Experimental Investigation of Blast Impact on Concrete Using Steel Fibres

Ms.Abibharathi.M[1], **Mr.Mohamed Nizar.N**[2]

[1] *PG Student, Department of Civil Engineering, Chendhuran College of Engg & Tech,*
Pudukkottai,Tamilnadu,India
Contact No: 8675752005, Email Id: abi.murugan92@gmail.com
[2] *Assistant Professor, Department of Civil Engineering,Chendhuran College of Engg & Tech,*
Pudukkottai,Tamilnadu,India.
Contact No: 9943451327, Email Id: nizar21189@gmail.com

Abstract

The world has seen many divesting blasts during the last decade which killed many people and demolished many buildings. With the increased number of blasts the interest of research on blast resistant building materials and building techniques has increased in a rapid place. It is better go for protective measures during design and construction to withstand the worst that could happen. In this project thesis we are going to replace fly ash 30% with admixture and steel fibre 0%, 0.5%,1%,1.5%and 2% and the curing days from 7,14 & 28 days .Test were casting on cubes , cylinder and beam to conduct the compressive , split tensile and Flexural test of concrete for M30 concrete using IS method. Therefore the need of new materials and technologies is much essential for building blast resistant structures. It is found that steel fibers reinforced concrete has shown some satisfactory results during the blast, but still is not good enough to with stand completely for a blast. An experimental study on slab samples of M30 concrete with 10mm rod steel reinforcement with and without steel fiber reinforcement is tested and with different magnitude of energy release by blast.

Key words : *Steel Fibre, Fly ash ,Blasting Material ,Compressive strength, Tensile strength, Flexural strength*

1. INTRODUCTION

In the past few decades considerable emphasis has been given to problems of blast and earthquake. The most of the knowledge on this subject has been accumulated during the past few years. The blast problem is rather new information about the development in this field is made available mostly through publication of the Army Corps of Engineers, Department of Defence, U.S. Air Force and other governmental office and public institutes. Much of the work is done by the Massachusetts Institute of Technology, The University of Illinois, and other leading educational institutions and engineering firms. Due to different accidental or intentional events, the behaviour of structural components subjected to blast loading has been the subject of considerable research effort in recent years.

1.1 General

Difficulties that arise with the complexity of the problem, which involves time dependent finite deformations, high strain rates, and non-linear inelastic material behaviour, have motivated various assumptions and approximations to simplify the models. Conventional structures, particularly that above grade, normally are not designed to resist blast loads;With this in mind, developers, architects and engineers increasingly are seeking solutions for potential blast situations, to protect building occupants and the structures.

1.2 EXPLOSION AND BLAST PHENOMENON

An explosion is defined as a large-scale, rapid and sudden release of energy. Explosions can be categorized on the basis of their nature as physical, nuclear or chemical events. In physical explosions, energy may be released from the catastrophic failure of a cylinder of compressed gas, volcanic eruptions or even mixing of two liquids at different temperatures. Explosive materials can be classified according to their physical state as solids, liquids or gases. Solid explosives are mainly high explosives for which blast effects are best known. They can also be classified on the basis of their sensitivity to ignition as secondary or primary explosive. The latter is one that can be easily detonated by simple ignition from a spark, flame or impact. Materials such as mercury fulminate and lead azide are primary explosives. Secondary explosives when detonated create blast (shock) waves which can result in widespread damage to the surroundings. Examples include trinitrotoluene (TNT) and ANFO.

The detonation of a condensed high explosive generates hot gases under pressure up to 300 kilo bar and a temperature of about 3000-4000C°. The hot gas expands forcing out the volume it occupies. As a consequence, a layer of compressed air (blast wave) forms in front of this gas volume containing most of the energy released by the explosion

1.3 BLAST WAVE SCALING LAWS

All blast parameters are primarily dependent on the amount of energy released by a detonation in the form of a blast wave and the distance from the explosion. A universal normalized description of the blast effects can be given by scaling distance relative to (E/Po)1/3 and scaling pressure relative to Po, where E is the energy release (kJ) and Po the ambient pressure (typically 100KN/m^2). For convenience, however, it is general practice to express the basic explosive input or charge weight W as an equivalent mass of TNT. Results are then given as a function of the dimensional distance parameter,

$$\text{Scaled Distance (Z)} = R \backslash W^{1/3}$$

Where R is the actual effective distance from the explosion.

W is generally expressed in kilograms.Scaling laws provide parametric correlations between a particular explosion and a standard charge of the same substance.

2. EXPERIMENTAL PROGRAMME MATERIAL USED

The material used in the experimental investigation include:

1. Cement
2. Fine and Coarse aggregate
3. Fly ash
4. Steel fibres

2.1 Cement

Ordinary Portland Cement (53 grade) was used for the investigation. Initial experiments like initial and final setting times and fineness tests were conducted. The results are shown in Table 1

Table - 1 : Physical properties of cement

S.No	Property	Value
1	Fineness	1.33
2	Specific gravity	3.05
3	Initial setting time	33 mins
4	Final setting time	600 mins

2.2 Fine Aggregate

Sand is naturally occurring granular material composed of finely divided rock and mineral particles. Normally river sand is used as fine aggregate for preparing concrete.

Table - 2 : Physical properties of Fine aggregate

S.No	Characteristics	Value
1	Type	River sand
2	Specific Gravity	2.59
3	Fineness Modulus	2.85
4	Grading Zone	II
5	Size	<4.75

2.3 Coarse Aggregate

Aggregate are the most available material in the world. Aggregate are a component of composite materials such as concrete and asphalt concrete, the aggregate serves as reinforcement to add strength to the overall composite material. Gravel of size 20mm is sieved and used.

Table - 3 : Physical properties of Coarse aggregate

S.No	Characteristics	Value
1	Type	Crushed
2	Specific gravity	2.74
3	Fineness modulus	7.48
4	Size	20mm(max)

2.4 Fly Ash

Fly ash is a fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures. That capability is one of the properties making fly ash a desirable admixture for concrete. In our study class f fly ash were used. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO).

Table - 4 : Chemical composition of Fly ash

Material	Sio_2%	Al_2o_3%	Fe_2o_3%	Cao %
Fly ash	46.16	24.14	11.55	35.05

2.5 Glued Steel Fibres

Glued steel fibres are filaments of wire, deformed and cut to lengths, for reinforcement of concrete, mortar and other composite materials, with hooked ends. It is easy to separate in the mixer and can avoid balling in concrete compared to individual steel fibres.

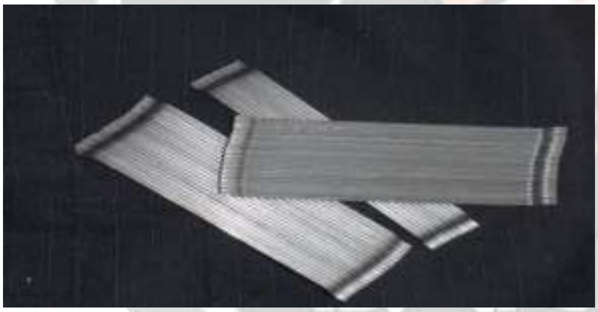

Fig – 1: Glued steel fibres

Table - 5 : properties of Glued steel fibres

Appearance	Relative density (g/cc)	Length	Ratio	Diameter
Both ends hooked	7.65	35	70	0.5

2.6 Blasting material

This is blast material; velocity is 50 m/s.

Fig – 2: Blasting material

3. EXPERIMENTAL METHODOLOGY

3.1 Methodology

a. To collect the raw materials.
b. To determine the properties of raw materials.
c. To cast cubes, cylinders and PCC beams with varying proportion of fly ash and steel fibres.
d. To conduct compressive strength test on cubes.
e. To conduct split tensile test on cylinders.
f. To conduct flexural strength test on PCC beams.
g. To determine the strength values for 7 days and 28 days.
h. To cast on slab samples of M30 concrete with 12mm rod steel reinforcement with and without steel fiber reinforcement is tested and with different magnitude of energy release by blast.

The concrete specimens will be prepared by the partial replacement of fly ash and steel fibre for the cement and coarse aggregate. M $_{30}$ grade of concrete is selected for casting the controlled and specimen concretes. The cement is replaced by 30% of fly ash and the volume of fraction (0%0.5%,1%,1.5%) of steel fibre. To get the optimum percentage of material about 24 cubes, 8 cylinders, 8beams are casted.

3.2 Work Plan

Controlled concrete - Controlled specimen
Controlled concrete+30%FA+0%SF- Specimen1
Controlled concrete+30%FA+0.5%SF- Specimen2
Controlled concrete+30%FA+1%SF- Specimen3
Controlled concrete+30%FA+1.5%SF- Specimen4
Controlled concrete+30%FA+2%SF- Specimen5

4. EXPERIMENTAL RESULTS

4.1 Test Results For Cubes

The test specimens are prepared in the standard size and cured in water for 28 days. After curing the specimens are tested to determine the 7,14 and 28 days strength. The casted specimens are placed in the compressive testing machine and the load is applied until the sample fails. The failure load is noted down and the compressive strength is calculated.

Size of the specimens = 150mmx150mmx150mm
Compressive strength = Failure load / surface area = P/ (150x150) (N/mm^2)

After calculating the compressive strength results were inserted to graph to analyze the production of strength of each different ratio.

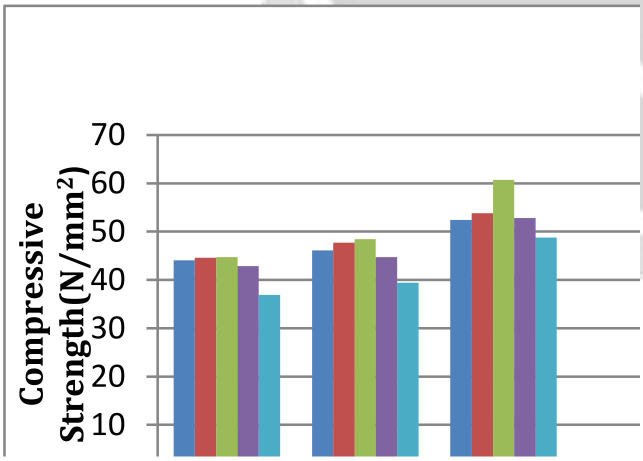

Chart – 1: Variation of compressive strength of concrete with optimum fly ash of 30% at different percentage of steel fibres

From the Graph (chart – 1) depicts that the compressive strength of concrete increases with curing period. The comparison of strength between the normal controlled concrete and specimens were also shown. It shows that the strength gradually increases upto 1% of steel fibre and decreases for 1.5%.

4.2 Test Results For Cylinders

The cylindrical specimens are prepared in the standard manner and cured. After curing apply the load until the specimen fails along the vertical direction. The failure load is noted down and the tensile strength is calculated.

Results were inserted to graph to analyze the production of strength of each different ratio.

Diameter of the specimen = 150mm
Length of the cylinder =300mm
Split tensile strength =2x(failure load)/(πx150x300) (N/mm^2 **)**

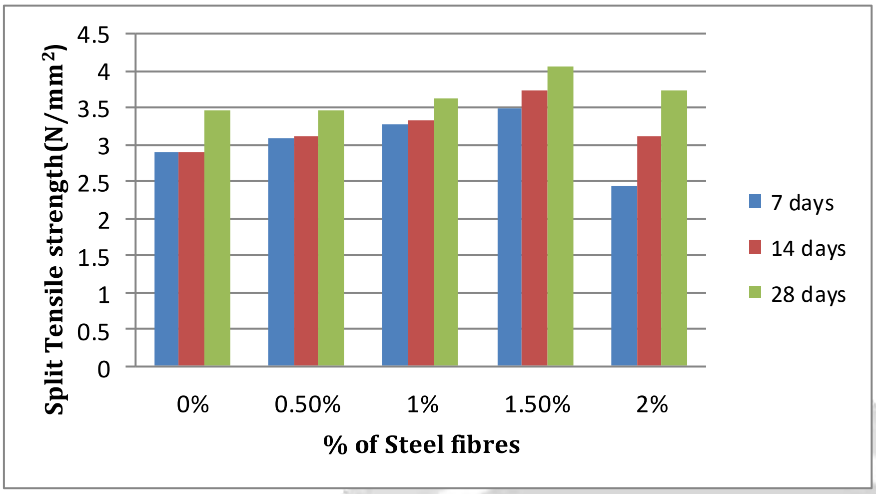

Chart – 2: Variation of split tensile strength of concrete with optimum Fly ash of 30% at different percentage of steel fibres

From the chart (2) it shows split tensile strength of steel fibre concrete.The main purpose of adding steel fibres is to reduce the brittleness of concrete and increase in strength.There is increase up to 1.5% beyond 1.5% there is a decrease in strength of concrete.

4.3 Test Results For Pcc Beams

The beam is casted with standard dimensions and cured for 28 days and is kept for drying for 24 hrs. The beam is placed in the compression testing machine with a gauge length of 400mm and load is applied gradually.The load at which plain concrete beam fails is noted. From the failure load the flexural strength is determined.

After calculating the flexural strength of each specimen, results were inserted to graph to analyze the production of strength of each different ratio.

Size of the beam= 100mm x 100mm x 500mm
Modulus of rupture = (3/2) x (wx400^2/100x100^2)

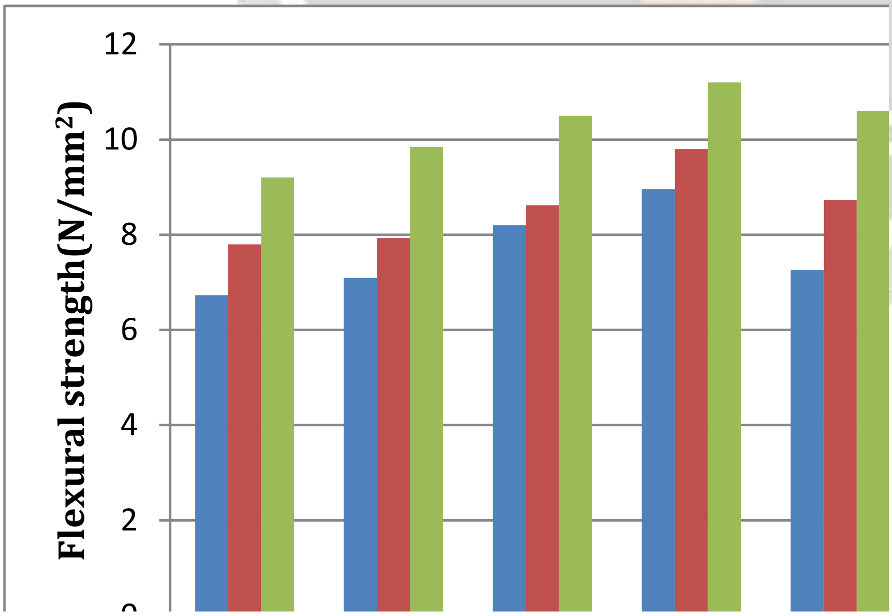

Chart – 3 : Variation of Flexural strength of concrete with optimum fly ash of 30% at different percentage of steel fibres

From chart (3) it shows the comparison of flexural strength of steel fibre concrete with the normal concrete. It is noted that the flexural strength of steel fibre concrete increase up to 1.5% beyond 1.5% there is a decrease in strength of concrete.

5. EXPERIMENTAL PROGRAM FOR BLASTING TEST

5.1 Casting Of Specimens For Slab Samples

The NRC and SFRC were poured separately into the mould of 600 mm × 600 mm × 150 mm to make them into test panels. The NRC and SFRC panels were later removed from the mould after consolidation and cured with wet gunny sacks for 28 days before the actual field blast test.

Fig - 3: Casting for NRC Slab samples

Fig – 4: Casting for SFRC samples

5.2 Blasting Test

The blast test conduct on NRC and SFRC samples in different magnitude of energy release by blast.

Fig – 5 : Blast test

5.3 Experimental Result

The experimental results on shows the blasting test of NRC and SFRC slab samples.The NRC slab sample is major cracks occurs in blast test.

The SFRC slab samples in minor cracks occurs in blast test. The final result is steel fibre concrete resist the cracks and impact load.

Fig - 6: shows the cracks form on NRC

Fig – 7: shows the cracks form on SFRC

6.CONCLUSION

1. The test results indicate that the SFRC suffered less damage compared to the NRC. Therefore the experimental results confirm the substantial ability of SFRC for resisting the blast load. Blasting trials have been carried out with varying charges to form the crack in desired direction.

2. The fracture positioning in the concrete specimen bar corresponded to the predicted position in which tensile stress concentration is initiated.

3. The impact tensile strength of the concrete for this investigation is significantly influenced by the Loading rate and it is found to be approximately twice the static values.

4. The use of SFRC can reduce the impact of the blast on the structure to some extent.

5. Even though it is much required to develop materials which are efficient enough to protect the structure with minor damage or without failing. Innovation of new materials for blast resistance is much required to maintain the structural integrity even at the conditions where it is exposed to high energy.

7. REFERENCES

1. **Mays, G. C. and Smith, P. D. (1995),** Blast effect on Buildings: Design of Buildings to Optimize Resistance to Blast Loading, Thomas Telford
2. **Yi, N.H., Nam, J.W., Kim, S.B., Kim, J.J.H., Byun, K.J.(2008)** " HFPB analysis of RC structures under blast loads considering concrete damage model", The 3rd ACF International Conference-ACF/VCA 2008.
3. **Baker. W. E, Cox. P. A., Westine. P. S, Kulesz. J. J, and Strehlow. R. A, (1983).** Explosion Hazzard and Evaluation. Elservier, Amsterdam, Oxford, NewYork.

4. **FEMA (Federal Emergency Managment Agency) (1998)**. Evaluation Of Earthquake Damage Concrete and Mansory Wall Buiding, Part 3. FEMA, Washington D.C
5. **Newmark, N.M and Rosenblueth, E (1971).** Fundamental of Earthquake Engineering. Prentice- Hall, Englewood Cliff, N.J.
6. **S.Lan, Tat Seng Lok, H.Leonard, 2005.** "Composites Structural Panels Subjected to Explosive Loading". Journal of Construction and building materials. 19, pp. 387-397.
7. **Jones, N. Structural impact, 1989,** 575 pp. (Cambridge University Press, Cambridge) (paperback edition, 1997) (Chinese edition, translated by P.Jiang and L. Wang, 1994, Sichuan Education Press,Chengdu).
8. **Mohd Rizam Zulkifli (2005)**. "Structure Subject To Blast Impact." Undergraduate Thesis, Military Academy Malaysia - Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia.
9. **Arthur. W**, (1990). "Military Demolition." *ACI Struct. Journal*, 86(3), 272-276.
10. **Baker. W. E, Cox. P. A., Westine. P. S, Kulesz. J. J, and Strehlow. R. A, (1983)**. *Explosion Hazzard and Evaluation*. Elservier, Amsterdam, Oxford, NewYork.