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Mechanical Property Evaluation of Self-Compacting Concrete Incorporated with Composite Fibre

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Abstract: ***Concrete is used nowadays in most of the application for its strength and durability. The limitation in the application is due to its brittleness which causes a sudden failure. Even if the concrete is incorporated with fillers like silica fume, fly ash, slags etc., because of high cement content and low water-cement ratio, it is subjected to early age cracking. To reduce this problem, the application of composite fibre forming hybrid concrete will help in reducing the crack width and improve the load carrying capacity with large amount of deflection before failure. The research led to the study of various engineering properties of different grades of concrete such as compressive strength, splitting strength, flexural strength, relative residual strength, Impact resistance, toughness, durability properties such as resistance to freezing and thawing, sulfuric acid and chloride attack, cracked permeability and effect of elevated temperature is studied with standard experimental investigation. In addition, the study is made with varying the dosage of fibre with varying volumetric fraction between steel, polymeric and glass fibre. Such concrete elements in which the dimensions are altered the efficiency is kept in consideration along with economy to avoid loss in financial and structural aspects.***

Keywords: Concrete, Hybrid Concrete, volumetric fraction

1. Introduction

Researches in improving the performance of self-compacting concrete (SCC) were made in recent years. Much concentration was given to strengthen the bond in SCC by fibre addition. In general, SCC consists of comparatively smaller aggregate and mortar content to regular better flowability. Application of suitable fibres will help in increase in the performance. Earlier studies experimentally prove that SCC will be a viable solution in case of packed reinforcement. In addition to the concept of SCC, fibre addition will enhance its performance. By incorporating fibres the mechanical property of the concrete changes there by long term performance increases. Experimentation with blended cements using fly ash or slag powder also justifies that high silica content replacement exhibits increase in the strength property. In addition, encasing with fibre reinforcement provides noticeable efficiency. The ratio adopted between aggregate and binder and mortar to fibre significantly shows variation in the experimental results. The toughness behaviors of such concrete were not much focused. Addition of steel fibres has a great influence in arresting cracks and exhibits improved flexural property. The major defect while using steel fibre in high volume mortar mixes might result in nesting. In case of polymeric fibres such as polypropylene fibres, improvement in the toughness property of the concrete under bending load and also effect in the durability aspects. The advantage of polymeric fibre over steel is that number of fibres located the crack bridging area will be more and post crack toughness will shows a sudden dip and gradual slope thereby increasing the ductility property of the concrete. Considering glass fibre, performance is very low compared to polypropylene or steel fibre in increasing the strength of the concrete but operational problem is much reduced in case of glass fibres without any nesting errors. In the recent researches, not much concentration were given in application of composite fibre in the same mix and evaluating its performance. Attempts were made in the present study is to investigate experimentally the influence of composite fibres in self-compacting concrete, giving more emphasis to post crack performance. Two different mixes with two volume fraction (0.5&0.75%) and three types of fibres (Steel (SF), polypropylene (PP) and glass (GF)) were considered for the study. A composite combination of steel(0.5%), polypropylene(0.25%) and glass fibres(0.25%) were added by 1% volume fraction. Total of 14 fibre concrete mixes were arrived and performance based assessment were made on the mechanical properties of all these mixes and detailed assessment were made. The combined effect of all the three fibres were assessed and results also proves modified concrete records better performance that conventional fibre reinforced concrete.

1.1 Objective of the study

The main objective of this study are listed as follows

1) To arrive a modified self-compacting concrete mix using its particle packing density
2) To increase the workability of the concrete by alternative material
3) To arrive a combination of single fibre reinforced concrete as well as composite combination for performance evaluation
4) To assess the various mechanical property of single and composite fibre reinforced concrete and to make a comparative assessment.

1.2 Scope of the Study

The major scope of the project is to identify a method to make self-compacting concrete to perform better. The effect due to the synergy of the composite fibres when compared to single fibre addition help to increase the efficiency of the concrete. The application of composite fibre in SCC will enhance the durability of the concrete mix. Hence this study provides a gate way for developing a new concrete mix by varying the compositing and incorporating single/composite fibres.

2. Experimental Methodology

A volumetric batching of concrete mixes was arrived based on the volume of the water to the paste with different combination of fibres (single/composite).Two control mix of concrete were arrived based on volumetric packing of the aggregates. Table 1 shows the combination of different mixes.

2.1 Materials

In this study, partial replacement of cement by blast furnace slag (GGBS) in the total binder content. Two types of aggregates are used as coarse (12.5mm & 20mm). M-Sand is used as full replacement with fine aggregate. Three different types of fibres are used for assessment. Steel fibre, polypropylene fibre and glass fibre in two different combinations (0.5% & 0.75%) and a composite fibre combination of steel, polypropylene and glass by 1% volume fraction is added along to the concrete. Total 2 conventional mixes and 14 fibre concrete mixes were arrived for assessment and comparative assessment is made under different condition.

Table 1: Composition of concrete mixtures

Mix ID	(v_f) %	Vol: of cement	Vol: of GGBS	Vol: of water	Vol: of paste	w/p	Vol: of CA (12.5mm)	Vol: of CA (20mm)	Vol: of M-sand
M1	0	134	90	156	380	0.7	120	180	300
M2	0	120	80	180	380	0.9	120	180	300
M1SF1	0.50	134	90	156	380	0.7	120	180	300
M1SF2	0.75	134	90	156	380	0.7	120	180	300
M2SF3	0.50	120	80	180	380	0.9	120	180	300
M2SF4	0.75	120	80	180	380	0.9	120	180	300
M1PP1	0.50	134	90	156	380	0.7	120	180	300
M1PP2	0.75	134	90	156	380	0.7	120	180	300
M2PP3	0.50	120	80	180	380	0.9	120	180	300
M2PP4	0.75	120	80	180	380	0.9	120	180	300
M1GF1	0.50	134	90	156	380	0.7	120	180	300
M1GF2	0.75	134	90	156	380	0.7	120	180	300
M2GF3	0.50	120	80	180	380	0.9	120	180	300
M2GF4	0.75	120	80	180	380	0.9	120	180	300
M1SPG	1	134	90	156	380	0.7	120	180	300
M2SPG	1	120	80	180	380	0.9	120	180	300

2.2 Investigation parameters

The new combination of materials were arrived and hence necessary initial workability studies were made to justify these concrete mixes with fibre reinforcement does not exhibit any clustering or nesting behavior. In harden concrete; cubes were casted for compressive strength evaluation and beams for flexural strength evaluation. In addition to the flexural behavior, the load-deflection pattern for all the concrete mixes was assessed and thereby toughness evaluation is made. Further performance evaluations were made under static (punching shear) and dynamic (impact strength) loading condition. Assessment of fibre concrete under different loading condition was made to determine the performance of concrete. Durability studies such as acid and chloride attack are evaluated at different age of concrete. Similarly at different ages, the drying shrinkage pattern was also assessed.

3. Experimental Results & Discussion

3.1 Mechanical Behavior

A systematic evaluation made to assess the mechanical behavior of different concrete mixes and tabulated in Table 2. Considering the compressive strength mix M1 records higher value than M2 mix and also both possess value greater than target mean strength. Considering steel fibre (SF) concrete mixes, the compressive strength mix M1SF1 with 0.5% volume fraction of steel fibre records higher value and mix M2SF3 with 0.5% volume fraction of steel fibre and also both possess value greater than mix M1SF2 & M2SF4 with 0.75% volume fraction of steel fibre. Considering polypropylene fibre (PP) concrete mixes, the compressive strength mix M1PP2 with 0.75% volume fraction of polypropylene fibre records higher value and mix M2PP4 with 0.75% volume fraction of polypropylene fibre and also both possess value greater than mix M1PP1 & M2PP3 with 0.5% volume fraction of polypropylene fibre. In case of glass fibre (GF) concrete mixes, the compressive strength mix M1GF2 with 0.5% volume fraction of glass fibre records higher value and mix M2GF4 with 0.75% volume fraction glass fibre and also both possess value greater than mix M1GF1 & M2GF3 with 0.75% volume fraction of glass fibre. Mix M1SPG consisting 0.5% of steel fibre, 0.25% of polypropylene fibre and 0.25% of glass fibre records the maximum value than all other conventional and fibre concrete mixes.

Considering the flexural strength mix M1 records higher value than M2 mix and also both possess value greater than target mean strength. Considering steel fibre (SF) concrete mixes, the flexural strength mix M1SF1 with 0.5% volume fraction of steel fibre records higher value and mix M2SF3 with 0.5% volume fraction of steel fibre and also both possess value greater than mix M1SF2 & M2SF4 with 0.75% volume fraction of steel fibre. Considering polypropylene fibre (PP) concrete mixes, the flexural strength mix M1PP2 with 0.75% volume fraction of polypropylene fibre records higher value and mix M2PP4 with 0.75% volume fraction of polypropylene fibre and also both possess value greater than mix M1PP1 & M2PP3 with 0.5% volume fraction of polypropylene fibre. In case of glass fibre (GF) concrete mixes, the flexural strength mix M1GF2 with 0.5% volume fraction of glass fibre records higher value and mix M2GF4 with 0.75% volume fraction glass fibre and also both possess value greater than mix M1GF1 & M2GF3 with 0.75% volume fraction of glass fibre.

Table 2: Evaluation of mechanical Properties

Mix ID	Fibre (%)	Compressive strength (MPa)	Flexural strength (MPa)
M1	0	67.80	10.35
M2	0	55.00	8.55
M1SF1	0.50	58.60	11.25
M1SF2	0.75	46.20	9.45
M2SF3	0.50	55.40	10.35
M2SF4	0.75	53.20	9.20
M1PP1	0.50	48.00	10.15
M1PP2	0.75	59.80	13.45
M2PP3	0.50	45.85	8.70
M2PP4	0.75	60.30	14.20
M1GF1	0.50	40.87	7.60
M1GF2	0.75	44.80	9.45
M2GF3	0.50	41.24	7.60
M2GF4	0.75	45.50	10.35
M1SPG	1	66.80	9.80
M2SPG	1	62.90	7.99

Mix M1SPG consisting 0.5% of steel fibre, 0.25% of polypropylene fibre and 0.25% of glass fibre records the maximum value than all other conventional and fibre concrete mixes. Hence to conclude, composite fibre combinations possess better performance than mono fibre addition.

4. Conclusion

The conclusions are arrived from the results obtained by experimentation with laboratory limitations. A new composite mix arrived using the packing concept of concrete ingredients. Fibres such as steel, polypropylene and glass were used to arrive fibre reinforced concrete mixes. Fourteen such mixes were arrived to evaluate the mechanical properties. From the test results it is clear that composite fibre mixes including all the three fibres records better results than other mixes. Hence application of such hybrid fibres will enhance the performance of concrete mix. Arriving mixes by using its packing strength will make the self compacting concrete much more efficient.

References

[1] B.Suja, T.Jenies & V. Jaganathan, 2016, ‘A Study on Characteristics Strength of Hybrid Fibre Reinforced Self Compacting Concrete Incorporating Rice Husk Ash’, Journal Of Mechanical And Civil Engineering, vol. 2, issue 2, pp.10-17.
[2] S.Deepak, & Dr V.Ramesh, 2015, ‘Properties of Municipal Solid Waste Incinerator Ash in Concrete’, International Journal of Engineering and Computer Science, Volume 4 Issue 6, pp. 12322-12326.
[3] P. S. V. R. Subrahmanyam, G. Narsaraju & B. Srinivasa Rao, 2015, ‘ Effect of Rice Husk ash and Fly ash Reinforcements on Microstructure and Mechanical properties of Aluminium alloy ($AlSi_{10}Mg$) Matrix Composites’, International Journal of Advanced Science and Technology, Vol.76, pp. 1-8.
[4] S.Arivalagan, 2014, ' Flexural behaviour of hybrid fibre (steel fiber and silica fume) reinforced self compacting composite concrete members', World Journal of Engineering, Volume 11 Issue 4,pp.323-330.
[5] M.Sahmaran, A.Yurtseven & I.Ozgur Yaman, 2005, ' Workability of hybrid fiber reinforced self-compacting concrete' , Building and Environment, Volume 40, pp.1672-1677.
[6] S.Ghanbarpour, H.Mazaheripour, S.H.Mirmoradi & A.Barari, 2010, ' The effect of type and volume fraction (VF) of steel fiber on the mechanical properties of self-compacting concrete' , Journal of Engineering , Design and Technology, Volume 8 Issue 3, pp.658-664.
[7] P.Groth & H.Thun, 2000, ' Influence of Steel Fibre Reinforcement on the Workability of Self-Compacting Concrete', Concrete Science and Engineering, Volume 2, pp.65-70.
[8] Joaquim Barros, Eduardo Pereira & Simao Santos, 2007, ' Light Weight Panels of Steel Fibre Reinforced Self Compacting Concrete', Journal of Materials in Civil Engineering, pp.295-303.
[9] T.Suresh Babu, M.V. Seshagiri Rao & D. Ramseshu, 2008,' Mechanical Properties and Stress-Strain Behaviour of Self Compacting Concrete with and without Glass Fibres', Asian Journal of Civil Engineering(Building and Housing), Volume 9, pp.457-472.
[10] Valeria Corinaldesi & Giacomo Moriconi, 2011, ' Characterization of Self-Compacting Concretes prepared with different fibres and mineral additions' , Cement & Concrete Composites, Volume 33, pp.596-601.
[11] P.Srinivasa Rao &T.Seshadri Sekar, 2008, ' Impact strength and workability behaviour of glass fibre self compacting concrete', International Journal of Mechanical Solids, Volume 3 , Issue 1, pp.61-74.
[12] Abhishek Sachdeva & Pankaj Singla, 2015 , ' Strength Evaluation of Steel Fiber Reinforced – Self Compacting Concrete' , International Journal of Engineering Research and Technology, Volume 4,pp.834-837.
[13] Abbas AL-Ameeri, 2013, ' The Effect of Steel Fiber on Some Mechanical Properties of Self Compacting Concrete', American Journal of Civil Engineering, Volume 1 , pp.102-110.
[14] B.Krishna Rao & V.Ravindra, 2010, ' Steel Fibre Reinforced Self compacting Concrete Incorporating

Class F Fly Ash ', International Journal of Engineering Science and Technology, Volume 2, Issue 9, pp.4936-4943.

[15] P.T.Shahana Sheril, 2013, ' Self Compacting Concrete Using Fly Ash and Glass Fibre ' , International Journal of Engineering Research and Technology, Volume 2, Issue 9, pp.936-946.