UHPFRC DEVELOPMENT MATERIAL PROPERTY CHARACTERIZATION AND STRUCTURAL APPLICATIONS

Sudarshan N M[1], T Chandrsekhar Rao[2]

[1]*Professor. Department of Civil Engineering, Satara College of Engineering & Mangement, Satara, Maharashtra, INDIA,*

msudarshan123@gmail.com

[2]*Professor, Department of Civil Engineering Bapatla Engineering College, Malleshwari, Bapatla A.P.*

hoshikonni@gmail.com

Abstract

UHPFRC (Ultra high performance fibre reinforced concrete) is new generation concrete with excellent mechanical, durability properties better resistance in failure of the structure porosity, lower Shrinkage and creep properties. The matrix material is designed, discretely sized optimal particles densely packed to achieve higher tensile and compressive strengths. This paper presents Historical development in fibre reinforced concrete to present day, the UHPFRC exhibits material characterization of UHPFRC curing methodology at elevated temperature. affects on the strength of the concrete various Commercial market products usage in architectural design and commercial structural applications.

Keywords: *UHPFRC, Cement, Microsilica, Sand, Quartz Sand, Steel Fibre, Super Plasticizer, Water Cement Ratio.*

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1. INTRODUCTION

The UHPFRC is a new cementitious material rapidly developed all over the world. The Cementious composite material is combination of mix proportion, Portland cement 53 grade, micro silica, quartz sand, fine aggregates, HRWRA, steel fibers, very low water cement ratio adopted in optimum mixture technique and curing regime play a vital role in promoting the strength of the concrete upto 30% higher compressive strength. The present day required high compressive strength concrete for special structures like foot bridges, Roads Runways, Industrial floors, repair and rehabilitation works, nuclear power plants. The material exhibits superior mechanical properties. Energy saving lowering global environmental Impact.

The researchers yudenfreund et al(1972) Roy et. al. (1972) yamato et al (1987) M M Red et al (1994) Collepardi et. al. (1996) Richard & Cheyrezy (1995) Rossi (2002) O.Bayard (2003), Redaclli and Muttoni (2007) Garas, Kahn, and Kurtis (2209) Kim, Ryu and Ko (2012) investigated and Contributed for the development of UHPFRC to achieve Higher compressive strengths economical, Eco-friendly, sustainable construction technology for structural members and significant economic benefit as a supplementary cement based material.

2. RESEARCH SIGNIFICANCE:

This Research paper presents the development applications, material properties of UHPFRC a wide range use in constructive optimize solutions for present day. The coarse aggregates are replaced by fine aggregates and other Ingredients. Silica Fume, Quartz sand steel fibers, Superplastizer low water cement ratio dense mixture casted and cured at elevated temperature to achieve higher strength using optimsed mixture, adopted Granular Particle packing theories The research provides optimized design mixture proportions numerous applications potential to structural construction technology.

3. UHPFRC COMPOSITION :

Material Mix proportions & Material Property characterization :

The Elimination of coarse aggregates enhances matrix density, optimization of granular packing of ingregadients, homogeneity, durability of the matrix material. Improving the compactness to reduce voids, porosity densely compacted cement material micro-structural behaviour. Enhancement of chemical resistance and matrix material micro silica Quartz sand.

The ductility of the concrete increased by incorporating small sized steel fibers. The fluidity and workability of the concrete increased addition of High range water Reducing agent (Super plasticizer) curing under Higher elevated temperature accelerates Pozzolanic reaction to achieve Higher compressive strength.

Table 1 - Historical Development of FRC

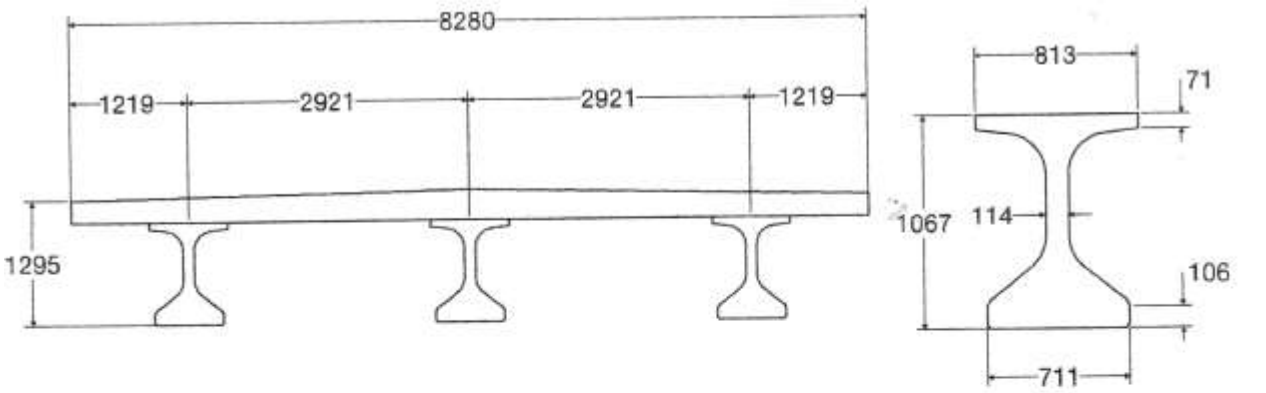
Year	Concrete Type
3000 BC	Horse Hair in construction material
1900	AFC
1950	HPFRC
1970	SFRC
1978	UHPC
1986	CRC
1997	RPC
2000	UHPFRC

AFC-Asbestos fibre concrete ,HPFRC-High performance reinforced concrete, MSFRC-Multiscale fibre reinforced concrete, UHPC-Ultra high performance concrete, CRC-Compacted reinforced concrete,RPC – Reactive powder concrete, UHPFRC-Ultra high performance fibre reinforced concrete.

Table 2. Properties of material

Standard	Sl. No.	Material	Material I.D.	Property Analysis
IS-12269-1987	1	Cement	C	OPC-53 grade S.G.- 3.5
IS-3831970	2	Sand	NS	S.G.- 2.63
IS-383 1970	3	Silica Fume	SF	S.G.- 2.25
ASTM-C494 Type F	4	Steel fibres	ST F	L=20 m = 0.16,mm
ASTM-C 494 Type F	5	Super Plasticizer	SP	SG -1.00
--	6	Quartz & Sand	Q	SG.- 2-59

C=Cement ,NS=Normal sand, SF=Silica fume, STF=Steel fibre, SP=Super plasticizer
Q=Quartz sand



(Dimensions in mm)

Figure 1. Mars Hill Creek Bridge U.S A.

(a)

(b)

Figure 2. (a)-Sun Yu Footbridge South Korea, (b)-Sherbrooke Footbridge Canada
(Wang & David)

GSA Analysis (Oasys) for UHPFRC

The GSA (Gene set analysis) Osays is the analysis of the complex structural architectural related problems can be easily solved. It helps:
In tackling all structural related design challenges and comprenssive design programme. The GSA software suits for resisiting the loads. engineers can carry out 3 Dimensional,linear, non linear P- Delta,static and dynamic analysis the Ritz vibration analysis and also includes the analysis and structural behavior of the UHPFRC, helps in architectural developments in search of concrete design enhancing the life span and low maintenance cost. The analysis provides data like, sway effects, deflections, displacements, stress –strain relation,beam coloumn design.
The UHPFRC material is a high mechanical properties influenced by the addition of fibres the resistance of the material increases yields to more load carrying capacity The architects are inspired by the UHPFRC material more widely suggested to use in foot bridges, roofs, staircase, overhanging lookouts etc.

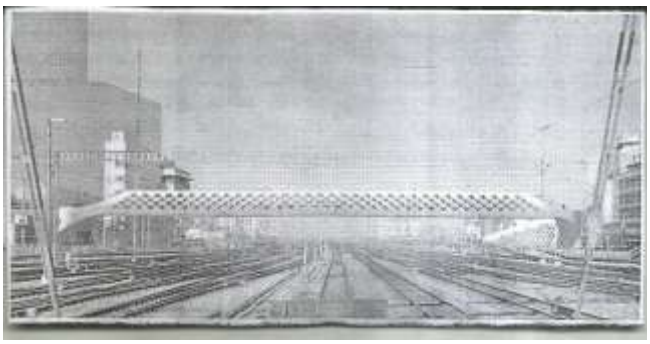


Fig.3 Negrelestig foot and slow traffic bridge

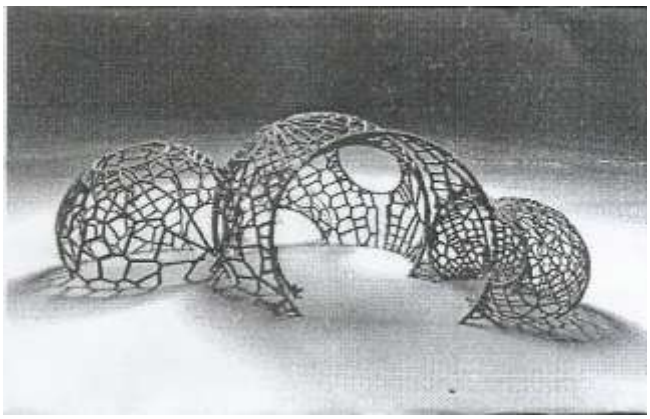


Fig. 4 GSA Model Structure

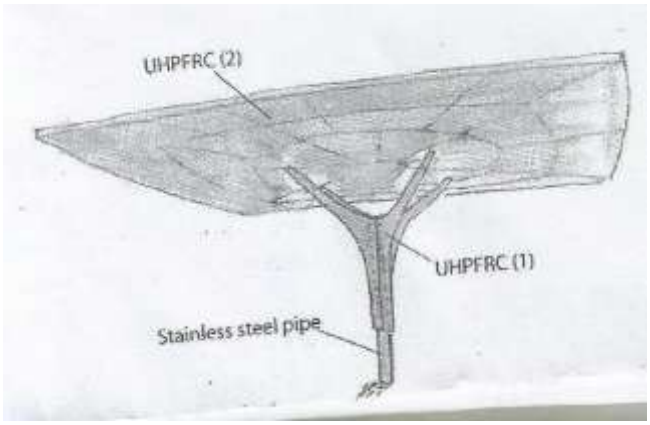


Fig 5. UHPFRC roof of the folly

4. UHPFRC STRUCTURAL APPLICATIONS

1) Economic Benefit as a supplementary cementitious material.
2) Higher Compressive, Flexural strengths yielding thinner sections.
3) Longer service life, No maintenance.
4) Suitable for construction of Foot Bridges, Vehicular Bridges, Roads. Runways.
5) Pre – cast beams, slabs and other products.
6) Impact resistance structures.
7) Defence, Nuclear structures
8) Hydraulic marine structures.
9) Strengthening material for repair & rehabilitation.
10) Industrial floors,& pavements.

5. COMMERCIAL PRODUCTS IN MARKET PLACE :

UHPFRC Products	Supplier	Country
Ductal / CHEMTEC	Lafarge	France
BSI	Core Tuff	U.S.A.
Cemtec	Densit	U.S.A.
Sika	Ceracem	France
Bache	CRC	Australia
Taktl	UHSFRC	Japan
Dura	UHFdC	Malasiya
Ducon	UHFRC Blends	Germany

UHPFRC Successful structural components :

Year	Structure	Country
1997	Sherbrooke foot bridge	Canada
1999	Cattenom Nuclear power plant	France
2003	LRT Station Canopy	Canada
2004	Rhurida Research Centre	France
2004	National Dance Centre	France
2004	PS34 Bridge	France
2004	Sun Yu Foot Bridge	South Korea
2006	Mars hill Bridge	USA
2007	Hikita Foot Bridge	Japan
2008	Wilson Hall	Malaysia
2010	Haneda Run way	Japan
2011	Sakata Foot Bridge	Japan
2015	Batu 6 Bridge	Malaysia

6. CONCLUSION

This paper reviews the historical perspective FRC material characterization, commercialised .structural applications The compressive strengths can be achieved upto 200 MPA on quality material ,optimized design mix proper mixing, &efficient regime curing methodology, use of suitable percentage of steel fibers upto 3%. Now days the UHPFRC structures more ductile durable heavy load resisting structures are successfully utilized all over the world in future the need of the UHPFRC material demand is gradually Increasing due to environmental impact earthquake effect, global climate change increase in load carrying capacity and high compressive strength requirement yield to the need of the material. Architects,structural engineers analyzed with GSA Oasys for better results,elegance.

7. REFERENCES

[1] Mix design and properties assessment of ultra high performance fiber reinforced concrete (UHFRRC) R. Yu. P. Spiesz, HJH Brouwers.

[2] Compressive behavior of UHPFRC (ACI material journal march-april 316, 319) Benjamin A & Grebeal (2007)

[3] Mechanical properties of Ultra High Performance Fibre Reinforced Concrete. Handy K. Shehab, Eldin A Mohamed, Mohamed Khater Syed Ahmed. Dept. of Structural Engineering faculty of Engineering.Zag zig university Zag Zig Egypt.

[4] S. Collepadi Coppole R. Tooli and V/s Collepadi 1996 Mechanical properties of Modified of Reactive powder concrete. Interim conference on Super plasticizer & Chemical Admixture in concrete by ACI Publication Rome.

[5] Mechanical Properties of Ultra High Performance Concrete. Prabhat Ranjan Prem, B.H. Bharatkumar, Nagesh R Iyer. World Academy of Science, Engineering and Technology (IJCSAE Vol. 6 No. 8, 2012.)

[6] Influence of Elevated Temperatures on the Behavior of Economical Reactive Powder Concrete, Alaa A. Bashandy (JCER 2013)

[7] Effect of different mix compositions and curing regimes on ultra high performance concrete compressive strength, Janis Justs, Genadij shakhmenko, Diana Bajare.

[8] Association Francaise de Genie Civil 2002, Interim Recommendations Paris, France for Ultra High Performance Fibre – Reinforced concretes.

[9] Bache H.H. 1987 Introduction to Compact Reinforced Composite, Nordic concrete research No. 6 PP 19-33.

[10] Influence of curing regimes on compressive strength of ultra high performance concrete, Prabhat ranjan Prem, B.H. Bharatkumar and Nagesh R. Iyer, CSIR campus, Taramani, Chennai India.

[11] Grasshopper model by Matt Obrien,Henket & Partners Esch 2005.