LOW COST OF CONSTRUCTION BY USING FLY ASH AS ALTERNATIVE

A thesis submitted
in Partial Fulfillment of the Requirements
for the Degree of

MASTER OF TECHNOLOGY

In

Structural Engineering

By

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2018-19

CERTIFICATE

This is to certify that the dissertation entitled **"LOW COST OF CONSTRUCTION BY USING FLY ASH AS ALTERNATIVE"** which is being submitted by **ABHIMANYU YADAV (ROLL NUMBER- 1160444001)** in partial fulfillment of the requirements for the award of Degree of **Master of Technology in Structural Engineering** of the BBD University, Lucknow, is a record of his own work carried out by him under our guidance and supervision. The results embodied in the dissertation have not been submitted for the award of any other Degree or Diploma.

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DECLARATION

I hereby certify that the work which is being presented in this thesis entitled ***"*LOW COST OF CONSTRUCTION BY USING FLY ASH AS ALTERNATIVE*"*** in partial fulfilment of award of degree of **Master of Technology** in **Structural Engineering** submitted in Department of Civil Engineering, Babu Banarasi Das University, Lucknow is an authentic record of my own work carried under the supervision of **Mohd. Afaque Khan**, Assistant Professor, BBD University, Lucknow, India.

I certify that the above statement made by the student is correct to the best of my knowledge and belief.

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ABSTRACT

Low Cost Housing is a different concept which deals with effective costing and following of techniques which help in reducing the cost construction through the use of faraway available materials beside with and technology improved skills without losing the power, performance and life of the structure. There is huge misconception that low cost housing is suitable for only subnormal works and they are built by using cheap building materials of low quality. The fact is that Low cost housing is done by proper management of resources. Economy is also achieved by postponing finishing works or implementing them in phases. Cost of reduction is achieved by selection of more efficient material or by an improved design. Construction of low cost housing by using the low cost construction materials increases the access to buildings by low income group peoples. Advantages of low cost building materials are **pollution prevention,** Reducing Energy Consumption and use of Natural materials, Use of Local material, **Energy** Efficiency, Use of non-toxic building materials, Longitivity, durability and maintenance of building material, Recyclability and reusability of building material and Biodegrability. The reviews on various low cost building designs and management are presented in this paper.

Key Words: -Low cost. Building materials. Construction.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank **God** for giving the opportunity to pursue my higher education at BBDU, Lucknow and for bestowing upon me the blessings to successfully complete the present work.

It is my proud privilege to express my gratitude and sincere thanks to my supervisor **Mohd. Afaque Khan,** Assistant Professor, Structural Engineering, BBDU for his invaluable suggestions, encouragement and guidance to accomplish my project work.

I am indebted to acknowledge **Mr. Anupam Mehrotra**, HOD, Department of Civil Engineering, BBDU for his encouragement, guidance and vision that inspired me to select the present theme of study.

I am grateful to **Mrs. Neeti Mishra,** Assistant Professor, Structural Engineering, BBDU for providing the invaluable suggestions and support during the project work.

I am also grateful to my batch mates for their helping hand, moral support and encouragement whenever I needed.

And I would like to thank all **the staff of Department of Civil Engineering, BBDU, Lucknow** who directly or indirectly helped me in this work.

I would like to express my deepest gratitude to **my parents** and all those who are closest to me for their endless love, prayers and encouragement. Your support has helped me a lot in accomplishing this project successfully.

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CHAPTER-1

INTRODUCTION

As the population grows, the price in every product hikes. Thereby, the cost in cement and constructions is increased. So, with the growth in population, the need for residential properties is marking in all time demand in the construction industry. Not only the growing population, but the environmental effect is also to be considered. Thus, utilization of the alternate materials can put a mark in today's construction by protecting the environment from unnecessary dumping and polluting. For our use, we have chosen fly ash and rice husk ash as the alternative materials for construction.

Concrete is the basic engineering material used in most of the civil engineering structures. Its popularity as basic building material in construction is because of, its economy of use, good durability and ease with which it can be manufactured at site. The ability to mould it into any shape and size, because of its plasticity in green stage and its subsequent hardening to achieve strength, is particularly useful.

Concrete like other engineering materials needs to be designed for properties like strength, durability, workability and cohesion. Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way.

With advent of new generation admixtures, it is possible to achieve higher grades of concrete with high workability levels economically. Use of mineral admixtures like fly ash, slag, meta kaolin and silica fume have revolutionized the concrete technology by increasing strength and durability of concrete by many folds.

What is mix design?

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The concrete mix design involves various steps, calculations and laboratory testing to find right mix proportions. This process is usually adopted for structures which requires higher grades of concrete. Concrete is an extremely versatile building material because, it can be designed for strength ranging from M10 (10Mpa) to M100 (100Mpa) and workability ranging from 0 mm slump to 150 mm slump. In all these cases the basic ingredients of concrete are the same, but it is their relative proportioning that makes the difference.

Basic Ingredients of Concrete: -

- Cement – It is the basic binding material in concrete.
- Water – It hydrates cement and also makes concrete workable.
- Coarse Aggregate – It is the basic building component of concrete.
- Fine Aggregate – Along with cement paste it forms mortar grout and fills the voids in the coarse aggregates.
- Admixtures – They enhance certain properties of concrete e.g. gain of strength, workability, setting properties, imperviousness etc.

Concrete needs to be designed for certain properties in the plastic stage as well as in the hardened stage.

Properties desired from concrete in plastic stage:-

- Workability
- Cohesiveness
- Initial set retardation

Properties desired from concrete in hardened stage:-

- Strength
- Imperviousness
- Durability

How to get the most economical mix design:-

Cement content can be reduced by selecting appropriate raw materials

- Use of graded sand with low silt content
- Aggregates should be equi-dimensional with min flakiness and elongation. For concretes up to M 40 grade rounded aggregates give best results.
- By using higher size of aggregates where cover and reinforcement spacing permit.

- By reducing the workability requirement of concrete: - Higher workability always comes at cost. Higher workability is achieved by increasing the cement content or by adding plasticizers.

- By using pozzolonic materials like fly ash & ground granulated blast furnace slag etc. These materials not only bring economy but also increase the workability of concrete.

- By correct use of compatible admixture. If admixtures are used judiciously after testing compatibility with cement, they substantially reduce the cement content. This is more so for higher grades of concrete and where higher workability is desired. The cost incurred on admixture in such cases is less than that required for additional cement.

Will use of 53 grade of cement result in lower cement consumption?

A higher grade of cement will enable us to use a higher order cement curve for calculating the water cement ratio. This means that a higher grade cement will allow us to use a higher water/cement ratio for achieving a given target strength. This will result in lower cement consumption for a given water demand. With advent of modern cement manufacturing technology the difference between 43 grade and 53 grade cement is reducing. Almost all the 43 grade cements available today have strengths required for E curve (strength range of 51.5 to56.4N/mm2) while some of the 43 grade cements give higher strengths to fit F curve (strength range of 56.4 to 61.3 N/mm2). Most of the 53 grade cements fall in F curve while some give higher strengths for which curves are not defined (Some call them as G curve with strength above 61.3 N/mm2). Hence the curve of cement (Strength range) governs the cement consumption rather than the grade of cement. If a 53 grade cement is stored for a long duration, its strength may drop to that of E curve or even D curve. Even a higher cement curve may not always ensure lower cement consumption. This is because the durability criterion restricts the maximum water/cement ratio for a given condition of exposure.

Factors Affecting Durability of Concrete:-

External Factors

- Sulphate attack
- Chloride attack
- Carbonation
- Effervescence (Leaching)
- Shrinkage / Creep
- Alkali Aggregate Reaction

Sulphate attack

Magnessium Sulphate, Sodium Sulpahte when present in solution react with hardened cement paste.

Remedy

- Use of sulphate resisting cement
- Low Water/ cement ratio (W/C below 0.5)
- Use of Pozzolona

Chloride Attack

Attacks the reinforcement resulting in corrosion

Remedy

- Use of low water/ cement ratio.
- Use of Pozzolonic materials.
- Protective coating on steel.

Carbonation

Depth of Carbonation (mm)	Age (Years)	
	M20	M40
5	0.5	4
10	2	16
15	4	36
20	7	64

Remedy

- Use of low w/c Ratio or Higher grade of concrete.
- Increase cover to reinforcement.

Leaching (Effervescence)

Hydration of cement by water leads to formation of Cement Gel and Lime $Ca(OH)_2$.

Remedy

- Use of low water/ cement ratio.
- Use of Pozzolonic materials.

Shrinkage

Plastic shrinkage and Drying Shrinkage

Remedy

- Early curing
- Protecting concrete from Wind/ Sun.
- Wetting of Aggregates / Subgrade.

Alkali Aggregate Reaction

Alkalis present in cement react with reactive form of silica present in Aggregates.

Remedy

- Use of non – reactive aggregates.
- Use of low Alkali cements with Alkali content less than 0.6 %.

CHAPTER-2

LITERATURE REVIEW

Many authors have reported the use of fly ash brick in the replacement of conventional clay brick, for the purpose of cost reduction. Many papers have been published on Low Cost Housing, some of them are:

Bredenoord J(2016) carried out study on sustainable Housing and Building Materials for Low-income Households; it is observed that sustainable goals for low-cost housing and applications are achievable. Measures concerning the physical development of neighborhoods, such as urban density and connectivity are equally as important as measures concerning community development. The final comprise support for community built organizations, small housing cooperatives (or similar forms of cooperation) and individual households – or small groups – that build and increase their houses incrementally. Adequate design and social organization and support are preconditions for achieving sustainability in incremental housing.

Felix Raspall(2016) carried out study on Building from End-of-Life: An Alternative Approach for Low-Cost Urban Housing, it is observed that Our research investigates the possibilities of beating into the life cycle of construction materials as a basis of unexploited construction components for low-cost housing. In the informal city, a market of salvaged materials is already in place. Though, in the urbanized world, reuse practices in construction are characteristically dismissed. This research contributes with strategies to secure very low-cost housing units consuming reused construction components, focused on the functional, aesthetic and economic aspects.

Iwuagwu ben ugochukwu et(2015) carried out study on Local building materials, it is observed that the paper recognizes the problem of inadequate housing as a critical challenge to sustainable urban growth and cities development. Extensive use of recycled materials help conserve restores and preserves the ecosystem. Green buildings wastes management ensures resources and energy efficiency. The closeness of materials saves cost and decreases pollution by fuel through transportation.

Ali Haider Jasvi1(2015) carried out study on Sustainable Use Of Low Cost Building Materials In The Rural, it is observed that, The main challenge is to use the materials in structural constituent for low cost housing and their adaptation to influences like – technical, social, ecological, physical – through different products. It encounters the idea about the need of housing in country side India and explains different uses of materials and the techniques of building construction for LIG people, urban poor's in different aspects of building. It covers the use of local materials in the building to reduce cost and it makes affordable houses for low income people

F. Pachecotorgal(2014) carried out study on Earth construction and Building materials, it is observed that in this paper earth construction has a major expression in less developed countries, on the other hand the mimetic temptations near more poisoning construction techniques based on reinforced concrete and bricks that fired up are likely to favor a change near a clear unsustainable design. In order to disclosure and highlight the importance of earth construction this article reviews some environmental benefits such as non-renewable resource consumption, waster generation, energy consumption, carbon dioxide emissions and indoor air quality.

Tomas.U.Ganiron et al(2014) carried out study on Prefabricated Technology in a modular home, it is observed that one of interesting perceptions in the study is that prefabricated components has a significance change in the terms of a construction cost as relate to the old-fashioned methods due to the materials and fast band short time duration of construction.

Sengupta Nilanjan(2013) carried out study of appropriateness of cost effective building construction technologies, it is observed that this paper studied the acceptability and adaptability potential of different cost effective building constructions through field survey, literature study and technical calculations and tried to find out the most appropriate one among those.

Swaptik Chowdhury(2013) carried out study on Prospects of low cost housing in India, it is observed that in this paper alternative construction materials mainly natural material such as bamboo, straw, usage of Bagasse –cement boards and panels, bagasse –PVC boards, Coir-CNSL board, Jute coir composites, coconut and wooden chips roofing materials, Manmade materials like fly ash, aerocon panels, ferrocement, rice husk were studied and the potential of these materials to be used as alternate building materials is brought out.

David William Dobson et al(2013) carried out study on Sustainable construction, it is observed that the objective in this paper were to found if there is a belief within the commerce that sustainability means increased cost and to investigate whether using sustainable construction methods save money by reducing a building carbon output and running costs. Following the literature survey, a questionnaire survey has been carried out to canvas opinions within industry. This paper will benefit customers and designers as they can see how integrating sustainability into new buildings will enable big savings on utility and maintenance costs once the building is operational.

R.Caponetto(2013) carried out study on Ecological materials and technologies in low cost building systems, it is observed that the high recyclability of natural materials that can be used in low cost building associated with construction techniques capable of exploiting the principles of bioclimatic architecture for liveliness needs allow us to create building environmentally conscious and responsible. At the same time the project of a special block was developed to meet the needs of sustainability and ease of construction.

John M.Hutcheso(2011) carried out study on project management of low cost housing in developing countries, it is observed that the study of this paper include designs, cost control systems, communications , contract law and planning. An appreciation of the evidence compounded from the problems portrayed throughout the paper leads to decisions of the need for simplifications of designs, the impact of inadequate local support and hence the need for detailed and complete advanced planning. In addition the conclusions stress the need for the careful collection of self-supportive teams of multi-disciplined professionals and sub professionals.

Vivan W.Y. Tam(2011) carried out study on cost effective of using low cost housing Technologies in construction, it is observed that construction methods of foundation, walling, roofing and lintel are compared. Strength and durability, safety and mental satisfaction are factors that assume top priority during cost reduction. It is found that about 26.11% and 22.68% of the building cost can be saved by consuming low cost housing technologies in assessment with the traditional construction methods.

Kuo-Liang Lin(2011) carried out study on Human Resource allocation for remote construction projects, it is observed that when allocating human resources for the management team of distant projects sites, these firms have the strategies between assigning regular staff and hiring local temporary employees. This paper first proposes a decision making model for human resource allocation in remote construction cost. The case study results show that regular project administrators, who are able to reduce managerial flaws and cut down project losses, are favored over local ones.

Preetpal Singh(2010) carried out study on Low Cost Housing Need For Today's World; it is observed that Construction cost in India is increasing at around 50 per cent over the average inflation levels. It have enumerated increase of up to 15 per cent all year, mainly due to cost of basic building materials such as steel, cement, bricks, timber and other inputs as well as cost of labour. As a result, the cost of building by means of conventional construction materials and construction is becoming beyond the affordable limits particularly for low-income groups of population as well as a big cross section of middle - income groups. So, there is essential to adopt cost-effective construction methods either by up-gradation of traditional technologies using local resources or applying current construction materials and methods with well-organized inputs leading to economic solutions. By using Low Cost Housing Technologies, we can reduce approx. 25% of the total cost of housing.

Mohannad sharif zami et al(2010) carried out study on Economic benefits of contemporary earth construction in low cost urban housing state, it is observed that stabilized earth is an alternative building material on each continent and in each age. This article reviews and argues the economic benefits of using earth as a building material and describes the associated construction techniques for urban housing provision in developing countries.

Rinku Taur et al(2009) carried out study on Low Cost Housing, it is observed that, This paper goals to argument out the various aspects of prefabricated construction methodologies for low cost housing by highlighting the different prefabrication techniques, and the economical advantages accomplished by its adoption. In a building the foundation, walls, entries and windows, floorings and roofs are the most important components, which can be analyzed individually based on the needs thus, improving the speed of construction and dropping the construction cost. The major current methods of construction systems considered here are namely, structural block walls, mortar fewer block walls, prefabricated roofing components like precast RC planks, precast hollow concrete panels, precast concrete/Ferro cement panels are considered.

B Bakhtyaretal(2009) carried out study on A Review on Low Cost Housing Process in Malaysia, it is observed that, The results confirmed that making balance between low income obligations and developer's profit-making is the key element for building more LCH in the country.

CHAPTER-3

MATERIALS & PROPERTIES

Concrete:-

This section covers the following topics.

- Constituents of Concrete
- Properties of Hardened concrete

Constituents of Concrete:-

Concrete is a composite material composed of gravels or crushed stones (coarse aggregate), sand (fine aggregate) and hydrated cement (binder).

The scattered coarse aggregates and the matrix surround them. The matrix consists of sand, hydrated cement and tiny voids.

Aggregate:

The coarse aggregate are granular materials obtained from rocks and crushed stones. They may be also obtained from synthetic material like slag, shale, fly ash and clay for use in light-weight concrete.

The sand obtained from river beds or quarries is used as fine aggregate. The fine aggregate along with the hydrated cement paste fill the space between the coarse aggregate. The important properties of aggregate are as follows.

- Shape and texture
- Size gradation
- Moisture content
- Specific gravity
- Unit weight
- Durability and absence of deleterious materials.

The nominal maximum coarse aggregate size is limited by the lowest of the following quantities.

- 1/4 times the minimum thickness of the member
- Spacing between the tendons/strands minus 5 mm
- 40 mm.

The deleterious substances that should be limited in aggregate are clay lumps, wood, coal, chert, silt, rock dust (material finer than 75 microns), organic material, unsound and friable particles.

Cement:

In present day concrete, cement is a mixture of lime stone and clay heated in a kiln to 1400 - 1600ºC. The information is revised as per IS:456 - 2000, Plain and Reinforced–Concrete Code of Practice.

- **Ordinary Portland cement** confirming to IS:269 - 1989,Ordinary Portland Cement,33 Grade – Specification.
- **Portland slag cement** confirming to IS: 455 - 1989, Portland Slag Cement–Specification, but with not more than 50% slag content.
- **Rapid-hardening Portland cement** confirming to IS: 8041 - 1990, Rapid Hardening Portland Cement – Specification.

Water:

"Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete and steel".

The water should satisfy the requirements of Section 5.4 of IS: 456 - 2000.

Admixtures:

IS: 1343 - 1980 allows using admixtures that conform to IS: 9103 - 1999, Concrete Admixtures – Specification. The admixtures can be broadly divided into two types: chemical admixtures and mineral admixtures. The common chemical admixtures are as follows.

- Air-entraining admixtures
- Water reducing admixtures
- Set retarding admixtures

- Set accelerating admixtures
- Water reducing and set retarding admixtures
- The common mineral admixtures are as follows.
- Fly ash
- Ground granulated blast-furnace slag
- Silica fumes
- Rice husk ash
- Metakoline

These are cementitious and pozzolanic materials.

FLY ASH:-

Ash is a residue resulting from combustion of pulverized coal or lignite in Thermal Power Plants. About 80% of total ash is in finely divided form which is carried away with flue gases and is collected by Electrostatic precipitator or other suitable technology. This Ash is called (dry) Fly Ash or chimney Ash or Hopper Ash. The balance 20% of the Ash gets collected at the bottom of the boiler and is referred as Bottom Ash. When Fly Ash and Bottom Ash is carried to storage pond in the form of water slurry and deposited, it is termed as Pond Ash. Fly Ash consists of inorganic materials mainly silica and alumina with some amount of organic material in the form of unburnt carbon. Its fineness is comparable to cement, however, some particles have size less than 1 micron in equivalent diameter. It possesses pozzolanic characteristics.

RICE HUSK ASH:-

About one ton of husk is produced from five tons of rice paddy and it has been estimated that some 120 million tons of husk could be available annually on a global basis for pozzolana production. As the ash content by weight is about 20%, there are potentially 24 million tons of RHA available as a pozzolana.

Traditionally, rice husk has been considered a waste material and has generally been disposed of by dumping or burning, although some has been used as a low-grade fuel. Nevertheless, RHA has been successfully used as a pozzolana in commercial production in a number of countries including Columbia, Thailand and India.

Amorphous RHA is a high quality pozzolana which, when mixed with a good quality lime, should produce a cement giving 7 and 28 days compressive strengths of mortars well in excess of 2 and 4 mega Pascal's (MPa) respectively. The pozzolanic reaction of RHA is relatively fast and, unlike most other pozzolanas, most of the strength gain of RHA-based cements will take place during the initial 28 days.

Properties of Hardened Concrete:-
8

The concrete in its applications has to be of good quality. It requires the following Attributes.

- High strengthwith low water-to-cement ratio
- Durability with low permeability, minimum cement content and proper mixing, compaction and curing
- Minimum shrinkageandcreepby limiting the cement content.

The following topics are discussed.

- Strength of concrete
- Stiffness of concrete
- Durability of concrete
- High performance concrete
- Allowable stresses in concrete.

Strength of Concrete:

The following sections describe the properties with reference to IS: 1343 - 1980. The strength of concrete is required to calculate the strength of the members. For concrete applications, high strength concrete is required for the following reasons.

- To have higher resistance in compression, tension, shear and bond.
- To have higher stiffness for reduced deflection.
- To have reduced shrinkage cracks.

Compressive Strength:

The compressive strength of concrete is given in terms of the characteristiccompressive strengthof 150 mm size cubes tested at 28 days (f_{ck}). The characteristicstrength is defined as the strength of the concrete below which not more than 5% of the test results are expected to fall. This concept assumes a normal distribution of the strengths of the samples of concrete.

The increase in strength with age as given in IS:1343 - 1980, is not observed in present day concrete that gains substantial strength in 28 days. Hence, the age factor given in

Clause 5.2.1 should not be used. It has been removed from IS:456 - 2000.

Tensile Strength:

The tensile strength of concrete can be expressed as follows.

- **Flexural tensile strength**: It is measured by testing beams under 2 pointloading (also called 4 point loading including the reactions).
- **Splitting tensile strength**: It is measured by testing cylinders under diametric compression.
- **Direct tensile strength**: It is measured by testing rectangular specimens underdirect tension.

In absence of test results, the Code recommends to use an estimate of the flexural tensile strength from the compressive strength by the following equation.

$$\mathbf{f_{cr} = 0.7 \sqrt{f_{ck}}}$$

Here,

f_{cr}= flexural tensile strength in N/mm^2

f_{ck}= characteristic compressive strength of cubes in N/mm^2

Stiffness of Concrete:

The stiffness of concrete is required to estimate the deflection of members. The stiffness is given by the modulus of elasticity. For a non-linear stress (f_c) versus strain (ε_c) behavior of concrete the modulus can be initial, tangential or secant modulus. IS:1343 - 1980 recommends a **secant modulus** at a stress level of about $0.3f_{ck}$. The modulus is expressed in terms of the characteristic compressive strength and not the design compressive strength. The following figure shows the secant modulus in the compressive stress-strain curve for concrete.

The modulus of elasticity for short term loading (neglecting the effect of creep) is given by the following equation.

$$\mathbf{E_{cc} = 5000\sqrt{f_{ck}}}$$

Here,

E_{cc} = short-term static modulus of elasticity in N/mm^2

f_{ck}= characteristic compressive strength of cubes in N/mm^2

The above expression is updated as per IS: 456 – 2000.

Durability of Concrete:

The durability of concrete is defined as its ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration. The common durability problems in concrete are as follows.

- Sulphate and other chemical attacks of concrete.
- Alkali-aggregate reaction.
- Freezing and thawing damage in cold regions.
- Corrosion of steel bars or tendons.

The durability of concrete is intrinsically related to its water tightness or permeability. Hence, the concrete should have low permeability.

The durability is addressed in IS: 1343 - 1980 in Section 7. In Appendix A there are guidelines on durability. Table specifies the maximum water-to-cement (w-c) ratio and the minimum cement content for different exposure conditions.

To limit the creep and shrinkage IS: 1343 - 1980 specifies a maximum cement content of 5303 kg per m of concrete (Clause 8.1.1).

High Performance Concrete:

High performance concrete is a concrete mixture, which possess high durability and high strength when compared to conventional concrete. This concrete contains one or more of cementious materials such as fly ash, Silica fume or ground granulated blast furnace slag and usually a super plasticizer. The term 'high performance' is somewhat pretentious because the essential feature of this concrete is that it’s ingredients and proportions are specifically chosen so as to have particularly appropriate properties for the expected use of the structure such as high strength and low permeability. Hence High performance concrete is not a special type of concrete. It comprises of the same materials as that of the conventional cement concrete. The use of some mineral and chemical admixtures like Silica fume and Super plasticizer enhance the strength, durability and workability qualities to a very high extent. High Performance concrete works out to be economical, even though it’s initial cost is higher than that of conventional concrete because the use of High Performance concrete in construction enhances the service life of the structure and the structure suffers less damage which would reduce overall costs. Concrete is a durable and versatile construction material. It is not only strong, economical and takes the shape of the form in which it is placed, but it is also aesthetically satisfying. However experience has shown that concrete is vulnerable to deterioration, unless precautionary measures are taken during the design and production.With the advancement of concrete technology, high performance concrete is getting popular in pre-stressed applications. The attributes of high performance concrete are as follows.

- High strength
- Minimum shrinkage and creep
- High durability
- Easy to cast
- Cost effective.

Traditionally high performance concrete implied high strength concrete with higher cement content and low water-to-cement ratio. But higher cement content leads to autogenously and plastic shrinkage cracking and thermal cracking. At present durability is also given importance along with strength.

MIX DESIGN

Concrete Mix Design – M 20 Grade of Concrete

- **REQUIREMENTS-:**

Specified strength=20N/Sqmm

Durability requirement:

- Exposure Moderate
- Mini. Cement Content = 300 Kgs/cum

Cement (Refer Table No. 5 of IS:456-2000):

- Make (Birla)
- Type OPC
- Grade 43

Workability:

Compacting factor = 0.7

Degree of quality control Good:

- **TEST DATA FOR MATERIALS SUPPLIED:-**

CEMENT:

Specific gravity = 3.05

Avg. comp. strength 7 days = 46.5 more than 33.0

28 days = 55.0 more than 43.0

COARSE AGGREGATE:

20mm Graded

Type Crushed stone aggregate

Specific gravity = 2.68

Water absorption = 1.46

FINE AGGREGATE (Coarse sand):

Type Natural (Ghaggar)

Specific gravity = 2.6

Water absorption = 0.5

Free (surface) moisture = 1.4

IS Sieve Size	% Retained	Cumulative % Retained	Percentage Passing
10mm	0.00	0.00	100.00
4.75mm	5.20	5.20	94.80
2.36mm	3.00	8.20	91.80
1.18mm	8.60	16.80	83.20
600 microns	25.80	42.60	57.40
300 microns	32.80	75.40	24.60
150 microns	20.70	96.10	3.90

- **TARGET MEAN STRENGTH (TMS):-**

Statistical constant K = 1.65

Standard deviation S = 4.6 Thus, TMS = 27.59 N/Sqmm

- **SELECTION OF W/C RATIO:-**

As required for TMS = 0.5

As required for „Moderate" Exposure = 0.55

Assume W/c ratio of 0.5

- **DETERMINATION OF WATER & SAND CONTENT:-**

For W/C = 0.6

C.F. = 0.8

Max. Agg. Size of 20 mm

Water content = 186 Kg/cum

Sand as percentage of total aggregate by absolute volume=35

Thus,

Net water content = 180.42 Kg/cum

Net sand percentage = 33 %

S.No.	Change In Condition	Adjustment (in %) required in			
		Water Content		Sand Content	
1.	Sand Conforming To Zone-II	0	0	0	0
2.	Decrease In CF By 0.1	-3	-3	0	0
3.	Each 0.05 Decrease In W/C Ratio. Required W/C Ratio=0.5 Decrease=0.6-0.5=0.1	0	0	-1	-2
4.	For Rounded Agg	NA		NA	
5.	Total Adjustment		-3		-2

- **DETERMINATION OF CEMENT CONTENT:-**

W/c ratio = 0.5

Water content = 180.42 Kg/cum

Thus, Cement content = 360.84 Kg/cum Adequate for moderate exposure Say 360 Kg/cum

- **DETERMINATION OF COARSE AND FINE AGGREGATE CONTENT:-**

Assume entrapped air as 2 % Thus,

cum = [180.42+360/3.05 + {1/0.33}*{FA/2.6}]/1000

& 0.98 cum = [180.42+360/3.05 + {1/0.67}*{CA/2.68}]/1000 Hence,

FA = 584 Kg/cum

CA = 1223.8 Kg/cum

WATER	CEMENT	FA	CA
180.42	360	584	1223.8
0.50	1.00	1.62	3.40

The final mix proportions of M-20 grade of concrete become:-

CONSIDER: Cement:FA: CA = 1:1.5: 3

Concrete Mix Design – M 30 Grade of Concrete:-

Similarly the design is worked out

CONSIDER: Cement: FA: CA = 1: 1: 2

ALTERNATE MATERIALS AND TECHNIQUES

- The foundation and base course of the floor is made of soil cement stabilized material.
- The load bearing walls have been constructed using soil cement stabilized blocks.
- Load bearing walls with light weight R.C.C.
- Rice Husk Ash and Lime has been used as cement in the fabrication of hollow.
- The roof is prefabricated and consists of battens tiles..
- Arches have been constructed by using old truck tyres to save shuttering and labour cost.
- Cost of doors, windows, and their frames has been reduced by casting them with Ferro cement.
- The roof is constructed with precast batten tiles.

SOME BUILDING COMPONENTS USED FOR SUCH CONSTRUCTION

FIG.1 PRECAST CONCRETE STONE MASONRY BLOCKS

FIG.2 FERROCEMENT BARREL SHELL ROOFING SYSTEM

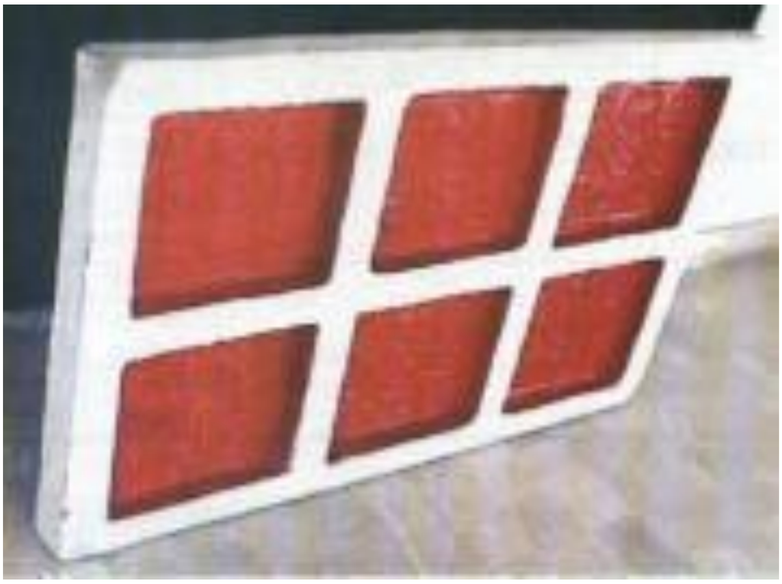


FIG.3 PRECAST REINFORCEMENT BURNT CLAY BRICK WAFFLE SLAB TILE FOR ROOFING

INTRODUCTION:-

Studies conducted at Canada Center for Mineral and Energy Technology (CANMET) and University of Calgary have indicated that structural concrete with 28 days strength around 60MPa and of adequate durability can be produced by the Canadian fly ash replacing up-to 60% cement by weight and incorporating high range water reducing and air entraining admixtures in concrete. Naik and Ramme2 presented two case histories wherein 70% cement was replaced by class C fly ash to pave a 254 mm thick roadway. To obtain high workability and durability a high range water reducing agent and an air entraining agent was added to the concrete mix. The other case reported by the same author’s involved placing of the same High Performance Concrete in the construction of 138 kV transformer foundations. No problems were reported during or after construction in both projects and the use of High Volume Fly ash Concrete (HVFC) resulted in considerable economy and technical benefits.

Malhotra etal.5 studied in detail the properties of concretes with a wide range of Canadian fly ashes at 58% of the total cementitious materials. These concretes were tested for compressive strength, creep strain and resistance to chloride ion penetration at various ages up to one year. The results of study by Joshi etal.6,7 indicated that with fly ash replacement levels up to 50% by cement weight, concrete with 28-day strength ranging from 40 to 60 MPa and with adequate durability can be produced with cost saving of 16% by 50% replacement level.

In India, Fly ash mission has initiated projects on use of higher volume fly ash concrete construction. Gujarat Ambuja cements had laid down a high volume fly ash (50%) concrete road at their Ropar Plant, Punjab. The grade of the concrete was M-40. How fly ash can be used as a construction material in various aspects is discussed below.

WHAT IS FLY ASH?

Power plants fuelled by coal produce more than half of the electricity we consume in India today. But in addition to electricity, these plants produce a material that is fast becoming a vital ingredient for improving the performances of a wide range of concrete products. That material is fly ash. Fly ash is comprised of the non-combustible mineral portion of coal. When coal is consumed in a power plant, it is first ground to fineness of powder. Blown into power plant’s boiler, the carbon is consumed- leaving molten particles rich in silica, alumina and calcium.

Ash Collection:

Ash can be collected in following categories -

- Dry Fly Ash
- Bottom Ash
- Conditioned Fly Ash

WHY FLY ASH UTALIZATION AS CONSTRUCTION MATERIALS?

Fly ash is an excellent resource material for construction industry. Fly ash utilization helps conserve natural resources like clay, lime stone required for making cement- thus saving environment.

- Fly ash is an excellent fill material for road/rail embankment.
- Fly ash is suitable for reclamation of both open cast and underground mines.
- DE coaled area can be reclaimed for agriculture/floriculture/afforestation.
- Less requirement of land for fly ash pond.
- Fly ash has pozzolanic properties and used in the production of Portland Pozzolana

Cement (PPC), therefore “Environment friendly”:

CHEMICAL COMPOSITION OF FLY ASH:

Since the particles solidify while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5µm to 100µm. They consist mostly of silicon dioxide (SiO_2), which is present in two forms: amorphous**,** which is rounded and smooth, and crystalline, which is sharp, pointed and azardous; aluminum oxide (Al_2O_3) and iron oxide (Fe_2O_3). Fly ashes are generally highly heterogeneous, consisting of a mixture of glassy particles with various identifiable crystalline phases such as quartz, mullite, and various iron oxides. Fly ash also contains environmental toxins in significant amounts, including arsenic; barium; beryllium; boron; cadmium etc.

Component	**Bituminous**	**Subbituminous**	**Lignite**
SiO_2 (%)	20-60	40-60	15-45
Al_2O_3 (%)	5-35	20-30	20-25
Fe_2O_3 (%)	10-40	4-10	4-15
CaO (%)	1-12	5-30	15-40
LOI (%)	0-15	0-3	0-5

CLASSIFICATION OF FLY ASH:-

There are two classes of fly ash defined by ASTM C618:

- Class F fly ash,
- Class C fly ash and
- Class N fly ash

The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash.

Class F fly ash:

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 10% lime (Cao). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quick lime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds.

Class C fly ash:

Fly ash produced from the burning of younger lignite or Sub-bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over lime. Class C fly ash generally contains more than 20% lime (Cao).

AREAS OF FLY ASH UTALIZATION:-

Pozzolana:

- Manufacture of Portland Pozzolana Cement.
- Part replacement of OPC in concrete works.
- High Volume fly ash Concrete.
- Manufacture of Ash Bricks and Building products.

High value Applications:

- Manufacture of Ceramics, Paints, synthetic wood.

Use of Fly Ash in concrete:

Fly ash is the most commonly used pozzolona with cement. A Pozzolana is essentially a siliceous material, which in itself -possessing no cementitious properties; will in finely divided form and in presence of water react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties.

The hydration of cement is an exothermic reaction resulting in formation of gel (binding material) & calcium hydroxide (free lime).

The two principle components of cement namely C_3S and C_2S react with water as follows: -

- $C_3S + H_2O = Gel + Ca(OH)_2$

The corresponding weights involved are as follows 100 + 24 = 75 + 49

- $C_2S + H_2O = Gel + Ca(OH)_2$

The corresponding weights involved are as follows:

100 + 21 = 99 + 22

Thus we see that in hydration of C_3S almost 50% lime by weight of C_3S is generated as compared to only 20% in case of C_2S. C_3S is responsible for early gain of strength while C_2S results in later gain of strength. Today's cements in an effort to give high early strength contain higher proportion of C_3S.Thus lime generated in concrete as a result of hydration is as much as 30% by weight of reacting cement.

The free lime generated as a result of hydration is water-soluble and tends to leach out. This makes concrete porous and more vulnerable to further attack from water and other chemicals.

The reactive silica present in fly ash converts free lime into calcium silicate hydrates, which is insoluble in water and possesses cementitious properties. It leads to further gain of strength at later ages in concrete. The IS allows up to 35% replacement ofcement by fly ash.

ADVANTAGES:-

- Improvement in workability
- Durability to thermal cracking
- Durability to Chemical Attacks

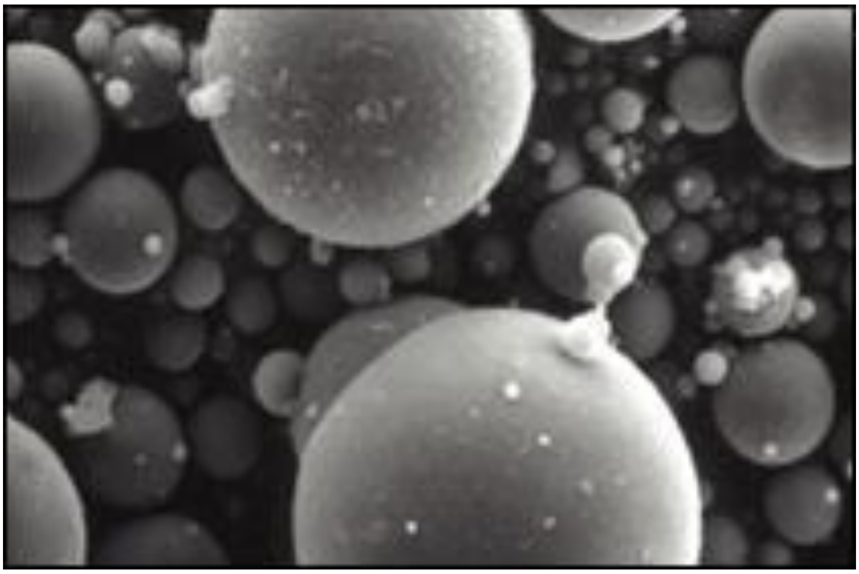
Proportioning Fly Ash Concrete Mixes

Proportioning fly ash concrete mixtures is only slightly more complicated than proportioning plain cement concrete mixtures. The same solid volume proportioning techniques described in ACI 211 are employed as are used with conventional concrete mixtures.

While fly ash is a cementitious material that greatly benefits concrete, the proportioning of concrete containing fly ash requires adjustments because of the physical properties of the ash. Viewed microscopically, fly ash particles are spherical in shape. Because of this and other physical attributes of fly ash, one can expect the following:

- The ball bearing shape significantly aids the workability of concrete. This allows for lower sand content than conventional mixes while handling remains similar. As the proportion of sand is reduced, all performance aspects of the concrete are enhanced.

The "ball-bearing" effect of fly ash particles creates a lubricating action when concreteis in its plastic state. This creates benefits in:



- **Workability:** Concrete is easier to place with less effort, responding better tovibration to fill forms more completely.

- **Ease of Pumping:** Pumping requires less energy and longer pumping distances arepossible.

- **Improved Finishing:** Sharp, clear architectural definition is easier to achieve, withless worry about in-place integrity.

- **Reduced Bleeding:** Fewer bleed channels decrease permeability and chemicalattack. Bleed streaking is reduced for architectural finishes.

- **Reduced Segregation:** Improved cohesiveness of fly ash concrete reducessegregation that can lead to rock pockets and blemishes.

- Again, because of fly ash's spherical particle shape, less water is required to achieve the same level of slump as in the control concrete. The addition of fly ash in conventional mixtures typically reduces the water needed by 5% to 10% over plain concrete (depending upon the quantity of fly ash), and this reduction can be further increased where high levels of fly ash are used.

- The specific gravity of fly ash is much lower than that of Portland cement; therefore, 100# of fly ash has a much greater solid volume than the same weight of Portland cement.

- The use of water-reducing admixtures is encouraged with fly ash concrete mixtures; however, certain factors must be considered:

- During warm temperatures, a normal dosage of water-reducing admixture is calculated on the combined weight of cement plus fly ash.

- During periods of low temperatures, it is advisable to use a conservative dosage of normal set time water-reducing admixture calculating the dosage based only on the weight of cement. Under cool temperatures, normal setting water-reducing admixtures may cause retarded concrete set. Reducing the dosage utilized during cool conditions can help maintain proper concrete set times.

DETERMINATION OF FLY ASH CONTENT:-

Several methods exist for the selection of the fly ash content in a mixture.

Specification:

The specifications for a particular project may define required fly ash content. The percentage of fly ash required may range from as little as 10% to as high as 50% or 60%, depending upon the intention of the engineer. Failure to adhere to the specified level of fly ash may result in concrete of substandard properties and may not be suitable for the intended purpose.

Water/Cementitious Materials Ratio Curves:

In this method, the Abrams law of water to cement ratio is utilized. As this law is applicable to plain cement concrete, so is it applicable to fly ash concrete. The objective is to construct a family of curves which are plotted together, with each curve indicating a specific percentage of fly ash by weight of total cementitious materials (typically 0%, 10%, 20%, 30%, etc.). This method is particularly useful where specifications require a maximum water/cementitious materials ratio.

Do not be surprised to find that for a fly ash mixture to be equivalent in strength to a plain cement mixture, the W/(C+FA) must be lower than the W/C. This is acceptable due to the fact that fly ash acts like a water reducer. Where cement is replaced by an equivalent weight of fly ash and the strengths are equal, they both have the same weight of cementitious materials but the fly ash mix will have a lower water demand.

Replacement Method:

Another successful method of designing fly ash concrete is by replacement. This involves selecting a conventional mix which has demonstrated an adequate performance level. Replacement tests should be run on a series of mixes containing fly ash in amounts ranging from 10% to 30% or more. To obtain 28-day strengths equal to the straight cement mix, it may be necessary to replace cement at a ratio exceeding 1:1. This can be determined by experimenting with mixes designed with replacement ratios of 1:1, 1:1.1, 1:1.2, etc. As in the other methods, specification factors will influence the selection of the optimum replacement percentage and ratio.

Note - The American Concrete Institute now defines that water to cement ratio is equivalentto water to cementitious materials ratio. This means that fly ash is counted by weight the same as Portland cement in this calculation. The importance of this to the concrete designer is the water reducing capability of fly ash. Where plain cement concrete may require 300# of water to provide the necessary degree of workability, fly ash concrete will use significantly less water, and may only require 90% of this, or 270# of water. If a max W/C of 0.5 is specified, the plain mix would need 600# of cement, while the fly ash mix would only need 540# of cementitious materials. The economic benefits are obvious.

Specifying Fly Ash for Use in Concrete

Over the past several decades, the use of fly ash in concrete has had a successful track record. The performance benefits fly ash provides to mechanical and durability properties of concrete have been well researched and documented in actual structures. Currently, fly ash is used in more than 50% of all ready mixed concrete placed in the United States, yet many design professionals continue to remain overly restrictive when it comes to using fly ash in concrete.

CEMENTITIOUS MATERIALS AND REQUIREMENTS:-

- Hydraulic Cement: ASTM C150 or ASTM C1157 or ASTM C595
  {Specify type of cement required for the work; C150 – I, II, III, V; C 595 – IP, IS; C 1157GU, HE, MS, HS, MH, LH}

- Pozzolan or Fly Ash: ASTM C618

{Specify class of fly ash if pertinent to the work – Class N, C or F}

LIMITATIONS ON QUANTITY OF FLY ASH:-

This is perhaps the most frequently applied restriction governing the use of fly ash in a concrete specification. When fly ash was originally used in concrete in the 1970s, therewas some basis for restricting its use. However, after extensive research and several decades of successful utilization of fly ash, there is no basis for a restriction on the quantity of fly ash that should be permitted to be used in concrete. Some may say that the ACI 318Building Code restricts fly ash use to 25% of total cementitious content. However, that is inaccurate. The new ACI 318-08 Building Code in Chapter 4 defines very severe freeze-thaw exposure (Exposure Class F3) as concrete exposed to freezing and thawing cycles that will be in continuous contact with moisture and exposed to deicing chemicals. For concrete structural members subject to Exposure Class F3, there is a limitation on the quantity of supplementary cementitious materials, expressed as a percentage of the total cementitious materials, as follows:

- Fly ash or other C618 pozzolans – max: 25 percent

- Total of fly ash or other pozzolans and silica fume – max: 35 percent

- Combined fly ash, pozzolana and silica fume – max: 50 percent with fly ash or pozzolona not exceeding 25 percent and silica fume not exceeding 10 percent

- Ground granulated blast-furnace slag – max: 50 percent

- Silica fume – max: 10 percent

The primary reason for these limits in the Building Code is to minimize the potential for deicer-related surface scaling that can subsequently compromise the concrete cover over reinforcement and initiate corrosion earlier than expected. There is no technical reason to extend this maximum 25% limit for other applications. It is seen that for adequate resistance to alkali silica reaction (ASR) with some types of aggregate and for sulphate resistance, more than 25% of fly ash frequently is required. Also, with greater quantities of fly ash, the durability of concrete related to resistance to ASR, sulphate attack and chloride-induced corrosion is further enhanced. Further, the use of fly ash in concrete supports sustainable construction.

Limitations on the loss on ignition (LOI) of fly ash to less than x% (x = 2is typically 2 or 4) Most commercially available fly ashes will not meet this specification limitation, so in effect; this requirement will prevent fly ash use. In fact, C618 already has a LOI limit of 6%.

LOI is a measure of unburnt carbon in fly ash. Certain forms of unburnt carbon can absorb air-entraining admixtures and affect air entrainment of concrete. So, some may argue that by restricting LOI contents, the air-entrainment problems due to fly ash can be reduced. However, that is inaccurate. In fact, the low-LOI fly ash in that study was more sensitive to air entrainment than the higher-LOI fly ash. The reason for this is that certain fly ashes have finer carbon, which, in spite of lower LOI, can have a more significant effect on air entrainment. So, restricting the LOI of fly ash to 2% or 4% does not eliminate the problems with air entrainment.

Specifying a maximum LOI limit does not resolve the air-entrainment problems related to fly ash use and might in fact provide a false sense of security because these effects may not be determined before concrete is placed in the structure.

28-DAY STRENGTH REQUIREMENT:-

In general, concrete containing fly ash has a slower rate of strength development and often results in higher later-age strength than with Portland cement concrete. For example specifying 8,000-psi compressive strength to be achieved at 56 instead of 28 days for columns will result in highly optimized mixtures. A later-age strength requirement when feasible will permit a higher quantity of supplementary cementitious materials, reduce the total cementitious content (paste volume) and therefore reduce the potential for cracking while improving long-term concrete durability. Many projects have been successfully completed where the specified strength had to be attained at 56 days. If there is a need to obtain information about the acceptability of concrete strength at an earlier age, one might use a percentage of the specified strength at the designated earlier age or an accelerated curing procedure in accordance with ASTM C684. This will allow for necessary quality-control actions if necessary.

Limitations on the class of fly ash or supplementary cementitious material:

Some specifications only permit the use of C618 Class F fly ash. In many parts of the country, good quality Class C fly ash is also available. In some regions, a good quality Class N pozzolan, such as calcined clay, is also used. Slag cement may be the preferred supplementary cementitious material in some markets. Concrete producers will generally not stock more than one or two types of supplementary cementitious materials. Project specifications must address local availability and experience to allow fly ash and pozzolans meeting C618, slag meeting C989 and silica fume meeting C1240 in the specification.

It is true that Class F fly ash is more effective in increasing concrete's resistance to

ASR and sulphate attack. However, rather than disallowing Class C fly ash, durability can be ensured through a performance specification as discussed below:

Requirement for Class F fly ash for resistance to Alkali Silica Reaction (ASR)

Design professionals often specify prescriptive requirements such as quantities of Class F fly ash, slag, low-alkali cement, the use of a non-reactive aggregate, etc., to avoid ASR-related distress in structures. Class C fly ash may not be allowed. Concrete resistance to ASR can be ensured by incorporating the performance option provided below in the concrete specification:

The requirement of a certain quantity, type of fly ash or another supplementary cementitious material for resistance to chloride ion penetration.

For concrete exposed to chlorides (deicing chemicals, marine exposure), it is well known that fly ash can increase resistance to deterioration related to the corrosion of reinforcing steel by reducing chloride ion penetrability of concrete, with increasing levels typically leading to improved performance. However, it is not advisable to invoke prescriptive proportions, type and choice of fly ash, silica fume and slag to attain the improved performance.

With greater quantities of fly ash, the durability of concrete related to resistance to ASR, sulphate attack and chloride-induced corrosion is further enhanced. Further, the use of fly ash in concrete supports sustainable constructions.

Requirement for Class F Fly ash for resistance to sulphate attack:

For different levels of sulphate exposure, the 318 Building Code has w/cm, compressive strength and cementitious type requirements. Concrete containing Class C fly ash is not known to be very effective against sulphate attack. Therefore, engineers prescribe only Class F fly ash for concrete exposed to sulphate environments. The new 318-08 Code adopts a more progressive approach and allows a performance-based evaluation of the proposed cementitious materials by ASTM C1012. The code also permits the evidence of past successful field performance to be used. The use of C1012 criteria ensures that the concrete is resistant to sulphate attack and does not restrict the use of Class C fly ash or any other material. The one disadvantage of this approach is the considerable lead time needed, since tests progress for six months to one year.

Reference to water to cement ratio (w/c):-

It is common for concrete to have supplementary cementitious materials such as fly ash and slag that are included in the calculation of w/cm. The ACI 318 Building Code has limitations on the maximum water - to - cementitious - materials ratio (w/cm) for various durability requirements. Referring to w/c may be misleading, and this should always be referred to as water - to cementitious - materials ratio (w/cm).

Minimum cementitious content Requirements:-

ACI 301 and 302 recommend minimum cementitious material content (not cement) for floor slabs only, primarily to improve finish ability. There is no technically valid reason to include a minimum cementitious content for other structural elements, provided the performance requirements for that element are achieved. Even for floor slabs, the finish ability can be determined by placing trial slabs rather than the prescriptive minimum cementitious material content approach, which does not necessarily ensure good finish ability. Also, a high minimum cementitious material content frequently leads to non-optimized mixtures, high paste contents, higher shrinkage and high temperatures due to heat of hydration and associated cracking.

CHAPTER-4

CONCRETE TESTS

The lab tests conducted by the team are:

- Slump cone test
- Compression test
- Splitting tensile test

SLUMP CONE TEST:-

Slump flow is one of the most commonly used concrete tests. This test involves the use of slump cone used with conventional concretes and alternative concrete. The slump flow test measures the “spread” or “flow” of the concrete sample once the cone is lifted.

Apparatus:

- Mould in the shape of a truncated cone with 200mm diameter at the base, 100mm diameter at the top and height of 300 mm.
- Base plate of stiff non - absorbing material
- Trowel
- Scoop
- Ruler

Procedure:

- Clean the cone. Dampen with water and place on the slump plate. The slump plate should be clean, firm, level and non-absorbent.
- Collect a sample.
- Stand firmly on the foot pieces and fill 1/3 the volume of the cone with the sample. Compact the concrete by 'rodding' 25 times.
- Now fill to 2/3 and again rod 25 times, just into the top of the first layer.

- Fill to overflowing, rodding again this time just into the top of the second layer. Top up the cone till it overflows.

- Level off the surface with the steel rod using a rolling action. Clean any concrete from around the base and top of the cone, push down on the handles and step off the foot pieces.

- Carefully lift the cone straight up making sure not to move the sample.

- Turn the cone upside down and place the rod across the up-turned cone.

- Take several measurements and report the average distance to the top of the sample.

- If the sample fails by being outside the tolerance (i.e. the slump is too high or too low), another must be taken. If this also fails the remainder of the batch should be rejected.

Interpretation of result:

Suggested ranges of workability of concrete measured in accordance with IS 1199are given below:

Placing conditions	Degree of Workability	Slump (mm)
Blinding Concrete; Shallow Sections; Pavements using pavers	Very low	Sec A
Mass Concrete; Lightly Reinforced sections in slab, beams, walls, columns; Floors; Hand placed pavements; Canal Lining; Strip footings	Low	25 – 75
Heavily Reinforced sections in slabs, beams, walls, columns; Slip form Work; Pumped Concrete	Medium	50 – 100 75 – 100
Trench fill; In-situ pilling	High	100 – 150
Tremie Concrete	Very High	Sec B

Sec A- In the very low category of workability where strict control is necessary, for examplepavement quality concrete, measurement of workability by determination of compaction factor will be more appropriate than slump (see IS 1199) and the value of compacting factor of 0.75 to 0.80 is suggested.

Sec B- In the very high category of workability, measurement of workability by determination of flow will be appropriate (see 1199).

COMPRESSION TEST:-

Compressive strengthis the capacity of a material or structure to withstand axiallydirected pushing forces. When the limit of compressive strength is reached, materials are crushed. Concrete can be made to have high compressive strength, e.g. many concrete structures have compressive strengths in excess of 50 MPa, whereas a material such as soft sandstone may have a compressive strength as low as 5 or 10 MPa.

The compressive strength of concrete is the most common performance measure used by the engineer in designing buildings and other structures. The compressive strength is measured by breaking concrete cubical or cylindrical specimens in a compression test machine or universal testing machine. The compressive strength is calculated from the failure load divide by the cross-sectional resisting the load and reported in pound –force per square inch (psi) in us customary units or megapascals (Mpa) in SI units.

APPARATUS:

- Compression Machine
- Universal Testing Machine

PROCEDURE:

- Cubical or cylindrical specimens for acceptance testing should be 150 x 150 mm size (for cubes) or 150 x 300 mm size (for cylinders) when specified. The smaller specimen tends to be easier to make and handle in the field and the laboratory.
- Recording the mass of the specimen before capping provides useful information in case of disputes.
- Specimens are to be dried out prior to testing.
- The specimens should be measured in in two right angles to each other to note down the exact size of the specimen.
- The specimens should be centered in the compression-testing machine and loaded to complete failure. The loading rate on the hydraulic machine should be maintained.
- The concrete strength is calculated by dividing the maximum load at failure by the average cross-sectional area.
- The technician carrying out the test should record the date they were received at the lab, the test date, specimen identification, cylinder diameter, test age, maximum load applied, compressive strength, type of failure, and any defects in the cylinders or cubes or caps.

- A 3 or 7 days test may help detect potential problems with concrete quality or testing procedures at the lab but is not a basis for rejecting concrete, with a requirement for 28 days or other age strength.

Interpretation of result:

The compressive strength of the specimen is calculated by using the formula:

$$\sigma = \frac{F}{A}$$

Where,

F = Load applied in Newton (N)

A= Area in m^2

SPLITTING TENSILE TEST:-

This test covers the determination of the splitting tensile strength of cylindrical concrete specimens. This method consists of applying a diametral compressive force along the length of a cylindrical specimen. This loading induces tensile stresses on the plane containing the applied load. Plywood strips can be used so that the load is applied uniformly along the length of the cylinder. The maximum load is divided by appropriate geometrical factors to obtain the splitting tensile strength.

APPARATUS:

- Testing machine – Any compression machine of reliable type of sufficient capacity.
- Bearing Strips

PROCEDURE:

- At least three specimens shall be tested for each age of tests.
- Specimens when received dry shall be kept in water for 24 hours before they are taken for testing.
- Central lines shall be drawn on the opposite faces of the cube using any suitable procedure and device that will ensure that they are in the same axial plane.
- The mass and dimension of the specimen shall be noted before testing.
- The bearing surfaces of the testing machine and of the loading strips shall be wiped clean.
- The test specimen shall be placed in the centering jig with packing strip and/or loading pieces carefully positioning along the top and bottom of the plane of loading of the specimen.
- The jig shall then be placed in the machine so that the specimen is located centrally.
- For cubic specimen, the load shall be applied on the moulded faces in such a way that the fracture plane will cover the trowelled surface.
- For cylindrical specimen it shall be ensured that the upper platen is parallel with the power platen.
- The load shall be applied without shock and increased continuously at a nominal rate within the range 1.2 N / (mm^2 / min) to 2.4 N / (mm^2 / min).

- The rate of increase of load may be calculated from the formula: (1.2 to 2.4) x 7r/2 x I x d N/min.

Interpretation of result:

The splitting tensile strength of cylindrical concrete specimens is calculated using the formula:

$\mathbf{f_{ct} = 2P / \pi LD}$

Where,

P = maximum load in Newton applied to the specimen

L = length of the specimen in mm

d = cross sectional dimension of the specimen.

UTILIZATION OF FLY ASH:

Introduction:-

The use of high volume fly ash (HVFA) concrete fits in very well with sustainable development. High volume fly ash concrete mixtures contain lower quantities of cement and higher volume of fly ash (up to 60%). The use of fly ash in concrete at proportions ranging from 35 to 60 % of total cementitious binder has been studied extensively over the last twenty years and the properties of blended concrete are well documented. The replacement of fly ash as a cementitious component in concrete depends upon several factors. The design strength and workability of the concrete, water demand and relative cost of fly ash compared to cement. From the literature it is generally found that fly ash content in the cementitious material varies from 30-80% for low strength (20 MPa) to high strength (100MPa).

To meet the demands imposed by the rapid industrialization, the need for new constructions is increasing; lead to search of new construction materials. Fly ash is most versatile construction material. Fly ash is an inorganic product of fusion after combustion of coal in boiler of thermal power plants is produced in huge quantities .It is estimated that about 100 million tons of fly ash is produced from 65 major coals based thermal power station. Fly ash properties results primarily from the type of coal burned, the type of combustion equipment used and the fly ash mechanism employed. Though for the last decade, various studies have been done to use fly ash as a resource in various industries, including building products (brick, cement, aggregate, concrete).But still in India, the utilization is very low. One of the prime reasons for this is the difficulty of producing quality-controlled fly ash materials that can meet market specifications. The use of fly ash in building construction not only increases the availability of building materials but also saves expenditure on disposal and reduces air and water pollution concrete characteristics. It should be regularly checked as a part of quality control measure. The Ash Utilisation Division (AUD), set up in 1991, strives to derive maximum usage from the vast quantities of ash produced at its power stations. The ash is now being looked at as a commodity that could generate wealth for the company in the long run. Research has shown that the quality of fly ash produced at NTPC's power stations is extremely good with respect to fineness, low unburnt carbon and has high pozzolanic activity and conforms to the requirements of IS 3812 - 2003-Pulverized Fuel Ash for use as Pozzolana in cement, cement mortar and concrete. The fly ash generated at NTPC stations is ideal for use in the manufacture of cement, concrete, concrete products, cellular concrete products, bricks/blocks/ tiles etc.

Objective and Scope of the Work:-

- The main purpose of this investigation is to develop confidence among users in India to use material like fly ash in the construction at the rural areas.
- In our proposal, we have conducted lab investigation using such materials in varying percentage for two different grades of concrete (M20 & M30).
- The test we conducted on the concrete are –
- Slump Cone test
- Compressive Strength
- Tensile Strength
- Because with the increase in the price of most of the products, if the poor villagers can build their house at least in a reduced price, then they will be happy.
- This can fulfill the dreams of poor people to live in concrete houses with less money.

Thus, the rural areas can be developed.

Materials:-

53 grade Ordinary Portland cement conforming to BIS 12269-1987 was used. Its physical properties and chemical composition are given in table –1 Class F fly ash from Dadri, New Delhi conforming to BIS 3812-2000 was used in the present study. Its physical properties and chemical composition are also given in table – 9.1.

Admixtures:

No admixtures have been used in our work.

Aggregates:

Crushed stones of 20mm down and 10mm down were used as coarse aggregate. Local river sand was used as fine aggregate in the concrete mixtures.

Table:<u>**Physical and Chemical analysis of Portland Cement and Fly Ash**</u>

Property	**Portland cement**	**Fly Ash**
CaO	61.5	3.68
Silica content `	20.6	60.27
Al2O	3 5.10	25.46
Fe2O3	3.90	6.02
LOI	1.51	1.10
Magnesia	3.00	0.29
Alkalies	0.35	2.64
SO3	2.10	0.12
Chloride	0.012	---
Specific gravity	3.14	2.25
Specific Surface cm2/g	2980	3980
C3S	47.7	
C2S	23.3	
C3A	6.9	
C4AF	11.9	

Experimental Program:-

The proportions of the trial mixtures for M20 and M30 grade concretes are summarized in Tables 3 to 9. These mixes were designed according to IS: 10262 and modified based on observations with the intention of using minimum cement content. The coarse and fine aggregates were weighed at room temperature. The coarse aggregate was then immersed in water for 24 hours. The excess water was decant off and the water remained in the container was determined by the weight difference between the two. In case of fine aggregate known quantity of water was added in the fine aggregate and was allowed to stand for 24 hours this procedure was used to insure that the aggregates were used in a saturated condition in order to know the exact value of the w/cm of the mixtures. For each concrete mixture 150mm cubes were cast for the determination of compressive strength and 300x150 mm cylinder were cast for determining the splitting tensile strength. No super plasticizer was used in any grade of concrete.

Properties of the Hardened Concrete:-

The compressive strength, rapid chloride ion penetration and permeability coefficient of various mixes are given in table13. The compressive strength of various concrete mixes at 7, 14 and 28 days with various percentages of fly ash is shown in Table's 10.2.1 – 10.2.3 and Figures 10.1 – 10.7. The cost analysis of various concrete mixes has also been calculated and are given in Tables 15.1 – 15.4.

CHAPTER-5

RESULTS AND CONCLUSIONS

Area of Cubes:

(150 x 150) mm^2 = 22500 mm^2

Dimensions of Cylinders:

Length (l) = 300 mm

Diameter (d) = 150 mm

ANALYSIS FOR SLUMP:-

SLUMP TEST VALUE:

FOR CONVENTIONAL METHOD					
Cement (kg)	Fine aggregate (kg)	Coarse Aggregate (kg)	Water (lit)	W/C	Slump
SLUMP VALUE FOR M 20 GRADE CONCRETE					
4.5	6.75	13.5	2.25	0.5	45
SLUMP VALUE FOR M 30 GRADE CONCRETE					
6	6	12	2.88	0.48	38

SLUMP TEST VALUE FOR M20 GRADE CONCRETE WITH FLY ASH								
Cement (kg)	Fly ash (kg)	Total cementitious content (kg)	Percentage	Fine aggregate (kg)	Coarse Aggregate (kg)	Water (lit)	W/(C+FA)	Slump
4.5	0	4.5	100%	6.75	13.5	2.25	0.5	45
2.25	2.25	4.5	50%-50%	6.75	13.5	2.25	0.5	40
2.7	1.8	4.5	60%-40%	6.75	13.5	2.25	0.5	42.3
3.15	1.35	4.5	70%-30%	6.75	13.5	2.25	0.5	43

RECORD OF SLUMP TEST VALUE USING FYL ASH:

SLUMP TEST VALUE FOR M20 GRADE CONCRETE WITH FLY ASH

SLUMP TEST VALUE FOR M30 GRADE CONCRETE WITH FLYASH

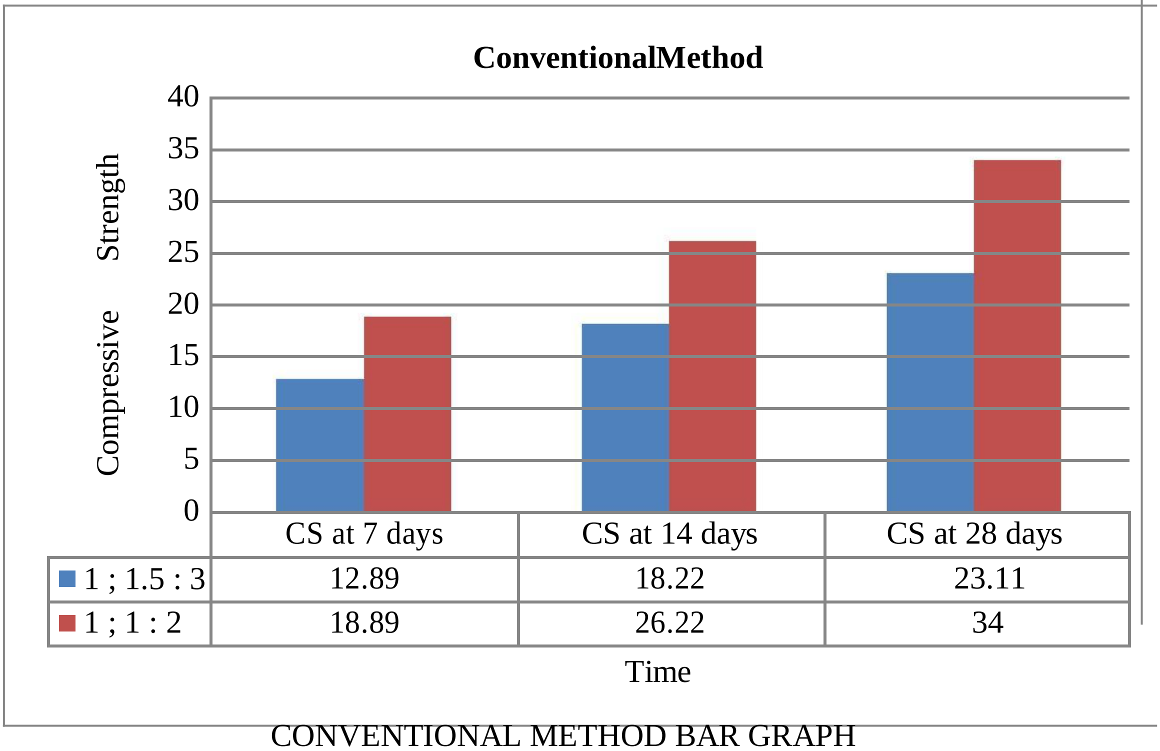
Cement (kg)	Fly ash (kg)	Total cementitious content (kg)	Percentage	Fine aggregate (kg)	Coarse Aggregate (kg)	Water (lit)	W/(C+FA)	Slump
6	0	6	100%	6	12	2.88	0.48	38
3	3	6	50%-50%	6	12	2.88	0.48	31
3.4	2.4	6	60%-40%	6	12	2.88	0.48	35
4.2	1.8	6	70%-30%	6	12	2.88	0.48	37

- **RECORD OF SLUMP TEST VALUE USING FLY ASH:**

ANALYSIS OF CUBES:-

COMPARISION OF COMPRESSIVE STRENGTH:

TRIAL MIX OF CONCRETE IN CONVENTIONAL METHOD									
Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Load (KN)			Area (sq. mm)	Compressive strength (N/sq. mm)		
			7 days	14 Days	28 days		7 days	14 days	28 days
TRIAL MIX OF M 20 GRADE CONCRETE									
4.5	6.75	13.5	290	410	520	22500	12.89	18.22	23.11
TRIAL MIX OF M 30 GRADE CONCRETE									
6	6	12	425	590	765	22500	18.89	26.22	34.00



CONVENTIONAL METHOD BAR GRAPH

COMPARISON OF COMPRESSIVE STRENGTH USING FLY ASH:

Cement (kg)	Fly ash (kg)	Total cementitious content (kg)	Fine aggregate (kg)	Coarse Aggregate (kg)	Load (KN)			Area (mm^2)	Compressive strength N/mm^2		
					7 Days	14 days	28 days		7 days	14 days	28 days
TRIAL MIX OF M 20 GRADE CONCRETE WITH 50 % FLY ASH											
4.5	0	4.5	6.75	13.5	290	410	520	22500	12.89	18.22	23.11
2.25	2.25	4.5	6.75	13.5	195	340	350	22500	8.67	15.11	20.00
TRIAL MIX OF M 20 GRADE CONCRETE WITH 40% FLY ASH											
4.5	0	4.5	6.75	13.5	290	410	520	22500	12.89	18.22	23.11
2.7	1.8	4.5	6.75	13.5	230	370	540	22500	10.22	16.44	24.00
TRIAL MIX OF M 20 GRADE CONCRETE WITH 30% FLY ASH											
4.5	0	4.5	6.75	13.5	290	410	520	22500	12.89	18.22	23.11
3.15	1.35	4.5	6.75	13.5	250	425	585	22500	11.11	18.89	26.00

COMPARISION OF COMPRESSIVE STRENGTH USING FLY ASH:

Cement (kg)	Fly ash (kg)	Total cementitious content (kg)	Fine aggregate (kg)	Coarse Aggregate (kg)	Load (KN)			Area (mm^2)	Compressive strength N/mm^2		
					7 Days	14 days	28 days		7 days	14 days	28 days
TRIAL MIX OF M 30 GRADE CONCRETE WITH 50 % FLY ASH											
6	0	6	6	12	425	590	765	22500	18.89	26.22	34.00
3	3	6	6	12	300	495	700	22500	13.33	22.00	31.11
TRIAL MIX OF M 30 GRADE CONCRETE WITH 40% FLY ASH											
6	0	6	6	12	425	590	765	22500	18.89	26.22	34.00
3.4	2.4	6	6	12	350	535	190	22500	15.56	23.78	35.11
TRIAL MIX OF M 30 GRADE CONCRETE WITH 30% FLY ASH											
6	0	6	6	12	425	590	765	22500	18.89	26.22	34.00
4.2	1.8	6	6	12	410	640	900	22500	18.22	28.44	40.00

CONCLUSION

M20 grade of concrete is lowest grade of concrete, which IS: 456-2000 recommends for use in reinforced concrete construction even for mild exposure condition. Higher grade of concrete is used either due to higher strength requirement or due to worse exposure conditions. It is clear from the controlled test results shown in Tables that M20 and M30 grade plain concrete (i.e. without fly ash) can be produced with less cement content than the minimum as suggested in IS: 456-2000 in its table 5. In such situations, one has to either overlook the code provisions or use higher cement content. Higher compressive strength values may be due to high grade of cement used and better controlled conditions in the laboratory. Similarly in case of M20 and M30 grade, compressive strength has been achieved with lower cement content. Replacing a suitable percentage of cement by fly ash can fulfill minimum cement content requirement.

- From the data tables and the graph, we can come to the point the regarding the strength, the mix ratio of 70 % cement 30 % fly ash gives the better strength as compared to other ratios.

- Therefore, whatever be the grade of concrete used for the construction, the partial replacement of 30% cement with fly ash can give the considerable strength for the construction of houses or schools or panchayat in the villages in order to reduce the total cost by 30%.

So, we conclude that by using fly ash we can reduce the cost of construction up to 25 % and by using rice husk ash the cost can be reduce by 18 %.

It can also be concluded that the reduction in the cost of construction do not affect the strength. As per the laboratory test conducted, the strength for these alternate materials proved out to be proper and considerable, compared to the conventional method.

Hence, this alternative method of construction is effective and convenient to use in today's construction works.

WEBSITES

- www.engineeringcivil.com
- www.precast.org.in
- www.theconstructor.org.in
- www.greenlivingideas.com
- www.1000projects.org.in
- www.youth4work.com
- www.icoste.org
- www.dirtcheapbuilder.com
- www.academia.edu
- www.brick2wall.com

REFERENCES

- Bredenhood J1, (2016) “Sustainable Housing and Building Materials for Low-income Households”, Jr ArchitEng Tech 5:158.

- Felix Raspall ,Mohit Arora2,(2014)“Building from End-of-Life: An Alternative Approach for Low-Cost Urban Housing” , Ethzurich.

- Iwuagu ben ugochukwu, Iwuagu ben chioma3, (2015), “Local building materials : affordable strategy for housing the urban poor in Nigeria”, Procedia Engineering, 118,pp-42-49.

- Ali HaiderJasvi , D.K. Bera4, (2015), “Sustainable Use Of Low Cost Building Materials In The Rural India”, International Journal Of Research In Engineering And Technology Volume: 04 Special Issue: 13, Pp-534-547.

- F. Fachecotogal(2014), Said jalai, (2012)5, “Construction & building materials, Construction & building materials”, 29, pp-512-5.

- Tomas U Ganiron& Mohammed Almaewae6, (2014) “Prefabricated Technology in a modular house”, Int. Jr of Advanced Sci& Tech, Vol-73, pp-51-74.

- Sengupta Nilanjan & Roy Souuvanic7(2013), “Study ofAppropriateness of cost effective building construction technologies in India.

- Swathikchowdhury, SangeetaRoy8(2013)“Prospects of low cost housing in India”,Geomaterials, pp-60-6.

- David william Dobson, Amur Sourani9, (2012), “Sustainable construction: Analysis of its cost & benefits”, American Jr of Civil Engg& Arch, Vol-1, pp32-38.

- R.caponette& G. De Francisc10, (2013) “Ecological materials & technologies in low cost building system”Int.Journal for housing sciences,Vol-37, pp229-238.

- John M.Hutcheson11, (2011), “Project Management of Low Cost Housing in Developing Countries”, Journal Architectural Science review, Vol-28, pp 8-11.

- Vivian W.Y. Tam12, (2011), “Cost effectiveness of using low cost housing technologies in construction”, Procedia Engg, 14, pp-156-160.

- Kuo-liang Lin13, (2011), “Human resource allocation for remote construction projects”, Jr of management in Engg

- J.M Huches14,(2011) “Project Management of Low Cost Housing in Developing Countries”, Journal Architectural Science review, Vol-28, pp 8-1.

- Preetpal Singh,(2010), Gurjeet Kumar15(2010), “Low Cost Housing: Need For Today’s World”, International Journal of Engineering Research-Online A Peer Reviewed International Journal, Vol-4, Issues-3.

- Mohammad sharifzami, Angela lee16, (2009),“Economic benefits of contemporary earth construction in low cost urban housing –state of the art review”, Jr. of building appraisal, Vol-5, pp-259-271.

- Rinku Taur ,Vidya Devi T17,(2009), “Low Cost Housing”, ACSGE-2009, Oct 25-27.

- IS 5816 : 1999 Indian standard splitting tensile strength of concrete method of test.

- Rice husk ash – a unique supplementary cementing material by P.K Mehta , V.M Malhotra.

- Study of properties of partial replacement of ordinary Portland cement by rice husk ask by Abhilasha Shukla, C.K Singh- International Journal of Science and Engineering.

- Comparitive study of strength and durability properties materials by M.Geeta International Journal of Engineering Science and Technology.

- High volume fly ash concrete technology, fly ash status summary report in India, produced by NTPC.
- Report produced by “headwater resources” – marketer for fly ash.
- Mix design manual by “durocrete engineering services pvt. Ltd.
- IS: 456-2000, Indian standard plain and reinforced concrete-code of practice, 4th revision, and 1st reprint sep-2000.
- IS: 1489 (part-i fly ash based) 1991, specification for portland-pozzolona cement, 3rd revision, BIS -1991.
- IS: 3812-1981, Indian standard specification for fly ash for use as pozzolona and admixture, 1st revision, bureau of Indian standard, New Delhi, June 1981.
- Astm C618 - 12 standard specification for coal fly ash and raw or calcined natural pozzolana for use in concrete