CSIR CRRI

CROSS ROADS
LINKING MOBILITY SOLUTIONS

IRF WORLD ROAD MEETING 2017
/ 14-17 NOVEMBER / DELHI / INDIA /

MECHANICAL PROPERTIES OF BINARY BLENDED CONCRETE MIXES FOR RIGID PAVEMENT

DINESH GANVIR
SENIOR SCIENTIST
CSIR-CENTRAL ROAD RESEARCH INSTITUTE, NEWDELHI
dineshvganvir@gmail.com

INTRODUCTION

- **Cement is the most expensive component in concrete**
- Production of cement emits approximately 5% of global carbon dioxide(CO_2) and consumes 5% of global energy
- Using Cement more efficiently will be beneficial in improving sustainability
- Cement content can be reduced by replacing a portion of it with supplementary cementitious materials(SCMs), which are generally less expensive and more environmentally friendly

INTRODUCTION

Benefits of Using SCMs

1. Improves the workability of concrete and decrease tendency to bleeding and segregation by enhancing the packing density of the concrete.

2. Reduces the pore size and porosity of both the cement matrix and the interfacial transition zone(ITZ), hence increasing the performance

3. Increases the durability in terms of permeability and increases resistance to thermal cracking and alkali aggregate expansion as a result of the pozzolanic reaction

BINARY BLENDED CONCRETE

Chemical reaction of pozzolanic material

Cement + Water → C-S-H (Gel) + $Ca(OH)_2$

$Ca(OH)_2$ + Pozzolanic Material + Water → C-S-H (Gel)

OBJECTIVE OF THE STUDY

- To study the influence of binary blended concrete mixes with flyash and ground granulated blast furnace slag for concrete pavement.

- To study the fresh and hardened properties of concrete mixes

- To study the short term and long term strength of concrete and drying shrinkage of concrete

EXPERIMENTAL PROGRAM

- CEMENT (OPC 43 GRADE)
- FLYASH
- GROUND GRANULATED BLAST FURNACE SLAG (GGBFS)
- SAND (FINE AGGREGATE)
- 10 MM (COARSE AGGREGATE)
- 20 MM (COARSE AGGREGATE)
- SUPERPLASTICIZER (PCE 0.4 %)

PHYSICAL PROPERTIES OF FLYASH

Sr No	Physical Properties	Results	Specified limits IS 3812-2013
1	Specific Gravity	2.14	-
2	Lime Reactivity	5.5 MPa	≥ 4.5 MPa
3	Residue Retain on 45μ (%)	25	≤ 34%

PHYSICAL PROPERTIES OF GGBFS

Sr No	Physical Properties	Results	Specified limits IS 3812-2013
1	Specific Gravity	2.96	-
2	Lime Reactivity	14.86 MPa	≥ 4.5 MPa

EXPERIMENAL PROGRAM

- A total of 13 mixtures were prepared (one control mixture, twelve binary mixtures) with various combinations of fly ash, GGBFS and Portland cement.

- Two series of concrete mixes with
  (1) Binary blended concrete with FA
  (2) Binary blended concrete with GGBFS.

- Mix design for PQC M40 Grade was done using a fixed cementitious content of 400 kg/m^3 with water cement ratio of 0.38 and 0.4% PC based superplasticizer was used

EXPERIMENTAL PROGRAM

•In preparing binary blended concrete, the replacement of cement by FA or GGBFS was considered as 20%, 30%, 40%, 50%, 60% and 70% by mass of cement

•Fresh properties of concrete were tested in term of compaction factor and harden properties of concrete were tested for compressive strength and flexural strength at 7, 28, and 90 days.

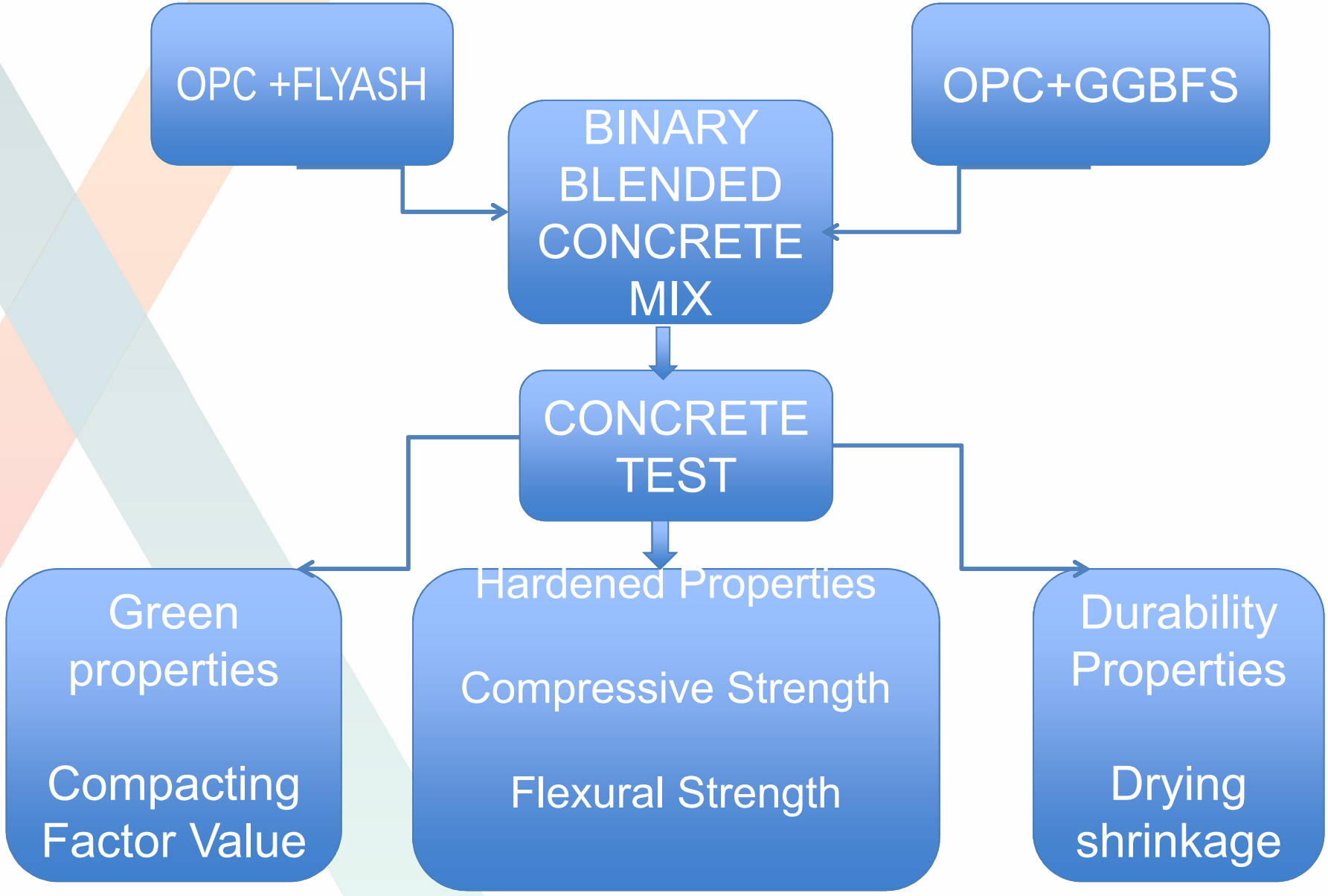
•Drying shrinkage of concrete was also tested after 28 days for all concrete mixes.

MIX PROPORTION FOR PQC

Mixes	Cement (kg)	FA (kg)	GGBFS (kg)	CA 20mm(kg)	CA 10mm(kg)	Sand (kg)	Water (kg)
*CM	400	0	0	715	584	641	160
+BF-20	320	80	0	715	584	609	160
BF-30	280	120	0	715	584	593	160
BF-40	240	160	0	715	584	577	160
BF-50	200	200	0	715	584	561	160
BF-60	160	240	0	715	584	545	160
BF-70	120	280	0	715	584	529	160
++BS-20	320	0	80	715	584	636	160
BS-30	280	0	120	715	584	634	160
BS-40	240	0	160	715	584	631	160
BS-50	200	0	200	715	584	629	160
BS-60	160	0	240	715	584	626	160
BS-70	120	0	280	715	584	624	160

*CM – Control Mix, +BF20 – Binary blended concrete with 20% FA, ++BS20 – Binary blended concrete with 20% GGBFS

FLOWCHART


OPC +FLYASH
OPC+GGBFS
BINARY BLENDED CONCRETE MIX
CONCRETE TEST
Green properties
Compacting Factor Value
Hardened Properties
Compressive Strength
Flexural Strength
Durability Properties
Drying shrinkage

SPECIMENS

Description of test	Specimen type	Size (mm)	Nos. of specimen	Total Nos. of specimen
Compressive strength	Cube	100 x100 x 100	9	117
Flexural strength	Beam	500 x100 x 100	9	117
Drying shrinkage	Prism	275 x75 x 75	2	26

RESULT & DISCUSSION

PROPERTIES STUDIED IN LABORATORY FOR PAVEMENT QUALITY CONCRETE

- PQC WORKABILITY (COMPACTING FACTOR)
- PQC COMPRESSIVE STRENGTH
- PQC FLEXURAL STRENGTH
- PQC DRYING SHRINKAGE

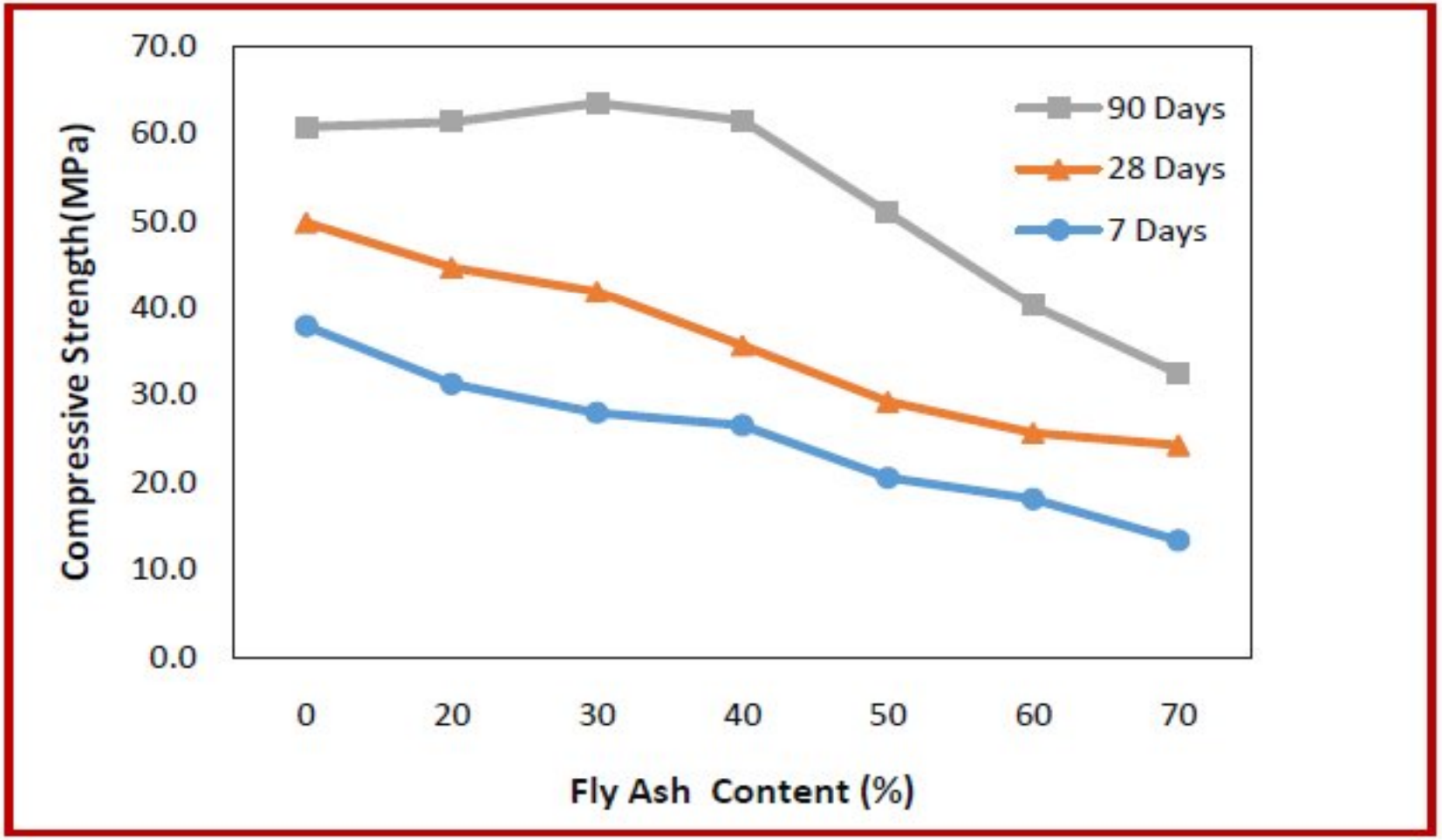
PQC WORKABILITY

(IS:1199, (BIS:2004)

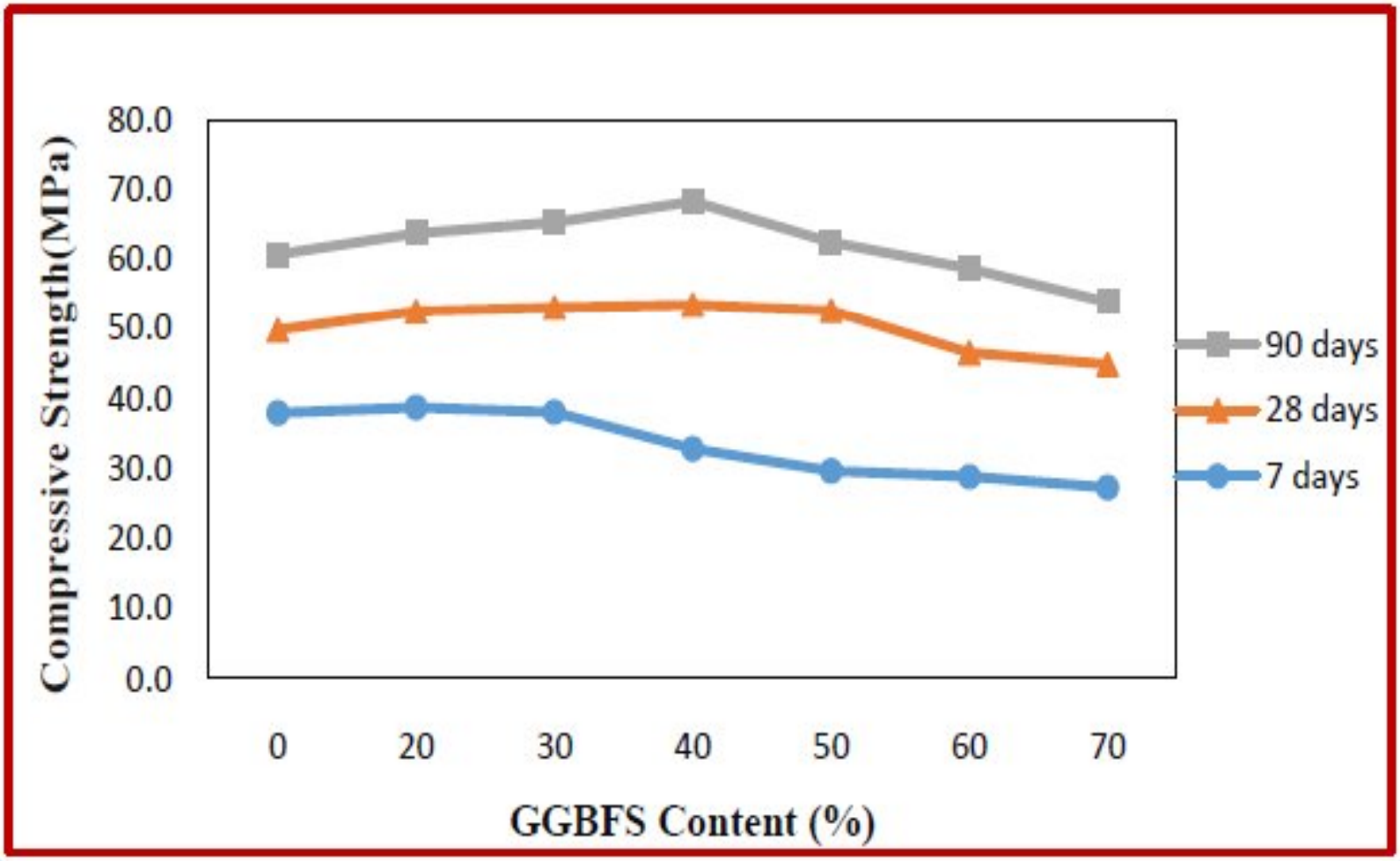
Control Concrete Mixes CF= 0.92

Cement Replacement by SCM (%)	Binary Blended Concrete with FA	Binary Blended Concrete with GGBFS
20	0.91	0.91
30	0.92	0.92
40	0.92	0.93
50	0.93	0.92
60	0.94	0.92
70	0.94	0.92

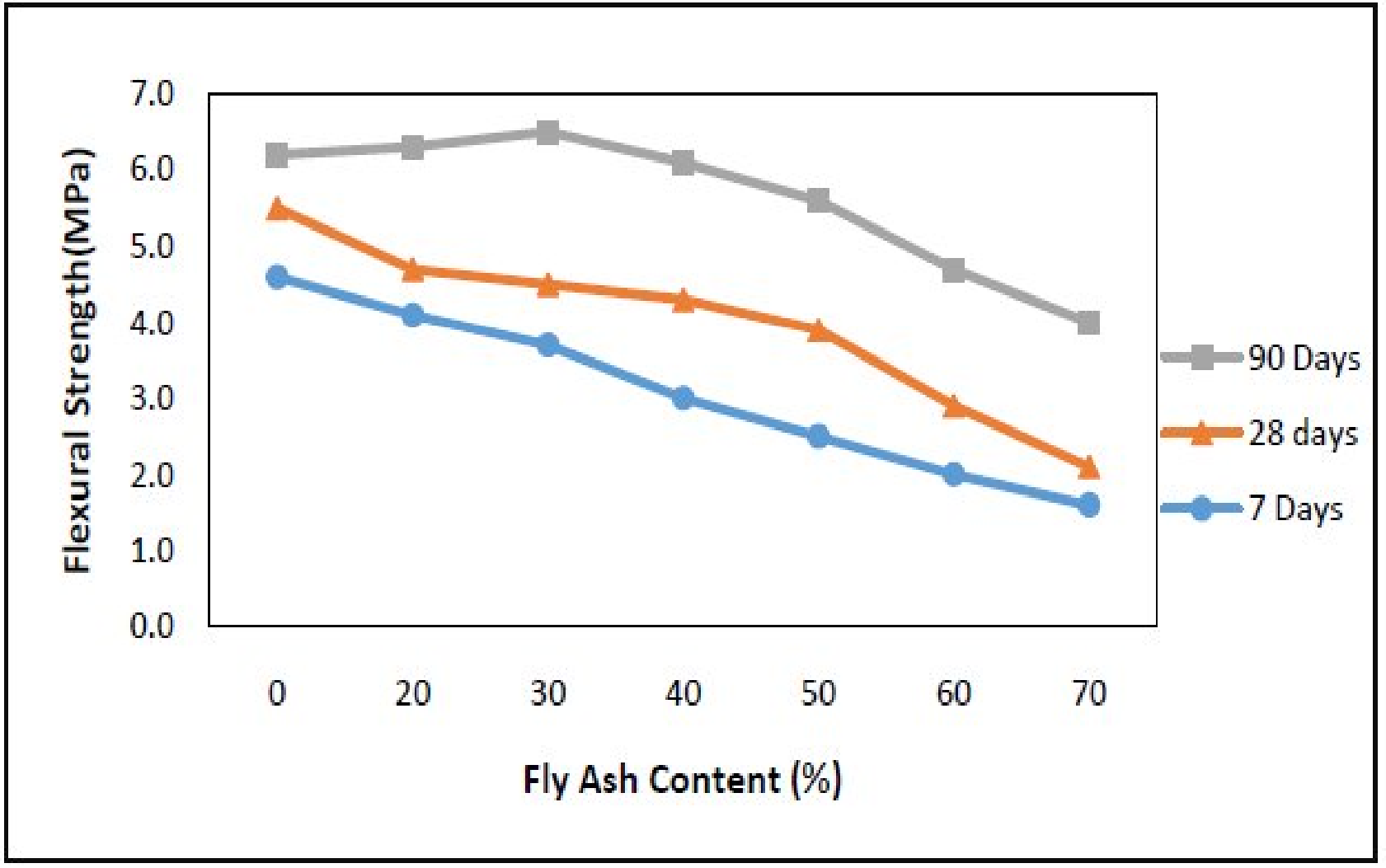
PQC COMPRESSIVE STRENGTH WITH FLYASH



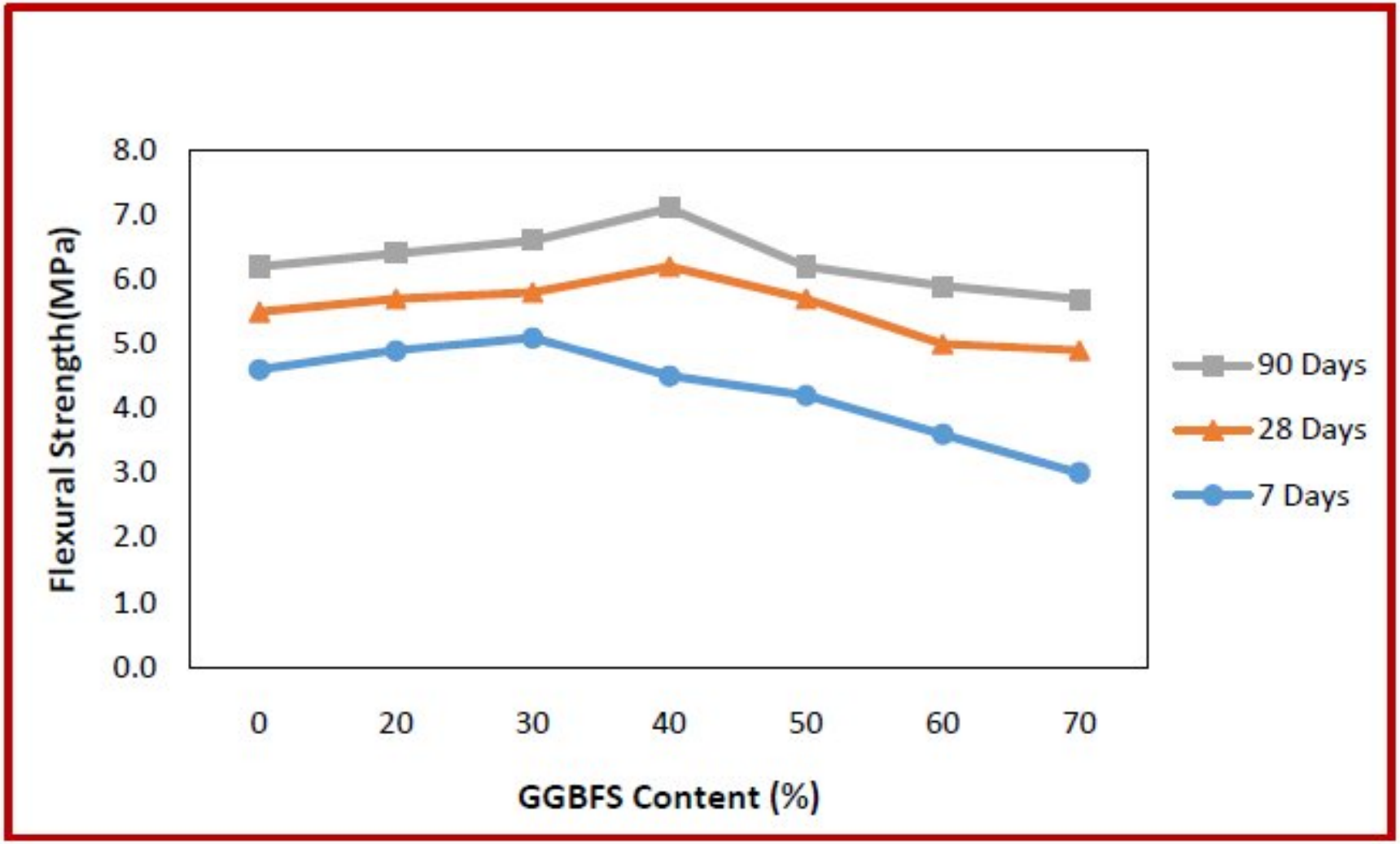
PQC COMPRESSIVE STRENGTH WITH GGBFS



PQC FLEXURAL STRENGTH WITH FLYASH

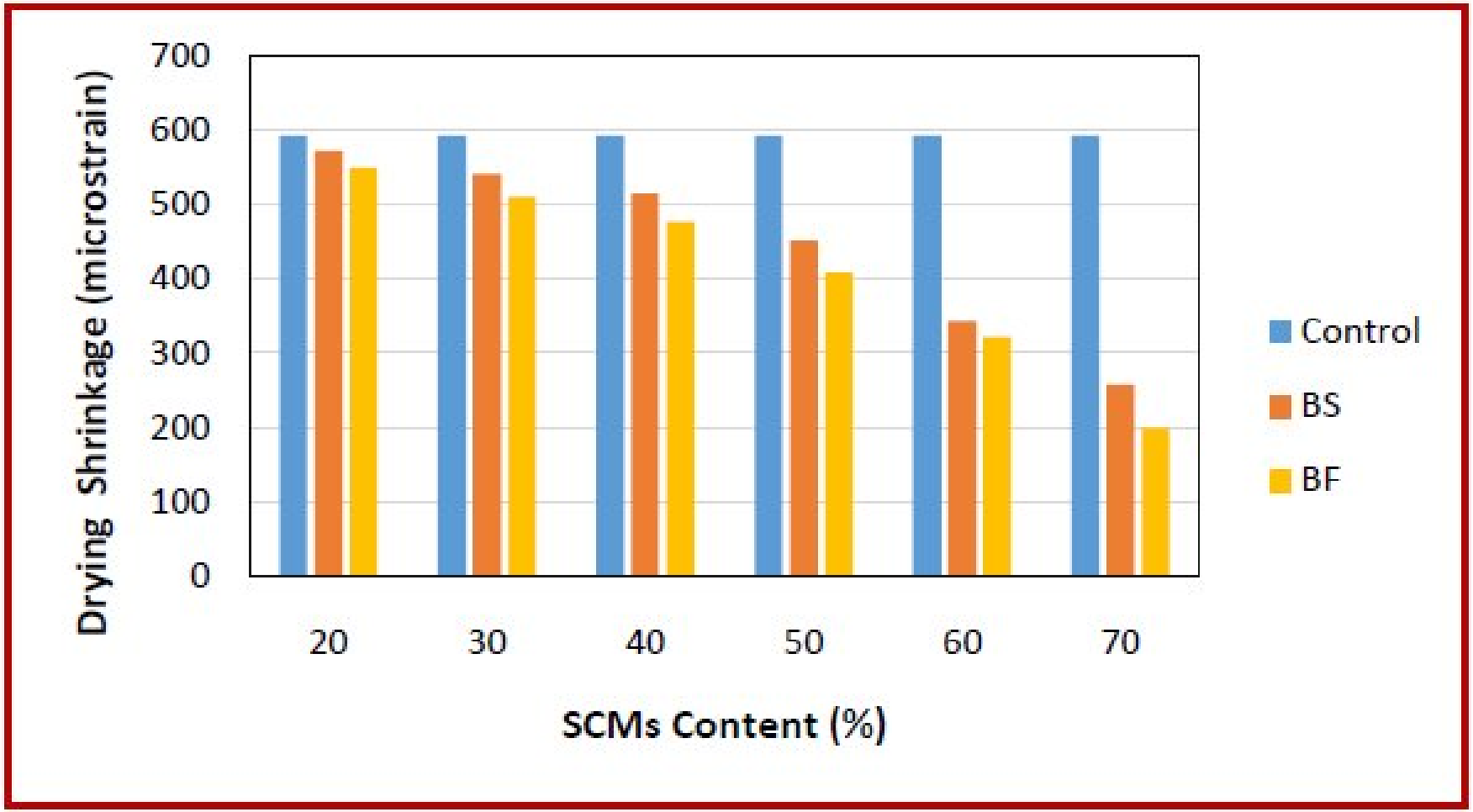


PQC FLEXURAL STRENGTH WITH GGBFS



DIGITAL DRYING SHRINKAGE APPARATUS

PQC DRYING SHRINKAGE (IS:1199)



CONCLUSION

- Workability of fresh concrete increased for FA based binary blended concrete.

- Workability of fresh concrete with GGBFS was comparable with the controlled mix.

- The compressive strength of all the mixes was less than control mix (37.9 MPa) at 7 days except the BS-20 (38.7 MPa) and BS-30 (38.1 MPa) mixes.

- The compressive strength of BS-20, BS-30, BS-40 and BS-50 were higher than control mix and they achieved design strength at 28 days.

- All the mixes achieved target compressive strength (48.3 MPa) except BF-60 (40.3 MPa) and BF-70 (32.5MPa) at 90 days.

CONCLUSION Contd.

- Optimum dosage for binary blended concrete with FA and GGBFS were 30% and 40% respectively at 90 days. But it can be replaced up to 50% and 70% with FA and GGBFS respectively to gain the target compressive strength

- The optimum value of flexural strength for binary blended concrete with FA and binary blended concrete with GGBFS were 4.7MPa (BF-30) and 6.2 MPa (BS-40) respectively

- Drying shrinkage reduce significantly for FA and GGBFS based concrete

- GGBFS blended concrete is more durable and also it gain strength more rapidly than FA blended concrete

THANK YOU FOR YOUR KIND ATTENTION