Experiences with HVFAC in Nuclear Industries

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CII seminar on High Volume Fly ash Concrete, 15th October 2004, Pune

Experiences with HVFAC in nuclear industries ……..

- R &D
- Project applications

Experiences with HVFAC in nuclear industries ……..

R &D

HVFAC mix up to 70% cement replacement level was developed with Indian ingredients.

HVFAC Mix

Mix Designation	Total binder (kg/m^3)	Cement (kg/m^3)	Fly ash		Water (kg/m^3)	w/b	sp (%)	CA (kg)	FA (kg)
			Quantity (kg/m^3)	% content of fly ash					
FM3	500	250	250	100.00[a] (50.0)[b]	150	0.300	1.00	1146.8	655.7
FM4	450	200	250	125.00 (53.3)	146.3	0.325	0.5	1181.8	675.8
FM5	400	200	200	100.00 (50.0)	140.0	0.35	1.25	1231.8	704.8

Note: a: percentage addition
b: percentage replacement

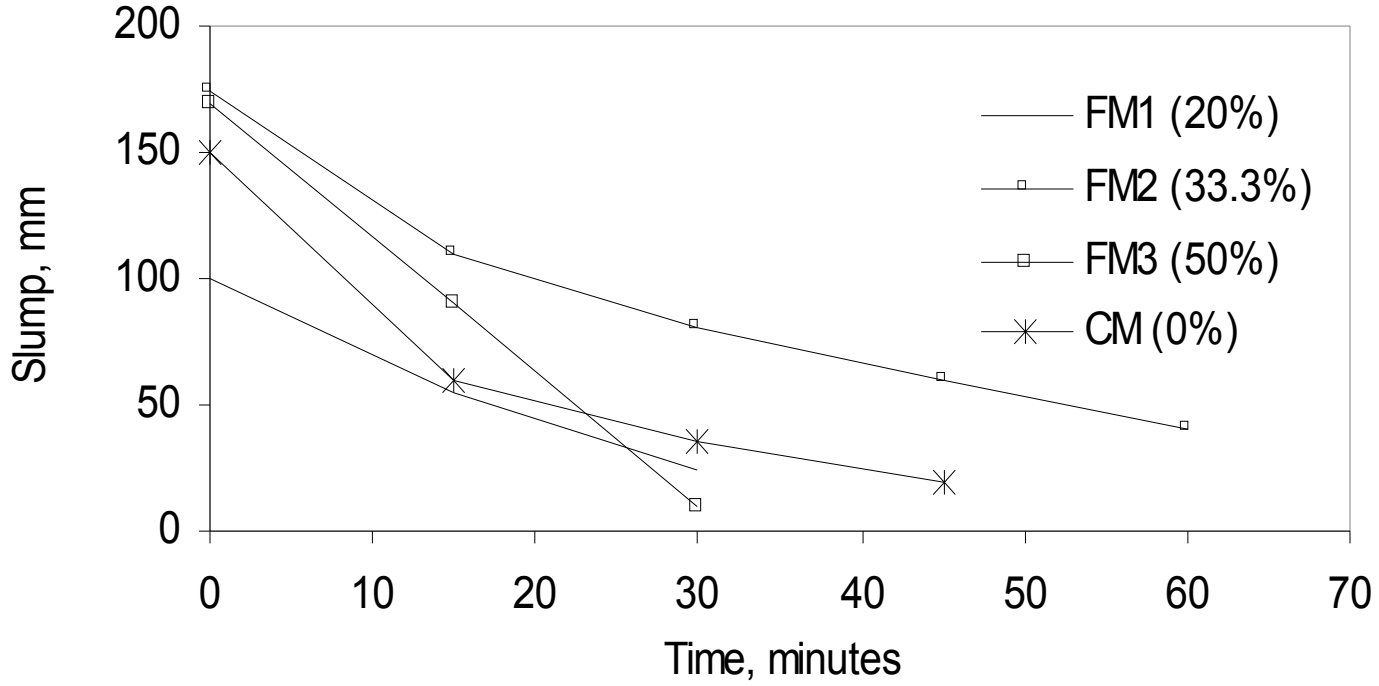
R &D

Properties of HVFA concrete

Mix designation	Slump (mm)	fc (Mpa)		fst (Mpa)		RCPT	
		7 days	28 days	7 days	28 days	7 days	28 days
FM3	170	41.0	58.8	3.12	3.85	4100	2672
FM4	165	37.9	56.7	2.47	3.68	4600	2014
FM5	170	33.5	48.1	2.3	3.48	4210	1827

Experiences with HVFAC in nuclear industries ……..

R &D



Variation of slump with time

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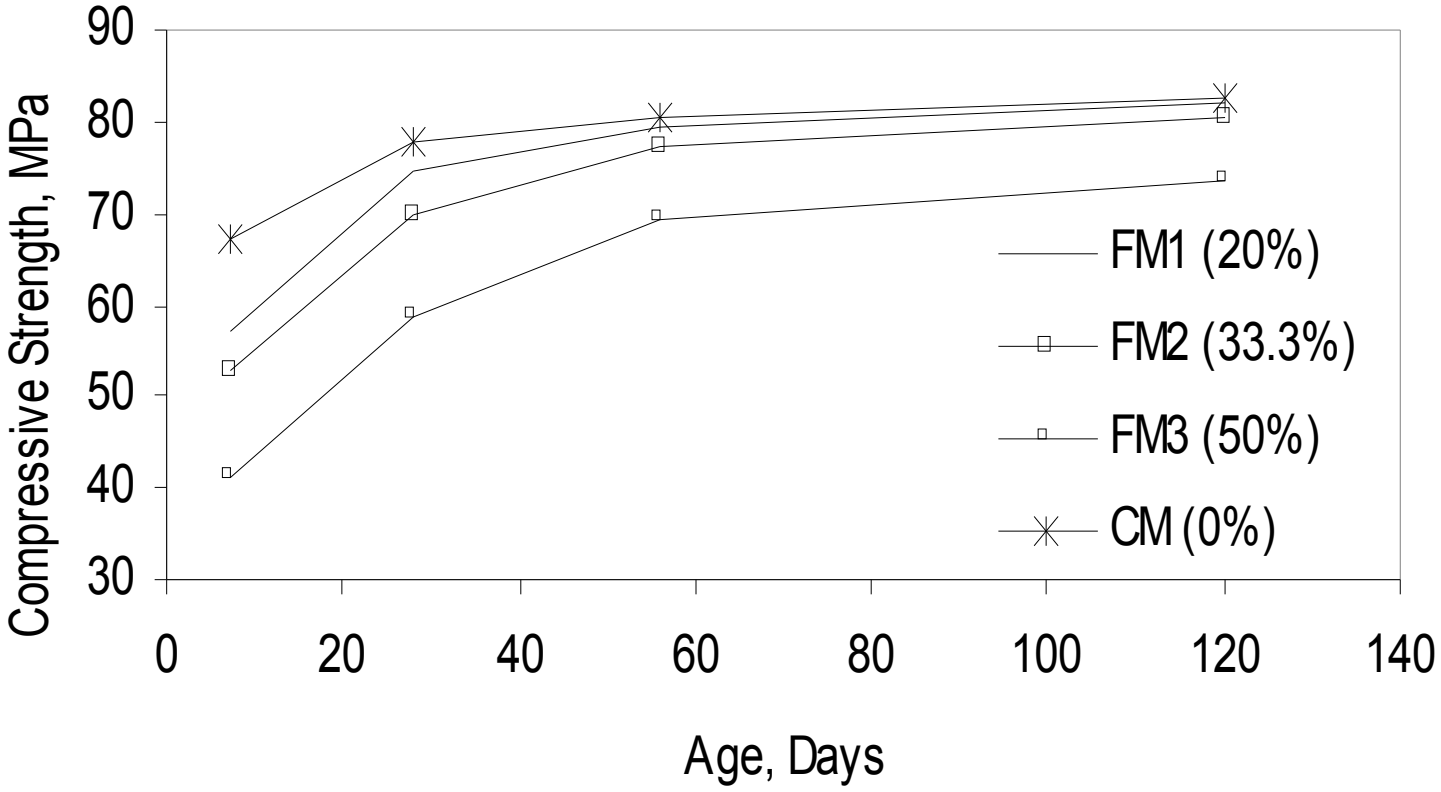
R &D



Variation of compressive strength with age

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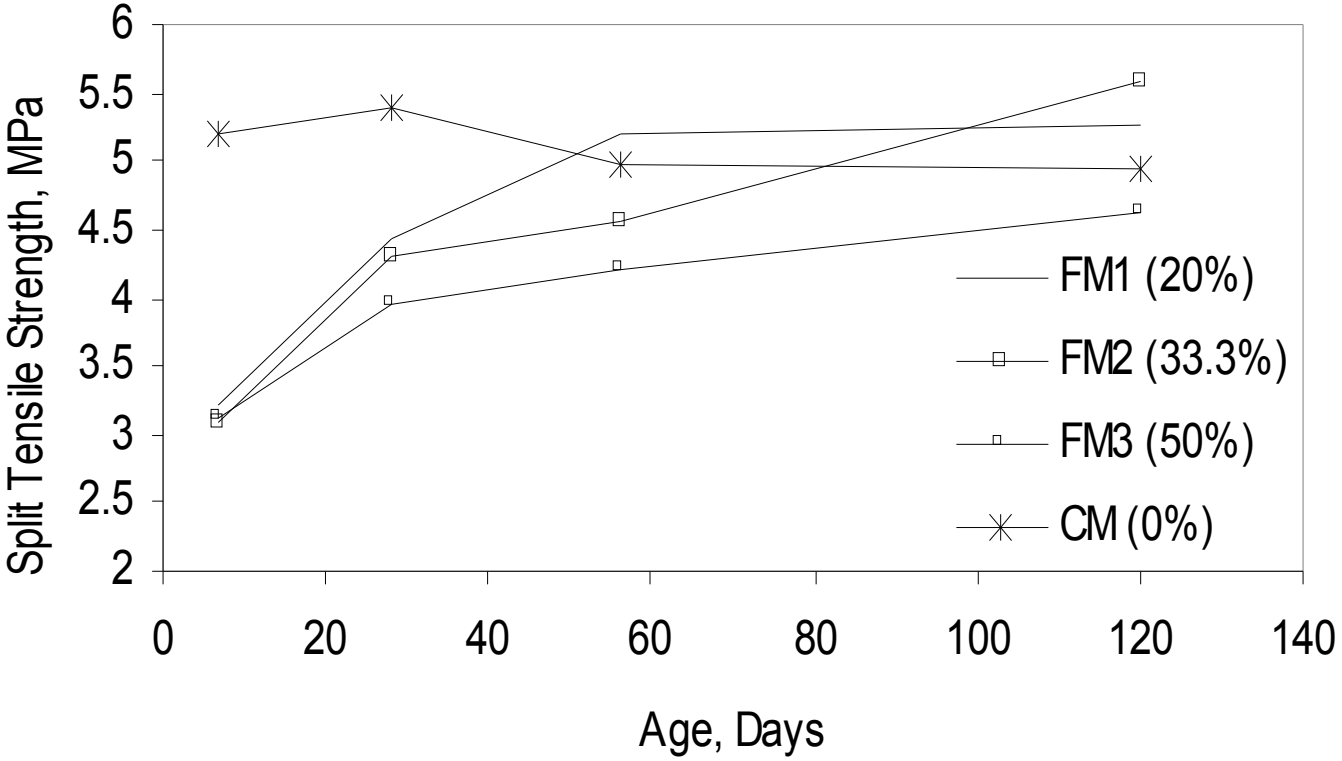
R &D



Variation of split tensile strength with age

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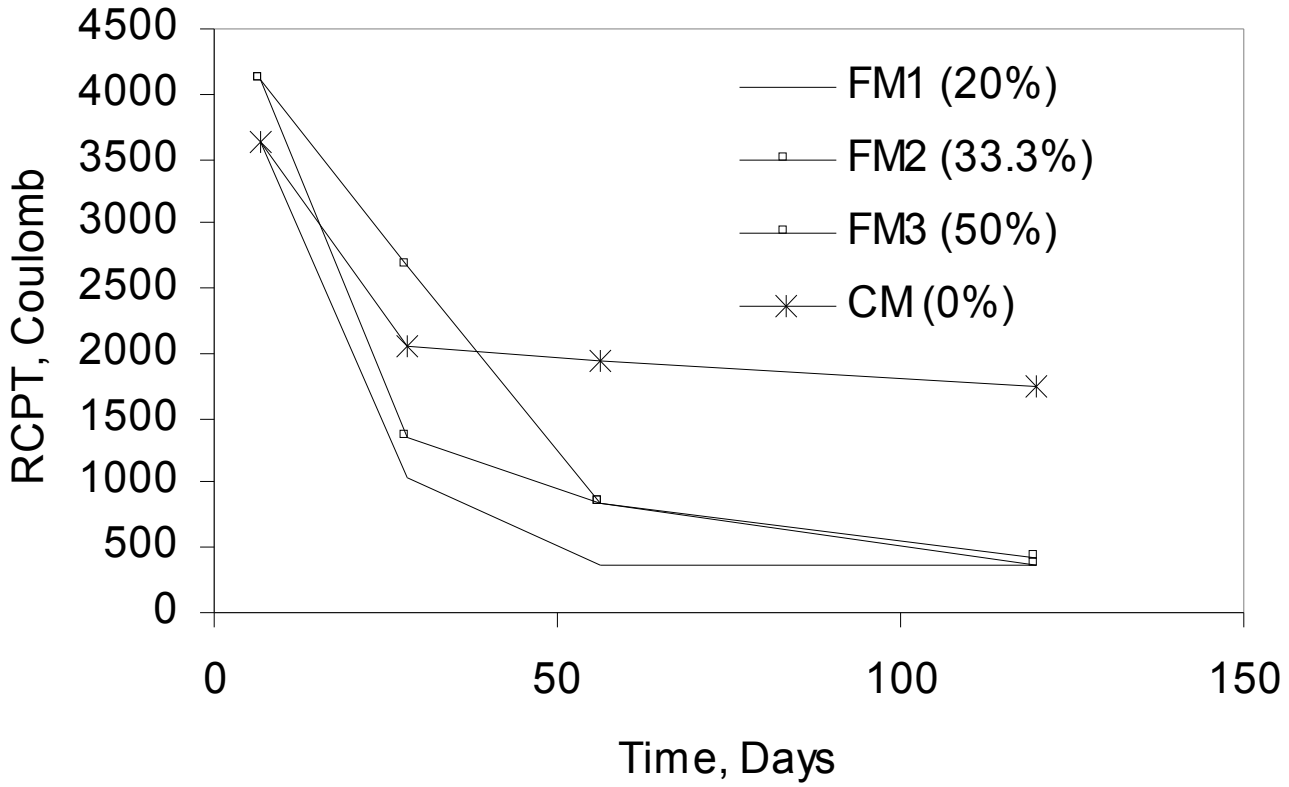
R &D



Variation of RCPT (Coulomb) value with age

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R &D

Further development on HVFA with Indian cement

Mix Designation	Total binder (kg/m^3)	Cement (kg/m^3)	Fly ash		Water (kg/m^3)	w/b	sp (%)	CA (kg)	FA (kg)
			Quantity (kg/m^3)	% content of fly ash					
FM6	500	200	300	150.00[a] (60.0)[b]	150	0.3	0.7	1136.3	649.7
FM7	500	150	350	233.3 (70)	150	0.3	0.7	1125.9	643.8
FM8	550	200	350	175 (63.6)	165	0.3	0.7	1070.7	612.2

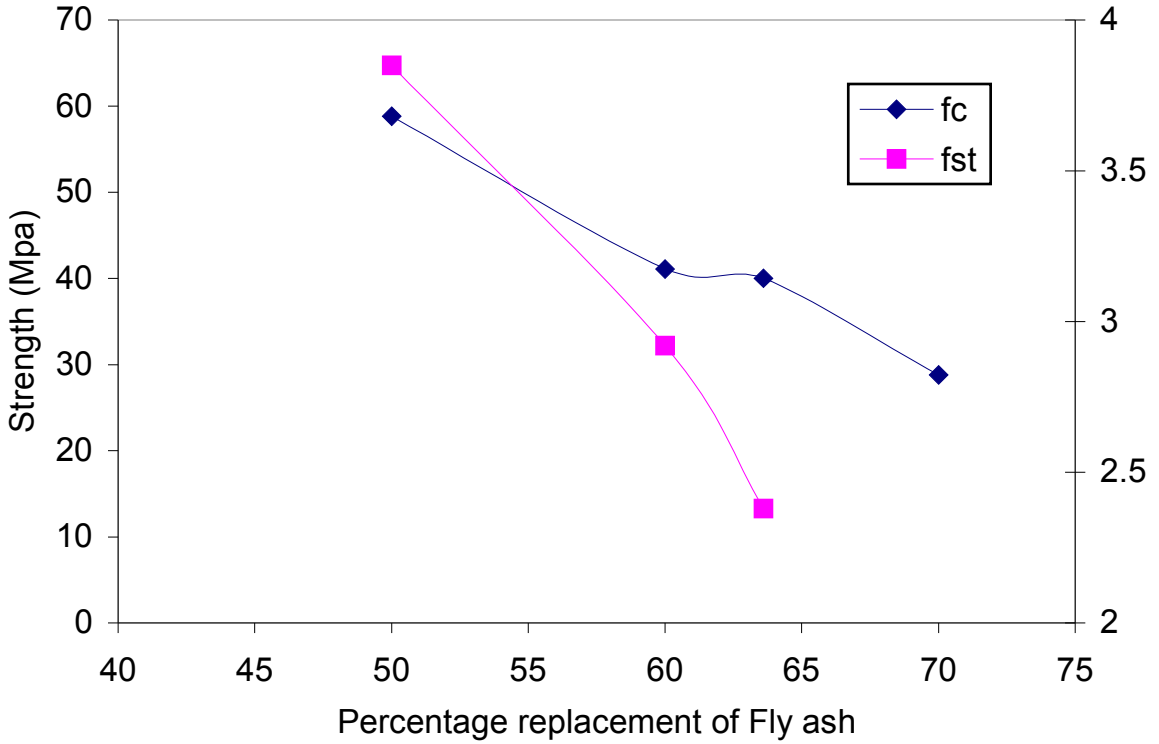
Note: a: percentage addition
b: percentage replacement

Experiences with HVFAC in nuclear industries …

R &D

Properties of HVFA concrete

Mix designation	Slump (mm)	Strength (MPa)	
		f_c	f_{st}
FM6	180	**41.1**	**2.92**
FM7	165	**28.2**	**RA**
FM8	190	**40**	**2.38**



Some more investigation on fly ash concrete

Mix proportions of different mixes

Mix	*Mineral Admixture*	*Coarse Aggr. (Kg/m^3)*	*Fine Aggr. (Kg/m^3)*	*Cement (Kg/m^3)*	*Mineral Admixture (%)*	*Mineral Admixture (kg)*	*Water (Kg/m^3)*	*w/b*	*Chemical Admixture (%)* [4]
MCM	-	1176.8	672.9	500.0	-	-	162.5	0.325	2.00
MFA	FA	1164.3	665.7	333.3	50.0[2] (33.3)[3]	166.7	150.0	0.300	0.70

Note: 1. % by weight of cement.
2. Quantity in terms of additionto cement
3.Quantity in terms of replacement of cement from total cement content.
4. %by weigh of total binder (cement + mineral admixture).

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R &D

Some more investigation on fly ash concrete

Details of different mixing methods

Mixing method	*Sequence of mixing*
I	CAg+FAg+C+W/3 (60 sec) → W/3+MA (60 sec) → W/3+CA (150 sec) → Total mixing time = 270 sec
II	CAg+FAg+C+ MA + W/3 (60 sec) → (2/3)W+ CA (210 sec) → Total mixing time = 270 sec
III	CAg + FAg + C + MA (60 sec) → W/3 (60 sec) → (2/3)W+ CA (150 sec) → Total mixing time = 270 sec
IV	For CM/GGBS/FA mixes CAg+FAg+C+ MA + W/3 (30 sec) → (2/3)W+ CA (120 sec) → Total mixing time = 150 sec
V	CAg+FAg+C+ MA + W/3 (90 sec) → (2/3)W+ CA (180 sec) → Total mixing time = 270 sec

CAg: Coarse aggregate; FAg: Fine aggregate; C: Cement
W: Water; MA: Mineral admixture CA: Chemical admixture
HRM: High reactivity Metakaolin FA: Fly ash
GGBS: Ground granulated blast furnace slag
SF: Condensed silica fume

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R &D

Some more investigation on fly ash concrete

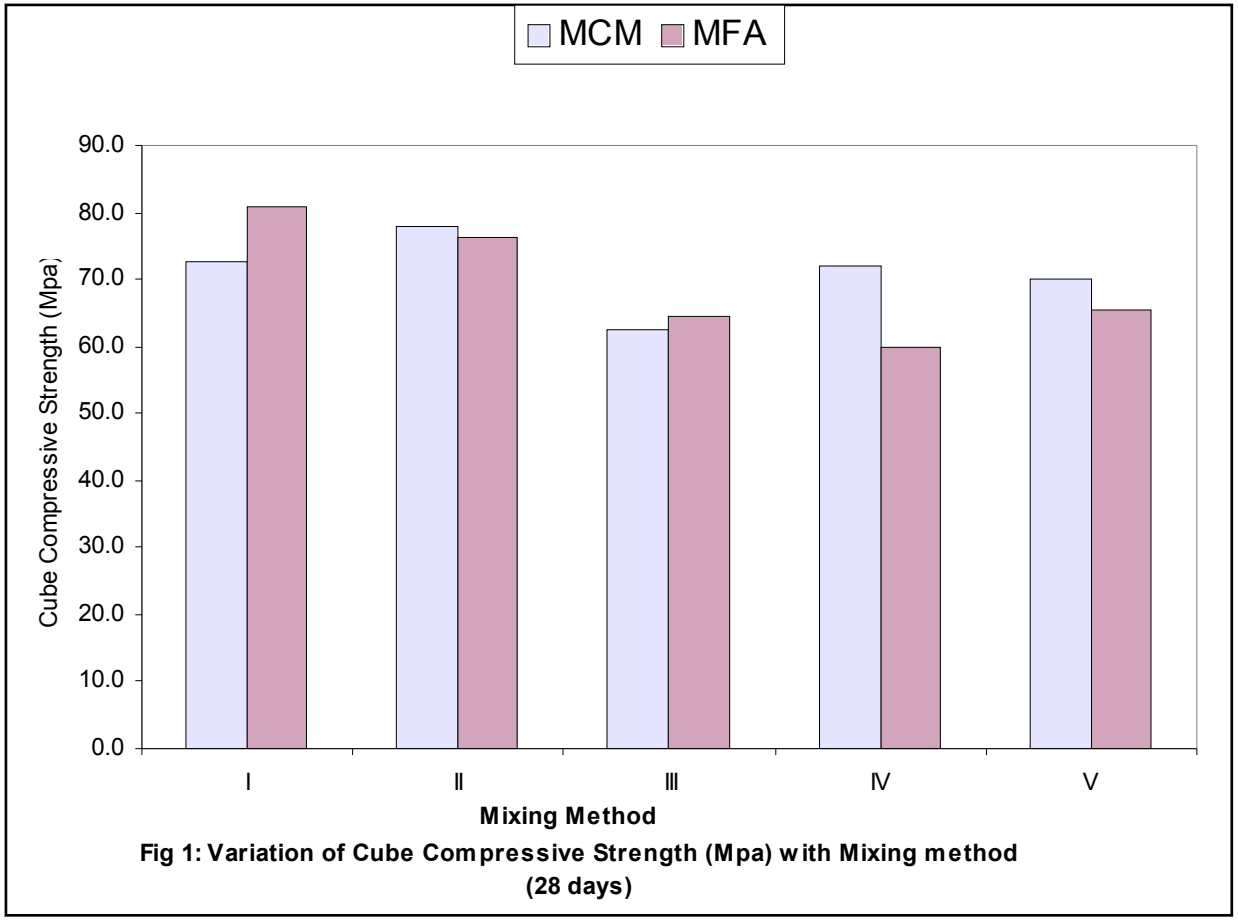

Fig 1: Variation of Cube Compressive Strength (Mpa) with Mixing method (28 days)

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R &D

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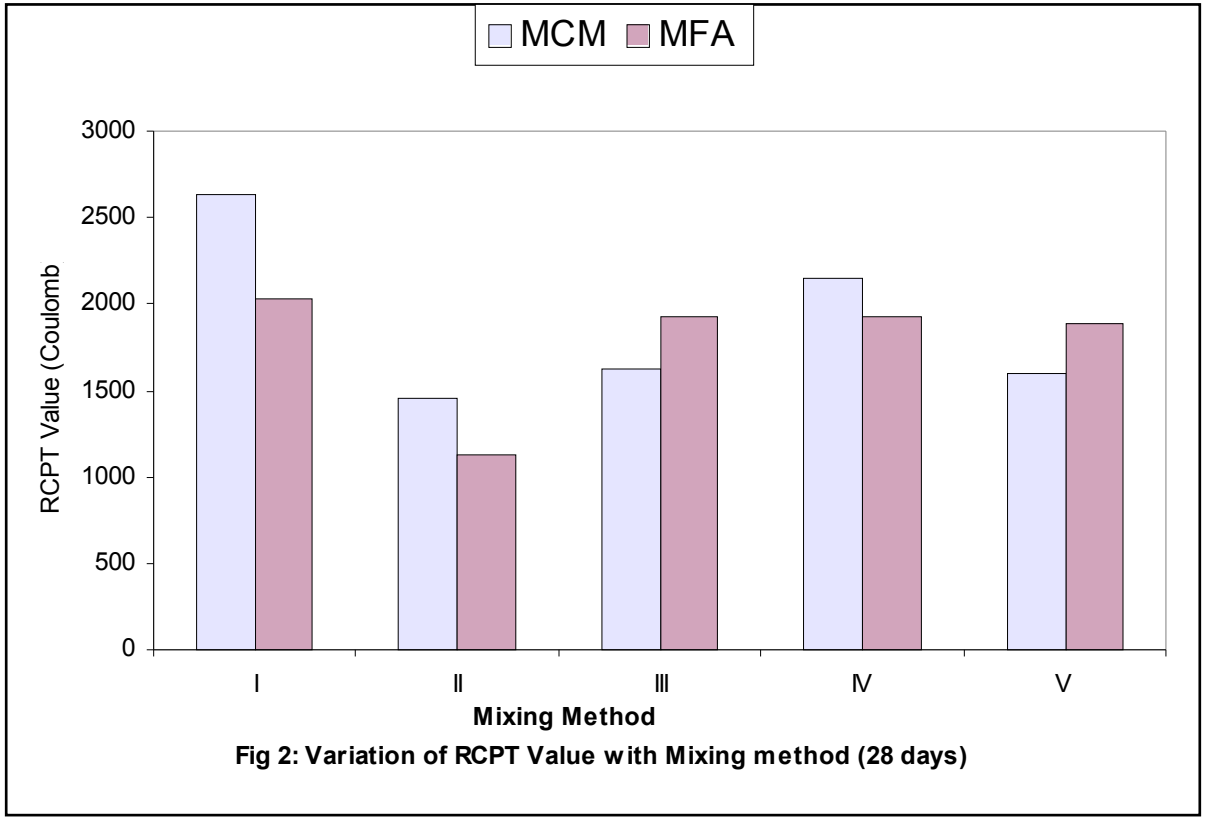

Fig 2: Variation of RCPT Value with Mixing method (28 days)

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R &D

Some more investigation on fly ash concrete

Mixing method	pH value	
	MCM	MFA
I	12.22	11.96
II	12.01	12.20
III	11.30	12.05
IV	12.38	11.98
V	11.38	11.48

Project applications

TAPP 3&4

- SCC of grade M40 for CCW Pumphouse
- M25 grade concrete for SFSB flooring
- M5 grade concrete for solid concrete blocks

KAIGA 3&4

- SCC of grade M30 for control building, turbine buildings, SRPH, tunnels and trenches.

RAPP 5&6

- M25 grade concrete for turbine buildings

Project applications

Cement =300 kg

Flyash = 200 kg (38% of Cm)

Microsilica = 25kg

C.A.(20mm) = 664 kg

F.A. = 976 kg

Water = 175 kg

Superplasticizer = 12.6 kg

VMA = 52.5 gms

W/Cm = 0.33

Slump flow = 650-700 mm

Comp Strength 28 Days = 48.0

(N/Sq. mm) 56 Days = 56.8

Project applications

	SFSB	Solid concrete blocks
Cement =	225 kg	90 kg
Flyash =	225 kg (50% of Cm)	36 kg (29% of Cm)
Water =	158 kg	125 kg
C.A. =	872 kg	1122 kg
F.A. =	859 kg	1106 kg
Superplasticizer =	12.6 kg	--
W/Cm =	0.32	0.99
Comp Strength (N/Sq. mm) 28 Days =	31.7	6.12
56 Days =	40.3	--

Project applications

- Kaiga 3&4, Karwar, Karnataka
  - Use of Self Compacting concrete (SCC) with 50% fly ash replacement (M30 grade)
  - Mix details:

Cement	225 kg
Fly ash	225 kg
Water	165 kg
Coarse Aggregate	713 kg
Fine aggregate	978 kg
Admixture (high range water reducing)	5.17 kg
Viscosity modifying agent	1.35 kg

Experiences with HVFAC in nuclear industries…

Project applications

- Location:
  - Safety related pump house
  - Turbine building
  - Control building
- Strength data

	28 days	56 days
Number of samples	32	19
Average strength	39.6 MPa	53.0 MPa
Standard deviation	2.6 MPa	3.6 Mpa
Characteristic value	36 MPa	47 MPa

Experiences with HVFAC in nuclear industries…

Project applications

- Rajasthan Atomic Power Project 5&6, Kota
  - Use of low volume fly ash (M25 grade concrete)
  - 23 % replacement

Cement	260 kg
Fly ash	80 kg
Water	160 kg
Coarse Aggregate	1000 kg
Fine aggregate	827 kg
Admixture (high range water reducing)	4.18 kg

Project applications

- Location
  - Turbine building
  - Tunnels and trenches

Experiences with HVFAC in nuclear industries…

Project applications

- Development of SCC mix at RAPP 5&6
  - Grade M25

Cement	225 kg
Fly ash	225 kg
Water	180 kg
Coarse Aggregate	624 kg
Fine aggregate	988 kg
Admixture (high range water reducing)	4.27 kg
Viscosity modifying agent	0.45 kg

Project applications

- Trial mix strength data

Parameter	MPa
7 day comp. Strength	19.58
28 day com strength	35.52
28 day cyl. Strength	28.94
28 day split tensile strength	2.73
28 day flexure strength	4.02
E at 28 days	28158

- Proposed to be used in plant structures.

Experiences with HVFAC in nuclear industries…

Concluding Remarks

1) It is possible to develop HVFAC with Indian Cement. The present work reports cement replacement up to 70%.

2) The initial strength of fly ash concrete is lower than that of control mix. HVFAC may be characterized by 56 days strength.

3) HVFAC has been used successfully in construction of Nuclear power plants in a limited way.