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Project Report on Analysis of steel fibre concrete with varying Aggregate grading

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CERTIFICATE
This is to certify that the following students have satisfactorily carried out B.E. projectworkentitled"Analysis of steel fibre concrete with varying Aggregate grading" ThisworkisbeingsubmittedfortheawardofdegreeofBachelorofCivilEngineering.It is submitted in the partial fulfilment of the prescribed syllabus of Savitribai PhulePuneUniversity,Punefor theacademicyear 2020– 2021.

ACKNOWLEDGEMENT
Weherebyaregratefultobeabletopresentourprojecton thetopic"Analysis of steel fibre concrete with varying Aggregate grading: And we wouldliketo givethanks to the people who havehelpedand supportedus throughthis.
We wish to express our deepest thanks to our project guide and lecturer Asst.Prof. Amol More sir for helping us with his valuable advice and ever readysupport during making of this project. Without his counsel, keen insight and positivereinforcement,we wouldn't havebeen able to deliverourverybest.
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We would also like to thank our institution and faculty members without whomthe seminar would have been a distant reality. We also extend thanks to our familymembersand ourwell-wishers who havestood byus.

ABSTRACT
Theusefulnessoffiberreinforcedconcrete(FRC)invariouscivilengineering applications is indisputable. Fiber reinforced concrete has so far been successfullyused in slabs on grade,architectural panels, precast products, offshore structures, structures inseismic regions, thin and thick repairs, crash barriers, footings, hydraulic structures and manyother applications.Fiber Reinforced Concrete (FRC) is gaining attention as an effective way toimprove the performance of concrete.Fibers are currently being specified in tunneling, bridgedecks,pavements,loadingdocks,thinunbonded overlays,concretepads,andconcretesslabs.These applications of fiber reinforced concrete are becoming increasingly popular and areexhibitingexcellentperformance.
iber-reinforcedconcrete (FRC)is concrete containingfibrousmaterialwhichincreasesitsstructural integrity. It contains short discrete fibers that are uniformly distributed and randomlyoriented.Fibersinclude steelfibers, glassfibers ,syntheticfibersand naturalfibers Thisstudypresentsunderstandingsrengthoffibrereinforcedconceret.Mechanicalpropertiesand durability of fiber reinforcedconcrete.

A) Relevance

Compared to other building materials such as metals and polymers, concrete is significantlymore brittle and exhibits a poor tensile strength. Based on fracture toughness values, steel is atleast 100 times more resistant to crack growth than concrete. Concrete in service thus crackseasily and this cracking creates easy access routes for deleterious agents resulting in earlysaturation,freeze-thaw damage,scaling, discolorationand steel corrosion.

The concerns with the inferior fracture toughness of concrete are alleviated to a large extentbyreinforcingitwithfibersofvariousmaterials. Theresultingmaterialwitharandom distribution of short, discontinuous fibers is termed fiber reinforced concrete (FRC) and is slowlybecoming a well accepted mainstream construction material. Significant progress has been madein the last thirty years towards understanding the short and long-term performances of fiberreinforced cementitious materials, and this has resulted in a number of novel and innovativeapplications.

Concrete is one of the most versatile building materials. It can be cast to fit any structuralshape from a cylindrical water storage tank to arectangular beam or column in a high risebuilding.Theadvantagesof usingconcreteincludehighcompressivestrength,good fireresistance,highwaterresistance, lowmaintenance, andlong servicelife.

Thedisadvantagesofusingconcreteincludepoortensilestrength,lowstrainoffractureandformwork requirement.Themajordisadvantageisthatconcretedevelopsmicrocracksduring curing. It is the rapid propagationof these micro cracks under applied stress that isresponsible for the lowtensile strength of the material. Hence fibres are added to concrete toovercomethesedisadvantages.

The addition of fibres in the matrix has manyimportant effects. Most notable amongtheimprovedmechanicalcharacteristicsofFibreReinforcedConcrete(FRC)areitssuperiorfracture strength, toughness, impact resistance, flexural strength resistance to fatigue,improvingfatigueperformanceis oneoftheprimaryreasons fortheextensiveuse of Steel Fibre Reinforced Concrete(SFRC)in pavements, bridge decks, offshore structures andmachinefoundation,wherethecompositeissubjectedtocyclicallyvaryingloadduringitslifetime.

Themainreasonsforaddingsteelfibrestoconcretematrixistoimprovethepost-cracking response of the concrete, i.e., to improve its energyabsorption capacity and apparentductility and to provide crack resistanceand crack control. Also, it helps to maintain structuralintegrityandcohesiveness in the material. The initial researches combined with thelarge volumeoffollow up research have led to the development of a widevariety of material formulations thatfitthedefinition of FibreReinforcedConcrete.

B) Present Theoriesand Practices

Numerousstudieshavebeencarriedouttostudythe Analysis of steel fibre concrete with varying Aggregate grading.Afewofthestudiesarereviewedandbrieflymentionedas follows.

HaiderM.Al-Baghdadi , FaizH.Al-Merib (2021) Department of CivilEngineering, Collegeof Engineering, Universityof Babylon,Babylon, Iraqthisstudyistoinvestigatetheinfluenceofsteelandsyntheticfiberparameters,alongwithdifferentcoarseaggregatemaximumsizes(CAMZs)onFRCperformance.Additionally,inpastresearch,theempiricalrelationshipsamongthecompressive,tensile,andflexuralstrengthsofplainconcreteandFRCwereassessed,andcorrelationsbetweenthesemechanicalpropertiesofFRC were examined.For each CAMZ, four fiber dosages for each fiber type were considered.

M Acikgens(2015)studiedcarriedoutthestudyBased on our experimental results on the effects of gradation and Dmaxon SFRC properties with constant cement dosages and W/C ratios, the following conclusions can be drawn.

In addition to reduce of the workability by using 1% steel fibres, most of the slump values of the SFRC mixture were 0. The results of the Ve-Be tests were more variable than the slump tests for SFRC. Changing the aggregate grading had a noticeable effect on the workability of both SFRC and reference concrete. The finest and the coarsest grading showed low workability for both Dmaxvalues. SFRC mixtures with smaller Dmaxwere more workable.

Dr. D.A.Sinha(2017)Addition of 1% steel fibres result in higher compressive strength and use of more than 1% steel fibres will bring down the compressive strength. Addition of 1% steel fibres result in higher tensile strength and use of more than 1% steel fibres will bring down the tensile strength

Flexural strength is found to increase as the percentage of steel fibres in it increases

Prof.Kalpan.Sutar (2015) The addition of fibers in concrete specimens like Cubes and Prisms here is a increase in strength up to some percentage level. The maximum percentage increase in compressive strength at 75% fibre contain it was 9.2%.The corresponding increase in flexural and strength value were 21.21% for 28 days.

Archana Dongre (2017) A brief state-of-the-art report on fiber reinforced concrete is presented.Our understanding of fiber-matrix interaction, reinforcement mechanisms and performance characteristics is fairly advanced.

Fiber reinforced concrete is a promising material to be used in the Middle-East for sustainable and long-lasting concrete structures. Its performance has already been proven in other hot and arid climates and in other chemically deleterious environments.Fiber reinforced concrete pavements prove to be more efficient than conventional RC pavements, in several aspects.

K.SrinivasaRao(2013)studied An increase in compressive strength and tensile strength has been observed for both standerd concrete and fibre reinforced standerd concrete whene exposed to tempreture of 50*c

Age of concrete has a role in attaining durable concrete, both M30 controlled concrete and M30 steel fibre reinforced concrete suffers more weight loss at later ages compared to early ages of concrete

At 200°C temperature, steel fiber reinforced standard concrete shows a decrease of 60% in weight loss compared to M30 controlled concrete at the age

Ulaka DC(2019)This study shows that concretes of the same mix ratio, maximum size of aggregate and water content will have their strength and workability properties differ if they are subject to a change in aggregate gradation. It shows that as the fineness modulus increases, the concrete becomes weaker but more workable. Finally the density of concrete in not affected by the maximum aggregate size or the grading of aggregates in the mix and could be the reason why the unit weight of mass concrete is usually specified as $24kN/m^3$ irrespective of the concrete mix ratio.

Prasad Rangaraju (2013)whether coarse aggregates or fine aggregates, failing to meet the standard SCDOT specifications have a broad range of impacts on various properties of concrete, depending on a number of factors. The impact on concrete properties ranges from nothing significant on certain properties (such as compressive strength, modulus of elasticity, density and others) to significant on certain other selected properties such as split tensile strength and rapid chloride ion permeability among others. The specific impact of a failed aggregate gradation not only depends on whether the aggregates fail on the coarser or the finer side of the gradation but also on the extent of the failure away from the acceptable gradation limits.

C) Scope of work

The aim of this study is to investigate the impact of the steel and synthetic fiberparameters(fiberlength,diameter,andshape),alongwiththeCAMZ,ontheworkability,compressive, tensile, and flexural strengths of FRC. The fiber length (l_f) from 13 mm to60 mm, CAMZ from 9.5 mm to 37.5 mm, and ratio of l_f/CAMZ in the range of 0.35–5.68were conducted in order for the results to be used in the proposed logical range of thel_f/CAMZ ratio. For each CAMZ, four fiber dosages of 0.0%, 0.5%, 1.0%, and 1.5% by thevolumeofconcreteforeachfibertypewereconsidered.Moreover,inthisresearch,correlationsamongtheflexural,splittingtensile,andcompressivestrengthsofsynthetic/steelFRC with different fiber parameters were analyzed and evaluated with past researchempiricalrelations.

D) Proposed work

Theobjectivesofproposedworkarelisted below:

1. The hardened properties, such as the compressive, splitting tensile and flexural strengths, were also analys
2. This study investigates the effects of changing the aggregate grading and maximum aggregate
3. Analysis different fibre type
4. In addition, the toughness of the SFRC was calculated
5.

E) Expected Date of completion: June 2021

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4.FIBREREINFORCEDCONCRETE-ACASESTUDY Archana DongrePaper 2017

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NOTATIONS

1. FRC–Fibre Reinforced Concrete
2. CAMZ– Coarse Aggregate Maximum Size
3. Lf–Length of Fibre
4. ASTM–American society for testing Material
5. W/C– Water cement ratio
6. MSF–Micro Steel Fibre
7. HSF–Hooked end Steel Fibre
8. MSYF– Micro Synthetic Fibre
9. G10–10 mm Coarse Aggregate
10. G19 – 19 mm Coarse Aggregate

I. INTRODUCTION

1.1 Introduction of the Project Work

Concrete is identified to be weak in resisting tensile stresses and can easily crack underlow-leveltensileforces.Incorporatingfiberintotheconcrete mixtureisatypicalmethodtomodifyconcretematerial. Duetothedistributionoffiberintheconcretemixture,themechanicalpropertiesoffiberreinforcedconcrete(FRC)mightbeimproved.Theamountofenhancementoftheperformanceofaconcretestructureismainlyproportionaltothevolumefraction,aspectratio,fibergeometry, fiberdistribution,andfiberorientation.

One of the effects on the fiber orientation and distribution in the concrete matrix isthe coarse aggregate maximum size (CAMZ), which significantly impacts the mechanicalproperties of FRC. With the CAMZ increased from 3 mm to 14 mm, the tensile strength andelasticity modulus reduce, while the fracture energy of concrete specimens is enhanced.Appa Rao and Raghu Prasad found that the fracture toughness and fracture energy ofconcretewereenhancedduetotheincreaseoftheCAMZfrom4.75mmto20mm.

Fig.1 Fiber Rein forced Concrete

Past research has investigated the effect of CAMZs of 8, 13, and 20 mm and fiber dosages of 0.0%, 1.0%, and 2.0% on the flexural performance of steel FRC . Accord- ing to Olivito and Zuccarell , to ensure a uniform and efficient fiber distribution, the steel fiber length should be two times more than the CAMZ. Additionally, steel FRC with a small CAMZ shows better flexural behavior, and the CAMZ of steel FRC should not go beyond a three-quarter steel fiber length [16]. The ratio of the length of the steel fiber to the CAMZ influences the mechanical properties of steel FRC as much as the fiber content

The steel fiber parameters have substantial effects on the properties of FRC. FRC with a 60 mm length of steel fiber exhibits higher flexural strength and fracture strength than the concrete with a 30 mm steel fiber length . On the other hand, Doo-YeolYoo et al. reported that the incorporation of a 30 mm fiber length in concrete showed less improvement in flexural performance compared with the FRC with a 13–19.5 mm fiber length. Other fiber parameters that impact the FRC properties are the fiber type and fiber shape, which

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may influence the dynamic and static concrete properties . The distribution and orientation of steel fiber have considerably influenced concrete perfor- mance . According to the investigations of MertYücelYardimci et al. and Lee and Kim , the CAMZ and properties of steel fiber influence the fiber fracture energy and orientation of steel FRC. In addition, another study by Su Tae Kang et al. reported that the ultimate flexural strength of steel FRC was mainly affected by the fiber distribution characteristics, with less impact on the first cracking strength.

Researchtodateonusingsteelfiberinconcretemixturesindicatesanimprovementin the mechanical properties of FRC. However, there is no study examining the effect ofthe CAMZ on the behavior of synthetic FRC. Additionally, for steel FRC, past researchhas investigated the impact of CAMZs less than 25 mm on concrete performance, alongwith limited studies on CAMZs larger than 25 mm. Therefore, in order to find optimalfiber strengthening and toughening with different CAMZs, it is necessary to understandthe correlations among the flexural, splitting tensile, and compressive strengths of syn-thetic/steel FRC with different fiber parameters. Studies about the relationship betweenfiberparametersandCAMZsofFRCarelimited.

1.2 Problem Statement

Plain, unreinforced concrete is a brittle material, with a low tensile strength and a low strain capcity. The role of randomly distributes discontinuous fibres is to bridge across the cracks that develop provides some postcracking "ductility". If the fibres are sufficiently strong, sufficiently bonded to material, and permit the FRC to carry significant stresses over a relatively large strain capacity in the post cracking stage. But As the steel fibres affect the mechanical properties of the concrete positively, they also affect workability negatively.

So need to add some different aggregate grading to achieve good workability with good strength and with optimum water cement ratio

1.3 Objectives

Thisprojectwascarriedoutwiththe followingpurposes:

12. The hardened properties, such as the compressive, splitting tensile and flexural strengths, were also analys
13. This study investigates the effects of changing the aggregate grading and maximum aggregate
14. Analysis different fibre type
15. In addition, the toughness of the SFRC was calculated

1.4 Scopeof theProjectWork

The aim of this study is to investigate the impact of the steel and synthetic fiberparameters(fiberlength,diameter,andshape),alongwiththeCAMZ,ontheworkability,compressive, tensile, and flexural strengths of FRC. The fiber length (l_f) from 13 mm to60 mm, CAMZ from 9.5 mm to 37.5 mm, and ratio of l_f/CAMZ in the range of 0.35–5.68were conducted in order for the results to be used in the proposed logical range of thel_f/CAMZ ratio. For each CAMZ, four fiber dosages of 0.0%, 0.5%, 1.0%, and 1.5% by thevolumeofconcreteforeachfibertypewereconsidered.Moreover,inthisresearch,corre-lationsamongtheflexural,splittingtensile,andcompressivestrengthsofsynthetic/steelFRC with different fiber parameters were analyzed and evaluated with past researchempiricalrelations.

II. LITERATURE REVIEW

Numerous studies have been carried out to study the affect of steel fibre in concrete. A few of the studies are reviewed andbrieflymentioned as follows.

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In addition to reduce of the workability by using 1% steel fibres, most of the slump values of the SFRC mixture were 0. The results of the Ve-Be tests were more variable than the slump tests for SFRC. Changing the aggregate grading had a noticeable effect on the workability of both SFRC and reference concrete. The finest and the coarsest grading showed low workability for both

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Dmaxvalues. SFRC mixtures with smaller Dmaxwere more workable.

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Jeetendra Prajapati1 (2019)

study of gradation, it can be concluded that the most of the aggregate available are of nominal maximum size 40mm with partially out of gradation limit given by IS383-1970. From mechanical test of aggregate, most of the aggregate samples can be concluded as medium strength aggregate although there is some variation in mechanical strength. The effect of the coarse aggregate source on compressive strength of various nominal mix concrete can be concluded based on the 7 days and 28 days compressive strength test results. The results of 7 and 28 days compressive strength test showed there is significant effect of coarse aggregate sources on the compressive strength of various nominal mix design concrete. As per the research result, keeping other parameters same, variation in coarse aggregate source only can cause up to 47% variation in the 28 days compressive strength.

Archana Dongre(2017)A brief state-of-the-art report on fiber reinforced concrete is presented.Our understanding of fiber-matrix interaction, reinforcement mechanisms and performance characteristics is fairly advanced. Fiber reinforced concrete is a promising material to be used in the Middle-East for sustainable and long-lasting concrete structures. Its performance has already been proven in other hot and arid climates and in other chemically deleterious environments.Fiber reinforced concrete pavements prove to be more efficient than conventional RC pavements, in several aspects

Compressive strength for fibre reinforced concrete is seen to be improved. It can be clearly seen that strength at 28 days for CSFRC 1% is better than other cases hence recommended

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Age of concrete has a role in attaining durable concrete, both M30 controlled concrete and M30 steel fibre reinforced concrete suffers more weight loss at later ages compared to early ages of concrete

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Prasad Rangaraju (2013)whether coarse aggregates or fine aggregates, failing to meet the standard SCDOT specifications have a broad range of impacts on various properties of concrete, depending on a number of factors. The impact on concrete properties ranges from nothing significant on certain properties (such as compressive strength, modulus of elasticity, density and others) to significant on certain other selected properties such as split tensile strength and rapid chloride ion permeability among others. The specific impact of a failed aggregate gradation not only depends on whether the aggregates fail on the coarser or the finer side of the gradation but also on the extent of the failure away from the acceptable gradation limits.

Karthik Obla(2007)Based on the results of this study, it can be concluded that there is no assurance that a concrete specification that includes a requirement for WG through compliance with CF and/or 8-18 charts will lead to reduced mixing water content or lower shrinkage as is typically the goal with these controls on aggregate grading.

The above conclusion does not mean that aggregate grading is unimportant for concrete performance. For example if adequate fine material is not present then the concrete can become prone to segregation, and high bleeding. On the other

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hand too much of fine material may make it sticky and difficult to finish.

III. METHODOLOGY

3.1 AnalysisofFibre Reinforced Concrete

Compared to conventional concrete, fiber reinforced concrete mixes are generally characterizedby higher cement factor, higher fine aggregate content and smaller size coarse aggregate. A fibermix generally requires more vibration to consolidate the mix. External vibration is preferable toprevent fiber segregation. Metal trowels, tube floats, and rotating power floats can be used tofinish the surface. Mechanical Properties of FRC Addition of fibers to concrete influences itsmechanical properties which significantly depend on the type and percentage offiber. Fibers withend anchorage and Properties and Applications ofFiber Reinforced Concrete.High aspect ratiowere found to have improved effectiveness. It was shown that for the same length and diameter,crimped-end fibers can achieve the same properties as straight fibers using 40 percent lessfibers[S].Indeterminingthemechanicalproperties ofFRC,thesameequipmentandprocedureas used for conventional concrete can also be used. Below are cited some properties of FRCdeterminedby differentresearchers.

CompressiveStrength:
The presence of fibers may alter the failure mode of cylinders, but the fiber effect will be minorontheimprovementof compressivestrength values (0 to15 percent)

ModulusofElasticity:
Modulus of elasticity of FRC increases slightly with an increase in the fibers content. It wasfound that for each 1 percent increase in fiber content by volume there is an increase of 3 percentinthemodulus of elasticity.

Flexure:
Theflexuralstrengthwasreportedtobeincreasedby2.5 timesusing4percentfibers.
Toughness: ForFRC,toughnessis about10to40 timesthatofplain concrete.

SplittingTensileStrength:
The presence of 3 percent fiber by volume was reported to increase the splitting tensile strengthofmortar about2.5 times that of theunreinforcedone.

FatigueStrength:
The addition offibers increases fatigue strength of about 90 percent and 70 percent of the staticstrengthat2 x106 cyclesfor non-reverseand fullreversal ofloading, respectively.

ImpactResistance:
Theimpactstrengthforfibrousconcreteisgenerally5to 10timesthatofplainconcretedependingon thevolumeof fiber.

CorrosionofSteelFibers:
A lyear exposure of steel fibrous mortar to outdoor weathering in an industrial atmosphereshowed no adverse effect on the strength properties. Corrosion was found to be confined only tofibers actually exposed on the surface. Steel fibrous mortar continuously immerse in seawater for10yearsexhibiteda15percentlosscomparedto40percentstrengthdecreaseofplainmortar.

StructuralBehaviorofFRC
Fibers combined with reinforcing bars in structural members will be widely used in the future.Thefollowing aresomeof thestructural behavior

Flexure
The use of fibers in reinforced concrete flexure members increases ductility, tensile strength,moment capacity, and stiffness. The fibers improve crack control and preserve post crackingstructuralintegrity of members.

Torsion:
The use of fibers eliminate the sudden failure characteristic of plain concrete beams. It increasesstiffness, torsional strength, ductility, rotational capacity, and the number of cracks with lesscrackwidth.

Shear:
Addition of fibers increases shear capacity of reinforced concrete beams up to 100 percent.Addition of randomly distributed fibers increases shear-friction strength, the first crack strength,andultimatestrength.

Column:
The increase of fiber content slightly increases the ductility of axially loaded specimen. The useoffibers helps in reducing theexplosivetypefailurefor columns.

HighStrengthConcrete:
Fibers increases the ductility of high strength concrete. The use of high strength concrete andsteelproducesslendermembers.Fiberadditionwill

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helpincontrollingcracksanddeflections.

CrackingandDeflection:
Testshaveshownthatfiberreinforcementeffectivelycontrolscrackinganddeflection,inaddition to strength improvement. In conventionally reinforced concrete beams, fiber additionincreasesstiffness, and reduces deflection.

3.2 Types of Fibres
3.2.1 Steel Fiber Reinforcedconcrete:

Steel fiber-reinforced concrete is basically a cheaper and easier to use form of rebar reinforcedconcrete. Rebar reinforced concrete uses steel bars that are laid within the liquid cement, whichrequires a great deal of prep work but make for a much stronger concrete. Steel fiber-reinforcedconcreteusesthinsteelwiresmixedinwiththecement.Thisimpartstheconcretewithgreaterstructuralstrength,reducescrackingandhelpsprotectagainstextremecold.Steelfiberisoftenusedin conjunction with rebar or oneoftheother.

FIG3.1STEELFIBERS

3.1.2GLASSREINFORCEDCONCRETE:

Glassfiber-reinforced concrete uses fiberglass, much like you would find in fiberglass insulation,to reinforce the concrete. The glass fiber helps insulate the concrete in addition to making itstronger. Glass fiber also helps prevent the concrete from cracking over time due to mechanicalor thermal stress. In addition, the glass fiber does not interfere with radio signals like the steelfiberreinforcementdoes.

FIG3.2 GLASSFIBRES

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- Veryhightensilestrength1020 to4080N/mm2.
- Showscomparableimprovementindurabilit ytoconventionalE-glassfiber.

3.1.3 SYNTHETICREINFORCEDCONCRETE:

Synthetic fiber-reinforced concrete uses plastic and nylon fibers to improve the concrete'sstrength. In addition, the synthetic fibers have a number of benefits over the other fibers. Whilethey are not as strong as steel, they do help improve the cement pumpability by keeping it fromsticking in the pipes. The synthetic fibers do not expand in heat or contract in the cold whichhelps prevent cracking. Finally synthetic fibers help keep the concrete from spalling duringimpactsor fires.

FIG3.3SYNTHETICFIBRES

3.1.4 NATURALFIBREREINFORCEDCONCRETE:

Historically, fiber-reinforced concrete have used natural fibers, such as strew or hair. Whilethese fibers help the concrete's strength they can also make it weaker if too much is used. Inaddition if the natural fibers are rotting when they are mixed in then the rot can continue while inthe concrete. This eventually leads to the concrete crumbling from the inside, which is whynaturalfibers areno longer used in construction.

Fig. 3.4 Strew fibre

3.1.5 ASBESTOSFIBER REINFORCED CONCRETE:

- ✓ Mineralfiber,mostsuccessfulofallasitcanbemixe dwithportlandcement.
- ✓ Tensilestrengthofasbestosvariesbetween560to9 80N/mm2.
- ✓ Asbestoscementpastehasconsiderablyhigherfle xuralstrengththanPortlandcementpaste.
- ✓ Forunimportantconcretework,organicfiberslike coir,juteandcanesplitsarealsoused.

FIG3.5 ASBESTOSFIBRES

3.1.6 CARBONFIBER REINFORCED CONCRETE:

- ✓ Possesveryhigh tensilestrength2110 to2815N/mm2 andYoung'smodulus.
- ✓ Cementcompositeconsistingofcarbonfibersshowveryhighmodulusofelasticityandflexuralstrength.

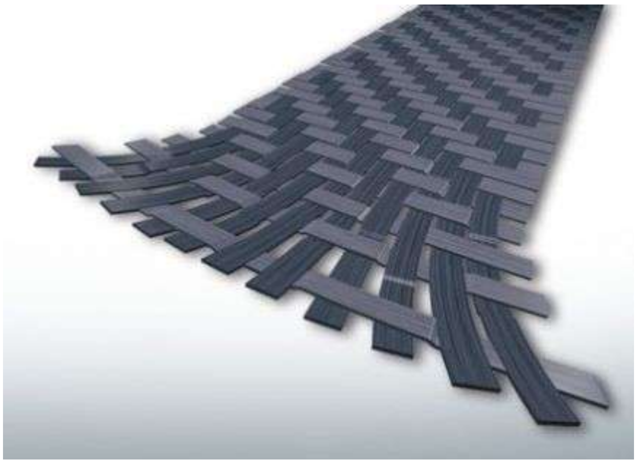

FIG3.6 CARBONFIBRES

IV. ANALYSEEXPERIMENT PROGRAM BASED ON PAPER STUDY

4.1 Material:

ThecompositionofPortlandcementutilizedinthisstudyislistedinTable-1,in accordance with ASTM .In Table, the physical composition of the cementis presented along with the ASTM limits. River sand (fine aggregate) passedthrough a 4.75 mm sieve was used. The sieve analysis of the fine aggregate and the passingoftheoveralllimitofASTMarelistedinTable 3 .Forthecoarseaggregate,threeCAMZswereused(CAMZ=9.5mm,19mm,and37.5mm),namelyG10,G19,andG38, respectively. The sieve analysis of the coarse aggregates is listed in Table 4 . This tableshowsthatthegradingofthecoarseaggregatewaswithintheASTMlimits.

Three fiber configurations, namely micro steel fiber, hooked end steel fiber, and macrosynthetic fiber, were used. For the micro steel fiber (HAREX copper-plated micro-filamentsteel fiber), the fiber length was 13 mm. In addition, for the hooked end steel fiber (HAREXfiber), lengths of 35 mm and 60 mm were used. Fiber lengths of 19, 38, and 54 mm wereusedforthemacrosyntheticfiber(FortaFerroconcretefiber).Thepropertiesofthestudiedfibersarelistedin Table 5 ,andFigureshowsaphotoofeachfibertype.

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Table1. Portlandcementcomposition

Constituent	ChemicalComposition	Cement(TypeI)%byWeight
Aluminumoxide	Al2O3	5.45
Iron oxide	Fe2o3	3.41
Magnesia	MgO	3.7
Sulfate	SO_3	2.25
Tricalciumaluminates	C_3A	9.85
Tricalciumsilicate	C_3S	40.43
Diacalciumsilicate	C_2S	28.1
Tricalciumaluminaferrite	C_4AF	8.12

Table2. Physicalcompositionofthecement

Physical properties	Test results
Fitness, specification (m2/kg)	
Turbidimeter test	190
Air permeability	310
Soundness using autoclave method	0.12%
Setting time at which vicat's instrument was used	
Initial (min)	120
Final (min)	280
Compressive strength for the cement paste cube	
3days (Mpa)	16
7days (Mpa)	25

Table No.3 Sieve analysis of the fine aggregate

Sieve size (mm)	Commulatieve passing%	% passing of the overall limit of ASTMC33-03 (30)
9.5	100	100-100
4.75	97	95-100
2.36	92	80-100
1.18	72	50-85
0.6	41	25-60
0.3	14	5-30
0.15	4	0-10

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Table No.4 Sieve analysis of the coarse aggregate

Aggregate Id	Sieve Size(mm)	Cumulative Passing%*	%Passing of the overall limit of ASTMC33-03{30}
G10	9.5 4.75 2.36 1.18	96 25 8 0	85-100 10-30 0-10 0-5
G19	19 4.2 4.75 2.36	98 51 4 0	90-100 20-55 0-10 0-5
G38	37.5 11.2 9.5 4.75	96 45 21 3	95-100 35-70 10-30 0-5

TABLE NO.5 Properties of fibre provided by the manufacturer

Fiber type	material	Length(if)(mm)	Diameter(df)(mm)	Aspect ratio(if/df)	Tensile strength Mpa
Microsteel fibre	Steel	13	0.2	65	>2100
Hooked end	Steel	35	0.55	64	900-2200
Hooked end	Steel	60	0.75	80	900-2200
Macro synthetic	Copolymer / polypropene	19	0.34	56	570-660
Macro synthetic	Copolymer / polypropene	38	0.34	112	570-660
Micro synthetic	Copolymer / polypropene	54	0.34	168	570-660

a) b)

 

C) d)

 

e) f)

Table6. Mixconstituents

Constituents	**Mix1**	**Mix2**	**Mix3**
Cement (kg/m3)	450	450	450
Water (kg/m3)	203	203	203
Water/Cement ratio	0.45	0.45	0.45
Sand (kg/m3)	723	723	723
Coarse Aggregate (Kg/m3	1010	1010	1010
CAMZ (mm)	10	19	38
Fibre content (%) by volime	0/0.5/1.0/1.5	0/0.5/1.0/1.5	0/0.5/1.0/.5

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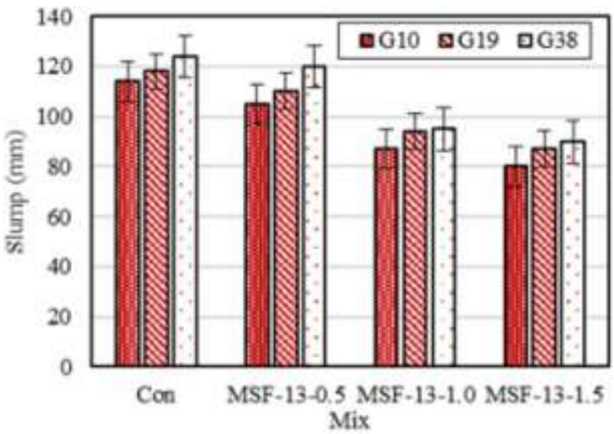
4.3.Results and Discussions:

4.3.1 EffectofFiberPropertiesonFlowability

The effects of the fiber type, dosage, and CAMZ on the slump of fresh synthetic/steelFRC are depicted. It should be highlighted that regardless of the fiber type, thefiber inclusion into the concrete damagingly impacted the flowability of fresh FRC. For themicro steel fiber (MSF), maximum slump declines of 7.9%, 23.7%, and 29.8% occurred forMSF concrete with 0.5%, 1.0%, and 1.5% fiber dosages, respectively, compared with thecontrol mix. Additionally, the hooked end steel fiber (HSF) added into the control concretehadhighernegativeeffectsontheslumpresults comparedwiththeMSFmixtures,withthe maximum slump decreases being around 10%, 28%, and 34% for HSF concrete with0.5%,1.0%,and1.5%fiberdosages,respectively,forbothfiberlengths(35mmand60mm).Moreover,Figure,showsgreaterinfluencesfromthelongestfiberlengthsoftheHSFandsyntheticfiber(SYF)ontheflowabilitycomparedwiththeshortfibers.Thereductionin the fresh concrete flowability with incorporated synthetic/steel fiber might be attributedto the scattering of the fiber in fresh mixture concrete, which established interfacial bondingbetween the fibers and the concrete matrix . In Figure, the results of the slump testrevealthattheslumpoffreshsynthetic/steelfibermixproducedadecreasingtendency.

with the synthetic/steel fiber length’s increase.Thus, the impact of the fiber–concretematrixtooktheleadforthedecreaseofthemixslump,eventhoughthenumberoffiberswaslower in the same fiber dosagewith the same volume of concrete.



Furthermore,theslumpoffreshsynthetic/steelmixturealongwithcontrolmixtureenhancedastheCAMZincreasedfrom9.5mmto37.5mm.Itshould benotedthat the increase of the CAMZ may decrease the small particle content in the aggregate,which negatively influences the amount of concrete mixture covering the coarse aggregate,causinganincreaseoftheslump.

4.3.2 EffectofFiberPropertiesontheCompressiveStrength

Thecompressivestrengthof the control concrete was reduced by increasing the CAMZ, and the percentage decreaseswere 6.6% and 16.6% for the Con-G19 and Con-G38 mixtures, respectively, compared withtheCon-G10mixture.Forspecimenswithincubatingsynthetic/steelfiber,theresultsdisplay that the compressive strength of the FRCs was improved by the incorporation offibers, and the maximum percentage increases were around 62%, 85%, and 82% for theMSF-13-1.5-G10, MSF-13-1.5-G19, and MSF-13-1.5-G38 mixtures, respectively, comparedwith the Con mixtures. It should be highlighted that regardless of the fiber type and dosage,thefiberinclusionintotheconcretesignificantlyimpactedthecompressivestrengthoftheFRC.Thisenhancementmaybeduetothefactthatthefiberscanbridgemicrocracksandmacrocracksthatformintheconcretematrix.ItshouldbehighlightedthatthecompressivestrengthwasonlymarginallyaffectedbytheCAMZcomparedwiththefiber dosage and geometrical properties, such as the length and diameter, which had aninsignificantinfluenceonthecompressivestrength

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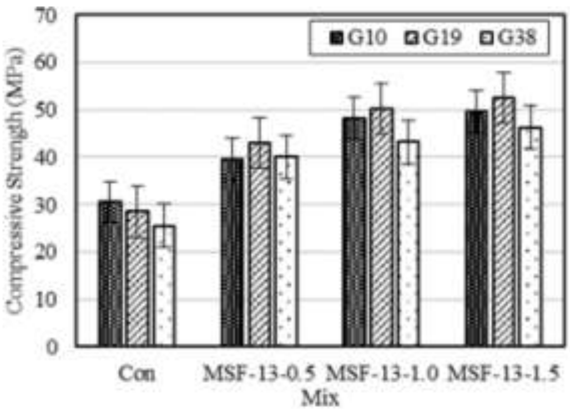


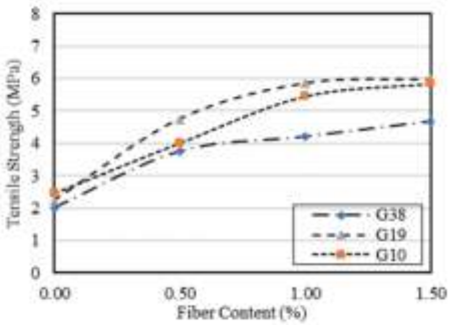
(a)

Thegreatestimprovementofthecompressive strengthwasprovidedbyusingtheMSFwitha1.5%fiberdosagealongwitha19mmCAMZ(G19).Thismaybeduetothefact that the MSF had a higher fiber content among the other fiber types in the same fiberdosage.

4.3.3 EffectofFiberPropertiesontheTensileStrength

The effects of the fiber type, dosage, and CAMZ on the splitting tensile strength arepresentedinFigure. the splitting tensile strength of the control concrete wasreducedbyincreasingtheCAMZ,andthepercentagedecreaseswere8.6%and18.0%forthe Con-G19 and Con-G38 mixtures, respectively, compared with the Con-G10 mixture. Onthe other hand, the results show that adding fiber into the concrete significantly enhancedthetensilestrength,withthegreatestimprovementsof165%,193%,and231%occurringforthe SYF-54-1.5-G10, SYF-54-1.5-G19, and SYF-54-1.5-G38 mixtures, respectively, comparedwith the control mixtures. This behavior is primarily recognized as the bond between theconcrete matrix and the fiber. Generally, the improvement of the FRC behavior was muchmoresignificantinthetensionbehaviorthaninthe compressionbehavior.

For the specimens with steel fiber, it can be seen that the splitting tensile strength ofMSF provided the highest increase compared with the other concrete mixture with hookedend steel fiber types, while the splitting tensile strengths of the synthetic fiber specimensprogressively enhanced with the increase of the length of the synthetic fiber. The splittingtensile strength improvement of the synthetic fiber specimens might be due to the syntheticfibers being pulled out after debonding between the fiber and concrete matrix rather thanbeing broken . Thus, a longer embedment length of the synthetic fiber into the concretematrixcanprovidelargerpulloutforces.



(a)

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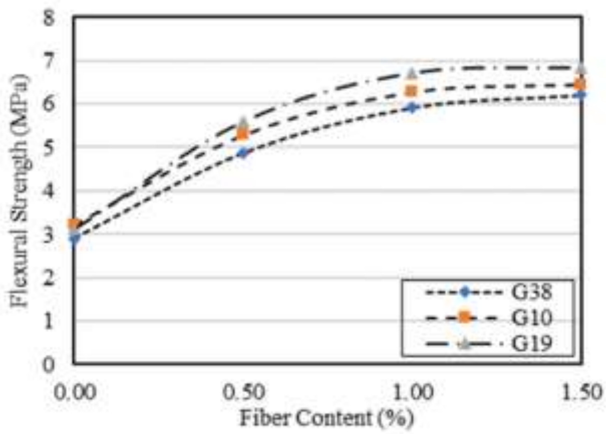
The tensile strengths of the FRC specimens improved with a CAMZ up to 19 mm andthendeclinedwithaCAMZof37.5mm,asshownin Figure5.WiththeriseoftheCAMZ,the total surface area of the coarse aggregate reduced, which decreased the concrete matrixquantity around the aggregate. This may have impacted the fiber-embedded matrix, whichled to providing weak pullout forces.Therefore, with the optimum CAMZ, the bondingstrengthat theinterface betweenthe concretematrix andfiber couldbe enhanced,andthus the strengthening influence of the fiber on the concrete strength would be enhanced.Nevertheless, the large CAMZ might have a disadvantage in the distribution of fiber inconcrete,reducingthestrengtheningimpactoffibero ntheconcretestrength.

The change rules of the splitting tensile strength ratio of the FRC to thesplitting tensile strength of the control concrete with various ratios (R_t) of the fiber length tothe CAMZ multiplied by the fiber dosage (R_t= (l_f/CAMZ) f_d). In this figure, the splittingtensile strength ratio significantly rises with the ratio (R) increase with good correlation. Inaddition, there is a significant relationship between the tensile strength ratio and ratio (R_t)for all CAMZs. This is primarily accredited to the crack bridging effect formed by the fibers.The bridging effect developed by fibers crossing cracks was improved with the increase oftheR$_t$factor,whichenhancedtheFRCmachinalperfo rmance.Theresultsdemonstratethat the fiber reinforcing effect on the tensile strength was substantial, with the ratio (R_t) ofthefiberlengthtotheCAMZmultipliedbythefiberdo sage(R_t=(l_f/CAMZ)

4.3.4 EffectofFiberPropertiesontheFlexuralStrength

It should be highlighted the CAMZ decreased the flexuralstrength by 2.8% and 9.7% for the Con-G19 and Con-G38 mixtures, respectively, comparedwith the Con-G10 mixture. For the effects of adding synthetic/steel fiber into the controlconcrete, the flexural strength significantly enhanced, and the maximum increments were115%,137%,and153%fortheSYF-38-1.5-G10,SYF-38-1.5-G19,andSYF-38-1.5-G38speci-
mens, respectively, compared with the Con specimens. This behavior of flexural strengthimprovement was attributed to the bridging fiber effect, which carried the load after theconcretematrixstartedcrackinguntiltheinterfacial debondingbetweenthefibersandthe matrix (pulled out) or fiber rupture occurred . In general, the flexural strength ofsynthetic/steel FRC depicted a trend of improving as the fiber dosage increased. However,the amount of improvement depended on the fiber configuration, as shown in Figure.Besidesthat,theincreaseoftheflexuralstrength withaCAMZof38mmshowedthegreatest increase for the synthetic and hooked end steel fiber specimens, while the microsteelfiberspecimensexhibitedbetterperforman cewithaCAMZof19mm.Moreover,most of the hooked end fiber had pulled out from the concrete matrix while synthetic fiberswere still involved in load transferring across the cracks, as shown in Figure . This actionwasmostlyattributedtotheconfigurationofeach fibertype.



(a)

Ascanbenoted,thesynthetic fibers had a larger surface area than the hooked end fibers, causing a higher bondstrengthbetweenthesyntheticfiberandtheconcretematrix.Additionally,thesameexplanationsdrawnforthedifferencesintensilestrengthwiththeriseofthefiberdosage,length,andCAMZ wereprimarilyaccountablefor thedifferencesinflexural strength.

Another approach would be to take the effect of the synthetic and steel fiber param- eters(fiberlength,diameter,andshape)alongwiththeCAMZonthecompressive-to-flexural-strength ratio as the brittleness ratio. The brittleness ratio is the ratio between thecompressive strength and the flexural strength listed in Table. For the synthetic and steelFRC specimens, the brittleness ratio and percentage changes are presented in Table. Thelowtensilecapacitywascausingearlydamagetothe concrete,whichcorrespondedtoahigh brittleness ratio of the concrete. As shown in Table, the Con specimens for all CAMZsexhibited the highest brittleness ratios among all synthetic and steel fiber specimens due tothe low flexural strength and splitting tensile strength, Thismaybeduetotheinadequatehookedendfiberperformance with a low fiber dosage and small CAMZ.

V. CONCLUSION

In the present study,and analysis of the effects of steelandsyntheticfiberparameters(fiberlength,diameter,shape,anddosage)alongwithdifferentCAMZson mechanicalproperties, .The following conclusions weredrawnbased on the study.

1. The slump test revealed that the slump of fresh synthetic/steel fiber mix produced adecreasing tendency with the synthetic/steel fiber length's increase.This decline inthe fresh concrete flowability might have been due to the fiber length increase, whichraised the overlap between fibers. Thus, the impact of the fiber–concrete matrix tookthe lead for the decrease of the mix slump,even though the number of fibers waslowerinthesamefiberdosagewiththesamevolumeofconcrete
2. Thecompressivestrengthwasonlymarginallyaffectedbythe CAMZcomparedwiththefiberdosageandgeometricalproperties,suchasthelengthanddiameter,whichhad an insignificantinfluence onthe compressivestrength
3. ThesplittingtensilestrengthoftheFRCspecimensimprovedwithaCAMZupto19mmandthendeclinedwithaCAMZof37.5mm.WiththeriseoftheCAMZ,thetotalsurfaceareaofthecoarseaggregatereduced,whichdecreasedtheconcretematrix quantity covering the aggregate. Therefore, the large CAMZ might havehadadisadvantageinthefiberdistributionoffiberintheconcretethatreducedthestrengthening impact ofthe fiber onthe concrete strength.
4. The synthetic fibers had a larger surface area than the hooked end fibers, causing ahigher bond strength between the synthetic fiber and concrete matrix. In addition,the same explanations drawn for the differences in tensile strength with the rise ofthe fiber dosage, length, and CAMZ were primarily accountable for the differences inflexuralstrength.
5. The flexural strength ratio significantly rose with the ratio (Rf) increase with goodcorrelation.Additionally,therewasasignificantrelationshipbetweentheflexural strengthratioandratio(Rf)forallCAMZs.

6. The mechanical properties of synthetic and steel FRC could be influenced by manyfactors,such as the fiber type,steel fiber geometry,fiber parameters,aspect ratio,and fiber dosage

7. It should be highlighted that the regression analysisinvestigation was conducted for all compressive strengths, splitting tensile strengths,and flexural strengths of the synthetic and steel FRC with the considerationofthesefactors.Thesefactorswerea fiberlengthfrom13mmto60mm,CAMZfrom9.5mmto37.5mm,andratioofthefiberlengthtotheCAMZintherangeof0.35–5.68.Therefore, it can be noted that there were strong correlations from the regressionanalysisofthemechanicalpropertyresultsofsyntheticandsteelFRC.

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