against each brick create economical construction work.The brick which produce by us that can be utilise in construction accourding to there load carrying capacity as follow:

1. TYPE- A BRICK:

This type of brick is crushing strength is nearly same as regular brick so we can use this type of brick in

a) Construction of external wall,
b) Commesrical and residential work,
c) At place of heavy loading like ground floor construction where dead load are more.

2. TYPE- B BRICK:

This type of brick is crushing strength is nearly same as regular brick so we can use this type of brick in

a) For parapet wall,
b) Internal wall where loading is less,
c) Boundary wall of garden, park.
d) Also it can use at top floor where dead load is minimum.

3. TYPE- B BRICK:

This type of brick is crushing strength is nearly same as regular brick so we can use this type of brick in

a) This type of brick can be use for the rainwater harvesting purpose
b) For brickback coba purpose and also where less important work is progress.

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[6] Badr El-Din Ezzat Hegazy, Hanan Ahmed Fouad and Ahmed Mohammed Hassanain*(2012) “Incorporation of water sludge, silica fume, and rice husk ash in brick making.”
[7] In Egypt, similar studies investigated the use of sludge as a complete or partial substitute for clay in brick manufacturing (Hassanain, A.M., 2008; Ramadan, M.O., et al., 2008; Hegazy, B.E., 2007).
[8] In another study that was carried out in Taiwan, researchers blended the water treatment sludge with the excavation waste soil to make bricks. The conclusion of the study indicated that 15% was the maximum water treatment sludge addition to achieve firstdegree brick quality (Chihpin, H., et al., 2005).
[9] A research carried out in the UK, investigated the incorporating of two waste materials in brick manufacturing. The study used waterworks sludge and the incinerated sewage sludge ash as partial replacements for traditional brick-making raw materials at a 5% replacement level (Anderson,M., et al., 2003).