

STUDY THE EFFECT OF BOTTOM FLYASH IN THE CHARACTERISTIC STRENGTH OF CONCRETE

Submitted in partial fulfilment of the requirements for the award of Bachelor
of engineering degree in
Civil Engineering
By

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **SURYAKIRAN J (37200072)** and **HARIKRISHNAN RV (37200079)** who carried out the project entitled “**STUDY THE EFFECT OF BOTTOM FLYASH IN THE CHARACTERISTIC STRENGTH OF CONCRETE**” under our supervision from October 2020 to April 2021.

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DECLARATION

We, Suryakiran J(37200072) and Harikrishnan R V(37200079) hereby declare that the Project Report entitled “STUDY THE EFFECT OF BOTTOM FLYASH IN THE CHARACTERISTIC STRENGTH OF CONCRETE” done by me under the guidance of Dr. S. Nandhakumar is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

1.

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**SIGNATURE OF THE
CANDIDATES**

DATE:

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ABSTRACT

A mixture of calcium carbide residue and bottom fly ash is an innovative new binder for concrete of using Ordinary Portland Cement. To this end, both CRFA and OPC concrete using limestone and recycled concrete aggregate as a coarse aggregate were prepared to investigate the compressive strength of concrete by compression test, split tensile test and flexural test. Thus, the test result indicates the values of compressive strength in CRFA concretes are similar to those embedded in OPC concrete. Calcium carbide residue and bottom fly ash are waste products from acetylene gas factories and powder plants respectively, which can react with siliceous materials through pozzolanic reactions, resulting in a product similar to those obtained from the cement hydration process. The mixture of CCR and Bottom fly ash can produce a cementitious material because CCR contains a large amount of Ca(OH)_2 while Bottom fly ash is a pozzolanic material. Construction and demolition waste are produced every day around the world. Thus, the idea of using recycled concrete aggregate in new production appears to be an effective utilization of concrete waste. Thus, this paper presents the Study on Concrete by Adding Calcium Carbide Residue, Bottom fly Ash and Recycled Coarse Aggregate to compare the Compressive Strength of concrete.

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LIST OF ACRONYMS

CCR	Calcium Carbide Residue
BFA	Bottom Fly Ash
NCA	Natural Coarse Aggregate
RCA	Recycled Coarse Aggregate
OPC	Ordinary Portland Cement
LOI	Loss on Ignition

LIST OF CHEMICAL FORMULAS

SiO ₂	Silicon dioxide
Al ₂ O ₃	Aluminum Oxide
Fe ₂ O ₃	Ferric Oxide
CaO	Calcium Oxide
SO ₃	Sulphur Trioxide
MgO	Magnesium Oxide
K ₂ O	Potassium Oxide
Na ₂ O	Sodium Oxide
P ₂ O ₅	Phosphorus pent oxide
TiO ₂	Titanium dioxide

LIST OF PHYSICAL UNITS

g	Gramme
kg	Kilogramme
KN	Kilo Newton
mm	millimeter

CHAPTER-1

INTRODUCTION

Through the years, there has been a continuous increase in the demand for concrete due to lack of construction in all around the world. Nowadays, the amount of raw materials has been decreasing due to the approximately 30 billion tonnes per year's consumption of concrete. As a result, it is necessary to find substitute material to be used in concrete production. During production, the process of producing both Portland cement and aggregate results in significant environmental impacts. In particular, cement manufacturing can release carbon dioxide to the atmosphere. Using explosive on Limestone Mountain can produce a significant amount of dust that affects surrounding areas and has become one of the causes of health problems, sometime may cause earthquake. While substitute material has been used for protecting environment from various issues. By using pozzolanic material in concrete, the strength has been increased when compare to conventional concrete but it achieves later only. Bottom fly ash is mainly used in the production of cement, although while replacing the cement as bottom fly ash gives better strength but it is used as low levels because of later strength achievement.. Thus, this study aimed to utilize bottom fly ash in the way that provides the greatest benefit. Numerous studies have been investigated that the possibility of using CRFA mixture as binder instead of using ordinary Portland cement. Thus this result confirms that CRFA is the binding material used in concrete. Although, many pozzolans had to be brought to be a substitute material for replacing cement. Calcium carbide is a chemical composite which mainly contains of white compound of calcium and carbon, which can be used as pozzolans in binder in concrete to achieve strength. Calcium carbide is produced from limestone and coal mainly used in the production of acetylene gas.

Moreover, by using CRFA used in concrete gives the lower heat evolution and less permeability when compared to normal conventional concrete. And it is good resist to chloride attack than in conventional concrete. Therefore, CRFA used as cementitious material in concrete production. It needs more studies on the properties of material which is to be used as substitute material in concrete production. The main purpose of this research is to examine the strength in concrete by using CRFA as a binder. The use of recycled concrete aggregate gives more compressive. Recycled concrete aggregate was obtained from a compressive strength of more than 40MPa and it also passed the crushing, sorting and washing process to achieve better quality. Recycled concrete aggregate should have the maximum size but not being more than 19mm.

It is usually obtained from crushing the concrete but it has lower quality when compared to conventional concrete. Recycled concrete aggregate having better water absorption and it has high porosity. This gives the better strength. Calcium carbide residue used throughout the study and obtained from a disposal of acetylene gas factories.

While replacing the coarse aggregate as recycled concrete aggregate, it is necessary know about the composition, type and properties of aggregate.

CHAPTER-2

REVIEW OF LITERATURE

2.1 GENERAL

A general of the various research work done on the calcium carbide residue, fly ash, and recycled concrete aggregate in the place of ordinary Portland cement and natural coarse aggregate in the past few years is reviewed in this chapter.

2.2 REVIEW OF LITERATURE ON INFLUENCE OF CALCIUM CARBIDE RESIDUE ON CONCRETE PROPERTIES

Mahmut Altieret al., (2018), made an investigation on conversion of harmful materials calcium carbide slag (CCS) and flue gas in to CaCO_3 particles through an accelerated mineral carbonation process. The formation of CaCO_3 particles from CCS depending on time was monitored via SEM. The experiments of this study showed that presence of Nucleate in the slurry played a curial role in the carbonation process, and the conversion ratio of Co_2 into a solid carbonate phase was higher than that in the experiments conducted with Nucleate. The crystalline size of CaCO_3 particles varied between 11.55 and 38.11 nm depending on the production conditions. Each obtained CaCO_3 particles were identified as calcite, which is in high demand in many industrial applications.

Sumi Siddiyua et al., (2018), have done an experimental study, in which the Rammed earth has been considered as a sustainable construction technique that uses local soil to build a structural wall. Chemical stabilisation is a recent technique for this purpose and Portland cement is the most commonly used binder material. In this study, industrial by products such as calcium carbide residue (CCR) and bottom fly ash (BFA) ratios, soil specimens were

grouped as A and B. The unconfined compressive strength for both groups was tested after four different curing times.

Sakonwan Hanjitsuwan et al., (2018), worked on the strength development and durability of alkali-activated bottom fly ash (BFA) mortar with calcium carbide residue (CCR) as additive cured at ambient temperature. CCR was used to partially replace BFA as additional calcium in the alkali-activated binder system by a weight percentage of 0%, 10%, 20% and 30%. Sodium hydroxide and sodium silicate solutions were used as a liquid alkaline activation in all mixtures. The setting time of alkali-activated BFA mortar with CCR has decreased whereas its strength development has increased. This literature concludes that, the highest 28-day compressive strength of alkali-activated BFA mortar was found in the mix of 70% BFA and 30% CCR. Which is about 40MPa.

Meysam Pourabbas Bilondi et al., (2018), have done a study on the visibility of using calcium carbide residue (CCR) as an alkaline activator and recycled glass powder (RGP) as a precursor to improve properties of clay soils. A compressive strength test was run on the specimens to investigate their mechanical behaviour. The effect of different factors such as the CCR content, RGP content, initial synthesis temperature and curing time was investigated. SEM/EDX analysis confirmed the formation of a geo-polymeric gel. This literature concludes that both CCR and RGP materials can be used to stabilize clay soil.

John tri hatmoko et al., (2017), made a study on the expansion soil, which is wide separated all over the world, also Indonesia. Its existence results on damage of building structures due to its low strength and high expansion. As a result, improvement of this soil is extensively investigated and continually in progress. Calcium carbide residue (CCR) is a hazardous waste produced from burning acetylene. This research was undertaken to

improve the physical and mechanical behaviour of expansion soil stabilised with CCR and BA, and it was done in two steps. The first step was improvement of the physical and mechanical behaviour of expansion clay by adding CCR to the original soil. This study indicates that the MDD and unconfined compressive strength were significantly increased. Moreover, addition of bagasse ash on CCR soil mixture improves soil ductility.

Sakonwan Hanjitsuwan et al., (2017), This article presents the comparative study using Portland cement (PC) and calcium carbide residue (CCR) AS promoter on the properties of bottom fly ash (BFA) geo-polymer cured at ambient temperature. Two calcium promoters: PC and CCR were used to replace BFA at the amount of 10%, 20% and 30% by height of binder. Sodium hydroxide and sodium silicate solutions were used as liquid alkaline activation in all mixtures. This article concludes that the use of calcium promoters to replace BFA resulted in the decreasing of setting time whereas its strength development enhanced. The highest compressive strength of BFA geo- polymer mortars could be absorbed at the BFA replacement with 30% of PC and 30% of CCR which were 13.8 and 11.4 MPa, respectively. The outcome of this research could help divert significant quality of waste materials from landfills and considerably reduce environmental damage caused by carbon emission due to PC production.

Charin Namarak et al., (2017), made an investigation on improvement of the compressive strength of mortar made from bottom fly ash (BFA) and calcium carbide residue (CR) as a binder, finesses of binder, curing temperatures, and cement contents were the studied parameters in this study. Mortars casted for 24 h were oven-cured at temperatures of 30, 45, 60 and 75°C for 24 h, and then cured in water at room temperature until the testing age. The result concludes that the fineness of CR-BFA binder is the most important factor to increase the compressive strength of CR-BFA mortar.

High curing temperature enhanced the compressive strength of mortar at an early age but was less effective at a later age. Moreover, substituting some of the GCR-GFA binder with Portland cement can accelerate and increase the mortar strength at various rates.

Yan-Jun Du et al., (2016), worked on field trial, which is conducted to ascertain the viability of using CCR stabilized clayey soil as a highway sub grade course material. The results indicated that in the top zone of the filled soil layers with 94% degree of compaction, the CCR stabilised sub grade soil exhibited higher values of CBR and resilient modulus, and lower values of resilient deflection and DCP index relative to the quick lime stabilised soil. The field trial results indicated that CCR had negligible environmental effects and further more resulted in low construction costs. Based on the field test results, CCR was found to be a viable alternative binder for stabilising the sub grade soils. The outcomes of this research are significant from engineering, economic and environmental perspectives.

Songsuda Vichan et al., (2016), made an investigation on calcium carbide residue (CCR) and biomass ash (BA) required as a stabilising chemical additive which causes a pozzolanic reaction. The result of this investigation includes the strength development of stabilized clay with CCR and BA blend is influenced by the inter relationship of various factors, including the binder content, the water content and curing time. From two factorial experiments, the strength of stabilised clay at specific curing time and initial water content was the function of the CCR content, the BA content and their combined effect. When the initial soil water content was constant at 1.2 and 1.4 times the optimum water content (OWC) and the binder contents ranged from 5% to 30% of the dry weight of soil, the strength depended on the clay water-binder ratio and the curing time.

Suksun Horpibulsu et al., (2015), conducted an experimental study on calcium carbide residue (CCR) bottom fly ash (BFA) which is the waste products from acetylene gas factories and power plants, respectively. In the active zone, the Natural pozzolanic material in the soil is adequate to produce a pozzolanic reaction. Hence, the input of BFA into this does not significantly improve strength. Strength in the inert zone can be significantly increased by adding FA. The deterioration zone is not recommended for the use in practise, even with the input of BFA. The result of this research concludes the unsoundness due to free lime hinders strength development. The research sounds that the soaked and unsoaked strength vary between 0.45 and 0.65. It is proved in this literature that, a mixture of CCR and BFA can be used for soil stabilisation instead of ordinary Portland cement.

Masimawati Abdul Latif et al., (2015), did an evaluation on the physical properties, setting time, density and compressive strength of calcium carbide kiln dust (CCKD) as a potential cement alternative for a mortar. CCKD is the by-product of calcium carbide (CC) production. This by-product leads to environmental pollutions as CCKD has no valuable and beneficial usage, hence it is disposed as landfills. This study explores the possibility of adding CCKD to mortar mixtures by replacing ordinary Portland cement (OPC). The results indicated that there is a systematic increase in initial and final setting time with the decrease of density and mortar strength. The mixture compressive strength was lower than control mortar at all ages. It can be concluded that CCKD mortar mixtures may utilized to compensate setting rate of cement based materials. However, more research and development, especially on optimum mix design, setting time, early strength and durability of concrete should be carried out.

Nattapong Makaratat et al., (2015), have done a study on the concrete that utilizes a calcium carbide residue and bottom fly ash mixture

as the concrete binder instead of Portland cement. The ground calcium carbide residue (CR) was mixed with classified bottom fly ash (BFA) at a ratio of 30:70 (CR: BFA) by weight and used as binder to cast CR-BFA concrete specimens. In addition, the modulus of elasticity of CR-BFA concrete was measured. The results indicated that the CR-BFA mixtures could be used as a cementitious material for a concrete without using Portland cement. Increasing the binder content and reducing the W/B ratio improved the compressive strength of CR-BFA concrete, similar to normal concrete. The addition of 3% CaCl_2 by weight of binder yielded CR-BFA concrete that exhibited high work-ability and accelerated the compressive strength at early ages.

Apichit Kampala et al., (2015), made an investigation on reuse of waste materials for pavement applications in of great international interest. This paper presents basic and engineering properties of the recycled calcium carbide residue (CCR) stabilized clay. The strength development and the reduction in void ratio with time confirm that the pozzolanic reaction still prevails even after remoulding. The research outcome reinforces the possibility of using the recycled CCR stabilized clay as fill and pavement materials. The strength and resistance to compressibility are slightly lower than those of the original CCR stabilised clay for the same CCR content while the unit weight of recycled CCR stabilised clay is much lower, which reduces the over burden on the foundation.

2.3 REVIEW OF LITERATURE ON INFLUENCE OF BOTTOM FLY ASH ON CONCRETE PROPERTIES

Satish H et al., (2013) made an detailed experimental investigation was done to study the effect of partial replacement of cement by Bottom Fly Ash (BFA) and Rice Husk Ash (RHA) in combine proportion started from 30% BFA and 0% RHA mix together in concrete by replacement of cement

with the gradual increase of RHA by 2.5% and simultaneously gradual decrease of BFA by 2.5%. Last proportion was taken 15%BFA and 15% RHA. Investigation reported that compressive strength increases by 30.15% in compared with targeted strength and reduces by 8.73% compared with control concrete at 28 days, flexural strength increases by 4.57% compared with control concrete at 28 days, split tensile strength decreases by 9.58% compared with control concrete at 28 days, were obtained at combination of 22.5% BFA and 7.5% RHA. Partial replacement of BFA and RHA reduces the environmental effects, produces economical and eco-friendly concrete.

Chung-Ho Huang et al., (2013) gives an experimental investigation dealing with concrete incorporating very high volumes of Class F fly ash (HVFA). A rational mix design method was developed for concrete with 20–80% fly ash replacement for cement. Test results indicated that the setting times and the air content of fly-ash concrete increased as the fly ash replacement level increased. The compressive and flexural strength of the HVFA concrete mixtures demonstrated continuous and significant improvement at late ages of 91 and 365 days. Relation was formulated for flexural and compressive strength for all grades of HVFA concrete. The concrete mixture containing low-LOI fly ash exhibited superior mechanical properties than those of the corresponding mixture containing high-LOI fly ash. These results confirm the feasibility that up to 80% of Class F fly ash can be suitably used as cement replacement in concrete by using a rational mixture proportions.

Amir Fauzi et al., (2016) this research was conducted to compare class C and class F fly ash as cementitious materials. The fly ash was supplied by local power plants in Malaysia. The chemical composition analysis showed that class F fly ash has more Si and Al content compared to class C fly ash which affects the amount of the produced gel during the pozzolanic reactivity

or/and geopolymerization. Finally, the microstructure images indicated the similarity of the fly ash particles shape on both classes. Furthermore, the microstructure images showed a correlation between the chemical composition and the bond structure in terms of the high element content (Si and Al) forming the gel and the bond structure in the cementitious process during pozzolanic reaction or and geopolymerization.

Faiz Uddin Ahmed Shaikh et al., (2016), this paper presents mechanical and durability properties of geopolymer concrete containing recycled coarse aggregate (RCA). The RCA is sourced from local construction and demolition (C&D) waste in Perth, Australia. The RCA is used as a partial replacement of natural coarse aggregate (NCA) in geopolymer concrete Class F fly ash is used as the source material for the geopolymer and 8 M sodium hydroxide and sodium silicate alkali activators are used to synthesise the fly ash geopolymer in this study. Relevant Australian standards are used to measure all the above properties except the sorptivity which is measured according to ASTM standard. Results show that the compressive strength, indirect tensile strength and elastic modulus of geopolymer concrete decrease with an increase in RCA contents, which is also true for both 7 and 28 days. Excellent correlations of compressive strength with indirect tensile strength and elastic modulus are also observed in geopolymer concrete containing RCA. The measured durability properties such as sorptivity, water absorption and volume of permeable voids of geopolymer concrete were also adversely affected by the incorporation of RCA and these properties increase with an increase in RCA contents. The effects of RCA on the measured mechanical and durability properties of geopolymer concrete follow similar trend in cement concrete.

M. Ondova a et al., (2012) Along with a slight increase in population, uncontrolled pumping of raw materials for production of materials and energy

and urbanization of the environment, there is the increase of harmful emissions and waste generation. Mineral resources are limited considerably. This is also true for conventional raw materials for production of construction materials and fuel. One of the main challenges of the 21st century is oriented on the increasing effectiveness of the materials processing and significantly reduced energy usage. Because concrete is the most used building material in the world, the new approach consists in change in the design of concrete structures and in developing and implementing new concrete processing technologies based on cement reduction demand. Although new technologies are being developed to solve these problems, there is a viable solution for the present time utilization of alternative raw materials i.e. fly ash. The current annual worldwide production of by-products is estimated about 700 million tons of which 70 % is fly ash at least. Large quantities of fly ash are available at low costs around the world and the use of fly ash concrete seems to offer the best solution to reducing consumption of cement. The paper is aimed at the study of the mechanical properties of hardened fly ash - concrete composites with various proportions of fly ash as well as the investigation of the chemical admixtures influence on the concrete properties.

Guohao Fang et al., (2018) Alkali-activated fly ash-slag (AAFS) concrete is a new blended alkali-activated concrete that has been increasingly studied over the past decades because of its environmental benefits and superior engineering properties. This paper aims to provide a thorough understanding of workability and mechanical properties of AAFS concrete cured at ambient temperature and to obtain the optimal mixtures for engineering application. In addition, equations provided by ACI code, Euro code and previous researchers for ordinary Portland cement concrete overestimated the values of splitting tensile strength, flexural strength and dynamic elastic modulus of AAFS concrete. The optimal mixtures of AAFS concrete were set as slag content of 20–30%, AL/B ratio of 0.4, 10 M of SH,

and SS/SH ratio of 1.5–2.5 considering the performance criteria of workability, setting time and compressive strength.

Rawaz Kurda et al., (2018) This paper presents an overview of previous studies on the environmental impact (EI) and toxicity of producing recycled concrete aggregates (RCA), bottom fly ash (BFA), cement, super plasticizer, and water as raw materials, and also on the effect of replacing cement and natural aggregates (NA) with BFA and RCA, respectively, on the mentioned aspects. EI and toxicity were analysed simultaneously because considering concrete with alternative materials as sustainable depends on whether their risk assessment is high. Therefore, this study mainly focuses on the cradle-to gate EI of one cubic meter of concrete, namely a biotic depletion potential (ADP), global warming potential (GWP), ozone depletion potential (ODP), photochemical ozone creation (POCP), acidification potential (AP), eutrophication potential (EP), non-renewable energy (PE-NRE) and renewable energy (PE-Re). In terms of toxicity, leach ability (chemical and Eco toxicological characterization) was considered. The results also include the economic performance of these materials, and show that the incorporation of BFA in concrete significantly decreases the EI and cost of concrete.

Raharjo. D et al., (2013) made an experimental investigation on innovative concrete that does not require vibration process to its placing. SCC is able to flow under its own weight, enables it to meet or filling formwork and reached its highest density. SCC requires a mineral Admixture such as bottom fly ash, superplasticiser and other compounds such as iron slag waste from steel mill wastes in the form of fine aggregate in order to meet the specified flow ability. There were 33 variation of concrete mixture using 495 samples total mixture have been tested. Each composition contained various superplasticiser dosage from 0.5 to 1.8% of cementitious weight. The dosage of silica fume was also varied 0%, 10% and 20% of bottom fly ash weight.

The goal that expected from this study is to obtain the optimal material composition of the mixture that produces the maximum compressive strength but cheaper and competitive in price.

B. Kondraivendhan et al., (2015) in this study, compressive strength and flow behaviour of bottom fly ash incorporated cement paste and mortar were investigated. For this purpose, four water to binder ratios ($w/(c + f)$) such as 0.25, 0.35, 0.45 and 0.55 with three curing ages and five wide range of fly ash replacement levels (f/c ratio) namely 0, 0.1, 0.2, 0.3 and 0.4 were introduced in the experimental scheme. The workability of the mixture was ensured through Marsh cone and flow table tests for fly ash blended cement paste and mortar, respectively. The test result showed that compressive strength increases with age as expected in all cases and an empirical relationship for compressive strength of blended cement paste and mortar with mix factors such as $w/(c + f)$ ratio, f/c ratio and age is also proposed. The estimated compressive strength versus $w/(c + f)$ ratio curves for different curing ages and f/c ratios resembles the nature of Abram's strength versus w/c ratio curves.

2.4 REVIEW OF LITERATURE ON INFLUENCE OF RECYCLED CONCRETE AGGREGATE ON CONCRETE PROPERTIES

Krzysztof Zielinski et al., (2017), made a study on the most important guidelines, currently in force, regulating the scope of use of recycled aggregates. The issue of using construction rubble was recognized in Europe not earlier than in the nineties of the twentieth century. This was due to economic and ecological considerations. Recycled aggregate is characterized by high volatility of physical and mechanical properties. The quantity and type of various kinds of impurities harmful to the durability of concrete is virtually unpredictable. This article also contains the results and the analysis of comparative studies of selected physical and mechanical characteristics of

concrete produced with the use of natural aggregate and concrete produced with the use of recycled aggregate obtained from milling of masonry.

Suvash Chandra Paul et al, (2017), worked on the research summary of “mechanical behaviour and durability performance of concrete containing recycled concrete aggregate”. The report concludes in this article is related to an important parameter of optimum content of recycle concrete aggregate (RCA) in production of new concrete for both structural and non-structural applications. The various types of physical, mechanical and durability tests are performed for concrete made with different percentages of RCA. This data helps the readers to understand the mechanism of RCA in relates to the concrete properties.

Zaki I. Mahmoud et al., (2017), made a study on preservation of environment and natural resources has recently attracted researchers to study the use of recycled aggregates from demolished concrete in new concrete structures. This paper presents an experimental study on punching shear behaviour of simply supported natural and recycled coarse aggregate concrete slabs. The experimental work was conducted on recycled coarse aggregate concrete (RCAC) slab specimens and natural coarse aggregate concrete (NCAC) slabs. The ACI mix design procedure was adopted to achieve strength of concrete at 28 days of 35 MPa. This study concludes that the ultimate punch crack load, ultimate punch load, stiffness and energy absorption decrease as the replacement of natural coarse aggregate with recycled coarse aggregate increases. The recycled aggregate size increases the cracking and failure load increases. The measured ultimate failure loads have been compared with code predictions. The Euro code 2 equations gave the best correlation with the experimental results.

B.M. Vinaykumar et al., (2017), made an experiment deals with utilization of Coarse Recycled Concrete Aggregate (RCA) and fine Recycled

Concrete Aggregate (FRCA) in High Performance Concrete (HPC) mixes. The concrete mix is designed for target strength of 60MPa. The HPC mixes with 20% FRCA content shows reduction in workability and requires a higher dosage of Super plasticizer (SP) to achieve a slump of 170 mm. The durability tests such as sulphate and acid attack are conducted for the mix containing 20% CRCA and FRCA. The mix is found to be least susceptible to sulphate attack. The significant reduction in compressive strength is noticed, when the HPC mix is exposed to H2SO4 solution.

Ahmed Shaban Abdel-Hay et al., (2017), worked on the Construction and demolition wastes which are produced every day around the world. Thus the idea of using recycled concrete aggregate in new concrete production appears to be an effective utilization of concrete waste. This paper presents the results of an experimental study to evaluate the effects of recycled concrete aggregate (RCA) percentages under different curing conditions. The concrete Specimens were exposed to three different curing conditions, moist, open-air. And painted specimens using the substance. The study concludes that curing using paint material was the most efficient method of curing at all ages and percentages of recycling except at 100% recycling, where the maximum value of both compressive and tensile strengths was obtained using water curing. In moist curing, full replacement of coarse aggregates gave the highest compressive strength at age of 28 days. In all cases of recycled aggregate Ratios, curing using water caused a decrease in the concrete permeability.

2.5 COMMENTS FROM THE LITERATURE REVIEW

From the literature review it was observed that,

1. Compared with OPC, CCR concrete has higher compressive strength.
2. The compressive strength of the cement with calcium mortar gave better strength.

2.6 OBJECTIVE OF THE PROJECT

1. To study the physical and mechanical properties of the materials.
2. To reducing the carbon dioxide emission in cement by replacing of calcium carbide residue and fly ash.
3. To find the significant compressive strength of the concrete containing Portland cement (PC), calcium carbide residue (CCR) and recycled concrete aggregate (RCA) with various ratios to that of the conventional concrete.

2.7 SHORT SUMMARY

This chapter discusses the work done in the various literature published in the past years on the properties of calcium carbide residue, fly ash and recycled coarse aggregate influence in concrete. The studies on the development of bond strength in various mixes are limitedly reported in the literature.

CHAPTER-3

METHODOLOGY

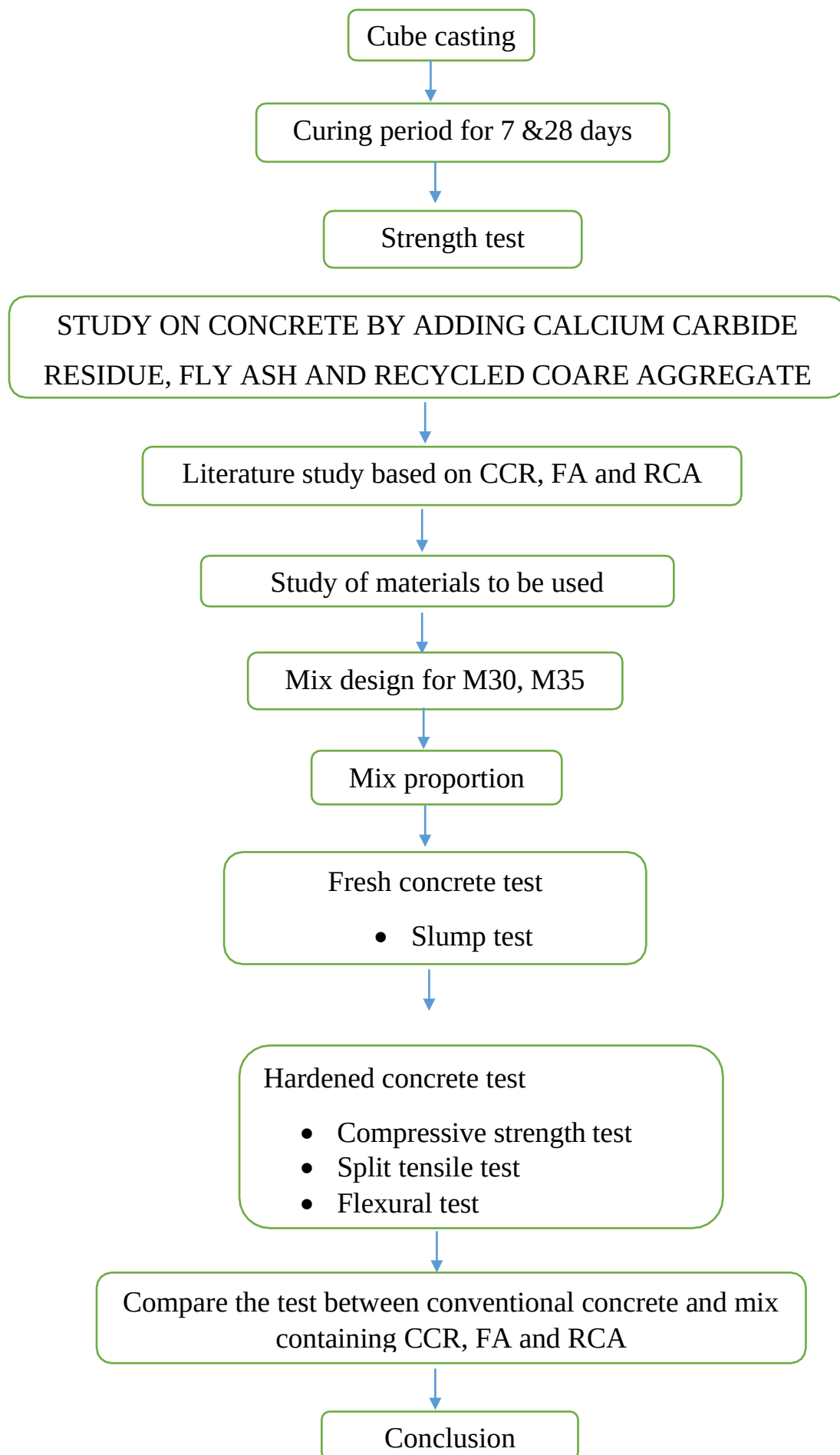
3.1 GENERAL

This chapter discusses the methodology of the project work, based on the study of the literature.

3.2 METHODOLOGY

From the literature study it is found that calcium carbide residue and fly ash has good compressive strength. The material availability survey is carried out and the materials are tested for its chemical and physical properties. Design mix calculation will be made to obtain target strength of 30MPa. The water cement ratio required for the design mix calculation will be obtained through consistency test. Initially trial will be casted to obtain the correct mix ratio. Then the replacement of cement by calcium carbide residue and fly ash will be made in that mix ratio by volume.

Four mix proportions 10%, 20%, 30% of calcium carbide residue and bottom fly ash with 15% of recycled concrete aggregate has been chosen based on the previous literature study as a partial replacement of cement and natural coarse aggregate. After replacement the design mix has to be revised. Then the setting time of the new design mix is to be identified. The compressive strength and flexure strength of conventional concrete, calcium carbide residue and fly ash concrete is compared with that of control mix. Then based on the results obtained from the above comparison, beam element is casted. The behaviour of the beam element casted using conventional concrete, calcium carbide residue and fly ash concrete.



CHAPTER-4

MATERIAL PROPERTIES

4.1 MANUFACTURED SAND

Manufactured sand or M-sand is a substitute of river sand. Used in this project for concrete production. This is mainly crushed fine aggregate Produced from a source material with suitable strength, durability and shape characteristics. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Some of the advantages of manufactured sand are given below,

- It is well graded in the required proportion.
- It does not contain organic and soluble compound that affects the setting time and properties of cement, thus the required strength of concrete can be maintained.
- M-Sand is obtained from specific hard rock (granite) using the state of-the-art International technology, thus the required property of sand is obtained.

4.2 NATURAL COARSE AGGREGATE

Aggregate is a broad category of coarse to medium grained particulate material used in construction, Aggregates are the most mined materials in the world. The advent of modern blasting methods enabled the development of quarries, which are now used throughout the world, wherever competent bedrock deposits of aggregate quality exist. In many places, good limestone, granite, marble or other quality stone bedrock deposits do not exist. In these areas, natural sand and gravel are mined for use as aggregate. The demand for aggregates can be partially satisfied through the use of slag and recycled concrete. However, the available tonnages and lesser quality of these

materials prevent them from being a viable replacement for mined aggregates on a large scale.

PROPERTIES	M SAND	NCA	RCA
Fineness modulus	2.7	6.74	6.6
Specific gravity	2.63	2.72	2.45
Water absorption (%)	2.2	0.41	5.71
Unit weight (Kg/m ³)	1640	1550	1445
Void content (%)	35.85	42.5	40.8
Los angles abrasion loss (%)	-	18.05	29.74
Aggregate crushing value (%)	-	20.40	24.10
Porosity (%)	26.15	39.09	42.65
Bulk density (Kg/m ³)	1.75	1.63	1.43

Table 4.1: Physical properties of M-SAND, NCA and RCA

4.3 RECYCLED COARSE AGGREGATE

When structures made of concrete are demolished or renovated, concrete recycling is an increasingly common method of utilizing the rubble. Concrete was once routinely trucked to landfills for disposal, but recycling, has a number of benefits that have made it a more attractive option in this age of greater environmental awareness, more environmental laws, and the desire to keep construction costs down. Recent statistics show that the increasing demand of construction aggregate could reach 48.3 billion metric tons by the year 2016. There are a variety of benefits in recycling concrete rather than dumping it or burying it in a landfill.

- Save landfill space.
- Conserve natural resources by reducing the need for gravel mining, water, coal, oil and gas.
- When used as the base material for roadways, reduces pollution from waste transport to landfills and dumps.

4.4 ORDINARY PORTLAND CEMENT

Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and non-specialty grout. Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates, (3 CaO-SiO_2 , and 2 CaO.SiO_2), the remainder consisting of aluminium and iron-containing clinker phases and other compounds. The ratio of CaO to SiO_2 shall not be less than 2.0. The magnesium oxide content (MgO) shall not exceed 5.0% by mass.

PROPERTIES	CCR	BFA	OPC
Fineness modulus(μm)	2.7	3.8	4.6
Specific gravity	2.32	2.28	3.15
Mean particle size (μm)	26.12	85	28.9

Table 4.2: Physical properties of CCR, BFA and OPC

4.5 CALCIUM CARBIDE RESIDUE

Calcium carbide residue (CCR) is a waste by-product from acetylene gas production. The main component of CCR is Ca(OH)_2 , which can react with siliceous materials through pozzolanic reactions, resulting in a product similar to those obtained from the cement hydration process. Thus, it is possible to use CCR as a substitute for Portland cement in concrete. The

dominant component of CCR is Ca(OH)_2 , it provides a potential application in cement manufacturing industry and can be used as a cement replacement material. The pure material is colourless, however pieces of technical-grade calcium carbide are grey or brown and consist of about 80-85% of CaC_2 (the rest is CaO (calcium oxide), Ca_3P_2 (calcium phosphide), CaS (calcium sulphide), Ca_3N_2 (calcium nitride), SiC (silicon carbide), etc.).

4.6 BOTTOM FLY ASH

Bottom fly ash is a by-product of the combustion of pulverized coal in electric power generation plants. When the pulverized coal is ignited in the combustion chamber, the carbon and the volatile materials are burned off. However, some of the mineral impurities of clay, shale, feldspars, etc., are fused in suspension and carried out of the combustion chamber in the exhaust gases,. As the exhaust gases cool, the fused materials solidify into spherical glassy particles are called bottom fly ash. The size of bottom fly ash particles varies but tends to be similar to slightly larger than type 1 Portland cement. The bottom fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters.

CHEMICAL PROPERTIES (%)	CCR	BFA	OPC
Silicon dioxide (SiO_2)	5.4	33.9	30
Aluminium oxide (Al_2O_3)	2.9	17.4	20.9
Ferric oxide (Fe_2O_3)	1.5	13.0	4.6
Calcium oxide (CaO)	62.87	25.7	3.4
Sulfur trioxide (SO_3)	0.87	3.36	2.8
Loss on ignition (LOI)	26.9	0.8	0.9
Magnesium oxide (MgO)	0.21	1.4	1.5
Potassium oxide (K_2O)	0.01	0.9	1.5
Sodium oxide (Na_2O)	0.01	8.8	0.4

Table 4.3: Chemical properties of CCR, BFA and OPC

CHAPTER-5

MATERIAL TESTING

5.1 GENERAL

The material used for concrete are fine aggregate, coarse aggregate, cement and water. Since in this project we are using calcium carbide, fly ash and recycled coarse aggregate for the replacement of cement and coarse aggregate are also investigated along with conventional materials used for concrete.

5.2 TEST FOR COARSE AGGREGATE

5.2.1 SPECIFIC GRAVITY

Procedure

1. Weigh the pycnometer with its cap screwed on while weighing it should be clean and dry. Take it as W_1 .
2. Take about some amount of wet soil unscrews the cap. Put the wet soil in the pycnometer and weigh correctly with its cap. Take it as W_2 .
3. Add sufficient quantity of water to cover the soil and screw the cap tightly on the pycnometer.
4. Stir well and connect the pycnometer with vacuum pump for about 10 to 15mins and add more water and fill completely with water. Weigh it and take it as W_3 .
5. Thoroughly dry the pycnometer from outside and weight.
6. Remove the soil sample and clean the pycnometer thoroughly. Then fill it water and weigh it. Take it as W_4 .

OBSERVATION

Weight of pycnometer (w_1) = 0.600kg

Weight of pycnometer + coarse aggregate (w_2) = 0.950kg

Weight of pycnometer + soil + water (w_3) = 1.700kg

Weight of pycnometer + water (w_4) = 1.470kg

Formula and Calculation

$$\begin{aligned} G &= (w_2 - w_1) / (w_2 - w_1) - (w_3 - w_4) \\ &= [0.950 - 0.600] / [(0.950 - 0.600) - (1.700 - 1.470)] \\ &= 2.70 \end{aligned}$$

Result

Specific gravity of coarse aggregate (G) = 2.70

5.3 TEST FOR FINE AGGREGATE

5.3.1 SPECIFIC GRAVITY

Procedure

1. Weigh the pycnometer with its cap screwed on while weighing it should be clean and dry. Take it as W_1 .
2. Take about some amount of wet soil unscrews the cap. Put the wet soil in the pycnometer and weigh correctly with its cap. Take it as W_2 .
3. Add sufficient quantity of water to cover the soil and screw the cap tightly on the pycnometer.
4. Stir well and connect the pycnometer with vacuum pump for about 10 to 15mins and add more water and fill completely with water. Weigh it and take it as W_3 .

5. Thoroughly dry the pycnometer from outside and weight.
6. Remove the soil sample and clean the pycnometer thoroughly. Then fill it water and weigh it. Take it as W_4 .

OBSERVATION

Weight of pycnometer (w_1) = 0.640kg

Weight of pycnometer + fine aggregate (w_2) = 1.59kg

Weight of pycnometer + soil + water (w_3) = 2.080kg

Weight of pycnometer + water (w_4) = 1.5kg

Formula and Calculation

$$\begin{aligned} G &= (w_2 - w_1) / (w_2 - w_1) - (w_3 - w_4) \\ &= [1.59 - 0.640] / [(1.59 - 0.640) - (2.080 - 1.5)] \\ &= 2.56 \end{aligned}$$

Result

Specific gravity of fine aggregate (G) = 2.56

5.4 TEST FOR RECYCLED COARSE AGGREGATE

5.4.1 SPECIFIC GRAVITY

Procedure

1. Weigh the pycnometer with its cap screwed on while weighing it should be clean and dry. Take it as W_1 .
2. Take about some amount of wet soil unscrews the cap. Put the wet soil in the pycnometer and weigh correctly with its cap. Take it as W_2 .
3. Add sufficient quantity of water to cover the soil and screw the cap tightly on the pycnometer.
4. Stir well and connect the pycnometer with vacuum pump for about 10 to 15mins and add more water and fill completely with water. Weigh it and take it as W_3 .
5. Thoroughly dry the pycnometer from outside and weight.
6. Remove the soil sample and clean the pycnometer thoroughly. Then fill it water and weigh it. Take it as W_4

OBSERVATION

Weight of pycnometer (w_1) = 0.640kg

Weight of pycnometer + fine aggregate (w_2) = 1.39kg

Weight of pycnometer + soil + water (w_3) = 1.96kg

Weight of pycnometer + water (w_4) = 1.5kg

Formula and Calculation

$$\begin{aligned} G &= (w_2 - w_1) / (w_2 - w_1) - (w_3 - w_4) \\ &= [1.39 - 0.640] / [(1.39 - 0.640) - (1.96 - 1.5)] \\ &= 2.58 \end{aligned}$$

Result

Specific gravity of recycled coarse aggregate (G) = 2.58

5.5 TESTS FOR CEMENT

- a) Consistency test
- b) Initial Setting time test

5.5.1 CONSISTENCY TEST

Procedure:

The following procedure is adopted to find out standard consistency.

1. Take about 400gms of cement and prepare a paste with a weighed quantity of water for the first trial.
2. The paste must be prepared in a standard manner and tilled into the

vicatmould within 3-5 minutes.

3. After completely filling the mould to expel air. A standard plunger 10 mm diameter, 50 mm long is attached and brought down to touch

the surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight.

4. Take the reading by noting the depth of penetration of the plunger. Conduct a 2nd trial and find out the depth of penetration plunger.
5. Similarly, Conduct trials with higher and higher water/ cement ratios till such time the plunger penetrates for a depth of 33-35 mm from the top.
6. That particular percentage of water which allows the plunger to penetrate only to a depth of 33-35 mm from the top is known as the percentage of water required to produce a cement paste of standard consistency.
7. This percentage is usually being denoted as p. the test is required to be conducted in a constant temperature and constant humidity (90%).

Observation

Weight of cement taken = 400 gms

Initial % of water = 10 %

Plug for standard consistency = 10 mm

S.No	Quantity of water added (ml)	Depth of penetration (mm)
1	60	22
2	80	14
3	100	10
4	120	8

Table 5.5.1.1 Consistency for cement

Result

The amount of water needed for standard consistency= 30%

5.5.2 INITIAL SETTING TIME

Procedure

1. Take about 400gms of cement and prepare a paste with a weighed quantity of water for the first trial.
2. The paste must be prepared in a standard manner and tilled into the vicatmould within 3-5 minutes.
3. Lower the needle gently and bring it contact with the surface of the test block and quickly release it. In the beginning the needle will completely pierce through the test block.
4. After some time when the paste starts losing its plasticity, the needle may penetrate only to a depth of 33-35 mm from the top.
5. The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the block to a depth equal to 33-35 mm from top is taken as initial setting time.

S.no	Time of penetration (min)	Depth of penetration (mm)
1	10	0
2	15	2
3	20	3
4	25	4
5	30	5
6	35	6

Table 5.5.2.1 Initial setting time for cement

Result

Initial setting time = 35 minutes for sample cement.

CHAPTER-6

MIX DESIGN

6.1 MIX DESIGN FOR M₃₀:

1. Grade designation - M₃₀
2. Type of cement - OPC 53 grade
3. Maximum nominal size of aggregate - 20mm
4. Minimum cement content - 320 kg/m³
5. Maximum w/c ratio - 0.40
6. Workability - 100mm (slump)
7. Exposure condition - Severe
8. Method of concrete placing - pumping
9. Degree of supervision - Good
10. Type of aggregate - Crushed angular aggregate
11. Maximum cement content - 450 kg/m³

6.1.1 TEST DATA FOR MATERIALS:

1. Specific gravity of cement - 3.15
2. Specific gravity of coarse aggregate - 2.74
3. Specific gravity of fine aggregate - 2.56 (Msand)

6.1.2 TARGET STRENGTH FOR MIX PROPORTIONING:

$$F_{ck}' = f_{ck} + t_s$$

From IS 10262-1982 table 2 value of accepted proportion of low result 1 in 20 $t=1.65$

$$F_{ck}' = f_{ck} + 1.65S$$

From IS 10262-2009 table 1 Assume standard deviation for M₃₀ grade

$$S = 5 \text{ N/mm}^2$$

$$F_{ck}' = 38.25 \text{ N/mm}^2$$

6.1.3 SELECTION OF W/C RATIO:

From Table 5 of IS 456, maximum water -cement ratio = 0.45

Based on experience, adopt water - cement ratio = 0.40

$$0.40 < 0.45$$

Hence ok.

6.1.4 SELECTION OF WATER CONTENT:

From Table 2, maximum water content for 20mm aggregate = 186 lt (For 25 to 50 mm slump)

$$\begin{aligned}\text{Estimated water content for 100mm slump} &= 186 + \frac{6}{100} * 186 \\ &= 197 \text{ lt}\end{aligned}$$

6.1.5 CALCULATION OF CEMENT CONTENT:

Water – cement ratio = 0.40

$$\text{Cement concrete} = 197 / 0.40 = 493 \text{ kg/m}^3$$

From Table 5 of IS 456, maximum water – cement content for severe exposure condition = 320 kg/m³

$$493 \text{ kg/m}^3 > 320 \text{ kg/m}^3$$

Hence ok.

6.1.6 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE:

From Table 3, volume of Coarse aggregate corresponding to 20mm size and Fine aggregate (zone I) for water – cement ratio 0.50 = 0.60. In the present case water cement ratio is 0.40. Therefore volume of Coarse aggregate is required to be increased to decrease the Fine aggregate content. As the water – cement ratio is lower by 0.10, the proportion of volume of Coarse aggregate is increased by 0.02. Therefore, corrected proportion of volume of coarse aggregate for the water – cement ratio is 0.40 = 0.62.

$$\text{Volume of Coarse aggregate} = 0.62$$

$$\text{Volume of fine aggregate} = 1 - 0.62 = 0.38$$

6.1.7 MIX CALCULATIONS:

1. Volume of concrete = 1m^3

$$\begin{aligned}
 2. \text{ Volume of cement} &= \frac{\text{mass of cement}}{\text{Specific gravity of cement}} * \frac{1}{1000} \\
 &= \frac{493}{3.15} * \frac{1}{1000} \\
 &= 0.156 \text{ m}^3
 \end{aligned}$$

$$\begin{aligned}
 3. \text{ Volume of water} &= \frac{\text{mass of water}}{\text{Specific gravity of water}} * \frac{1}{1000} \\
 &= \frac{197}{1} * \frac{1}{1000} \\
 &= 0.197 \text{ m}^3
 \end{aligned}$$

$$\begin{aligned}
 4. \text{ Volume of all in aggregate} &= 1 - 0.156 - 0.197 \\
 &= 0.647 \text{ m}^3
 \end{aligned}$$

$$\begin{aligned}
 5. \text{ Mass of coarse aggregate} &= (\text{d} * \text{volume of coarse aggregate} * \text{Specific gravity of coarse aggregate} * 1000) \\
 &= 0.647 * 0.62 * 2.74 * 1000 \\
 &= 1099 \text{ kg}
 \end{aligned}$$

$$\begin{aligned}
 6. \text{ Mass of fine aggregate} &= (\text{d} * \text{volume of coarse aggregate} * \text{Specific gravity of fine aggregate} * 1000) \\
 &= 0.647 * 0.38 * 2.56 * 1000 \\
 &= 629 \text{ kg}
 \end{aligned}$$

6.1.8 MIX RATIO:

$$\text{Cement} = 493 \text{ kg/m}^3$$

$$\text{Water} = 197$$

$$\text{Fine aggregate} = 629 \text{ kg/m}^3$$

$$\text{Coarse aggregate} = 1099 \text{ kg/m}^3$$

Water/cement ratio = 0.40

6.2 MIX DESIGN FOR M₃₅:

1. Grade designation - M₃₅
2. Type of cement - OPC 53 grade
3. Maximum nominal size of aggregate - 20mm
4. Minimum cement content - 320 kg/m³
5. Maximum w/c ratio - 0.40
6. Exposure condition - Severe
7. Method of concrete placing - pumping
8. Degree of supervision - Good
9. Type of aggregate - Crushed angular aggregate
10. Maximum cement content - 450 kg/m³

6.2.1 TEST DATA FOR MATERIALS:

1. Specific gravity of cement - 3.15
2. Specific gravity of coarse aggregate - 2.74
3. Specific gravity of fine aggregate - 2.56 (Msand)

6.2.2 TARGET STRENGTH FOR MIX PROPORTIONING:

$$F_{ck}' = f_{ck} + t_s$$

From IS 10262-1982 table 2 value of accepted proportion of low result 1 in 20 $t=1.65$

$$F_{ck}' = f_{ck} + 1.65S$$

From IS 10262-2009 table 1 Assume standard deviation for M₃₀ grade

$$S = 5 \text{ N/mm}^2$$

$$F_{ck}' = 43.25 \text{ N/mm}^2$$

6.2.3 SELECTION OF W/C RATIO:

From Table 5 of IS 456, maximum water -cement ratio = 0.45

Based on experience, adopt water - cement ratio = 0.40

$$0.40 < 0.45$$

Hence ok.

6.2.4 SELECTION OF WATER CONTENT:

From Table 2, maximum water content for 20mm aggregate = 186 lt (For 25 to 50 mm slump)

$$\begin{aligned}\text{Estimated water content for 75mm slump} &= 186 + \frac{3}{100} * 186 \\ &= 191.58 \text{ lt}\end{aligned}$$

6.2.5 CALCULATION OF CEMENT CONTENT:

Water – cement ratio = 0.40

$$\text{Cement concrete} = 191.58 / 0.40 = 478.95 \text{ kg/m}^3$$

From Table 5 of IS 456, maximum water-cement content for severe exposure condition = 320 kg/m³

$$478.95 \text{ kg/m}^3 > 320 \text{ kg/m}^3$$

Hence ok.

6.2.6 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE:

From Table 3, volume of Coarse aggregate corresponding to 20mm size and Fine aggregate (zone I) for water - cement ratio 0.50 = 0.60. In the present case water cement ratio is 0.40. Therefore volume of Coarse aggregate is required to be increased to decrease the Fine aggregate content. As the water - cement ratio is lower by 0.10; the proportion of volume of Coarse aggregate is increased by 0.02. Therefore, corrected proportion of volume of coarse aggregate for the water - cement ratio is 0.40 = 0.62.

$$\text{Volume of Coarse aggregate} = 0.62$$

$$\text{Volume of fine aggregate} = 1 - 0.62 = 0.38$$

6.2.7 MIX CALCULATIONS:

1. Volume of concrete = 1m³

$$2. \text{ Volume of cement} = \frac{\text{mass of cement}}{\text{Specific gravity of cement}} * \frac{1}{1000}$$

$$= \frac{478.95}{3.15} * \frac{1}{1000}$$

$$= 0.152\text{m}^3$$

$$3. \text{ Volume of water} = \frac{\text{mass of water}}{\text{Specific gravity of water}} * \frac{1}{1000}$$

$$= \frac{191.58}{1} * \frac{1}{1000}$$

$$= 0.191\text{m}^3$$

$$4. \text{ Volume of all in aggregate} = 1 - 0.152 - 0.191$$

$$= 0.657 \text{ m}^3$$

$$5. \text{ Mass of coarse aggregate} = (d * \text{volume of coarse aggregate} * \text{Specific gravity of coarse aggregate} * 1000)$$

$$= 0.657 * 0.62 * 2.74 * 1000$$

$$= 1116\text{kg}$$

$$6. \text{ Mass of fine aggregate} = (d * \text{volume of coarse aggregate} * \text{Specific gravity of fine aggregate} * 1000)$$

$$= 0.657 * 0.38 * 2.56 * 1000$$

$$= 639\text{kg}$$

6.2.8 MIX RATIO:

$$\text{Cement} = 478.95 \text{ kg/m}^3$$

$$\text{Water} = 191.58 \text{ lt}$$

$$\text{Fine aggregate} = 639 \text{ kg/m}^3$$

$$\text{Coarse aggregate} = 1116 \text{ kg/m}^3$$

$$\text{Water/cement ratio} = 0.40$$

CHAPTER-7

TEST ON FRESH CONCRETE

7.1 FRESH CONCRETE TEST

- a) Slump cone test
- b) Compaction factor test

7.1.1 SLUMP CONE TEST

Procedure

1. The internal surface of the mould is thoroughly cleaned and freed from sulphurs moisture and adherence of any old set concrete before commencing the test.
2. The mould is placed on a smooth horizontal right and non-absorbent surface.
3. The mould is then filled in four layers each approximately $\frac{1}{4}$ of the height of the mould.
4. Each layer is tamped 25 times with rod taking care to distribute the strokes evenly over the cross section and the concrete are stuff off level with a trowel and tamping rod.
5. The mould is removed from the concrete immediately by raising it slowly and carefully in vertical direction.
6. This allows the concrete to subside. This subside is referred as slump of concrete.
7. The difference in level between the height of the mould and that of the height of point of the subside of concrete is measured.
8. The pattern of slump indicates the characteristics of concrete in addition to the slump value. If the concrete slump is even, then it is called as true slump. If one half of the cone slides down, it is called as shear slump.



Fig 7.1.1.1 Slump cone

Formula and Calculation

Slump value = $h - h_1$ (mm)

Where, h - height of concrete

h_1 - height of subsidence

Height of mould = 300 mm

S.no	w/c ratio	Initial height of concrete (h) mm	Height of subsidence concrete (h_1) mm	Slump ($h - h_1$)	Remarks
1	0.3	300	0	300	True
2	0.4	300	30	270	True
3	0.5	300	100	200	Shear
4	0.6	300	170	110	Collapse

Table 7.1.1.1 Slump cone test

Result

The slump value of the concrete is 270mm.

7.1.2 COMPACTION FACTOR TEST

Procedure

1. Weight the empty cylinder (W_1) of the compaction factor apparatus and place it below the lower hopper check trap doors. If opened, close it.
2. Prepare concrete mix as designed.
3. Fill the prepared concrete in the upper hopper. Level it up to the brim without causing compaction.
4. Open the drop door of the upper hopper. This will allow the concrete to fall into the lower hopper.
5. Release the trap door of the lower hopper causing concrete to fall into the cylinder.
6. Clean the outer surface of the cylinder and weigh it (W_2).
7. Empty the cylinder.
8. Refill it immediately with the same concrete in four layers. Each layer shall be heavily compacted with ramming rod.
9. Wipe the outer face of the cylinder and level the surface of the concrete. Weigh it (W_3).
10. Repeat the above procedure for different w/c ratio and obtain the corresponding weights. Calculate compaction factor as per the given formula and calculation.

OBSERVATION

Grade of concrete = M_{30}

Weight of empty cylinder = 7.66kg

S.no	w/c ratio (by weight)	Weight of concrete in kg		Compaction factor = W_2/W_3
		With partially compacted concrete, W_2	With fully compacted concrete, W_3	
1	0.4	16.55	18.95	0.87
2	0.5	18.23	19.55	0.93
3	0.6	20.13	21.68	0.92

Table 7.1.2.1 Compaction factor test

Result

The compaction factor for given concrete is 93%

CHAPTER-8

EXPERIMENTAL INVESTIGATION

8.1 GENERAL

Production of quality concrete requires meticulous care exercised at every stage of manufacture of concrete. It is interesting to note that the ingredients of good concrete and bad concrete are the same. If meticulous care is not exercised and good rule are not observed the resultant concrete is going to be of bad quality with the same material if intense care is taken to exercise control at every stage it will result in good concrete. Therefore, it is necessary for us to know what are the good rules to be followed in each stage of Preparation of mould.

1. Batching
2. Mixing
3. Placing
4. Compacting
5. Curing
6. Finishing

8.2 CASTING

Preparation of mould size

1. Cube size =150mm x 150mm x150mm
2. Cylinder size=300mm x150mm
3. Prism size =100mm x100mm x500mm



Fig 8.2.1 Casting of Specimen

8.3 WEIGH BATCHING

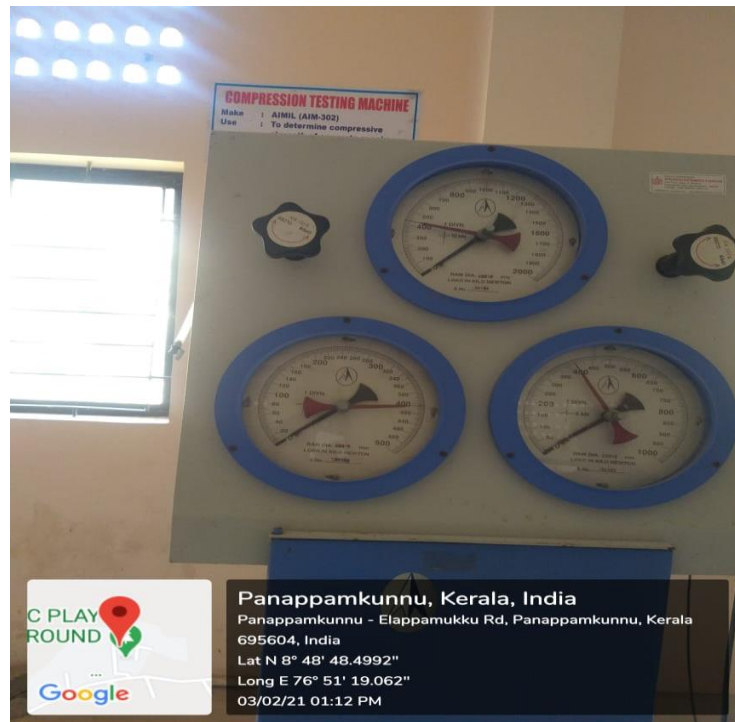
Strictly speaking weigh batching is the correct method of measuring the materials for important concrete invariably weigh batching system should be adopted. Use of weight system in batching, facilitates accuracy, flexibility and simplicity. Different types of weigh batches are available, the particular type to be used, depends upon the nature of the job. Large weigh batching plants have automatic weighing equipment.

On large work sites the weigh bucket type of weighing equipment is



used. This fed from a large overhead storage hopper and it discharge by gravity straight into the mixer. The weighing is done through weighing balanced machine.

Aggregate weighing machines require regular attention if they are to maintain their accuracy. Check calibrations should always be made by adding



Weights in the hopper equal to the full weight of the aggregate in the batch. The error found is adjusted from time to time.

In small jobs cement is often not weighed it is added in bags assuming the weight of the bag as 50 kg in reality through the cement bag is made of 50 kg at the factory due transportation handling at a number of places in loses some cement particularly when jute bags are used in fact the weight of a cement bag at the site is considerably less sometimes the loss of weight becomes more than 5 kg this is one of the sources of error in volume batching and also in weight batching when the cement is not actually weighed. But in important is maintained.

8.3.1 MEASUREMENT OF WATER

When weigh batching is adopted, the measurement of water must be done ate enough for the reason of spillage of water etc. it is usual to have the water in a horizontal tank or vertical tank fitted to the mixer. These tanks are after every batch. The filling is so designed to have a control to admit any sired quantity of water meters are fitted in the main water supply to the mixer which the exact quantity of water can be let into the mixer.

8.4 MIXING

Thorough mixing of the materials for the production of uniform concrete. Remixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. Two types are there machine mixing and hand mixing. Here machine mixing is adopted.

8.4.1 MACHINE MIXING

Mixing of concrete is almost invariably carried out by machine for reinforced concrete work and for medium or large scale mass concrete work. Machine mixing is not only efficient, but also economical when the quantity of

concrete to be produced is large.



Many types of mixers are available for mixing concrete. They can be classified as batch mixers and continuous mixers. Batch mixers produce concrete, batch by batch with time interval, whereas continuous mixers produce concrete sinuously without stoppage till such time the plant is working. In this materials fed continuously by screw feeders and the materials are continuously mixed charged. This type of mixers is used in large works such as Dams. In normal concrete work, it is the batch mixers that are used batch mixer may be of pan type or drum type.

Fig 8.4.1.1 Mixer Machine

Normally a batch concrete is made with ingredients corresponding to 50 kg materials if one has a choice for such a capacity mixer that should hold all the aerals for one bag of cement. The course depends on the proportion of the material. For example, for 1:2:4 mixes, the ideal mixers are of 200litres capacity, whereas ratio is 1:3:6 the requirement will be of 280 litres capacity to facilitate one bag mix.

Generally mixing time is related to the capacity of mixer. The mixing time between 1 to 2 minutes. Bigger the capacity of the drum more is the mixing However modem high speed pan mixer used in RMC, mixes the

concrete in 15 to 30 sec. One cubic meter capacity high speed pan mixer takes only minutes for batching and mixing. The batching plant takes about 2 minutes to load a transit mixer of 6m³ capacity.

Sometimes at a site of work concrete may be discharged from the drum and concrete may be kept rotating in the drum for a long time, as for instance when times evaporation of water and formation of excess fines may reduce the workability and hence bring about reduction in strength. The excess of fine also causes great shrinkage

8.5 PLACING OF CONCRETE

It is not enough that a concrete mix correctly designed, batched, mixed and transported, it is at most important that the concrete must be placed in the systematic manner to yield optimum result. The precaution to be taken and methods adopted while placing concrete in the under mentioned situations. Here the concrete is placed in moulds such as cubes, cylinders, and prism.



Fig 8.5.2 Placing of concrete

8.6 COMPACTION OF CONCRETE

Compaction of concrete is the process adopted for expelling the entrapped air from the concrete. In the process of mixing, transporting and placing of concrete air is likely to get entrapped in the concrete. The lower the workability higher is the amount of air entrapped in other words stiff concrete

mix has high percentage of entrapped air and therefore would need higher compacting efforts than high workable mixes.

If this air is not removed, the concrete loses strength considerably. The relationship between loss of strength and voids left due to lack of compaction, it can be seen from the fact that 5 percent voids reduce the strength of concrete by about 30 percent and 10 percent voids reduce the strength by over 50 percent; therefore, it is imperative that 100 percent compaction of concrete is one of the most important aims to be kept in mind in good concrete making practices.

Insufficient compaction increases the permeability of concrete, resulting in easy entry for aggressive chemicals in solutions which attack concrete and reinforcement, to reduce the durability of concrete. Therefore, 100 percent compaction of concrete is of paramount importance.

In order to achieve full compaction and maximum density with reasonable compacting efforts available at site, it is necessary to use a mix with adequate workability. It is also of common knowledge that the mix should not be too wet for easy compaction, which also reduces the strength of concrete. For maximum strength, the driest possible concrete should be compacted 100 percent, the overall economy with reasonable compacting efforts available in the field.

8.7 CURING

We have discussed the hydration aspect of cement. Concrete derives its strength by the hydration of cement particles. The hydration of cement is not a momentary action but a process continuing for long time. Of course, the rate of hydration is fast to start with but continues over a very long time at a decreasing rate. The quantity of the product of hydration and consequently the amount of gel formed depends upon the extent of hydration.

It has been mentioned earlier that cement requires a water/cement ratio about 0.23 for hydration and water/ cement ratio of 0.15 for filling the voids in the gel pores. In other words, a water/cement ratio of about 0.38 would be required to hydrate all the particles of cement and also to occupy the space in the gel pores.

Theoretically for a concrete made and continued in a sealed container water cement requirement of water for hydration at the same varieties would be left. However, it is seen that practically a water/cement ratio of 0.5 will be required for complete hydration in a sealed container for keeping up the desirable relative humidity level.



Fig 8.7.1 Curing tank

Curing can also be described as keeping the concrete moist and warm enough so that the hydration of cement can continue. More elaborately it can be described as the process of maintaining satisfactory moisture content and a favourable in concrete during the period immediately following placement, so

that hydration of cement may continue until the desired properties are developed to a sufficient degree to meet the requirement of service.

Curing is being given a place of increasing importance as the demand for high quality concrete is increasing. It has been recognized that the quality of concrete shows all round improvement with efficient uninterrupted curing. If curing is neglected in the early period of hydration the quality of concrete will experience a sort of irreparable loss. An efficient curing in the early period of hydration can be compared to a good and wholesome feeding given to a new born baby.

The quick surface drying of concrete result in the movement of moisture from the interior to the surface. The steep moisture gradient cause high internal stresses which are also responsible for internal micro in the semi plastic concrete.

8.8 FINISHING

Finishing operation is the last operation in making concrete in real scene does not apply to all concrete operations. For a beam concreting finishing may not be applicable whereas for the concrete road pavement airfield pavement or for the flooring of a domestic building, careful finishing is of great importance.

Concrete is often dubbed as a drab material incapable of offering pleasant architectural appearance and finish. This shortcoming of concrete is being rectified and concretes these days are made to exhibit pleasant surface finishes. Particularly made type of prefabricated concrete panels used as floor slab or wall unit are made in such a way as to give very attractive architectural affect. Even concrete claddings are made to give attractive look.

CHAPTER-9

TESTING

9.1 GENERAL

There are three types of test has been done

- a) Compressive strength test.
- b) Split tensile strength test.
- c) Flexural strength test.

9.1.1 COMPRESSIVE STRENGTH TEST

Compressive strength test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

Test procedure

1. Prepare mould for a size of 150 x 150 x 150 mm
2. After that mould should be placed in a compression testing machine of proper manner.
3. Then load is applying gradually to the specimen.
4. Finally when the specimen getting crack or failure that reading will be taken for calculation.

Formula

Compressive strength = Load / Area

Area = L x B

Where, L = Length of specimen.

B = Breadth of specimen.

S.No	Cube size (mm)	Compressive strength (N/mm ²)
1	150x150x150	18.6
2	150x150x150	19.2
3	150x150x150	21.4

Table 9.1.1.1 Conventional concrete test for cubes M₃₀ grade (7 days)

S.no	Cube size (mm)	Compressive strength (N/mm ²)
1	150x150x150	31.2
2	150x150x150	31.3
3	150x150x150	30.1

Table 9.1.1.2 Conventional concrete test for cubes M₃₀ grade (28 days)

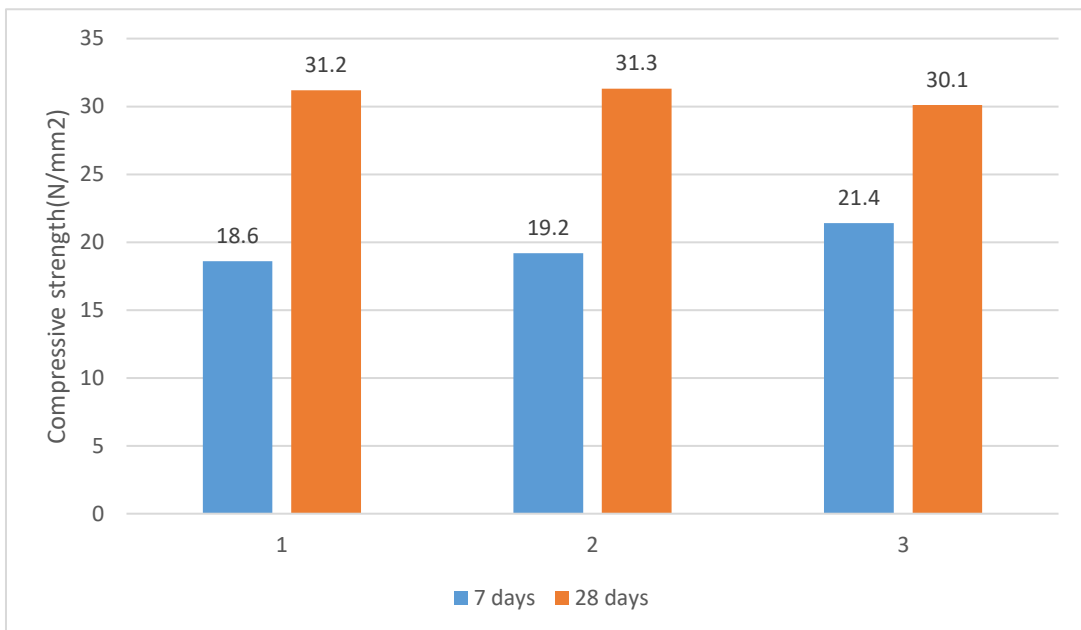


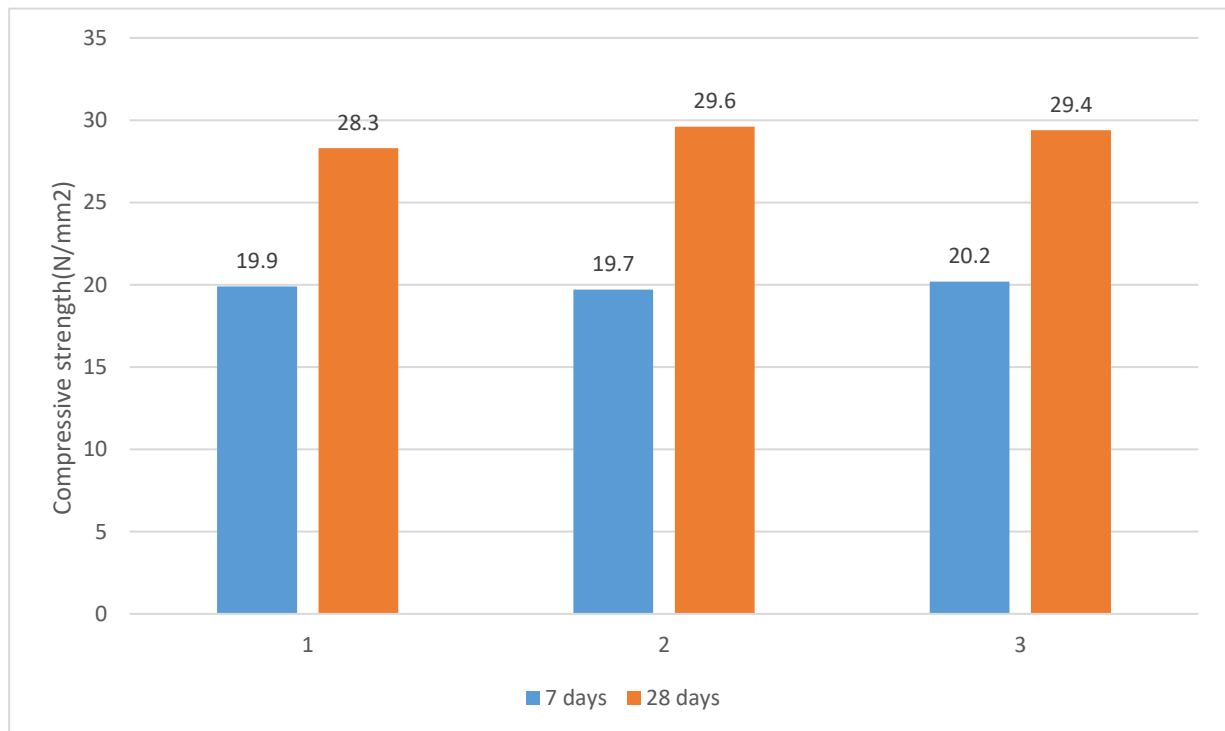
Fig 9.1.1.2 Conventional concrete for cube M₃₀ grade

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	19.9
2	150x150x150	19.7
3	150x150x150	20.2

**Table 9.1.1.3 Replacement of bottom fly ash 10%, CCR 20% and
RCA 25% concrete test for cubes M₃₀ grade (7 days)**

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	28.3
2	150x150x150	29.6
3	150x150x150	29.4

**Table 9.1.1.4 Replacement of bottom fly ash 10%, CCR 20% and RCA
25% concrete test for cubes M₃₀ grade (28 days)**



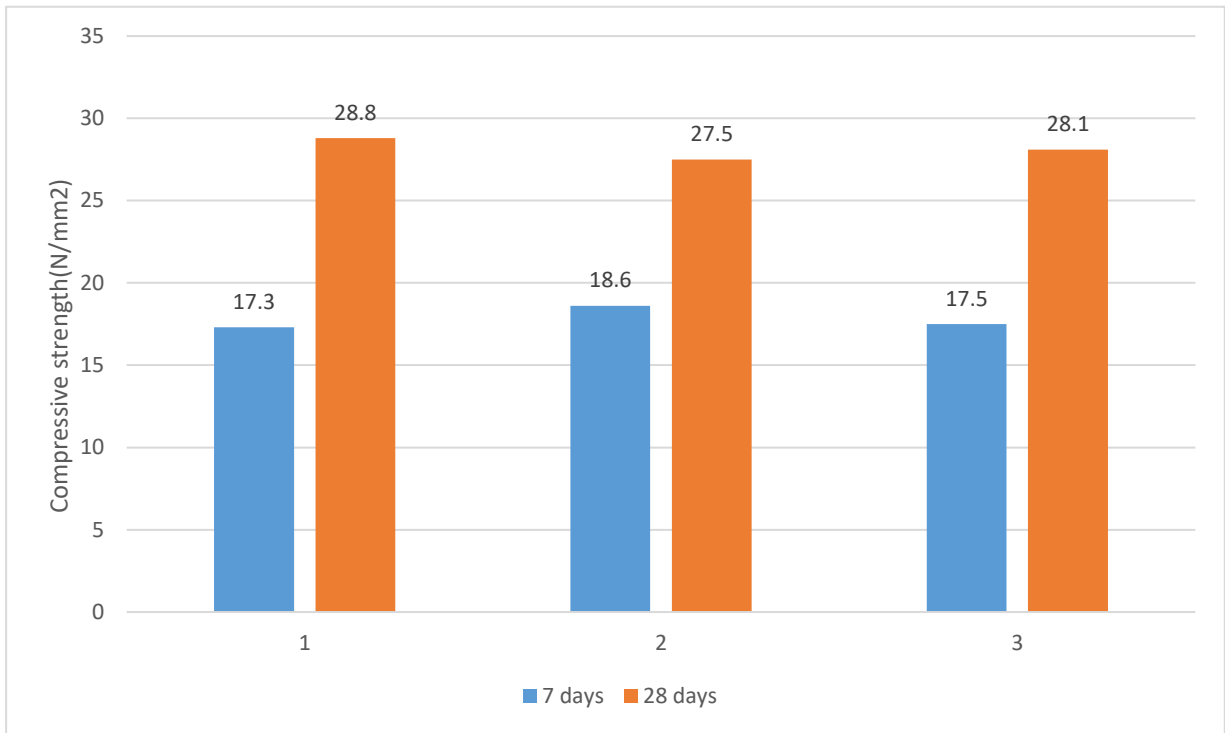
**Fig 9.1.1.3 Replacement of BFA 10%, CCR 20% and RCA 25% for cube
M₃₀ grade**

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	17.3
2	150x150x150	18.6
3	150x150x150	17.5

**Table 9.1.1.5 Replacement of bottom fly ash 20%, CCR 10% and
RCA 25% concrete test for cubes M₃₀ grade (7 days)**

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	28.8
2	150x150x150	27.5
3	150x150x150	28.1

**Table 9.1.1.6 Replacement of bottom fly ash 20%, CCR 10% and
RCA 25% concrete test for cubes M₃₀ grade (28 days)**



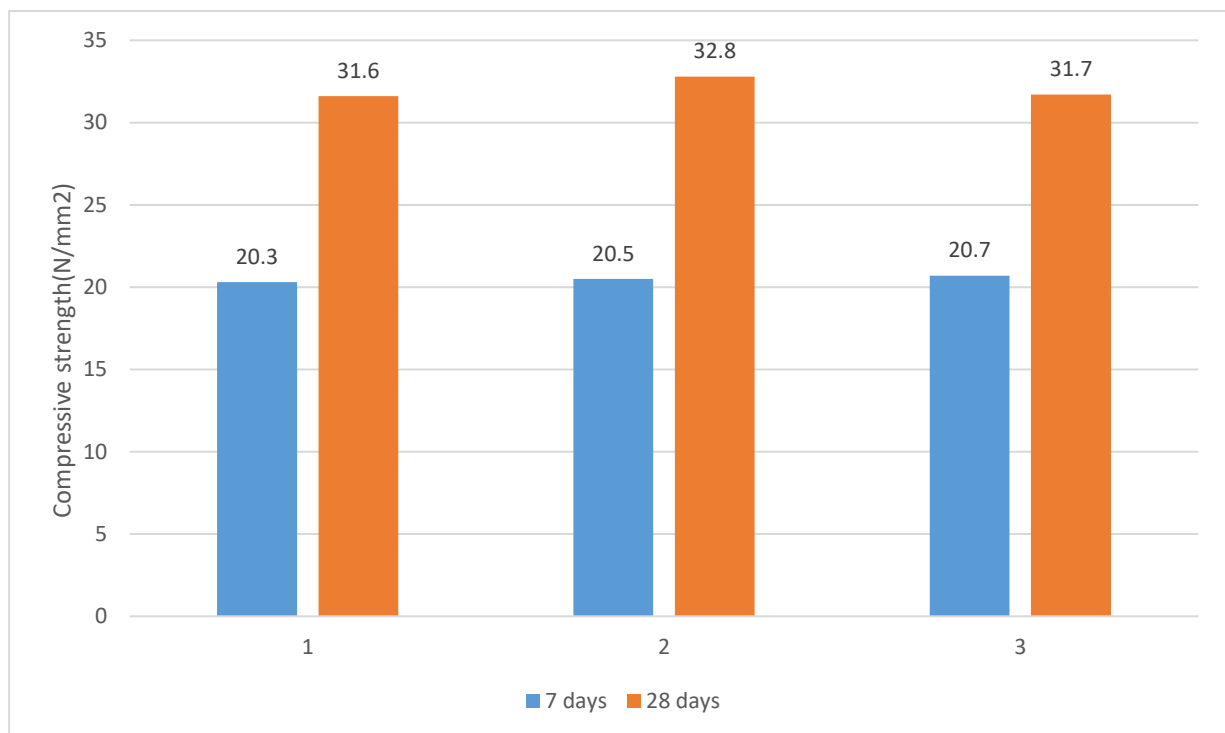
**Fig 9.1.1.4 Replacement of BFA 20%, CCR 10% and RCA 25% for
cube M₃₀ grade**

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	20.3
2	150x150x150	20.5
3	150x150x150	20.7

**Table 9.1.1.7 Replacement of bottom fly ash 20%, CCR 20% and
RCA 25% concrete test for cubes M₃₀ grade (7 days)**

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	31.6
2	150x150x150	32.8
3	150x150x150	31.7

**Table 9.1.1.8 Replacement of bottom fly ash 20%, CCR 20% and
RCA 25% concrete test for cubes M₃₀ grade (28 days)**



**Fig 9.1.1.5 Replacement of BFA 20%, CCR 20% and RCA 25% for cube
M₃₀ grade**

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	24.3
2	150x150x150	25.1
3	150x150x150	24.8

Table 9.1.1.9 Conventional concrete test for cubes M₃₅ grade (7 days)

S.no	Cube size (mm)	Compressive strength (N/mm ²)
1	150x150x150	36.3
2	150x150x150	34.2
3	150x150x150	36.4

Table 9.1.1.10 Conventional concrete test for cubes M₃₅ grade (28 days)

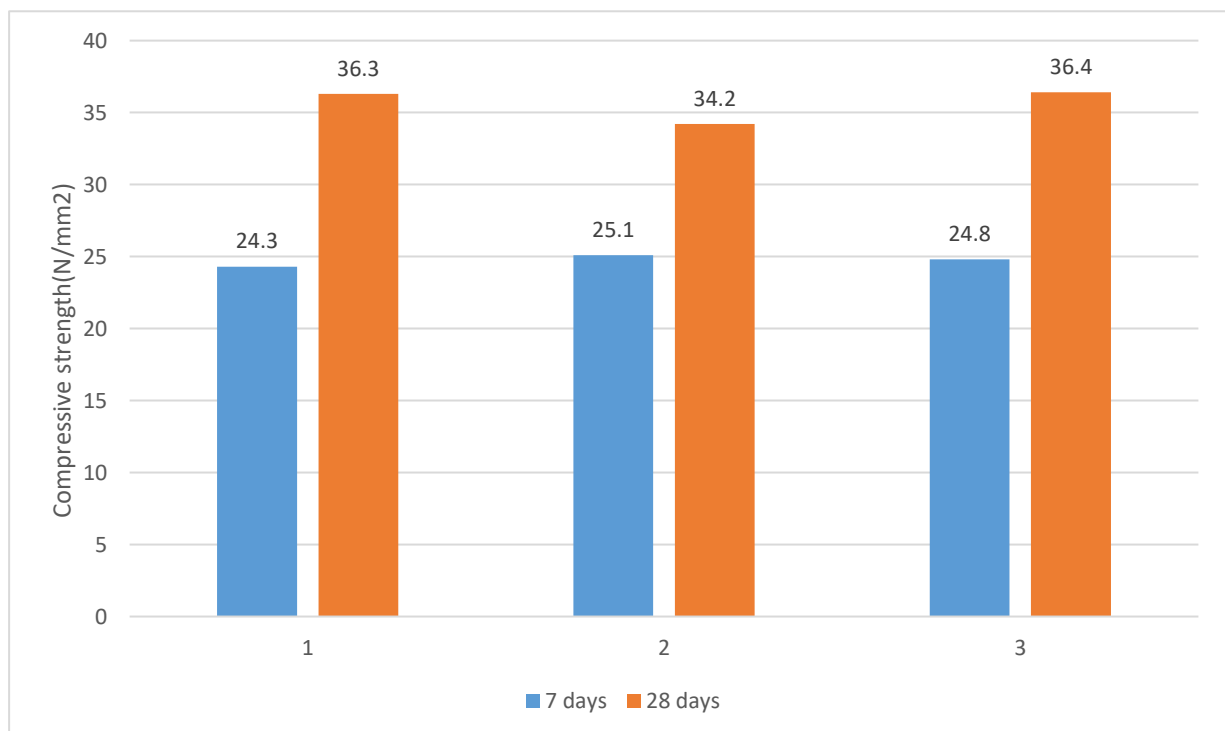


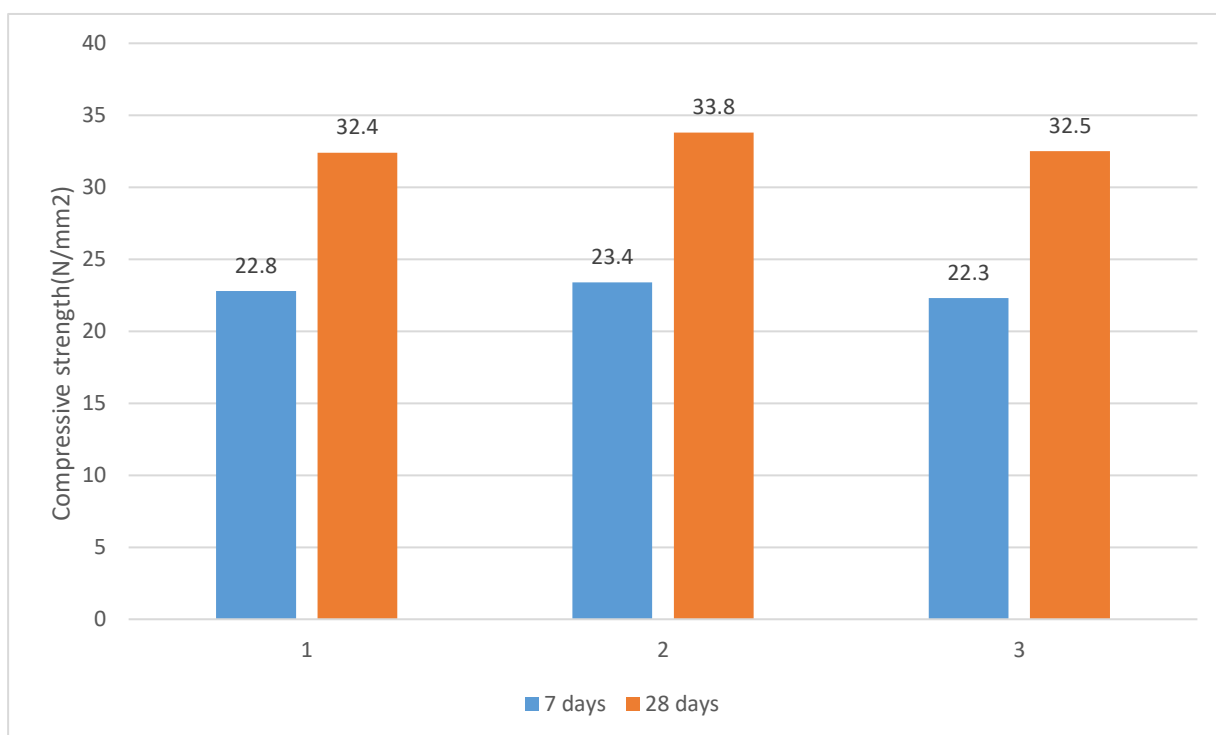
Fig 9.1.1.6 Conventional concrete for cube M₃₅ grade

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	22.8
2	150x150x150	23.4
3	150x150x150	22.3

**Table 9.1.1.11 Replacement of bottom fly ash 10% and, CCR 20%
and RCA 25% concrete test for cubes M₃₅ grade (7 days)**

S.no	Cube size (mm)	Compressive strength (N/mm ²)
1	150x150x150	32.4
2	150x150x150	33.8
3	150x150x150	32.5

Table 9.1.1.12 Replacement of bottom fly ash 10%, CCR 20% and RCA 25% concrete test for cubes M₃₅ grade (28 days)



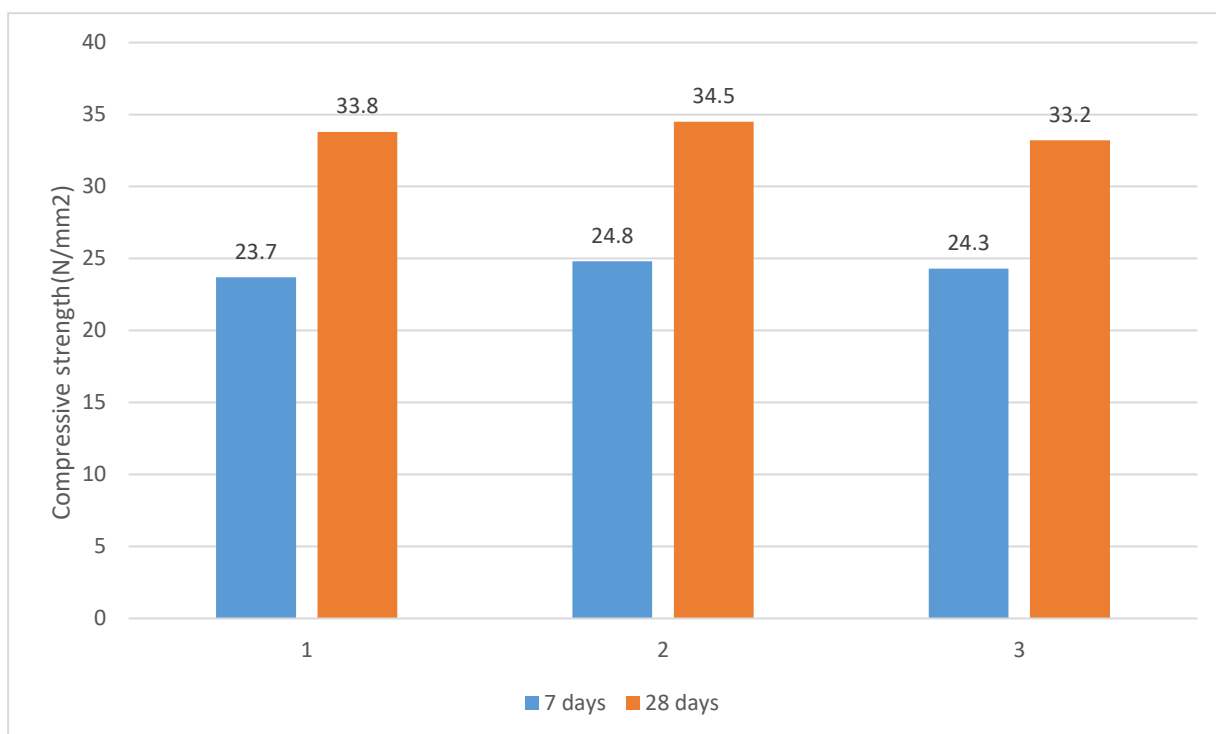
**Fig 9.1.1.7 Replacement of BFA 10%, CCR 20% and RCA 25% for cube
M₃₅ grade**

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	23.7
2	150x150x150	24.8
3	150x150x150	24.3

**Table 9.1.1.13 Replacement of bottom fly ash 20%, CCR 10% and
RCA 25% concrete test for cubes M₃₅ grade (7 days)**

S.no	Cube size (mm)	Compressive strength (N/mm ²)
1	150x150x150	33.8
2	150x150x150	34.5
3	150x150x150	33.2

Table 9.1.1.14 Replacement of bottom fly ash 20%, CCR 10% and RCA 25% concrete test for cubes M₃₅ grade (28days)



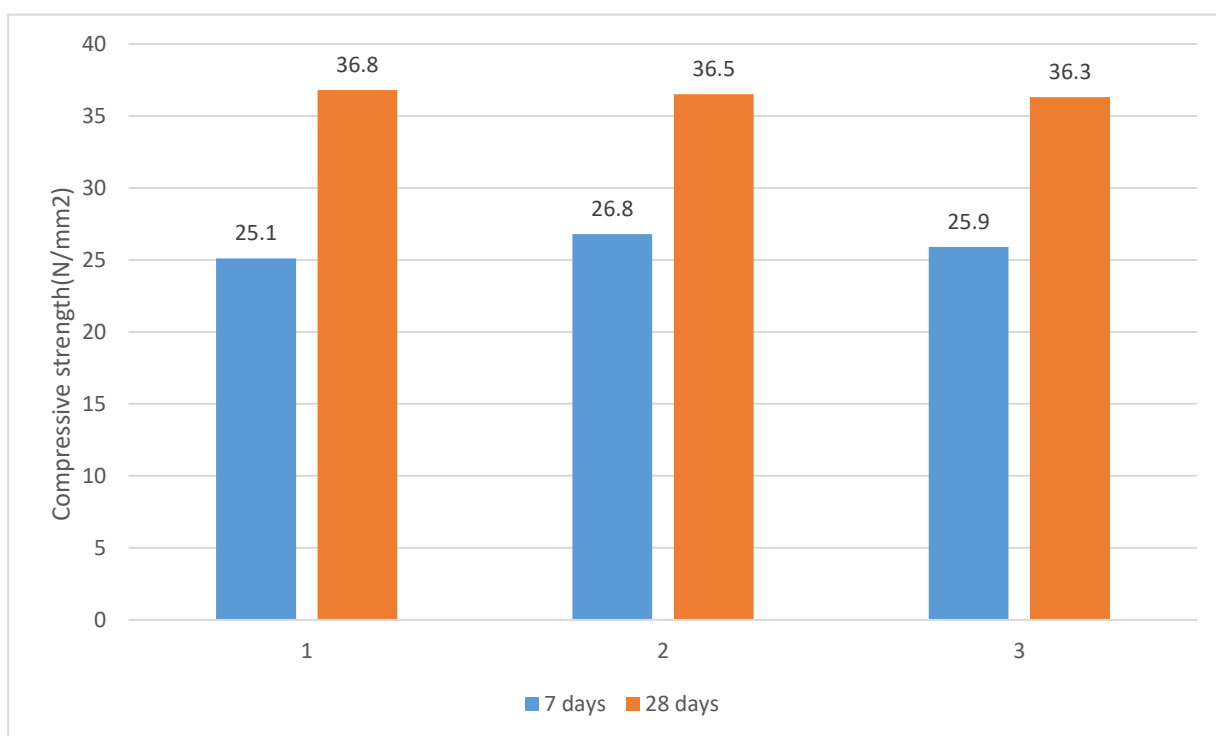
**Fig 9.1.1.8 Replacement of BFA 20%, CCR 10% and RCA 25% for cube
M₃₅ grade**

S.no	Cube size (mm)	Compressive strength (N/mm²)
1	150x150x150	25.1
2	150x150x150	26.8
3	150x150x150	25.9

**Table 9.1.1.15 Replacement of bottom fly ash 20%, CCR 20% and
RCA 25% concrete test for cubes M₃₅ grade (7 days)**

S.no	Cube size (mm)	Compressive strength (N/mm ²)
1	150x150x150	36.8
2	150x150x150	36.5
3	150x150x150	36.3

Table 9.1.1.16 Replacement of bottom fly ash 20%, CCR 20% and 25% concrete test for cubes M₃₅ grade (28 days)



**Fig 9.1.1.9 Replacement of FA 20%, CCR 20% and RCA 25% for cube
M₃₅ grade**

9.1.2 SPLIT TENSILE STRENGTH TEST

The concrete cylinders of 150mm diameter and 300mm height were cast for finding the split tensile strength. The prepared cylinders were cured in water for 7 and 14 days.

The cured specimens were taken out and dried. After drying, the specimen is placed horizontally between the loading surface of the compression testing machine and the load applied untill the failure of the

cylinder along the vertical diameter the test setup for split tensile.

The split tensile strength of concrete cylinders specimens was investigated by measuring the load and it was calculated by using the equation.

Formula

Split tensile strength = load/area

Area = $(\pi/4) \times D^2$

Where,

D = Diameter of specimen

S.no	Size (mm)	Area (mm ²)	Ultimate load KN	Tensile strength(N/mm ²)
1	150x300	17671.5	33.5	1.9
2	150x300	17671.5	31.8	1.8
3	150x300	17671.5	37.1	2.1

Table 9.1.2.1 Conventional concrete test for cylinder M₃₀ grade (7days)

S.no	Size (mm)	Area (mm ²)	Ultimate load KN	Tensile strength(N/mm ²)
1	150x300	17671.5	51.2	2.9
2	150x300	17671.5	54.7	3.1
3	150x300	17671.5	49.4	2.8

Table 9.1.2.2 Conventional concrete test for cylinder M₃₀ grade (28days)

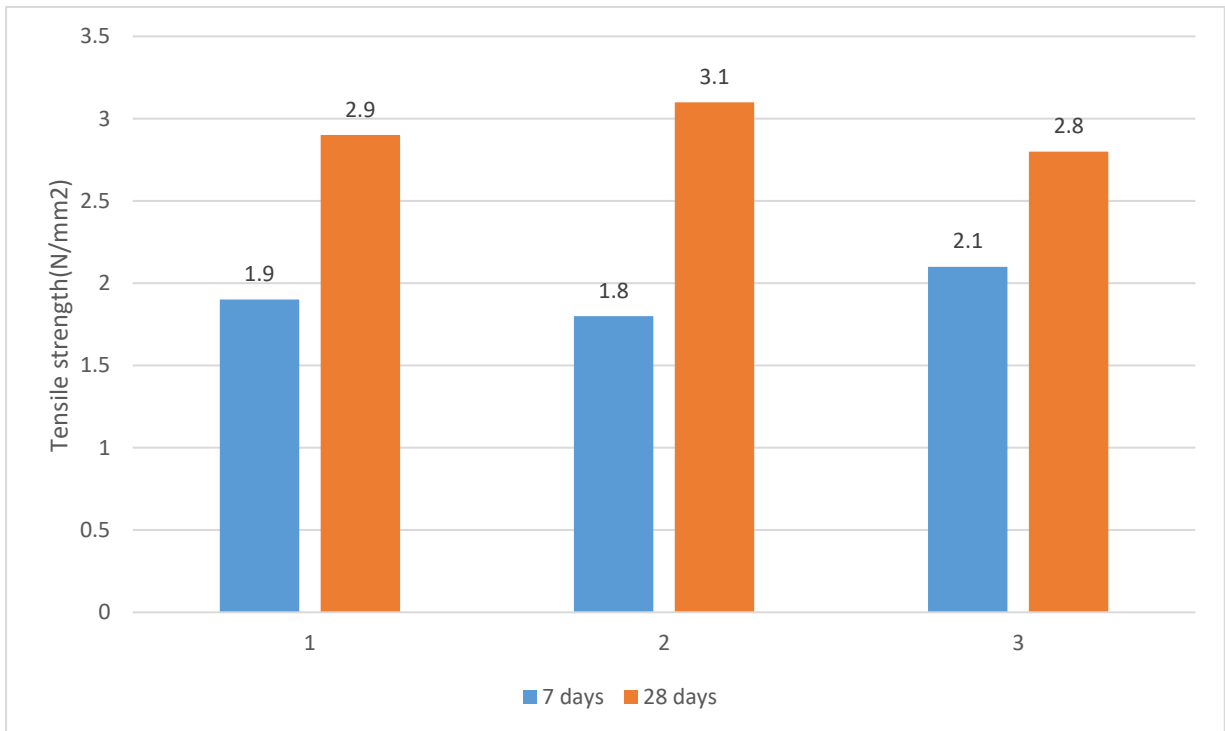


Fig 9.1.2.2 Conventional concrete for cylinder M₃₀ grade

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	33.5	1.9
2	150x300	17671.5	37.1	2.1
3	150x300	17671.5	30.0	1.7

**Table 9.1.2.3 Replacement of bottom fly ash 10%, CCR 20% and 25%
concrete test for cylinder M₃₀ grade (7 days)**

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	47.7	2.7
2	150x300	17671.5	51.2	2.9
3	150x300	17671.5	47.7	2.7

**Table 9.1.2.4 Replacement of bottom fly ash 10%, CCR 20% and RCA
25% concrete test for cylinder M₃₀ grade (28 days)**

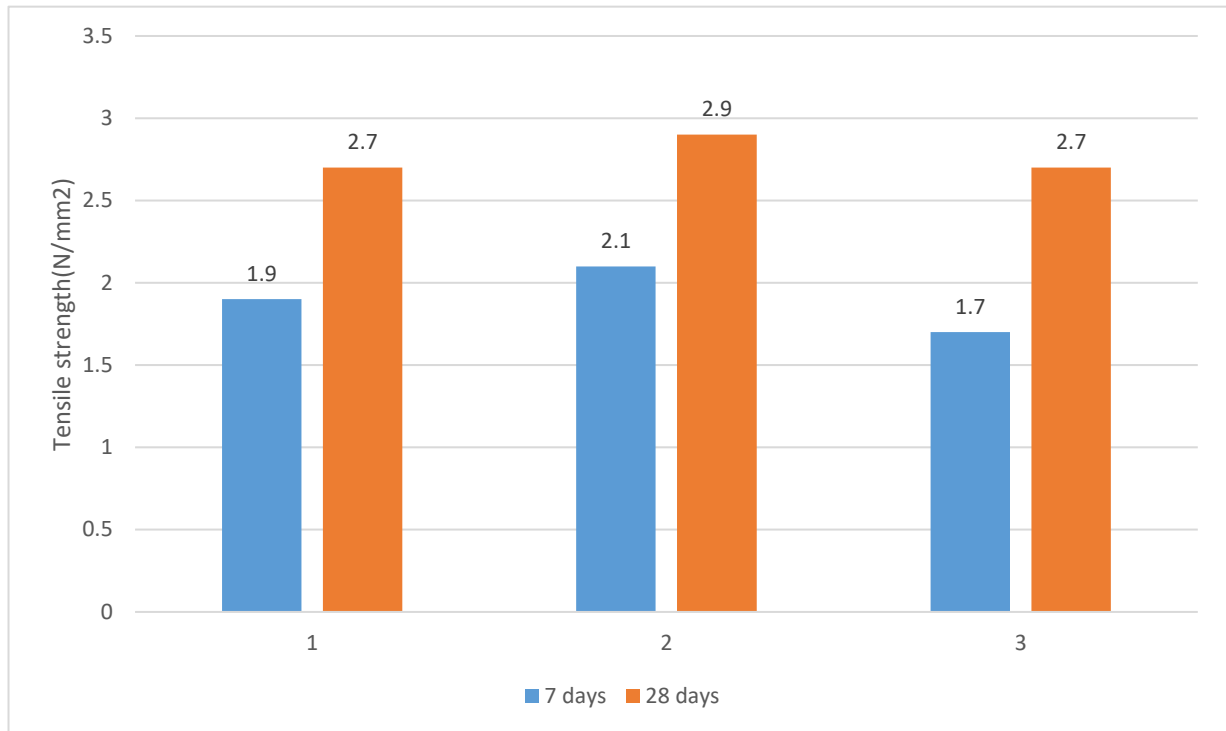


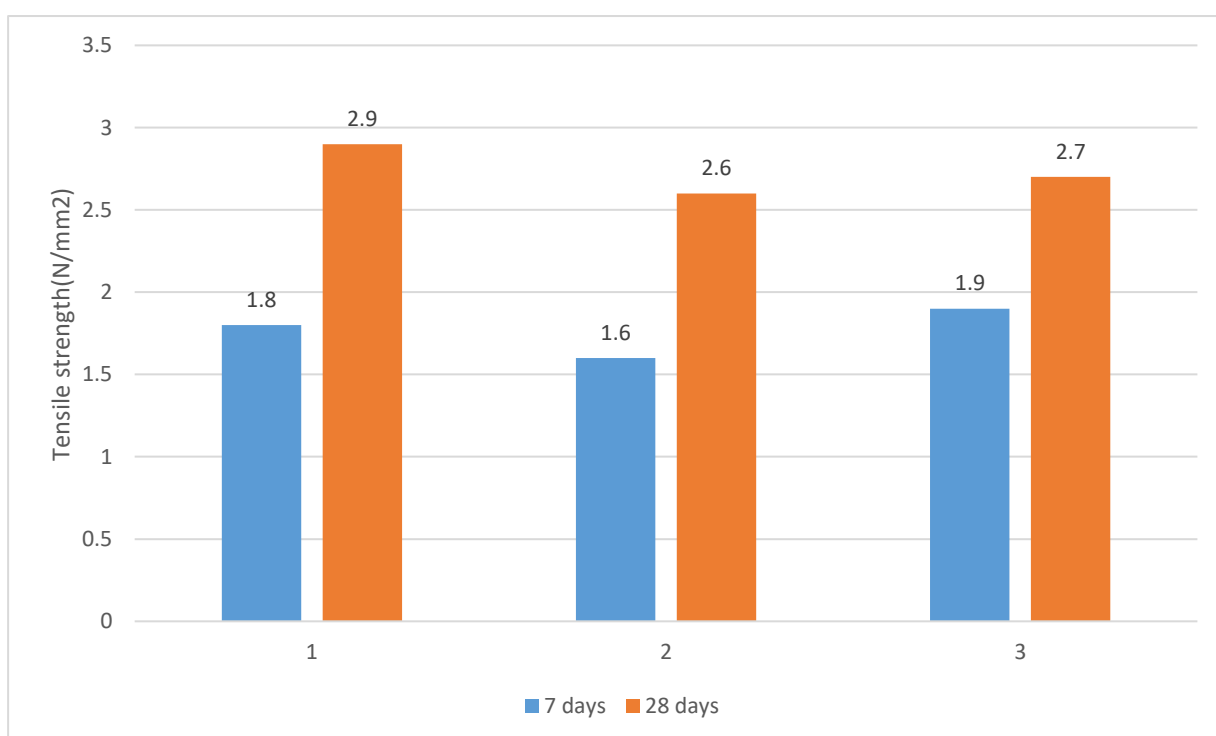
Fig 9.1.2.3 Replacement of BFA 10%, CCR 20% and RCA 25% for cylinder M₃₀ grade

S.no	Size (mm)	Area (mm ²)	Ultimate load KN	Tensile strength(N/mm ²)
1	150x300	17671.5	31.8	1.8
2	150x300	17671.5	28.2	1.6
3	150x300	17671.5	33.5	1.9

Table 9.1.2.5 Replacement of bottom fly ash 20%, CCR 10% and 25% concrete test for cylinder M₃₀ grade (7 days)

S.no	Size (mm)	Area (mm ²)	Ultimate load KN	Tensile strength(N/mm ²)
1	150x300	17671.5	41.0	2.9
2	150x300	17671.5	36.8	2.6
3	150x300	17671.5	38.2	2.7

**Table 9.1.2.6 Replacement of bottom fly ash 20%, CCR 10% and RCA
25% concrete test for cylinder M₃₀ grade (28 days)**



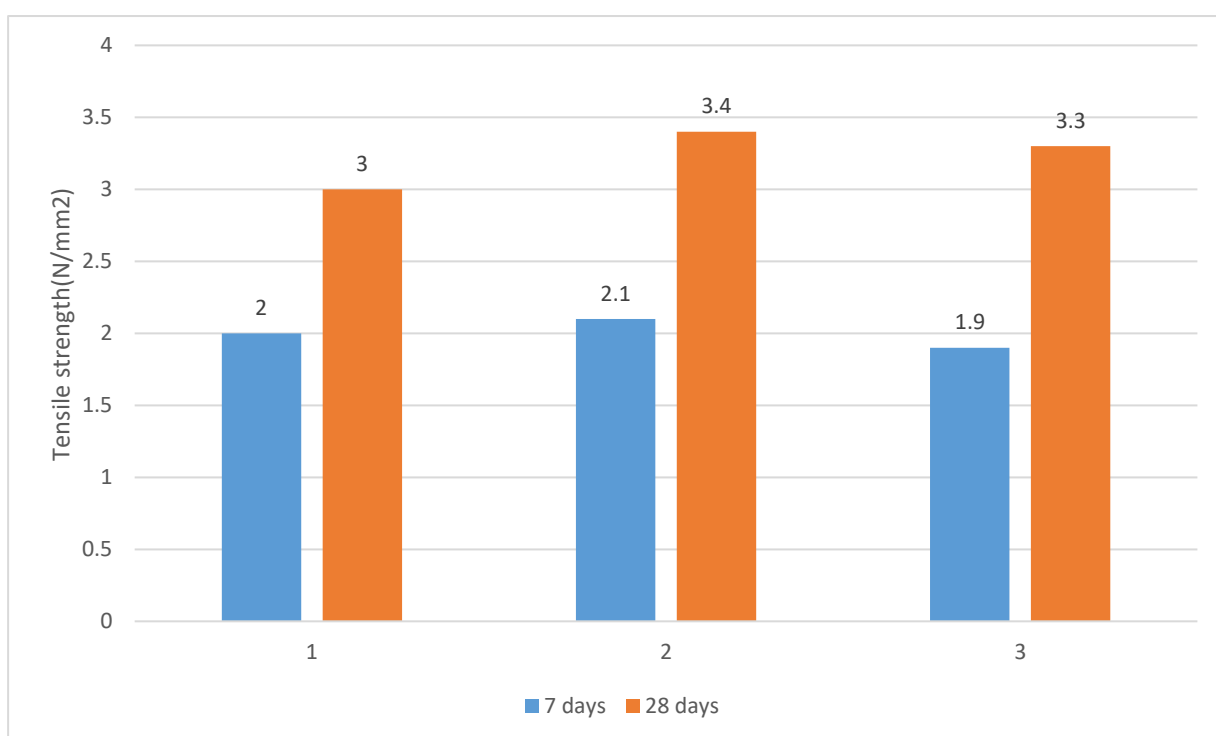
**Fig 9.1.2.4 Replacement of BFA 20%, CCR 10% and RCA 25% for
cylinder M₃₀ grade**

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	35.3	2.0
2	150x300	17671.5	37.1	2.1
3	150x300	17671.5	33.5	1.9

**Table 9.1.2.7 Replacement of bottom fly ash 20%, CCR 20% and
RCA 25% concrete test for cylinder M₃₀ grade (7 days)**

S.no	Size (mm)	Area (mm ²)	Ultimate load KN	Tensile strength(N/mm ²)
1	150x300	17671.5	53.0	3.0
2	150x300	17671.5	60.0	3.4
3	150x300	17671.5	58.3	3.3

**Table 9.1.2.8 Replacement of bottom fly ash 20%, CCR 20% and RCA
25% concrete test for cylinder M₃₀ grade (28 days)**



**Fig 9.1.2.5 Replacement of BFA 20%, CCR20% and RCA 25% for
cylinder M₃₀ grade**

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	42.4	2.4
2	150x300	17671.5	45.9	2.6
3	150x300	17671.5	45.9	2.6

Table 9.1.2.9 Conventional concrete test for cylinder M₃₅ grade (7days)

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	60.0	3.4
2	150x300	17671.5	65.3	3.7
3	150x300	17671.5	61.8	3.5

Table 9.1.2.10 Conventional concrete test for cylinder M₃₅ grade (28days)

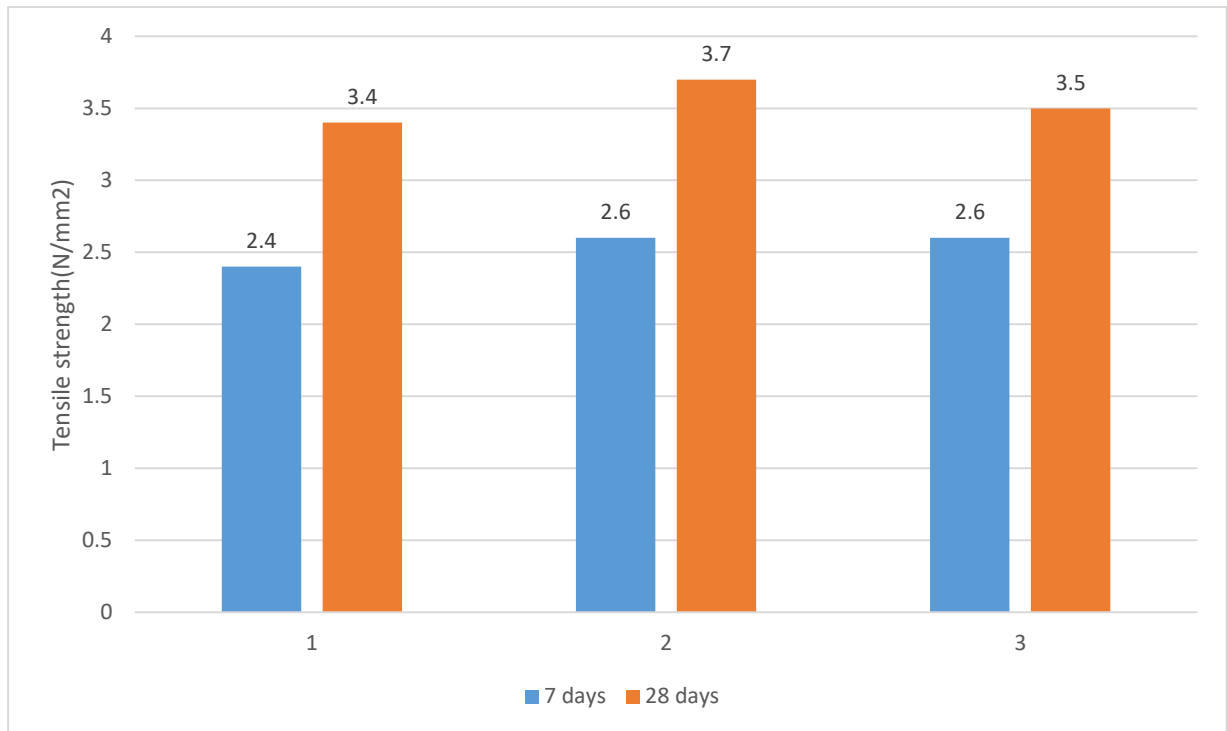


Fig 9.1.2.6 Conventional concrete for cylinder M₃₅ grade

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	37.1	2.1
2	150x300	17671.5	42.4	2.4
3	150x300	17671.5	38.8	2.2

**Table 9.1.2.11 Replacement of bottom fly ash 10%, CCR 20% and
RCA 25% concrete test for cylinder M₃₅ grade (7 days)**

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	56.5	3.2
2	150x300	17671.5	60.0	3.4
3	150x300	17671.5	56.5	3.2

**Table 9.1.2.12 Replacement of bottom fly ash 10%, CCR 20% and RCA
25% concrete test for cylinder M₃₅ grade (28 days)**

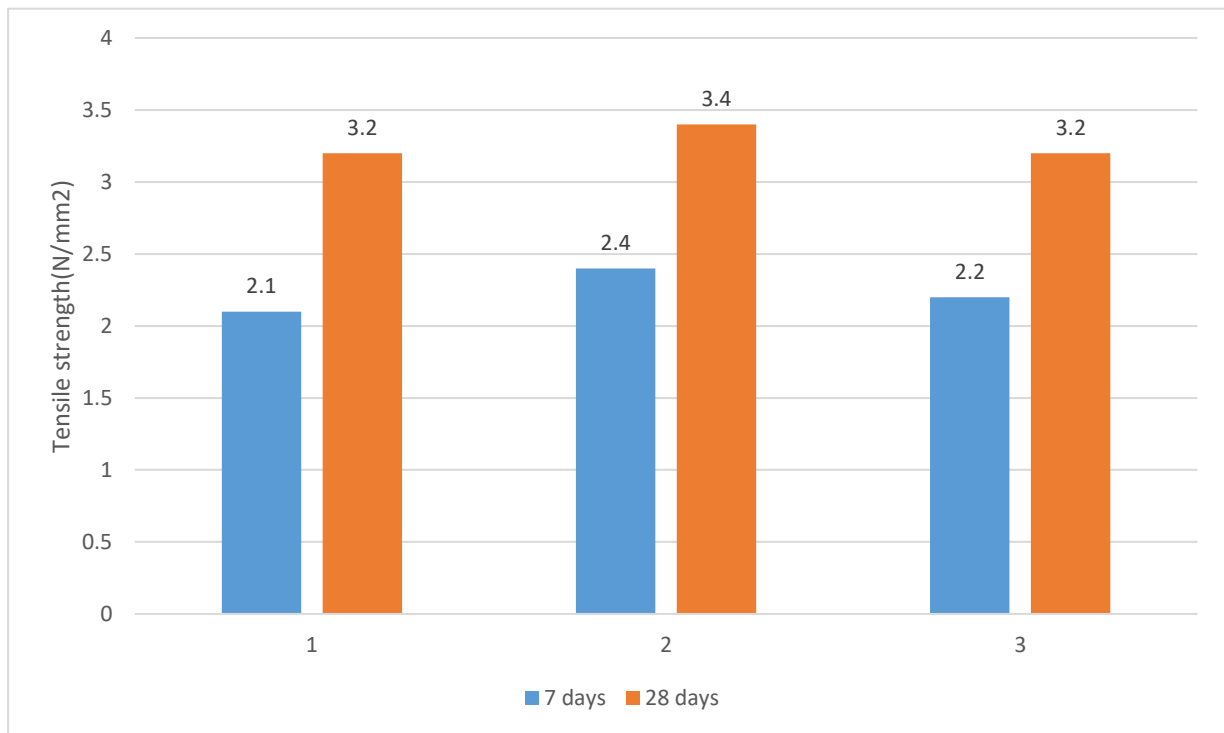


Fig 9.1.2.7 Replacement of BFA 10%, CCR 20% and RCA 25% for M₃₅ grade

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	37.1	2.1
2	150x300	17671.5	42.4	2.4
3	150x300	17671.5	40.6	2.3

**Table 9.1.2.13 Replacement of bottom fly ash 20%, CCR 10% and
RCA 25% concrete test for cylinder M₃₅ grade (7 days)**

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	61.8	3.5
2	150x300	17671.5	58.3	3.3
3	150x300	17671.5	54.7	3.1

**Table 9.1.2.14 Replacement of bottom fly ash 20%, CCR 10% and RCA
25% concrete test for cylinder M₃₅ grade (28 days)**

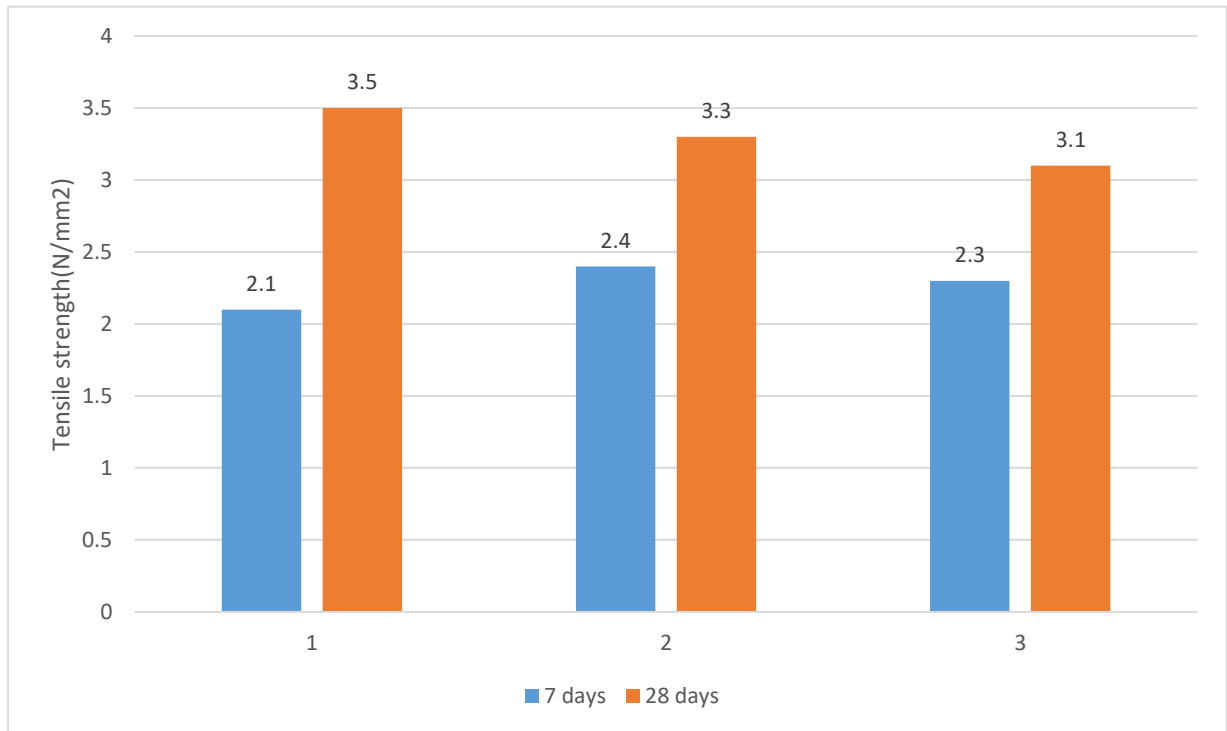


Fig 9.1.2.8 Replacement of BFA 20%, CCR 10% and RCA 25% for cylinder M₃₅ grade

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	42.4	2.4
2	150x300	17671.5	45.9	2.6
3	150x300	17671.5	40.6	2.3

**Table 9.1.2.15 Replacement of bottom fly ash 20%, CCR 20% and
RCA 25% concrete test for cylinder M₃₅ grade (7 days)**

S.no	Size (mm)	Area (mm²)	Ultimate load KN	Tensile strength(N/mm²)
1	150x300	17671.5	61.8	3.5
2	150x300	17671.5	65.3	3.7
3	150x300	17671.5	63.6	3.6

**Table 9.1.2.16 Replacement of bottom fly ash 20%, CCR 20% and RCA
25% concrete test for cylinder M₃₅ grade (28 days)**

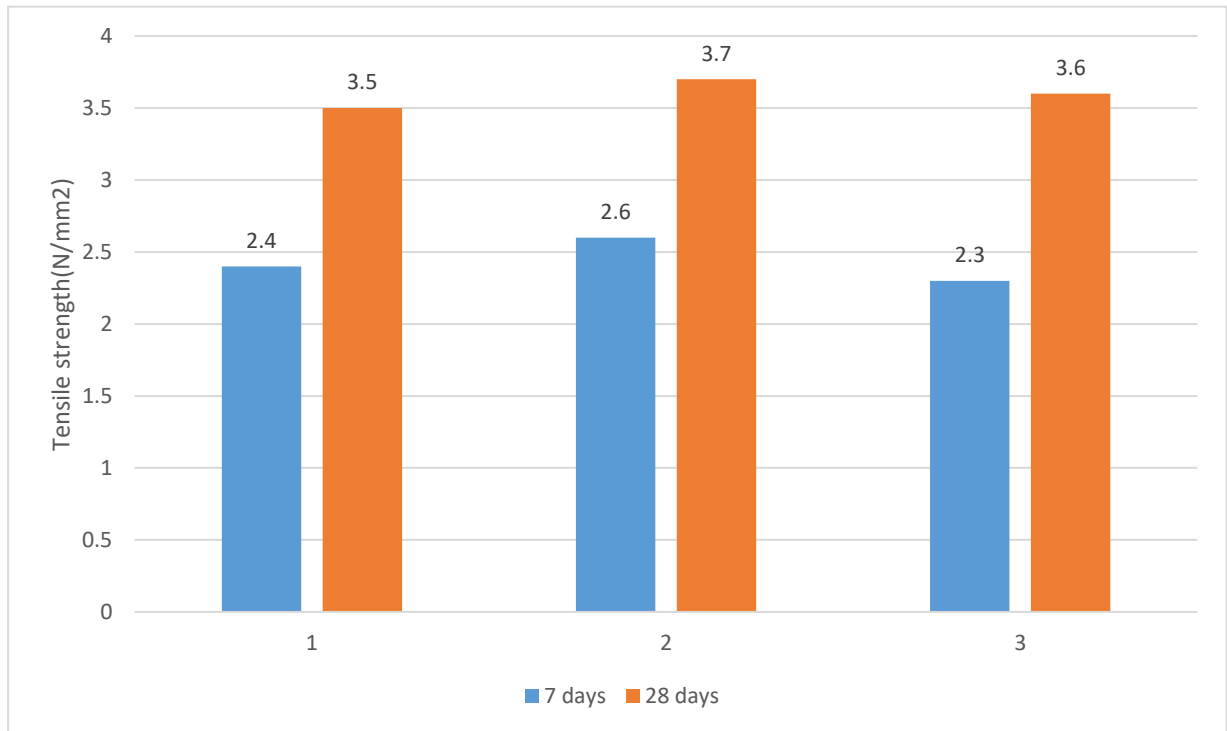


Fig 9.1.2.9 Replacement of BFA 20%, CCR 20% and RCA 25% for cylinder M₃₅ grade

9.1.3 FLEXURAL STRENGTH TEST

The concrete prism of 100x100x500mm size was cast for finding the compressive strength the prepared prism was cured in water for 7 and 28 days. The cured specimen were taken out and dried.

After drying the specimen is loaded using universal testing machine and the load is to be applied without shock until the specimen fails and the maximum load applied to the specimen during the test is to be recorded. Figure 4.4 shows test setup for flexural strength. The flexural strength of concrete prism specimen is to be expressed as the modulus of rupture f_b .

Fig 9.1.3.1 Flexural testing machine

S.no	Position and type of fracture(mm)	Area (mm ²)	Flexural strength(N/mm ²)
1	180	500*100	3.6
2	175.9	500*100	3.6
3	193.4	500*100	3.9

Table 9.1.3.1 Conventional concrete test for prism M₃₀ grade (28 days)

S.no	Position and type of fracture(mm)	Area (mm ²)	Flexural strength(N/mm ²)
1	165.9	500*100	2.9
2	170.8	500*100	2.4
3	166.3	500*100	2.6

Table 9.1.3.2 Replacement of bottom fly ash 10%, CCR 20% and RCA 25% concrete test for prism M₃₀ grade (28 days)

S.no	Position and type of fracture(mm)	Area (mm ²)	Flexural strength(N/mm ²)
1	149.1	500*100	2.2
2	155.3	500*100	2.4
3	163.4	500*100	2.1

Table 9.1.3.3 Replacement of bottom fly ash 20%, CCR 10% and RCA 25% concrete test for prism M₃₀ grade (28 days)

S.no	Position and type of fracture(mm)	Area (mm ²)	Flexural strength(N/mm ²)
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1	168.9	500*100	3.4
2	175.4	500*100	3.7
3	160.1	500*100	3.3

**Table 9.1.3.4 Replacement of bottom fly ash 20%, CCR 20% and RCA
25% concrete test for prism M₃₀ grade (28 days)**

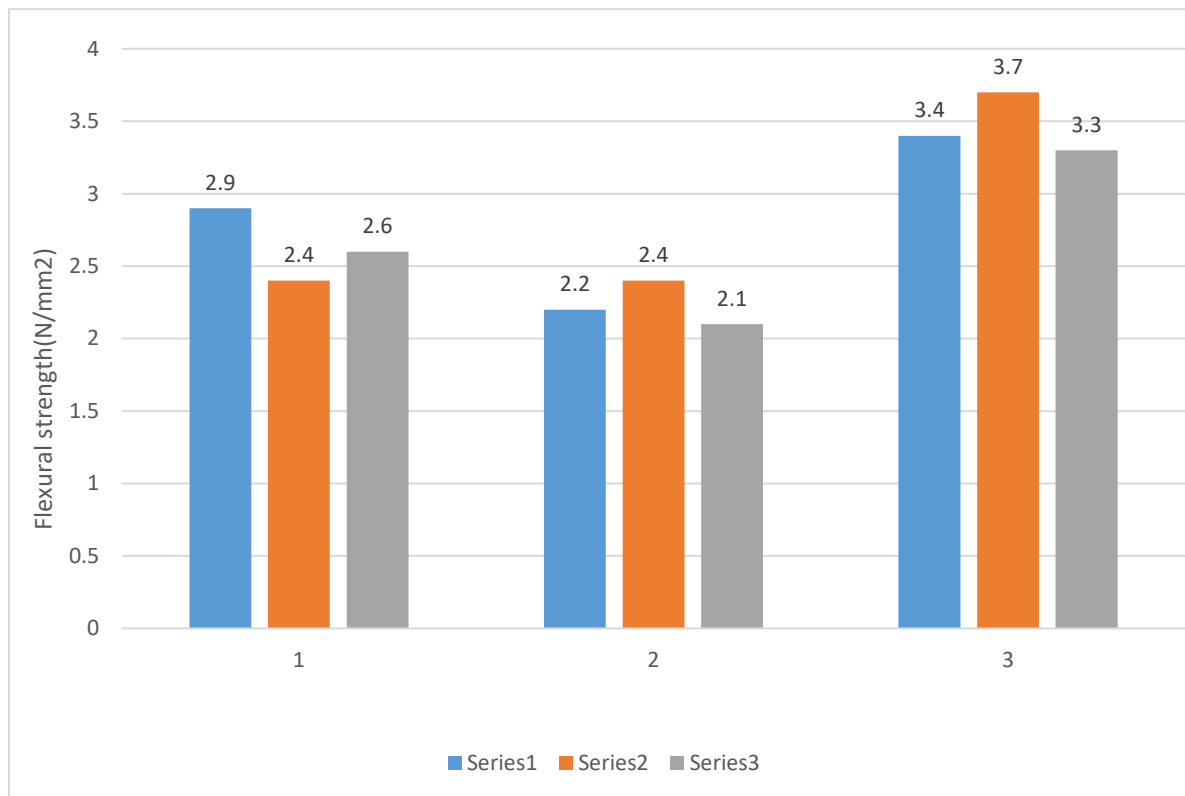


Fig 9.1.3.2 Replacement of BFA, CCR and RCA with various ratios for prism M₃₀ grade

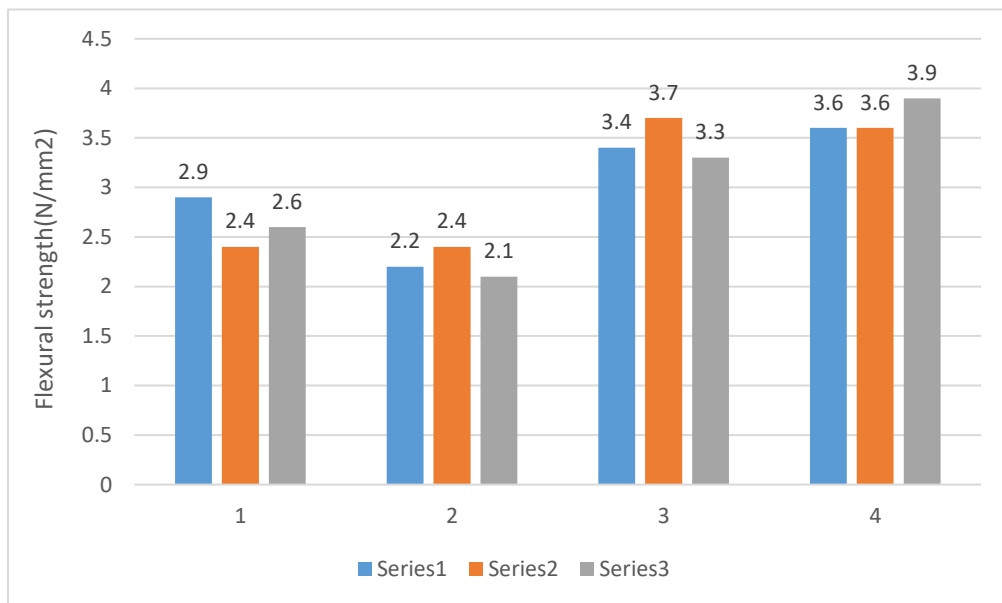


Fig 9.1.3.3 Comparison chart for flexural strength M₃₀ grade

S.no	Position and type of fracture(mm)	Area (mm ²)	Flexural strength(N/mm ²)
1	156.8	500*100	3.9
2	162.3	500*100	4.2
3	165.0	500*100	4.1

Table 9.1.3.5 Conventional concrete test for prism M₃₅ grade (28 days)

S.no	Position and type of fracture(mm)	Area (mm ²)	Flexural strength(N/mm ²)
1	159.3	500*100	2.9
2	164.5	500*100	3.3
3	169.7	500*100	3.2

Table 9.1.3.6 Replacement of bottom fly ash 10%, CCR 20% and RCA 25% concrete test for prism M₃₅ grade (28 days)

S.no	Position and type of fracture(mm)	Area (mm ²)	Flexural strength(N/mm ²)
1	168.7	500*100	3.4
2	170.6	500*100	3.5
3	173.4	500*100	3.7

Table 9.1.3.7 Replacement of bottom fly ash 20%, CCR 10% and RCA 25% concrete test for prism M₃₅ grade (28 days)

S.no	Position and type of fracture(mm)	Area (mm ²)	Flexural strength(N/mm ²)
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1	175.4	500*100	3.9
2	168.2	500*100	3.8
3	167.5	500*100	4.1

**Table 9.1.3.8 Replacement of bottom fly ash 20%, CCR 20% and RCA
25% concrete test for prism M₃₅ grade (28 days)**

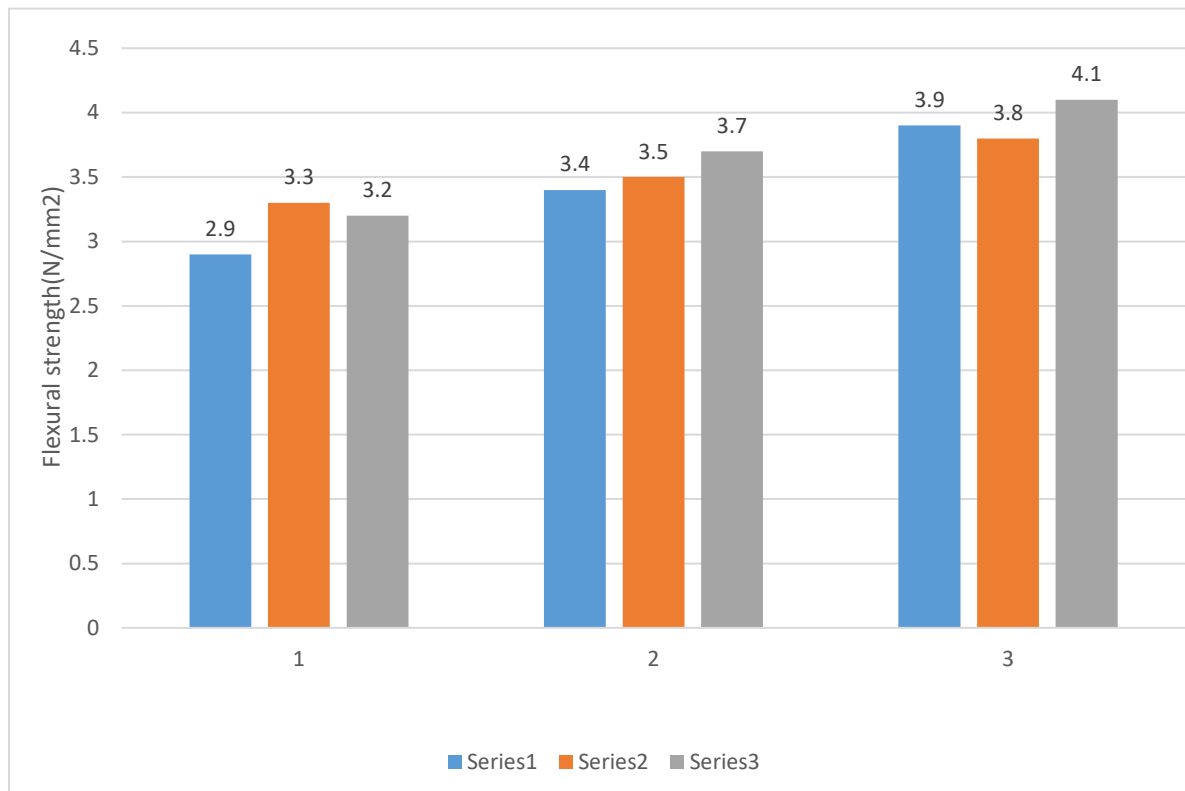


Fig 9.1.3.4 Replacement of BFA, CCR and RCA with various ratios for prism M₃₅ grade

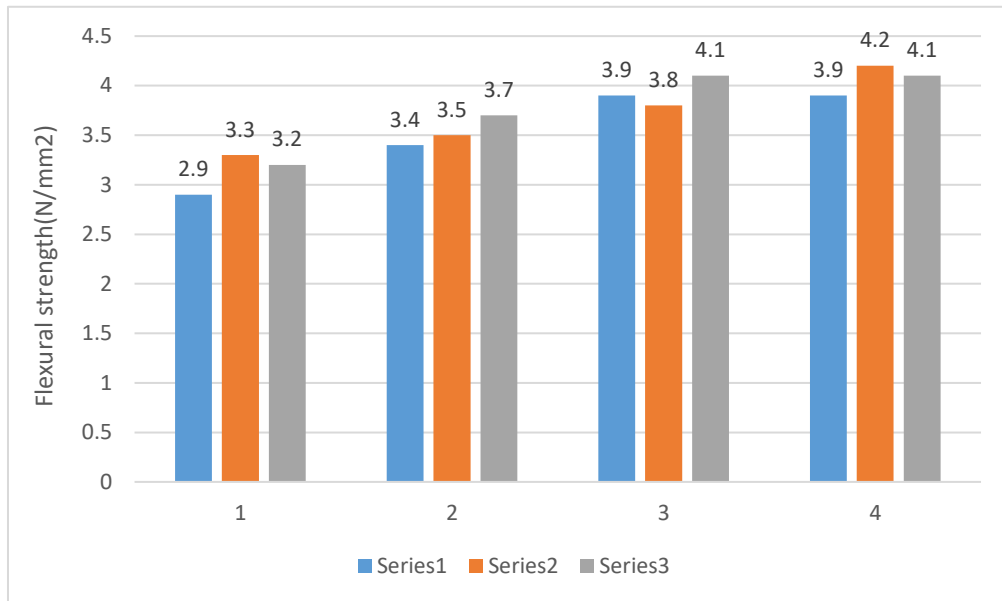


Fig 9.1.3.5 Comparison chart for flexural strength M₃₅ grade

CHAPTER-10

CONCLUSION

1. In this test result, two different types of grade were used such as M₃₀ and M₃₅ grade. In that three different ratios were replaced by cement and 25% of recycled coarse aggregate were used to check the compressive strength, split tensile strength and flexural strength.
2. The ratios such as bottom fly ash 10% calcium carbide residue 20%, bottom fly ash 20% calcium carbide residue 10% and bottom fly ash 20% calcium carbide residue 20%.
3. It was proved that the replacement of natural aggregate by RCA upto 20% has no negative influence on physic-mechanical properties of concrete.
4. The result on the physical properties of the recycled aggregate clearly show a higher capacity, rate of porosity also important upto 7% greater than that of natural gravel.
5. The result obtained after casting the concrete the optimum percentage of bottom fly ash and calcium carbide residue of compressive strength, split tensile strength and flexural strength is 10%.
6. While comparing three different ratios the optimum percentage of bottom fly ash and calcium carbide residue of compressive strength, split tensile strength and flexural strength is increased in the ratio of bottom fly ash 20% and calcium carbide residue 20% than the conventional concrete.

CHAPTER-11

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