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- Concrete Mix Design

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Contents

Experimental Investigation on Concrete using Waste Materials as Flyash, GGBS, PET Flakes and Fibres

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ABSTRACT

Concrete is a composite material created from Cement, fine aggregate, coarse aggregate, admixture. Nowadays the requirement of materials for concrete is high but the availability is less. Therefore the replacement for cement and sand are being done by fly ash, GGBS, and PET plastic pieces which in-turn will help both environment and construction industry.

As we know, Fly ash is a by-product of coal combustion and causes harm to both environment and society. The disposal of fly ash is costlier when compared to replace it in construction activities. Therefore 30% of Fly ash is replaced with cement in this experiment and study the properties of concrete.

GGBS is obtained by quenching of molten slag, which is in powdered form, In concrete, it helps to decrease the damages caused by analkali-silica chemical attack and also gives higher attrition to chloride.

Therefore 20% of GGBS is replaced with cement along with Flyash. Plastic as a material is a major challenge to the environmental pollution in which PET plastic is also a part. Therefore to use PET plastic in concrete could be a solution in solving an environmental problem. In this experiment 10%, 12%, 14% and 16% of PET Plastic are replaced to fine sand as an alternative source.

To help gain the tensile strength of concrete Recron 3s fibres are added at 0.25% of the volume of cement. .It is expected to show sufficient deflection before failure of concrete.

The concrete with all the additives and proper design mix .will be tested for compressive, Split tensile and flexural strength is tested for 3,7 and 28 days.

Keywords: PET-FLAKES, FLYASH, RECRON

1. INTRODUCTION

Plastic is one of the easily available material and which shows high potential in our daily routines and it also has low density, high strength and flexible to use for any work, The cost of the plastic is very less and it also requires low maintenance. Hence these properties of plastics contribute to extraordinary growth in the market. Plastic gives more merits than other material but it also causes environmental problems by increasing the solid waste stream.

Nowadays recycling of PET bottle is very less than compared to the production of a bottle, It is dramatically Increases the solid waste and it pushes for finding the solution to recycle at a higher rate. We have to give special attention towards plastic because it has non-biodegradable property and is increasing yearly up to 1.5%-2%.[10]

PET bottles pieces cannot a dumped and burnt as these are chances of fire which may contaminate the soil and vegetation.

Currently, Cities are now being transformed into smart cities around the world, therefore the main emphasis is of making the concrete green and sustainable, by using the smart materials, Flyash is one such material which adds to the concept of green concrete. It is a residual material which is produced by combustion of coal and it gives significant advantages by using in concrete, It enhances the workability, reduces the permeability, increases the strength, minimizes the bleeding, better surface finishing, reduces The heat of hydration and The particles of flyash are very small in size hardand round in shape. Therefore it minimizes the voids by filling themselves between the free spaces in concrete. It is also having "ball bearing "effect in the concrete and hence using less amount of water quantity. Fly ash is collected in electro-static precipitators and stored in power plant or in landfills. The overall 43% of fly ash collected is often used to supplement the production of cement.

GGBS is the by-product from Iron manufacturing industry along with iron coke, limestone in the furnaces and its physical appearance is in glassy and non-metallic granular. This component establishes the pozzolanic properties.

In the manufacturing of Iron at 1500^0C to 1600^0C, the hot molten slag is floated above the furnace,It's the composition is 30 to 40 % of SiO2and 40% of CaOwhich are also the requirement for chemical composition in cement. [27]

Recron Polypropylene fibres are stereo-regular polymer it is having a high significance in industries as it is 100% synthetic fiber and formed by 80% of monomer propylene, It is the by-product of petroleum product. Thesefibres were mainly introduced in textile industries in 1970 's, Now it is the 4th most important fibre class after polyester, Nylon, and acrylic.

When these fibres are mixed with concrete it increases the homogeneity in mix and achieves in stabilizing the movement of solid particles and reduces blocking the bleeding action in concrete due to which the surface abrasion and enhancing the strength and frost resistance, It also reduces the spalling of concrete in fibre, These are an increase which avoids the sudden failure action.

LITERATURE REVIEW

“Use of plastic fibre in concrete” in this topic, Concrete is filled with different percentage of plastic by partial replacing of sand by 0.5 % 1% 1.5% 2%,and tested for 3,7 and 28 days which gives high compression, flexural for 1.5% replacement and it achieves in increases 5% compared to conventional.[1]

“Experimental investigation on the properties of0concrete with plastic PET (bottle) fibres as fine aggregates” in this project partially replaced traditional sand by 0.5% 1% 2% 4% 6% with PET bottle fibres for M25 ,test conducted for 3 7 ,28 days which it gives results high for 2 % replacement of PET.[2]

“Concrete incorporated with optimum percentages of recycled polyethylene terephthalate (PET) bottle fiber” in this project replacement of sand is done by 0.5% 1% 1.5% and 2% of PET for 1 % of replacement helps to increases the strength of compression about 10% compared to normal concrete.[3]

“Re-UseOf Poly-ethylene Plastic Waste In C0ncrete” this research shows increasing percentage of PET decreases the Compressive strength, the partial replacement of sand by 2% 4% 6% of PET when 2 % of PET gives increasing compressive strength,[4]

“experimental investigation on the properties of0concrete with carbon black and PET” in this project utilization of PET and carbon black, PETis varied with percentages of 10 and 20 %, carbon black varies with 10% 20% and 30% in that when replaced with 10% of PET and 30 5 carbon black gives the high strength.[5].

“Use Of Recycled Plastic Waste As Partial Replacement For Fine Agg In Concrete” in this project they are partial replacing the sand by PET waste as 5% 6% 8%10%15% and 20% in that considering the which gives lower compression strength mix then they partially replacing cement by silica fume 5% 10%and 15% to the least compression PET mix and increasing compression strength to 15% replacement cement with 20% of PET about 22.5% compared to 0%silica fume and 20% PET in concrete.[6]

“Hardened properties of polyethylene terephthalate based concrete” in this project addition of PET waste flakes 1% 2% 3% 4% 5% to the weight of cement it gives optimum results to 2% of PET addition.[7]

“An experimental study on the properties of PET fibre reinforced concrete” in this adding the PET fibres to concrete 2% 4% and 6% in that compression and flexural is increased for 4% of PET.[8]

“Effect of partial replacement of fine aggregate in concrete with low-density polypropylene” in this topic natural sand is partially replaced with plastic polypropylene about 5%,10%,15% and 20%.In that 10 % of replacement reaches the optimum strength of concrete. [29]

“Strength and behavior of concrete contain waste plastic”In this paper, they investigated results by addition of plastic waste polyethylene about 1 %, 3% and 5% to the volume of sand. The strength of concrete increased 4.1% for 1% of PET mix. [17]

“Experimental Investigation on partial replacement of waste plastic in concrete “they are researched as partial replacement of sand by PET plastic by 5%,10%,15% and 20%.In that 5% of replacement gives the higher strength and 10% gives strength within permissible limit.[18]

“Use of plastic waste in sand concrete” in this research it concluded as replacement of sand is done by plastic fibres powder content about 10% 20%, 30%, and 40%.and also plastic fibre also used about 0.5%,1%,1.5% and 2%.in that concrete gain strength optimum at 20% of fibre and 1.5% of fibre when it replaced with sand.[20].

2. RESEARCH METHOD

MATERIALS ARE USED:

CEMENT: We have used 53 grade of OPC MAHA CEMENT according to the requirement as per IS 1489 PART I, 1991.

FINEAGGREGATES: It is filler material in the concrete, which is formed by the river or crushed stones etc. In this project, we have used river sand Zone II grade. As per IS:383-1970. [20].

COARSEAGGREGATES: Coarse aggregate is the inert material in concrete. We have used the crushed stone aggregates which are 20 mm downsize, a Basic test of aggregate is calculated as per code IS 2386- 1963.[24].

WATER: Using the Water which is portable, drinkable and contains the less impurities, It is confirming the requirement for concreting and Curing as per IS: 456-2000.[23].

ADMIXTURE: It is a chemical agent which helps to reduce the water content in the concrete and it is also increases the workability of concrete, In this project, we have used the admixture as Complast SP 430.[15].

PET (POLY-ETHYLENETEREPHTHALATE) Flakes: Poly-Ethylene Terephthalate is plastic which is used for the manufacture of plastic bags, Bottles, and many other materials and it causes the wastages or waste plastic in the environment. PET flakes having the size less than 4.75mm, specific gravity 1.32 and texture of the plastic is uniform.[13].

FLYASH: Fly ash is in the form of powder, it is the by-product of pulverized coal. Which wascombustion in the electric power plant, In this project, We have used 30% of class F type of fly-ash in concrete with the specific gravity of 2.02 (IS 3812).[26].

GROUND-GRANULATED BLAST FURNACE SLAG: It is the co-product which is produced with iron. Slag in the furnace is cooled instantly by quenching in a large quantity of cold water and it is called as granulation, to produce granulated blast furnace slag.

In this project, we used 20% of GGBS with partial replacement of cement to enhance the compressive strength.[28].

RECRON3SPOLYPROPYLENEFIBRES: It is a reinforcing fibre that improves properties such as abrasion, tensile, burst, and bulk. About 0.25% volume of fibre is used in this project.

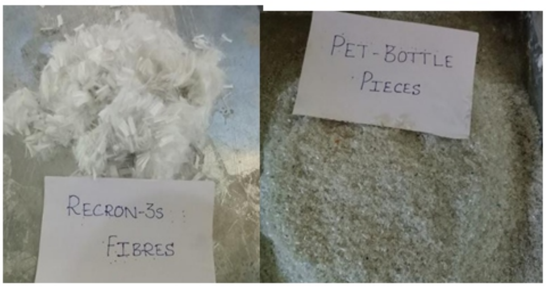

Figure 1: RECRON 3S FIBRES AND PET FLAKES

3. RESULT AND ANALYSIS :

MIX DESIGN: The mix is designed for M40 grade of concrete, Calculation is done with reference of IS 456-2000 and IS 10262-2009.

Table 1: Proportion for 1 meter-cube, M40 grade

CEMENT kg/m^3	FLYASH (30%) kg/m^3	GGBS (20%) kg/m^3	SAND kg/m^3	COARSE AGG kg/m^3	W/C RATIO l/m^3
221.8	118.8	55.44	942.71	1311.66	0.4
1			2.38	3.31	0.4

Table 2: ProportionFor Mixing

Specimens	% FLY-ASH	% GGBS	Percentage of PET fibers	% RECRON 3S FIBRE	Specimens for compressive strength 3, 7 and 28 days	Specimens for Flexural strength 3, 7 and 28 days	Specimens for Split tensile strength 3, 7 and 28 days
A1	30%	20%	10%	0.25%	3	3	3
A2	30%	20%	12%	0.25%	3	3	3
A3	30%	20%	14%	0.25%	3	3	3
A4	30%	20%	16%	0.25%	3	3	3

Table Error! No text of specified style in document.: Partial replacement of sand by various % of the PET by their volume for the requirement of concrete for one specimen

10 % PET	CEMENT	SAND	CA	FLYASH	GGBS	PET	W/C
CUBE	0.89	3.43	5.31	0.48	0.22	0.187	0.636
CYLINDER	1.41	5.43	8.4	0.76	0.355	0.295	1
PRISM	4.192	16.03	24.8	2.24	1.047	0.873	3
12 % PET							
CUBE	0.89	3.35	5.31	0.48	0.22	0.22	0.636
CYLINDER	1.41	5.3	8.4	0.76	0.355	0.355	1
PRISM	4.192	15.67	24.8	2.24	1.047	1.048	3
14 % PET							
CUBE	0.89	3.28	5.31	0.48	0.22	2.62	0.636
CYLINDER	1.41	5.19	8.4	0.76	0.355	0.414	1
PRISM	4.192	15.32	24.8	2.24	1.047	1.22	3
16 % PET							
CUBE	0.89	3.2	5.31	0.48	0.22	0.3	0.636
CYLINDER	1.41	5.06	8.4	0.76	0.355	0.473	1
PRISM	4.192	14.96	24.8	2.24	1.047	1.4	3

TESTING PROCEDURE:

Compression test, Split tensile test and the Flexural test is conducted according to as per Is 516: 1959 methods of tests for strength of concrete.

Figure 2: Testing methods for the strength of concrete

Table 4: Compression Results

Sample No	% Of Mixing	Compression Strength In (N/mm²) 3 days	Compression Strength In (N/mm²) 7 days	Compression Strength In (N/mm²) 28 days
Conventional	0%	18.14	27.02	47.42
A1	10%	19.28	27.73	46.48
A2	12%	16.35	24	41.79
A3	14%	15.65	19.54	37.25
A4	16%	14.88	19.24	35.21

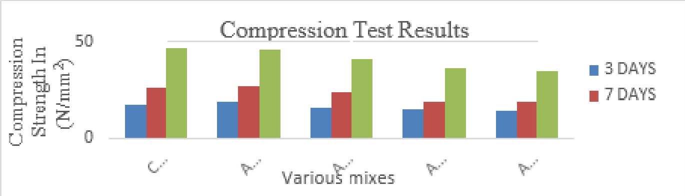

Figure 3: Compression Test Results

Table 5: Split Tensile Test Results

Sample No	% Of Mixing	Split Strength In (N/mm²) 3 days	Split Strength In (N/mm²) 7 days	Split Strength In (N/mm²) 28 days
Conventional	0%	2	2.84	4.95
A1	10%	2.01	2.98	4.99
A2	12%	1.66	2.57	4.59
A3	14%	1.26	2.37	4.27
A4	16%	1.15	2.13	3.88

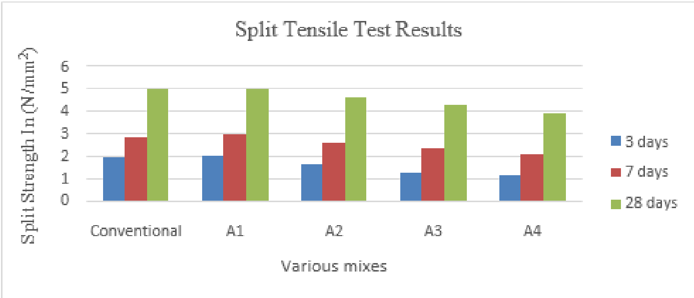

Figure 4 : Split Tensile Test Results

Table 6:Flexural Test Results

Sample No	% Of Mixing	Flexural Strength In (N/mm²) 3 days	Flexural Strength In (N/mm²) 7 days	Flexural Strength In (N/mm²) 28 days
Conventional	0%	2.84	3.46	4.6
A1	10%	3.11	3.64	4.8
A2	12%	2.66	3.2	4.35
A3	14%	2.4	2.93	4.17
A4	16%	2.31	2.75	3.91

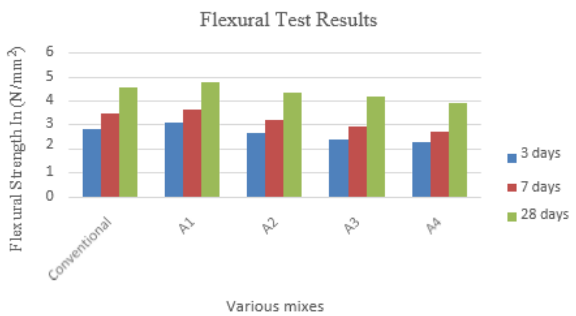

Figure 4: Flexural Test Results

DURABILITY TEST:

In this test taking the specimen which is cured for 28 days and weighing accurately Then it is subjected to Sulfuric acid (H_2SO_4) which having pH=2.5 and pH=3 for 7 days, after the seven days, wiping the specimen with cloth and allow to dry and weighing the weight of the specimen.[24].

Table 7:Results of Sulfuric Acid-Attack

Designation of mix	The weight of specimen before testing	The weight of specimen after testing	Loss in percentage
Normal	8.5	8.47	0.353
A1	8.48	8.46	0.236
A2	8.44	8.41	0.355
A3	8.43	8.4	0.356
A4	8.02	7.98	0.49

4. CONCLUSION

1. The compressive strength of the mix A1 shows higher strength for 3 days and 7 days compared to conventional mix. After 28 days, the strength is satisfactory and equivalent to conventional concrete.
2. The split tensile strength of mix A1 also shows the higher strength compared to conventional mix.
3. The flexural strength of mix A1 is more compared to other mixes and conventional mix.
4. The test results of durability for A1 mix concrete indicates it can resist the acid attack when compared to other mixes.
5. The overall results indicate that the properties of concrete of mix A1 which contains 10% of PET flakes, Fly ash replacement of 30%, GGBS replacement of 20% and recronfibre of 0.25% showed promising results compared to other mixes.
6. If can also be noted that the strength in tension has increased which is also an important factor for the concretes.
7. As the by-products and waste materials have been added to the concrete, the waste material management environmental issues can also be served.
8. It can be concluded that the PET flakes at maximum 10% can be added beyond which the strength decreases. Further experiments can be performed by varying the mixes and studying the properties of the concrete.

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Rehology Behaviour and Mechanical Properties of Fly Ash Contened Self Compacting Concrete

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A B S T R A C T

Early SCC relied on very high contents of cementitious paste, the mixes required particular and well-controlled placing methods to avoid segregation, but the high contents of cement paste made them susceptible to shrinkage and high heat generation. The overall costs were very high and applications therefore remained very limited.

After series of progressions it is no longer a material consisting of cement, aggregates, water and admixtures. Now a day SCC is a hot topic in the industry and that there are possibilities of using it for a wide variety of purposes.

Self-Compacting Concrete is considered to be the most hopeful building material for the expected revolutionary changes on the job site as well as on the desk of designer civil engineers. Self-compacting concrete consists basically of same components as normal vibrated concrete except that excess of the finer material as water reducing agent, is used. SCC has excellent deformability, high resistance to segregation and can filled in heavily reinforced section without applying any vibration. This paper presents a brief review note on the state-of-the-art of self-compacting concrete using waste material, future sustainability and an eco- environment friendly concrete.

In economic point of standard SCC is hardly 10-15% costlier, but it reduces the site man power and time of project completion. This concrete provides thinner section, desired architectural view and freedom in structural design. In environment point of view many industrial wastage like fly ash, silica fume, steel waste fibers, glass fibers, solid waste of stone industries, rice husk ash, slag waste, petroleum waste, and ground granulated blast furnace slag waste which contributes in global warming as well as their Sevier disposal problem. The present research work aim at the viability of the possible utilization of the natural river sand locally available and fly ash for the development of the self compacting concrete and shall include the following points for the properties, durability and repair application study of fibrous self compacting concrete and self compacting concrete:

Keywords: Rehology; Mechanical Property; SCC; Fly Ash; Fresh Concrete;

1. INTRODUCTION

A concrete that is capable of consolidating under its own weight & occupying all the spaces in the forms, without segregation & without any external compaction effort, is termed as Self Compacting Concrete (SCC)."SCC is ideally suited for the concreting of structures, which have heavily congested reinforcement or wherein access for concreting is difficult. The problem of the durability of concrete structures due, among other things, to a significant reduction in the number of skilled workers in Japan's construction industry has led to the development of SCC in the beginning of 1990s. SCC originated in Japan and being used about 30% of concrete. Now it is developed all over world and replacing conventional concrete. Self-consolidating concrete is an emerging technology that utilizes flow able concrete that eliminates the need for consolidation. However, the basic principles of this material are substantially based on those of flowing, unsegregable, and super plasticizers. The most important benefit of SCC is the increase in durability.

SCC has proved to be a most revolutionary material in the field of concrete technology especially in the last one decade. Super plasticizer is one of the essential constituents of SCC. It is important that the properties of SCC are maintained for an Adequate period of time, 90 min. or more after completion of mixing so that concrete can be properly transported & placed. This paper deals with three aspects of future sustainable development of SCC i.e. economic, social, and environmental effect.

It can be regarded as "the most revolutionary development in concrete construction foe several decades". Originally developed to offset a growing shortage of skilled labour. This concept is now taken up as the concrete that meets special performance and uniform requirements that cannot always be obtained by using conventional concrete. Early SCC relied on very high contents of cementitious paste, the mixes required specialized and well-controlled placing methods to avoid segregation, but the high contents of cement paste made them prone to shrinkage and high heat generation. Generally it seems that the overall costs were high and applications therefore remained limited but it is not true. It has proved beneficial economically because of a number of factors as noted below:

- Faster Construction,
- Reduction in manpower,
- Easier Placing,
- Uniform and complete compaction,
- Better surface finish,
- Improved durability,
- Increased bond strength
- Greater freedom in design,
- Reduced noise levels, due to absence of vibrations and
- Safe working environment

The widespread research carried out by the various researchers in the field of the SCC including need, development and study of the properties of fresh and hardened, strength behaviour, mix design procedures of conventional concrete, SCC mix is reviewed. Based on the detailed literature review the following observations can be made on the present state-of-art of self compacting concrete technology.

- Concrete strength is affected by many factors, which made the concrete.
- Coarse aggregate contains is limited to 50% of the degree of packing for avoiding collision and contact in the SCC mix.
- Fine aggregate is limited to 60% of the degree of packing.
- W/P ratio and superplasticizer dosages are varied so as to obtain SCC. This is varied to obtain the required range of yield stress and viscosity for self compactability.
- It is found that by controlling some parameters of fresh concrete, the hardened properties of hardened concrete can be significantly improved.

SCC mixes must meet three properties

a) Ability to flow in to and completely fill intricate and complex forms under its own weight.

b) Ability to pass through under its own weight and bond to congested reinforcement.

c) High resistance to aggregate segregation.

Numbers of methods are available for proportioning SCC Mixtures. They can be broadly classified in to four categories.

1. Empirical Method
2. Rheology based methods
3. Particle packing models
4. Statistical methods

Rheology based method require rheometers which are very costly (starts more than 10 lakhs) to make justification for use in SCC design. So it is not possible to adopt these methods. Particle packing models may further be classified as discrete and continuous models. Discrete models are based upon the assumption that each class of the particles will pack to its maximum density in volume available.

Before proceeding towards the objective of the study certain assumptions and limitations were discussed. The assumptions made were as follows:

- Cement, fine Aggregate and coarse aggregate as required in bulk and tested only initially for their physical characteristics and variation during casting schedule have not recorded. Although same lot of material were used.
- It is assumed that whole of the material having same property as initially found.
- The relative humidity and temperature at the casting place remain significant.

- The 3 and 7 days curing was done in normal mode but the 28 days equivalent curing was executed in accelerated curing tank in controlled conditions Concept of maturity was applied for equivalence.
- Calibration of the compression testing machine was carried out before and after testing schedule and found almost equal. It is unlikely to affect the results.
- The properties of superplasticizer Glinium51 was taken as provided by the manufacturer of the products.
- The properties of fly ash were taken as per the testing reports of the "Suratgarh Thermal Power Plant Station".
- The fly ash procured in controlled conditions without strict control over temperature and relative humidity at the storage place.
- The durability process of the various mixes was performed in accelerated mode with higher consternations of chlorides and high temperature ranging 40-60 degree. Equivalence of shorter span cycles was attempted with normal deterioration process.
- Change in the combinations (i.e. the properties and source of ingredients, types and grades of concrete, type of fibers, durability parameters etc.) Studied can affect the overall strength and durability parameters of the various types and grades of the concrete.

On the basis of experimental study of the parameters, the detailed interpretations were made for all the selected parameters for strengths and durability.

2. POZZOLANIC MATERIALS

IS: 456 – 2000 allows the use of the fly ash and others in certain percentage as supplementary pozzolanic materials as shown in Table 2.5 to improve the durability and strength performance of concrete. Many researchers have found that the addition of fly ash in concrete improves the performance and durability of the concrete. The utilization of these thermal power plants waste (like flyash) as supplementary cementitious material in concrete reduces the cost of the construction and also improves energy saving with ecological benefits.

Table 1: Mineral Admixtures (IS 456 - 2000)

Material	Permissible Cement Replacement	Blended Products
Fly ash	10% to 25%	Portland Pozzolona Cement (PPC)
GGBS	25% to 65%	Portland Slag Cement (PSC)
Silica fume	5% to 10%	-
Rice husk ash	Depend upon quality	-
Metakaolin	Depend upon quality	-

Table 2: Physical Properties of Fly Ash (form Source)

S. No.	Physical Properties	Test Results
1	Colour	Light Grey
2	Fineness (m^2/Kg)	224
3	Specific Gravity	2.23
4	Bulk Density (Kg/m^3)	700
5	Lime Reactivity -average compressive strength after 28 days of mixture	6.4 MPa

Table 3 Chemical Properties of Fly Ash (form Source)

Sr. No.	Constituents	Percent by Weight
1	Loss on ignition	2,03
2	Silica (SiO_2)	64.77
3	Iron Oxide (Fe_2O_3 + Fe_2O_3)	3.98
4	Alumina (Al_2O_3)	5.98
5	Calcium Oxide (CaO)	4.88
6	Total Sulphur (SO_3)	0.14

3. DEVELOPMENTS OF VARIOUS CONCRETE MIXES

3.1 Normal Conventional Concrete (NC)

In Indian scenario, more than 50 percent of total concrete produced having low to medium strength. Therefore considering wide range applicability, concrete mixes up to M40 grades are selected for this study. In first phase M25, M30, M35 and M40 grades of conventional concrete was designed (Table 4.1) in accordance with IS: 10262-2009 and IS: 456-2000 assuming good degree of quality control and moderate exposure condition using natural sand as fine aggregate. The concrete mix proportions per cubic meter of concrete are tabulated in Table 4.1 for comparative study. The same grades of Self Compacting concrete (SCC) and Fibrous Self Compacting Concrete (FSCC) mixes were also designed.

3.2 Self Compacting Concrete (SCC) and Fibrous Self Compacting Concrete (FSCC):

With the latest development in SCC, the purpose of the research efforts has been to make SCC a standard concrete rather than special one. The EFNARC (2005) specification defines specific requirements for the SCC material, its composition and application. This includes the useful data and guidance to designers, concrete manufactures, contractors, specifying authorities and testing organizations.

An attempt was initially made to obtain the constituents of SCC mixes based on general guide lines given by Okamura (1997), Nan et al (2001) and EFNARC (2005). Using the mix quantities of the different ingredients obtained from EFNARC methods, mixes have been prepared and checked for their self compactability. The ingredients obtained from the mix design method and the self compactability tests results were reported in Table 4.2 for present work. The SCC mixes were tested to check their rheological as well as hardened properties. The rheological properties of SCC mixes are studied by conducting different laboratory tests. An iterative by trial and error procedure is adopted, till a homogeneous, stable and consistent SCC mix is obtained.

3.3 Test Methods for developing SCC Mixes

Equipments required in order verifying the requirements of self compactability used to check the three important rheological properties (filling ability, passing ability and segregation resistance) of self compacting and fibrous self compacting concrete.

The sequential procedure adopted in this study is as follows: Initially mix proportion was obtained for a reference normal conventionally compacted concrete mix using IS method of design (IS: 10262 – 2009). In the absence of any codal recommendation available for design of self compacting concrete (SCC), the proportions were altered based on the EFNARC guidelines. As per the guidelines, usually the coarse aggregate varies from 28% to 35% of the total mass of concrete and fine aggregate balances the volume of the other constituents. The coarse and fine aggregate contents are fixed by trials so that self – compactability can be achieved with adjustment in the water powder ratio and viscosity modifying agent quantity. The following typical range of proportions and quantities as given by EFNARC are used as guide lines.

- Water/powder content by volume 0.8 – 1.1
- Total powder content 400 -600 Kg/m3 [160 to 240 liters/m3]
- Coarse aggregate content 28% to 35% by volume of the mix
- Water content < 200 Kg/m3
- Sand content is used to balances the volume of the other constituents
- Adjust the superplasticizer and VMA dosage

Based on the above guidelines, the trail mixes of self compacting concrete and fly ashself compacting concrete were arrived at. Initially the required amount of all dry materials such as coarse aggregate, fine aggregate, fly ash and cement were mixed for 1 minute. Then 50%of water was added slowly and mixing continued for 5 minutes. Finally, the remaining water remixed with superplasticizer is added and mixing continued for 2 minutes. Then the fresh concrete is tested for the rheological properties of self compacting concrete and fibrous self compacting concrete. Once various criteria of self compactability of mix were satisfied, the test specimens (cubes and beams) were cast.

2. TEST RESULTS & INTERPRITATTION

2.1 Flexural Strength

Standard beams of 100 mm X 100 mm X 500 mm size beam were casted for 7 days and 28 days flexural strength test. The flexural strength of three beams with its average value and standard deviation were reported in this section.

Table 4.16: Flexural Strength (N/mm^2) of NC at 7 Days

S No.	Mix	Beam 1	Beam 2	Beam 3	Average Strength	Standard Deviation
1	NC 25	3.34	3.73	4.12	3.73	0.39
2	NC 30	4.32	4.91	4.32	4.51	0.34
3	NC 35	5.1	4.32	5.3	4.91	0.52
4	NC 40	5.89	4.71	5.49	5.36	0.6

Table 4.17: Flexural Strength (N/mm^2) of SCC at 7 Days

S No.	Mix	Beam 1	Beam 2	Beam 3	Average Strength	Standard Deviation
1	SCC 25	2.94	3.14	3.92	3.34	0.52
2	SCC 30	3.73	3.92	4.32	3.99	0.3
3	SCC 35	4.32	4.32	5.49	4.71	0.68
4	SCC 40	4.91	4.71	5.1	4.91	0.2

Table 4.18: Flexural Strength (N/mm^2) of FSCC at 7 Days

S No.	Mix	Beam 1	Beam 2	Beam 3	Average Strength	Standard Deviation
1	FSCC 25	3.92	4.91	4.32	4.38	0.49
2	FSCC 30	5.1	5.3	5.89	5.43	0.41
3	FSCC 35	5.69	6.08	5.89	5.89	0.2
4	FSCC 40	6.28	5.89	6.08	6.08	0.2

Table 4.19: Flexural Strength (N/mm^2) of NC at 28 Days

S No.	Mix	Beam 1	Beam 2	Beam 3	Average Strength	Standard Deviation
1	NC 25	5.49	4.91	5.49	5.3	0.34
2	NC 30	5.1	5.89	5.69	5.56	0.41
3	NC 35	5.69	6.08	6.47	6.08	0.39
4	NC 40	5.89	6.28	6.67	6.28	0.39

Table 4.20: Flexural Strength (N/mm^2) of SCC at 28 Days

S No.	Mix	Beam 1	Beam 2	Beam 3	Average Strength	Standard Deviation
1	SCC 25	4.71	4.51	5.3	4.77	0.3
2	SCC 30	5.1	4.91	5.49	5.17	0.3
3	SCC 35	5.69	5.69	5.89	5.76	0.11
4	SCC 40	6.47	5.89	5.89	6.08	0.34

Table 4.21: Flexural Strength (N/mm^2) of FSCC at 28 Days

S No.	Mix	Beam 1	Beam 2	Beam 3	Average Strength	Standard Deviation
1	FSCC 25	6.47	5.89	6.08	6.15	0.3
2	FSCC 30	6.08	6.67	6.47	6.41	0.3
3	FSCC 35	6.67	6.08	6.87	6.54	0.41
4	FSCC 40	6.08	6.87	7.65	6.87	0.78

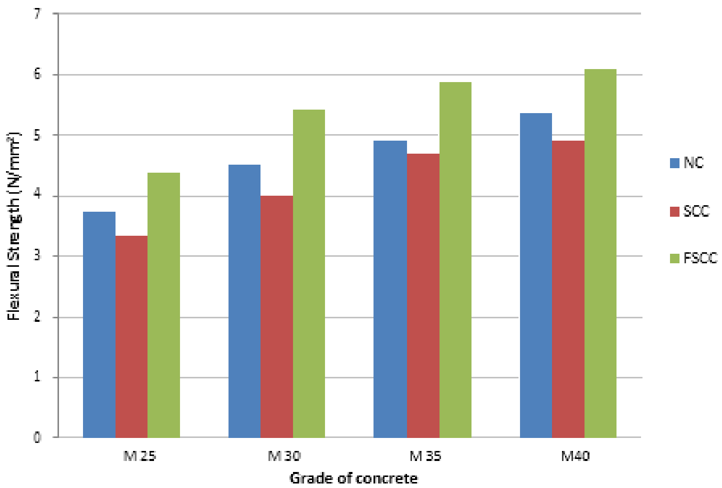

Figure 4.4: Flexural Strength of NC, SCC and FSCC at 7 Days

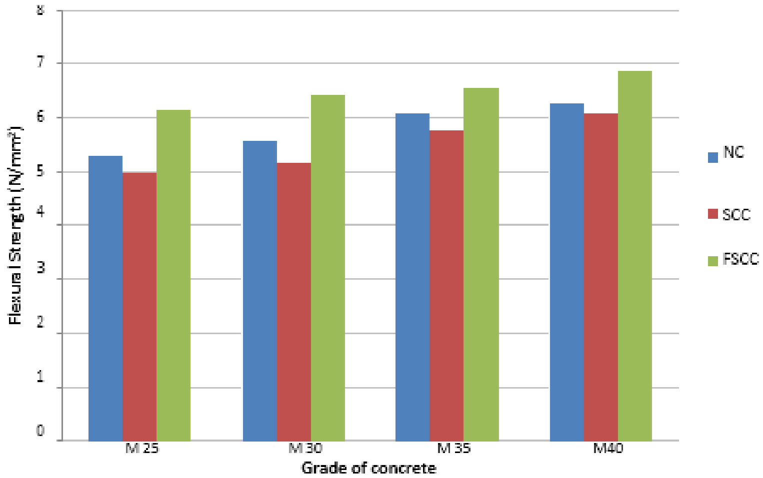

Figure 4.5: Flexural Strength of NC, SCC and FSCC at 28 Days

4.2 Modulus of Elasticity

The modulus of elasticity of NC, SCC and FSCC for M 25 grade of concrete is calculated with the IS code method and from the stress strain curve drawn for cube specimen subjected to gradually increasing compressive load. The results are shown in respective tables.

Table 4.22: Load Deformation for Normal Conventional Concrete of Grade 25

S. No	Load (Kg)	Deformation (mm)
1	0	0
2	10000	0.05
3	20000	0.13
4	30000	0.22
5	40000	0.3
6	50000	0.45
7	60000	0.55
8	70000	0.8
9	80000	1.07
Crushing load	80333	

Table 4.23: Load Deformation for Self Compacting Concrete of Grade 25

S. No	Load (Kg)	Deformation (mm)
1	0	0
2	10000	7
3	20000	17
4	30000	29
5	40000	37
6	50000	55
7	60000	67
8	70000	80
9	80000	117
Crushing load	84000	

Table 4.24: Load Deformation for Fibrous Self Compacting Concrete of Grade 25

S. No	Load (Kg)	Deformation (mm)
1	0	0
2	10000	4
3	20000	8
4	30000	14
5	40000	23
6	50000	35
7	60000	47
8	70000	62
9	80000	110
Crushing load	91000	

Table 4.25: Modulus of Elasticity of NC, SCC and FSCC

S No	Mix	Modulus of Elasticity (N/mm^2) by IS 456 - 2000	Modulus of Elasticity (N/mm^2) by Stress Strain Curve
1	NC 25	29593.07	26141.56
2	NC 30	31839.44	27089.45
3	NC 35	33342.92	28567.47
4	NC 40	35457.72	30465.12
5	SCC 25	30257.23	25346.45
6	SCC 30	32066.34	27983.47
7	SCC 35	33830.46	31132.45
8	SCC 40	34992.86	32345.34
9	FSCC 25	31496.03	26930.08
10	FSCC 30	32848.14	27985.48
11	FSCC 35	33290.39	30123.48
12	FSCC 40	36417.72	32897.5

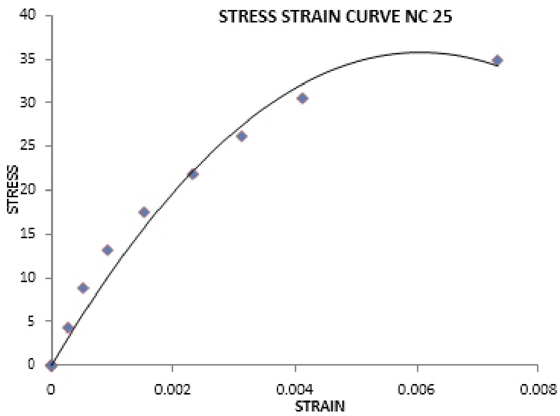

Figure 4.6: Stress Strain Curve for NC 25

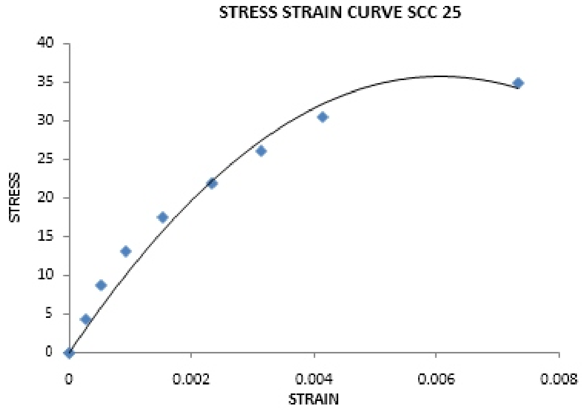

Figure 4.7: Stress Strain Curve for SCC 25

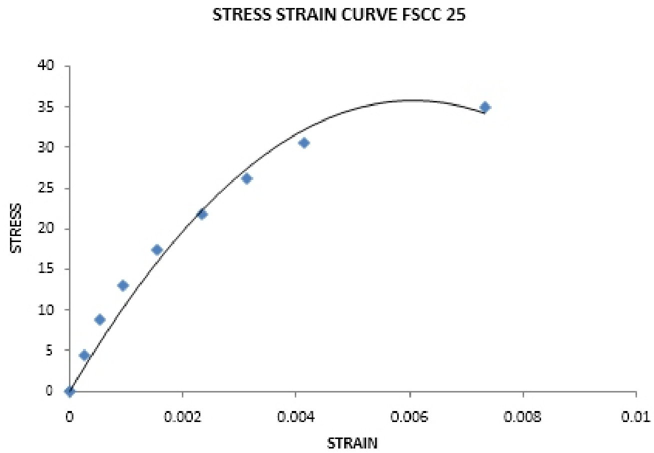

Figure 4.8: Stress Strain Curve for FSCC 25

5. CONCLUSIONS

- It is observed from the test results obtained, the later age strengths of SC and FSCC mixes with local materials are very close to the strengths of the same NC mixes, than their strengths at earlier ages. This may be attributed to the contribution of pozzolanic reaction of fly ash at later ages.
- The number of tests conducted for rheological characteristics of SCC and FSCC is more in the present investigation, but it may be limited to 2-3 tests to check the rheology of the SCC and FSCC in the field.
- The difference in modulus of elasticity evaluated with stress strain curve is lesser for the M 35 and M 40 grades of SCC and FSCCs in comparison to IS code equation.
- SCC has high potential for greater acceptance and wider applications in construction field.
- Surface finish and durability aspects of SCC have been studied globally and are found to be superior to those of conventional concrete. In fact SCC is superior to in respect of all properties.
- SCC's unique properties give it significant economic, constructability, aesthetic and engineering advantages and eco friendly because of using waste material.

• SCC provides benefits beyond those of conventional concrete in all three aspects of sustainable development: economic, social, and environmental as discussed earlier in paper.

• With the use of fly ash, as partial replacement of cement, up to 60% by volume of binder, we can reduce cost incurred in production of SCC.

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A review of Opened Reinforced Concrete Beams with and without Strengthening

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A B S T R A C T

The transverse holes in the webs of beams in buildings are necessary for the passage of service ducts and piping in order to minimize the story height and to attain economic requirements. Use of externally bonded Fiber-Reinforced Polymer (FRP) sheets, strips or/and steel plates is a modern and convenient way for strengthening of RC beams. Several researchers have been carried out on reinforced concrete beams with web openings strengthened with fiber-reinforced polymer composite. Some of them focused on shear strengthening compared with flexural strengthening that had the largest shear and others studied the effect of openings on shear and flexural separately. This paper attempts to address an important practical issue that is encountered in shear strengthening of opened reinforced concrete beams with carbon fiber reinforced polymer (CFRP) laminate. A simple technique of applying fiber-reinforced polymer contributed with steel plate for strengthening the RC beams with openings under different load application proposed in this paper.

Keyword- carbon fiber reinforced polymer, web opening, concrete beams, shear strengthening.

INTRODUCTION

Recently develop fiber reinforced polymer (FRP) composite materials and became available for a wide range of applications, including seismic retrofit of reinforced concrete beam. FRP wrapping has many advantages, including extremely low weight-to strength ratios, resistance to corrosion, high elastic modulus, and ease of application. And also, unidirectional FRP confining can improve structural ductility without considerable stiffness amplification, thereby maintaining the bridge dynamic properties.

Transverse opening in Reinforced concrete beams in practice is a facility, which allows the utility line to pass through the structure. This type of design encourages the designer to reduce the height of the structure, which leads to an economical design. Because of sudden changes in the dimension of cross-section of the beam; the corners of opening would be subjected to stress concentration, and it is possible to induce transverse cracks in the beam. The maintenance, rehabilitation and upgrading of structural members, is perhaps one of the most crucial problems in civil engineering applications. Moreover, a large number of structures constructed in the past using the older design codes in different parts of the world are structurally unsafe according to the new design codes. Since replacement of such deficient elements of structures incurs a huge amount of public amount and time, strengthening has become the acceptable way of improving their load carrying capacity and extending their service lives (GyuseonKim,et al 2008). The use of fiber-reinforced polymer (FRP) materials in civil infrastructure for the repair and strengthening of reinforced concrete structures and also for new construction has become common practice. The most efficient technique for improving the shear strength of deteriorated RC member is to externally bond fiber-reinforced polymer (FRP) plates or sheets. FRP composite materialshave experienced a continuous increase of use in structural strengthening and repair applications around the world, in the last decade (ISIS 2007).

In addition, when the FRP was compared with steel materials, it was found that it provided unique opportunities to develop the shapes and forms to facilitate their use in construction. Although, the materials used in FRP, for example, fiber and resins are relatively expensive when compared with traditional materials, noting that the crises of equipment for the installation of FRP systems are lower in cost.

STRENGTHENING IMPORTANCE

A structural strengthening is needed when a structure has been built to resist to a particular system of loads and when this system of loads has changed with time. For example, this can happen for bridges when the traffic loads increase as the number of heavy vehicle's increases, or when the deck has to be widened in order to have an additional lane. In these cases, the bridge has to be strengthened. The same with buildings: a room designed for an office, for example, needs to be strengthened if we change its function into a storage room. A strengthening can also be needed when new regulations come up with more restrictive safety factors.

CARBON FIBER STRENGTHENING

Strengthening by carbon fiber is very interesting when the loads to be taken are not too large. This strengthening method is relatively easy and fast to put in place, because carbon is a very light material and the application is very simple. Moreover, contrary to a strengthening with steel, the carbon fiber composite is not sensible to corrosion, which is favorable from a durability point of view.

some proposals or recommendations have been adopted in different countries for the design of reinforced concrete structures reinforced or strengthened with FRP sheets, such as ACI 440 (2008), ACI 318- 95(1995), ACI 440.2R-02(2002), ACI 318-05(2005).

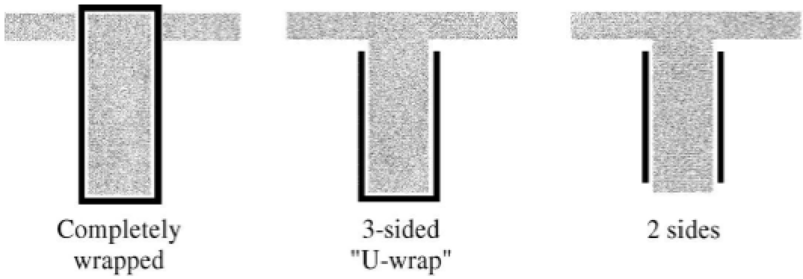

Figure. 1.Typical wrapping schemes for shear strengthening using FRP laminates.

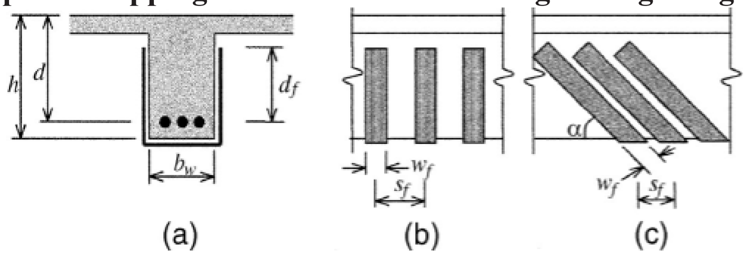

Figure. 2. Illustration of the dimensional variables used in shear-strengthening calculations for repair, retrofit, or strengthening using FRP laminates ACI 440.2R-02)

Figure. 3. Strengthening of RC girder by CFRP laminates in shear(M.B.S Alferjani et al 2013).

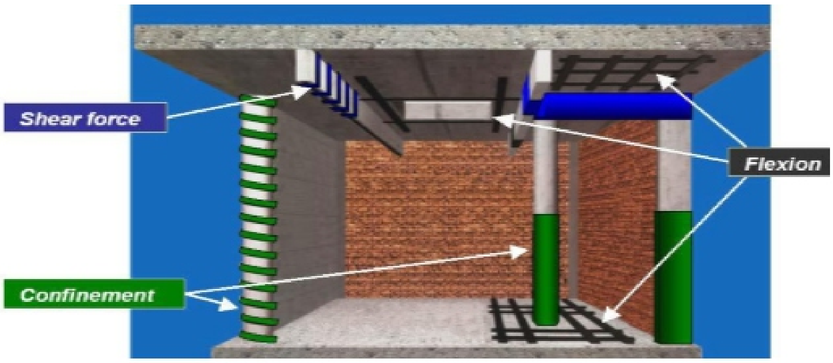

Figure 4 . Different kinds of carbon fiber strengthening (AmélieGrésille 2009)

Previous Researches on R.C Beams with Openings

Nonlinear finite element modeling and analysis of steel fiber reinforced concrete (SFRC) deep beams with and without openings in web subjected to two- point loading was presented by HayderQaisMajeed(2012). The percentage of steel fiber used in the study was varied from 0 to 1.0%.

The study concluded that the location of openings and the amount steel fiber are affects to the behavior and strength of deep beams. The results obtained by using finite element analysis are very close to that obtained by experimental work. Hayder Qais Majeed (2012) studied the experimental and nonlinear finite element (ANSYS 11) analysis to creating square openings in existing RC beams and strengthening with CFRP laminate. The results indicated that the strengthened beam recorded the highest failure load and its mode of failure was ductile. Vengatachalapathy.V, et al (2010)studied experimentally the behavior and ultimate strength of steel fiber reinforced concrete (SFRC) deep beams with and without openings in web subjected to two- point loading, nine concrete deep beams of dimensions 750mm×350mm×75mm thickness were tested to destruction by applying gradually increased load. The theoretical formula obtained by Kong and Sharp's was modified to calculate the ultimate load which compared by experimental results. The results was gave clear indicator that the behavior and strength of deep beam affected by the location of openings and the amount of web reinforcement, either in the form of discrete fibers or as continuous reinforcement. In terms of experimental application several studies were performed to study the behavior of retrofitted beams with openings and analyzed the various parameters influencing their behavior. WU Yan, et al (2004) investigated two reinforced concrete frames with openings beam to study many parameters such as to research failure pattern, dynamic response , hysteresis curves , energy dissipation and rigidity degeneration of RC frame with openings. Their results show that the openings do not affect the seismic behavior of reinforced concrete frame. The seismic resistance mechanism of two full-scale Single-span Holed Frame-supported Wall-beams was experimentally studied by QUA N X ueoyou et al (2009). Test results show that when only the vertical load exerted on top of the brick-wall, both symmetrically holed and non-symmetrically holed wall-beams displayed an evident composite arch action. The lower corner aside the hole of coup led w all may experience compression crushing, the beam end may have shear failure and the brick coup ling beam will be subjected to serious shear failure. The supporting beam suffered flexural failure around the holed span or splitting failure along the longitudinal bars between opening edge and the nearest beam end. Huang Tai-yun et al (2008)investigated 20 simply supported reinforced concrete beams with rectangular openings under concentrated load. Their Experimental results show that the shear capacity of beams was increased by strengthening stirrups and the bent-up steel bars at the opening sides, and the shear- compression failure can be avoided if the transverse reinforcements and the stirrups of chords are large enough.

Qiongjuan Zhao (2012)investigated by the ANSYS finite element analysis software the effect of variation of opening diameter, opening position and stirrup ratio around the hole on the mechanical behavior and shear capacity in reinforced concrete beam. Their results show that the opening location has a great effect on shear capacity of the beam and results calculated by the formula agrees well with the experimental data in literature and that obtained by using ANSYS for RC beams strengthened by FRP.

JIN Guo-fang, et al (2011)studied the loading test and finite element analysis of beams with hole. Results of stress variety and distributing were discussed and provided that if the beams designed with openings need to be strengthened and how to strengthen them.

The behavior of steel reinforced concrete (SRC) beams with an opening, including the effects of various opening shapes and different values of moment to shear ratio on the strength were investigated by C.-C. Che, et al (2008).the experimental study showed the failure of the specimens with low moment to shear ratio by shear cracking, and specimens with high moment to shear ratio demonstrated ductile behavior due to the confinement attributed to the stirrup and structural steel. The effect of small circular opening on the shear and flexural and ultimate strength of beams have been studied by Nilesh, et al (2013). The changes of diameter and openings positions are the main factors of their study. Their results showed that the presence of diagonal reinforcement and stirrups in top and bottom of opening is useful.

Seismic behaviors of steel moment resisting frame including opening in beam web was investigated by libo, yang qing-shan, et al (2009), JIANGHua, et al (2008) and CHEN Hui-rong (2009).Experimental results show that steel moment resisting frame (MRF) including opening in beam web closed to connection can satisfy the design requirement. Results shown that, rotations around beam-to-column connection decrease and brittle weld fracture can be avoided and seismic behaviors of steel MRF are improved due to opening in beam web. Analysis results show that with appearance of opening in beam web, the rigid of steel MRF is not weakened, and the failure mode of a ductile frame is formed. An experimental study of 29 simply supported RC beams with circular web openings under concentrated loads was carried out by CaiJian, et al(2009) to investigate influence the mechanical properties of the beams with circular web openings, including the size, location and eccentricity, spacing of web openings, ratio of shear span to effective section depth, and form and amount of reinforcement around the openings on shear capacity. Their results show that the openings size and location has great effect on shear behavior of reinforced concrete beams.

Factors that influence the mechanical behavior of 42 simply supported reinforced beams with openings, such as height and length of the opening, position of opening, eccentricity of opening, spacing of opening, ratio of shear span to effective depth of section, form and amount of reinforcement around the openings were investigated experimentally by Huang Taiyun, et al (2009). Their conclusions provided experimental proofs for the establishment of mechanical model and design method for this kind of reinforced concrete beam with opening. The effect of introducing openings in existing reinforced concrete beams were carried out by CaiJian, et al (1997.I, II, and III)and Yang Yu-hua,et al (1997, 2001).Results obtained from experimental work were compared with theoretical results and gave clear evident that is useful for engineering practice. They concluded that the presence of diagonal reinforcement was increased the shear capacity of beams and reduced the cracks width with low strain value around the opening. The results s how that the behavior of the beams is also affected by the size of the opening and yet it is not markedly affected by the double circular openings, which have a distance of more t ha n 1 time of the diameter of opening from its side t o t he side of the circular openings. M. A. Mansur (2006)summarized the analysis and designs of such beams under the most commonly encountered loading case of bending and shear. It has been shown that the design method for beams with large openings can be further simplified without sacrificing rationality and having unreasonable additional cost, and he wasexplained how to creating an opening in an already constructed beam and how to deal with multiple openings.

The design specifications of openings in the web for simply supported reinforced concrete (RC) beams and rectangular concrete beams conducted by previous researchers was reviewed by Soroush Amiri, et al (2011), and they were discussed and described the previous researches which are related to the openings in the web of reinforced concrete (RC) beams. Ammar Y. Ali, et al (2011) investigated the effect of the shape and dimensions of opening on the behavior of R.C beams and they was examined the effectiveness of CFRP reinforcement in enhancing the flexural capacity of RC beams with opening at the flexural region. Results obtained from the study show that the (L/h) ratio and FRP sheets has great effect to increase the stiffness and capacity of all beams.

Strengthening R/C beams with large circular and square opening located at flexure zone by Carbon Fiber Reinforced Polymer (CFRP) laminates was studied by S.C. Chin, N. Shafiq, et al (2011). They were explained clearly from the Test results that large opening at flexure reduces the beam capacity and stiffness; and increases cracking and deflection. Test results showed that large opening at flexure reduces the beam capacity and stiffness; and increases cracking and deflection. Investigation of the strength losses in RC beam due to the presence of large square openings placed at two different locations in shear region was examined by S.C. Chin,et al (2012). Also, in order to re-gain the beam structural capacity loss due to the openings, strengthening by CFRP laminates around the openings were studied. Nonlinear finite element program ATENA was used to validate the results. the mid-span deflection and cracks patterns of tested beams obtained by finite element model show good agreement with the experimental data.

The effects of opening shape and location on the structural strength of R.C. deep beams with opening was studied byHaider M. Alsaeq (2013). The FE program Used in this study shown fair agreement with the experimental results, with a difference of no more than 20%. The present work concludes that the opening location has more effect on the structural strength than the opening shape. It was concluded that placing the openings near the upper corners of the deep beam may double the strength, and the use of a rectangular narrow opening, with the long sides in the horizontal save up to 40% of structural strength of the deep beam. Nilesh H. Saksena, et al (2013) used finite element method using ANSYS 14.0 to simulate the simply supported concrete beams consisting of circular openings with varying diameters at different locations. Numerous models of simply supported reinforced concrete rectangular section beams with circular opening were loaded monotonically with two incremental concentrated loads. The beams were simulated to obtain the load-deflection behavior and compared with the solid concrete beam. The results obtained from this study showed that the performance of the beams with circular openings at center of span has lesser effect on the ultimate load capacity of the RC rectangular section beams. Introducing the circular opening of diameter of 45% of depth near the support reduces the ultimate load capacity of theRC rectangular section beams at least 32% compared to solid beam. An extensive experimental program consisting of testing eleven full scale RC beams were carried out by sreelathavuggumudi (2013). The variables investigated in this study included steel stirrups, shear span-to-depth ratio, GFRP amount. The test results illustrated in the present study showed that the external strengthening with GFRP composites can be used to increase the shear capacity of RC T-beams, but the efficiency varies depending on the test variables such as fiber orientations, wrapping schemes, number of layers and anchorage scheme. The shear capacity of these beams has increased compared to the control beam which can be further improved if the debonding failure is prevented.

Grahamsrichardsharp (1977) was concerned with the general behavior in shear of single-span reinforced concrete deep beams and in particular the effects of web openings on their ultimate strength and serviceability. The test specimens comprised seventy-five lightweight and sixteen normal weight reinforced concrete deep beams with span/depth ratios ranging from one to two. The effects of a varied range of web openings on deflections, crack widths, cracking loads, failure modes, and ultimate shear strengths were studied, and the influence of web reinforcement was investigated. Eleven full scale RC beams was carried out experimentally by Sreelatha Vuggumudi (2013)to investigate the shear performance and failure modes of RC T-beams strengthened with externally bonded GFRP sheets. Results indicated that the contribution of externally bonded GFRP to the shear capacity is significant and depends on the variable investigated. The debonding failures of FRP sheets followed by brittle shear failure are initiated failures of strengthened beams. The method of anchorage technique by using GFRP plates has been used to prevent the premature failures. A theoretical study is also proposed by using ACI guidelines for computing the shear capacity of the strengthened beams. The shear capacity of these beams has increased as compared to the control beam which can be further improved if the debonding failure is prevented. Mansur, M. A., et al (1999) they wrote this book to compile the state-of-the-art information on the behavior, analysis, and design concrete beams that contain transverse openings through the web. The behavior of such beams under bending, shear, and torsion is treated in the book. Design methods based on plastic hinge mechanism, plasticity truss and strut-and-tie models, and skew-bending theory are described and illustrated with numerical example.

A set of simple and reliable design equations for high strength concrete deep beams with opening was developed by Tae Min Yoo (2011). Deep beams with web opening but without web reinforcement are given particular attention in his investigation. The finite element method was used to conduct a series of parametric studies and the failure mechanism of concrete deep beams with opening was offered by numerical analysis through detailed examination of their ultimate load versus crack patterns and deflection response. Analyses the Eigen frequency of castellated beams with hexagon holes using Rayleigh method and the finite element analysis software were simulated by Xia Zhicheng, Cao Ji and XuDuo (2009). The effect s of the opening ratio, height distensible times, the ratio of height to span and displacement constraint on the natural frequency of castellated beams are studied. result s indicate that; castellated beams have better aseismic performance than the non-heightened H-type steel beams and the use of castellated beams is more economical than that of the plain web girders with the same section height in the large span. two single-bay and single story RC frames with opening beam with The pseudo-dynamic test was carried out by WU Yan-hai and CHENG Hao-de (2004) to investigate the failure pattern, dynamic response , hysteres is curves and energy dissipation and rigidity degeneration of RC frame with opening beam. They reported that the presence of openings in the beam frame structure does not affect the overall seismic performance and failure modes of the structure. The duration earthquake seismic waves was directly affect the cumulative damage to the frame structure under earthquake, showing structural role in the larger amplitude without cracking, but instead in the subsequent cracking of small amplitude. The mechanism of the structural destruction of the steel reinforced concrete when the openings are located in the bending shear sections is analyzed by GU Song and PAN Wen (2003). Results compared with some simplified design methods and using of reinforcement about upper and bottom - chord around openings was recommended.

CUI Hong-jian and WANG Feng-chao (2009) and WANG Yao (2005) presented an analytical discussion of current research and findings on reinforced concrete beams with openings at home and abroad covering its classification, mechanical property, modes of collapse, calculation of shear strength, deflection and crack characteristics. Finite element analysis method is introduced and results compared with that obtained from the seismic performance analysis. The characteristics of the cracks and the collapse modes were summarized to provide more references for the design and the calculation of this kind of the beams. Beams made by normal and high strength concrete were studied by Javadvaseghi amiri1et al (2004). They investigated the effect of small circular opening on the shear and flexural and ultimate strength. Main factors of the investigation are the changes of diameter, the position of opening and the type and location of reinforcement around the opening and changes in the strength of concrete. Their results showed that the presence of diagonal reinforcement and stirrups in top and bottom of opening is useful. Kiang-Hwee Tan, et al (2001)examined the adequacy of the ACI Code approach, modified for the inclusion of transverse openings and for shear design of a beam with circular openings. Their Test results indicated that crack control and preservation of ultimate strength may be achieved by providing reinforcement around the opening, then the premature crushing of the concrete can avoided by reduce the high stress in the compression chord by using Diagonal bars.

Nonlinear finite element analyses of three concrete beams with large rectangular openings in fixed place inside the flexural-shear section were carried out by Liu Hongmei, et al (2005). The beam′s stress, strain, deflection, crack and the ultimate carrying capacity with different diameter reinforced bars under alterable loads was computed and compared with tests results. The effect of opening Sizes and Locations on the Shear strength behavior of reinforced concrete deep beams without web reinforcement was studied by Hawraz Karim M. Amin, et al (2013). Many parameters effect the behavior of beam such as (l/d, a/d, f_c and maximum size of aggregate) was taken in to account. The finite element method with (Ansys+CivilFEM) release 12.0 program was used to predict the main parameters. From the results they were reported that the main parameters were effected the behavior of deep beam. The behavior of R.C.C. beam with rectangular opening strengthened by CFRP and GFRP sheets were studied by Rakesh Diggikar, et al (2013). beams were strengthened externally by Carbon fiber reinforced polymer (CFRP) and Glass fiber reinforced polymer (GFRP) sheets with different strengthening techniques i.e. around the opening, inside the opening, inside and around the opening and double layer around the opening. From their experimental results it is concluded that the ultimate load carrying capacity of the R.C.C. beam with opening strengthened with GFRP sheets of different schemes were increased in the range of 3.74 to 37.41% and beams strengthened with CFRP sheets increased in the range of 9.35% to 50.50%. S.C. Chin, et al (2012) presented two dimensional nonlinear finite element analyses of R.C beams to validate against the laboratory test results. The results of the finite element model show good agreement with that of the experimental beams.

Evaluation of Some Equation Presented In Some Codes:

The analytical equations determining the ultimate strength beams with opening According to ACI and AIJ codes and method are:

1- ACI code[28]: shear strength of section with opening given from equation below,

$$V = V_c + V_s + V_f (1)$$

$$V_c = \frac{1}{6}\sqrt{f_c^{/}}\, b_w\, (d - d_0) (2)$$

$$V_s = v_{sv} + v_{sd} = \frac{A_v f_{yv}}{s}(d_v - d_0) + A_d f_{yv} sin \propto (3)$$

$$V_f = A_{fv} f_{fe} (\cos\beta + \sin\beta) d_{frp} \text{ (Khalifa et al1998) } (4)$$

Where, $A_{fv} = 2\text{n}\, t_{frp} w_{frp}$

V_f is Contribution of CFRP reinforcement, d and d_0 are effective depth and diameter of opening respectively, A_v and A_d cross section of vertical and diagonal reinforcement respectively in (mm^2),dv the distance between longitudinal bars on top and bottom, b^w the width of section and s the distance between stirrups in mm, $f/_c$ is ultimate compressive strength of concrete and F_{yv} is yielding stress of shear reinforcement in N/mm2, α slope angle of diagonal reinforcement.(ACI 318-95), (ACI 318-05), (ACI 318M-08), (ACI 440.2R-02), (ACI 440.2R-08) and Ahmed M. Sayed1; et al (2013)

2- The Japanese code (AIJ) will use a formula of shear strength of beam with opening by estimation as below,(AIJ- 1994)

$$V_n = \left[\frac{0.092 k_u k_p \left(f_c^{/} + 17.7\right)}{\frac{M}{v.d} + 0.12}\left(1 - \frac{1.61 d_0}{h}\right) + 0.846\sqrt{\rho_w f_{yv}}\right] b d_v \ (5)$$

Where, p_w is ratio of shear reinforcement around the opening, k_u and k_p, are factors dependent to the height of section to longitudinal reinforcement ratio respectively.

The shear strength of beam with opening obtained from plastic truss method through the following equations:

$$V_n = b d_{tw} \rho_v f_{yv} \cot \emptyset_s (6)$$

$$\text{Where,} d_{tw} = d_v - \frac{d_0}{\cos \emptyset_s} - S_v \tan \emptyset_s (7)$$

3- ISIS Education Committee: Canada(ISIS- 2004)

The shear resistance is given as sum of the contributions from the steel, concrete and the FRP,

$$V_r = V_c + V_s + V_f (8)$$

$$V_c = 0.2\lambda\emptyset_c \sqrt{f_c} bd \ for\ d \leq 300mm \quad (9)$$

$$V_c = \left[\frac{260}{1000+d}\right]\lambda \emptyset_c \sqrt{f_c} bd \ for \ d \geq 300 \ (10)$$

But V_c >0.1 $\lambda \emptyset_c \sqrt{f_c} bd$ (11) $V_s = \frac{\emptyset_s A_v f_{yv} d}{s}$ (12)

The shear contribution of Vf can be determined using following expression,

$$V_f = \frac{\emptyset_f A_f E_f \varepsilon_f d_f (\sin\beta + \cos\beta)}{s_f} \ (13)$$

$A_f = 2t_f w_f$ (14) $s_f, w_f \ and \ \beta$ are the spacing, width and angle of the shear reinforcement to the longitudinal axis of beam respectively. d_f is the effective depth of FRP, ε_f effective strain of FRP.

$$\varepsilon_f = R.\varepsilon_{fu} \leq 0.004 (15)$$

where R is reduction factor.

$$R = \alpha\lambda_1 \left[\frac{f_c^{2/3}}{\rho_f E_f}\right]^{\lambda_2} (16)$$

α is reduction coefficient for effective strain, $\lambda_1 and \ \lambda_2$ are the experimentally derived parameters. The FRP reinforcement ratio can be determined from:

$$\rho_f = \left(\frac{2t_f}{b}\right)\left(\frac{w_f}{s_f}\right) \quad (17)$$

For the buildings, the maximum allowable shear strengthening is described as follow

$$V_r \leq V_c + 0.8\lambda\emptyset_c \sqrt{f_c} bd \qquad (18)$$

CONCLUSIONS AND RECOMMENDATION FOR FUTURE RESEARCH:

This paper reviewed the existing research works on opening reinforced concrete beams strengthened by fiber reinforcement polymer (FRP. conclusions and directions for future work in order to fill the gaps which exist in the work carried out thus far presented below.

-Future research is needed for a complete awareness for strengthening reinforced concrete beams with opening with FRP and steel plate under static or dynamic load, with the aim to efficiently contribute in the concrete structures repair tasks as well as, to decrease the structure dimensional stability.

-The contribution of strengthening materials such as FRP and steel plate in reinforced concrete beams with openings allows engineers to evaluate safety depending on required design life, environmental and stress conditions and generic FRP type.

-study the effect of different coefficients of thermal expansion between FRP system and the structure members.

- study the parameters including failure mode, opening size and location, end of anchorage, FRP orientation, number of FRP layer, spacing, strength scheme and shear capacity must be investigated under dynamic load.

- more laboratory testing should be carried out on different type of reinforced concrete beams with openings other than simply supported, such as continuous beams, steel orientation and pre-stressed beams. And,

- Improve the understanding of reinforced concrete beams with openings strengthened with CFRP or steel plate subjected to different loading type.

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The Practice of Procurement Systems in the Nigeria Construction Industry

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A B S T R A C T

In most of the developed countries, different types of procurement systems were practice in the construction projects to achieved good quality project delivery. The construction industry in Nigeria is still facing the challenges of good quality projects delivery as a result of the selection of appropriate procurement system for a particular project. Therefore, the aim of this study is to examine the type of procurement systems practice in Nigeria construction industry. To accomplish this aim the study adopted the quantitative research approach, since it reasoning through the philosophies of deductive approach. The structured questionnaire was used since it is straight forward and faster compare to other methods. The questions were design in Likert scale format and distributed to the professionals in the construction industry in Abuja, the Nigeria capital. 310 questionnaires were distributed and 64.51% of the questionnaires distributed were the one filled correctly and returned, which represent the data used for the analysis. The result obtained from the analysis shows that the two methods of procurement systems were the commonest type practice in the construction projects in Nigeria, these are traditional method and build and design methods. Therefore, this study suggests that the management of the construction industry and other stakeholders should develop strategy that would influence the use of appropriate procurement system for a particular project.

Keywords: procurement system, project delivery, construction industry and professionals.

1. INTRODUCTION

Procurement systems have become an important issue in the construction industry because of two reasons: the procurement of construction projects involves a series of processes that are interrelated and sequential. The effectiveness and efficiency of the processes have considerable impact on the success or failure of projects. Secondly, there are several procurement methods that are available for a developer to adopt in procuring a project. For this reason, one major challenge that the project developer faces is the method to adopt among the available procurement options (Bratt et al., 2013). However previous researchers described procurement method as the management of the total process involved in the construction project delivery (Bratt et al., 2013;Costa et al., 2013; Eriksson, 2013). It is also ways in which a client or a sub-client may procure a building or other construction work varied and complex. Hashim et al., (2013) further expressed that different variants of procurement are available for meeting different clients' needs and projects specifics. A number of factors have to be taken into account in determining the best method for a specific project. The variants of procurement methods available today

2.1 Traditional System

The traditional procurement system is predominant in the construction industry. It is characterized by the contractor not being responsible for the design or the documentation work (Goldfayl, 1999; Mok et al., 2014;Ali et al., 2009; Ali, et al 2011) and with a clear division between the design and construction process responsibilities (Rowlinson, 1999; Josephson and Lindstorm 2007). Peter et al., (2008), stressed that there are three types of traditional procurement method which is consist of lump sum contract, measurement contract and cost reimbursement/cost plus contract. This method allows for all contractors that fill competent to bid for projects in a free and competitive atmosphere similar to competitive market environment. In a typical traditional approach, the client initiates the project and produces a written scope statement, identifying the projects objectives and verifying the scope definition by the architects. The architect is responsible for defining the project scope in order to facilitate a clear assignment of responsibilities and to monitor the scope change control with the project team. The design team produces complete design documents before engaging the contractor, often affecting quality by not taking into considering buildability, constructability and life-cycle costing. However, Rahman et al., (2013) affirmed that there are certain conditions that warrant the use of traditional procurement, these include the followings:

- A programme allows sufficient time
- Consultant design is warranted
- A client wishes to appoint designers and contractors separately
- Price certainty is wanted before the start of construction
- Product quality is required and
- A balance of risk is to be placed between the client and contractor.

The main advantages of using a traditional approach of procurement is produces lowest bid, assuring quality control and familiar in the industry. The disadvantage of using traditional approach of procurement is that builders are not involved in the design process, slow nature of projects and potential adversarial (Peter et al., 2008).

2.2 Design and Build System

The Design and Build refers to the procurement strategy that entails the contractor carrying out the work; the design works as well as the construction and completion of the work. The main advantages of using a design and construct approach to procurement is that contractor act as single point of responsibility, price certainty, effective communication and multi-disciplinary approach. The disadvantages of design and build system are as follows: higher costs, the limitation of competition in the public section, difficulties in preparing an adequate and sufficiently comprehensive brief, requires early confirmation of conceptual design and absence of a bill of quantities (Vatalis et al., 2012; Peter et al., 2008).

2.3 Management Procurement System

Several variants of management procurement forms exist, which include; management contracting, construction management and design and manage. In the case of management contracting, the contractor has direct contractual links with all the works and a contractor is responsible for all construction work. In construction management, a contractor is paid a fee to professionals to develop a programme and coordinate the design and construction activities, and to facilitate collaboration to improve the project's constructability. The main advantages of using a management approach to procurement is to improved coordination and collaboration, time savings, roles, risks and also the responsibilities for all parties are clear and flexibility for changes in design The main disadvantages are as follows: the client with proactive in nature is requirement, price fluctuation problems, loss of vital time and information and also inadequate brief to the design team (Peter et al., 2008; Uttam et al., 2014):

However, management contracting system is most appropriate for large and complex projects which exhibit particular problems that militate against the employment of fixed price contract procedures. Typical examples of which are: Projects for which complicated machinery and / heavy equipment are to be installed concurrently with the building works; Projects for which the design process will of necessity continue throughout most of the construction periods; Projects on which construction problems are such that it is necessary or desirable that the design and management team includes a suitably experienced building contractor appointed on such a basis that his interests are largely synonymous with those of the employer's professional consultants.

2.4 Built-Own-Operate-Transfer (BOOT)

Developers use their capital to construct public facility in return for the right to operate and transfer. This type of contract focuses on final service delivery and relies upon the required performance standards being properly documented. Building contractors involved in this type of development are usually part of a consortium (Department of Infrastructure Building Services Agency, 1998). BOOT procurement system is less implemented in Nigeria construction industry. The main advantage of using these approaches is time and cost savings whereby the disadvantages of BOOT procurement system is due to additional cost and inflexibility.

metamorphosed from the need to improve construction project delivery, that is, project completion within budget and time.

Irizarry et al., (2013) asserted that procurement methods is on optimizing all parameters involved in project delivery namely, time, cost and quality. Procurement of projects within these constraints has continued to be a challenge to the design team, the contractors, and managers of investments (Hugeset al., 2006; Mok et al., 2014). Traditionally, construction projects starts with the client's brief on which designs are based. The Architect and Engineers prepare designs, in collaboration with Quantity Surveyor who advises on the cost implications of design variables. Tender process afterwards produces the contractor for the execution of the work. On the award, the successful contractor executes the work as designed under the supervision of the consultants. Thus, the approach separates the design, tendering process and construction as separate tasks. This separation of activities also led to sequencing of activities in which design is completed before construction commences.

2. PROCUREMENT SYSTEMS

There are variouskinds of project procurement systems being widely used in the construction industry which include traditional system and fast-tracking systems (turnkey; design and build; build-operate-transfer and management contracting, (Jim Smith et al., 2004; Masterman, 1992; Hugeset al., 2006).

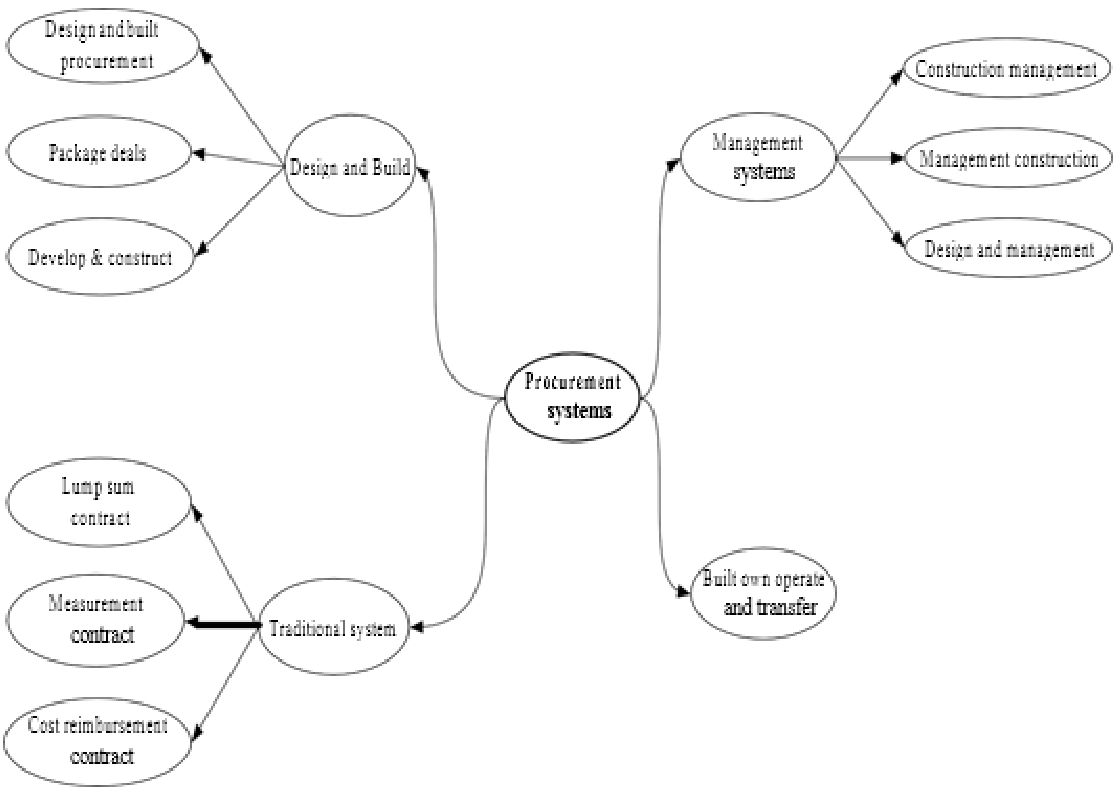

Figure 1: Types of procurement system practice in construction industry

3. RESEARCH METHOD

This research adopted the quantitative approach in order to obtain a very large sample data. The objective of employing a quantitative method is to minimize personal prejudice or bias and to ensure that the social reality would be presented as it is. It is expected to have true value, applicable and consistency (Cresswell 2003). In addition, quantitative data collection procedures create epistemological statements that reality is objective and unitary. Since the research adopted quantitative approach, therefore, the survey questionnaire was employed based on the nature of the construction industry. As a result, 310 questionnaires were distributed to the professionals in the construction site in Abuja, the Nigeria Capital. These professionals are: Quantity surveyors, Architects, Project managers, Engineers, Contract administrator, contract manager builders and others stakeholders in the construction industry. The questionnaires distributed was designed in Likert scale format in order to allow the respondents to participate freely without bias. 310 questionnaires were distributed to the aforementioned professionals in the construction projects site, and only 200 questionnaires distributed were filled correctly and returned which represent 64.51% of the data used for the analysis. The descriptive analysis was employed for data analysis through percentage rating.

4. THE DISCUSSION OF RESULTS AND FINDINGS

The results of the analysis in Figure 3 show the levels of procurement systems used in Nigeria construction industry. The result shows that 47.5% of the respondents have admitted that a traditional system is the most preferred system used in Nigeria construction industry. This implies that majority of the contract awarded in Nigeria is through traditional systems. Peter et al. (2008) highlighted that contractors are more familiar with traditional system as it is the most common types of procurement use in construction industry This result was supported by Walker and Hamps on (2003), and (Wearne 1997) that traditional system is separated into different process with design and construction.

The drawings, specification, and bill of quantities breakdown are provided by the client to the contractor during tender stage to make the pricing straightforwardness. It also gives the client to securer more competitive price, since the working drawings have been fully developed with full details for tendering. It eliminates any design or construction ambiguity or uncertainty that might causes the contractors to unnecessarily inflate the price. In a situation, where bill of quantities is used, the bidding tend to be more fair as such, the project cost is lower. The system also has a better cost control (Masterman, 1996; Walker and Brammer, 2012).However, 21% of the respondent's concords that design and build system are used in the procurement system in Nigeria construction industry. In Design and Build system, the cost of the construction projects is often higher than the traditional contracting system. As a results, of lack of design, specification detailing and absence of bill of quantities during tender stage. Therefore this affects the cost of the construction project and thereby results in cost overrun. Although, the client is required to come out with a conceptual design at an early stage for design and build system which create forums for variations and claims during the construction stage. In addition, 12.5% of the respondents indicated that management procurement is used in the contract awarding system in Nigeria construction industry, since the clients are always curious about time and cost overrun. 11.5% of the respondents agreed that the built own operate and transfer was used in in Nigeria construction industry especially in building the hostel in the high institution and other infrastructure projects in the country. In conclusion, 7.5% of the respondents signifies that turnkey system is also used in road construction, bridges, railways and others infrastructure projects that the price are very high. Turnkey system sometimes is called fast-tracking project delivery system where design and construction is put in one hand and its pre-tender process can allow fast construction date. It also allows the details of the project to run almost at the same time to each other, this means that it is going to reduce the overall project development period considerably. The results was illustrate in Figure 3 below:

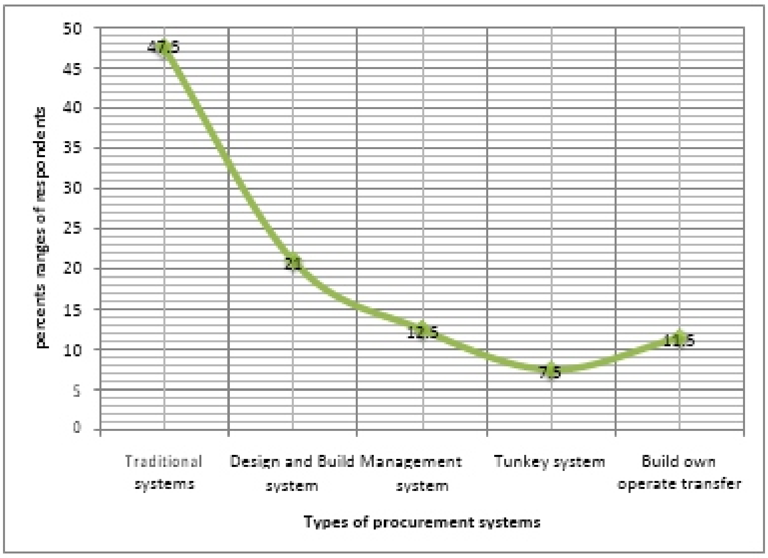

Figure 3: Precurement systems in Nigeria

5. CONCLUSION

From the results obtained from the analysis show that traditional method, design and build system and management contracting system are the major types of the procurement system commonly used in Nigeria construction industry. This is because Nigeria is a developing country with many challenges in the construction sectors especially inconsistency policy of the Government, change of leaderships, lack of continuity in the government actions and policy, corruption, lack of trust, poor working relationship and security problems. These are some of the factors that militate against the uses of the other method of the procurement system. Although, in some few projects in Nigeria the other method were used to avoid delays and for certain purpose. Therefore, the research suggests that the Government should create conducive environment that would facilitate the effective use of the other methods in order to avoid unnecessary delays, poor planning and disputes, conflicts, cost overrun. The management should develop a proactive strategy that would influence the use of right procurement method at the appropriate time.

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