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Innovations in Chemical Admixture Technology as Related to Sustainability, Part 2

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Combinations of poly carboxylate ethers and lignosulfonates in chemical admixtures for special performance.

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OUTLINE

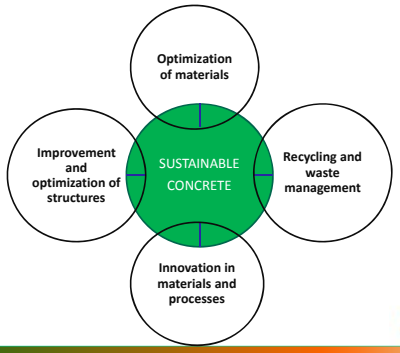
- Sustainable concrete
- Materials for chemical admixtures
- Combinations of Lignosulfonates and Polycarboxylate Ethers
- Experimental work
- Results and discussions
- Conclusions
- Path forward

CONCRETE

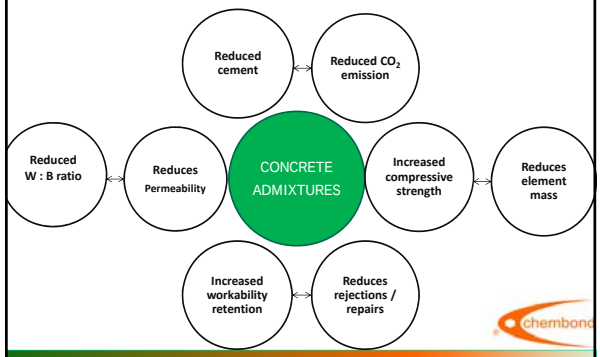
- C ombination of
- O rganic (Synthetic) and
- N atural ingredients
- C ast and C ured with / without
- R einforcement in the
- E nvironment using
- T echnology and
- E ffective human resources

SUSTAINABLE CONCRETE

– HOW TO

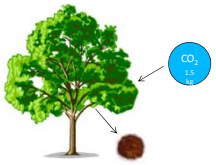


ROLE OF CONCRETE ADMIXTURES

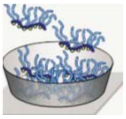


MATERIALS

LIGNOSULFONATES (LS)



- Green and sustainable chemical
- Carbon content of LS is 400 gm. / kg.
- 1.5 kg of CO_2 is withdrawn from atmosphere/kg of LS
- Steric + Electrostatic repulsion.
- Excellent compatibility with SNF, SMF and PCEs.
- Most grades are compatible with Alternative Cementitious Materials.



SULFONATED NAPTHALENE FORMALDEHYDE (SNF)

- Made using Napthelene, Formaldehyde and H_2SO_4.
- Works well for concretes up to 60 MPa.
- Better initial slump than LS.
- Compatible with most retarders and LS
- Long retention of slump is possible.
- Generally not compatible with PCEs.

POLYCARBOXYLATE ETHERS (PCE)

- Excellent dispersion helps high strengths
- Steric repulsion results in good water reduction at very low dosages.
- SCC can be made most of the times, without the use of VMAs
- Opens opportunities to obtain results with variety of cement types and ACMs.
- Dosage is very sensitive.
- Compatibility with retarders and defoamers is critical.

COMBINATIONS OF LIGNOSULFONATE AND PCE's

ASPECTS

- Synergy
- Cost
- Versatility
- Foaming tendency
- Compatibility
- Workability
- Strength development
- Cement compatibility

SCOPE

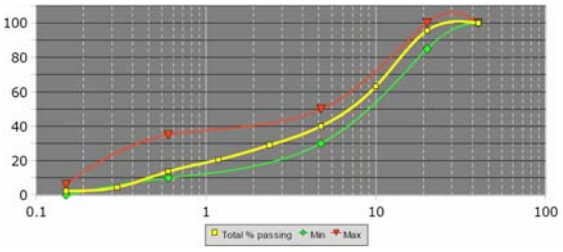
- Study Ca-LS and Na-LS combinations with PC-WR. The results are compared with SNF : LS combinations
- Na-LS from 2 different sources, PCE's from 3 different sources and Ca-LS from single source
- Concrete trials at two different dosages

EXPERIMENTAL WORK

CONCRETE PROPORTIONS

Material	Material Type & Source	Dry Wt Kg / M³	Moist. %	W.A. %	SSD Kg /M³
Cementitious	Ultratech OPC 53	416			416
	Fly Ash	78			78
	Mircrosilica	26			26
Aggregates	CA2: 20 MM	709	0	0.65	704
	CA1: 12 MM	472	0	0.85	468
	FA2: R. SAND	638	0	1.00	632
	FA1: C.SAND	0	0	0.00	0
Admixture	Sample 4	3.6			3.6
Water	Local Source	158			173
Theoretical plastic density - =		2501			2501
Water / Cement Ratio =		0.30			

COMBINED GRADATION

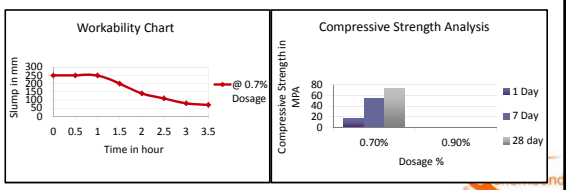


Sample 1

Admixture Formulations	
Test Mix	(%)
PC-WR 1	56
PC-SR1	24
Water	20
Total	100

Physical Properties	
% NVM	40.33
SG @ 25 °C	1.1
pH @ 25 °C	6.52
VISCOSITY FCB4 25 °C	52

Compatibility	
Viscosity After 24 Hrs at 25 °C	52
Viscosity After 7 Days at 25 °C	52
Viscosity After 30 Days at 25 °C	52

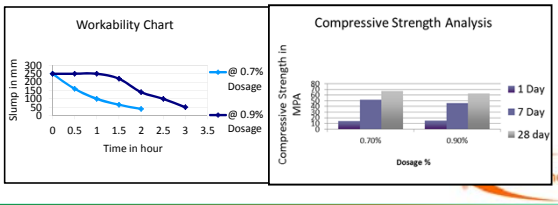


Sample 2

Admixture Formulations	
Test Mix	(%)
PC-WR 1	40
Na Ligno B	21.6
Water	38.4
Total	100

Physical Properties	
% NVM	40.54
SG @ 25°C	1.13
pH @ 25°C	5.62
VISCOSITY FCB4 25°C	45

Compatibility	
Viscosity After 24 Hrs at 25 °C	45
Viscosity After 7 Days at 25 °C	47
Viscosity After 30 Days at 25 °C	46

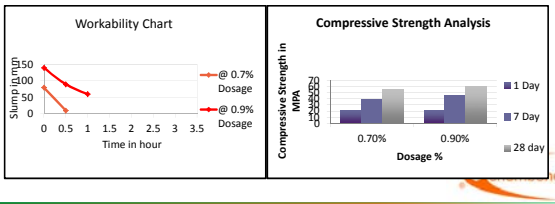


Sample 3

Admixture Formulations	
Test Mix	(%)
PC-WR1	24
Na Ligno	30
Water	46
Total	100

Physical Properties	
% NVM	39.97
SG @ 25°C	1.15
pH @ 25°C	5.3
VISCOSITY FCB4 25°C	32

Compatibility	
Viscosity After 24 Hrs at 25 °C	32
Viscosity After 7 Days at 25 °C	35
Viscosity After 30 Days at 25 °C	34

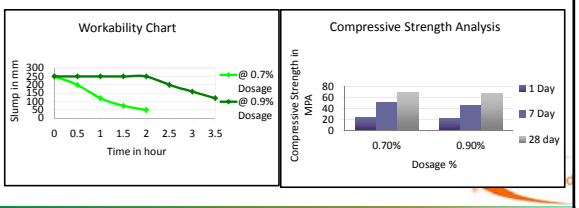


Sample 4

Admixture Formulations	
Test Mix	(%)
PC-WR1	56
Na Ligno B	12.8
Water	31.2
Total	100

Physical Properties	
% NVM	40.12
SG @ 25°C	1.12
pH @ 25°C	6.03
VISCOSITY FCB4 25°C	52

Compatibility	
Viscosity After 24 Hrs at 25 °C	52
Viscosity After 7 Days at 25 °C	55
Viscosity After 30 Days at 25 °C	55

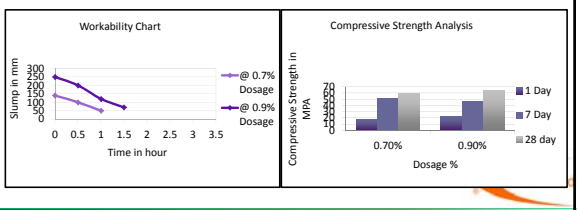


Sample 5

Admixture Formulations	
Test Mix	(%)
PC-WR1	40
Ca Ligno B	21.6
Water	38.4
Total	100

Physical Properties	
% NVM	39.81
SG @ 25°C	1.14
pH @ 25°C	5.77
VISCOSITY FCB4 25°C	54

Compatibility	
Viscosity After 24 Hrs at 25 °C	54
Viscosity After 7 Days at 25 °C	54
Viscosity After 30 Days at 25 °C	55

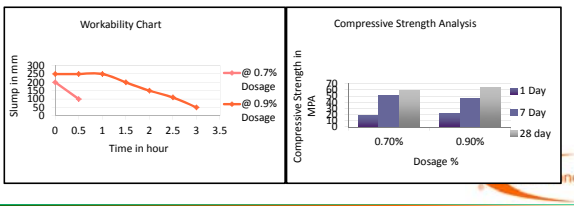


Sample 6

Admixture Formulations	
Test Mix	(%)
PC-WR1	40
Na Ligno R	21.6
Water	38.4
Total	100

Physical Properties	
% NVM	39.93
SG @ 25°C	1.13
pH @ 25°C	5.6
VISCOSITY FCB4 25°C	65

Compatibility	
Viscosity After 24 Hrs at 25 °C	65
Viscosity After 7 Days at 25 °C	71
Viscosity After 30 Days at 25 °C	70

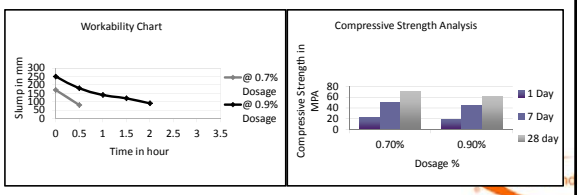


Sample 7

Admixture Formulations	
Test Mix	(%)
PC-WR2	33.2
Na Ligno	21.6
Water	45.2
Total	100

Physical Properties	
% NVM	40.28
SG @ 25^{0}C	1.14
pH @ 25^{0}C	4.79
VISCOSITY FCB4 25^{0}C	44

Compatibility	
Viscosity After 24 Hrs at 25 ^{0}C	44
Viscosity After 7 Days at 25 ^{0}C	45
Viscosity After 30 Days at 25 ^{0}C	43

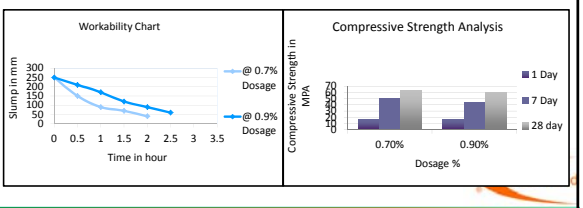


Sample 8

Admixture Formulations	
Test Mix	(%)
PC-WR3	40
Na Ligno	21.6
Water	38.4
Total	100

Physical Properties	
% NVM	40.36
SG @ 25^{0}C	1.14
pH @ 25^{0}C	5.12
VISCOSITY FCB4 25^{0}C	43

Compatibility	
Viscosity After 24 Hrs at 25 ^{0}C	43
Viscosity After 7 Days at 25 ^{0}C	44
Viscosity After 30 Days at 25 ^{0}C	44

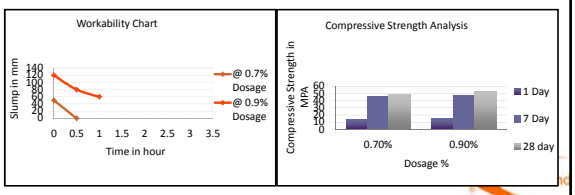


Sample 9

Admixture Formulations	
Test Mix	(%)
Na Ligno	21.6
SNF (42%)	47.6
Water	30.8
Total	100

Physical Properties	
% NVM	40.41
SG @ 25^{0}C	1.2
pH @ 25^{0}C	6.6
VISCOSITY FCB4 25^{0}C	18

Compatibility	
Viscosity After 24 Hrs at 25 ^{0}C	18
Viscosity After 7 Days at 25 ^{0}C	19
Viscosity After 30 Days at 25 ^{0}C	20

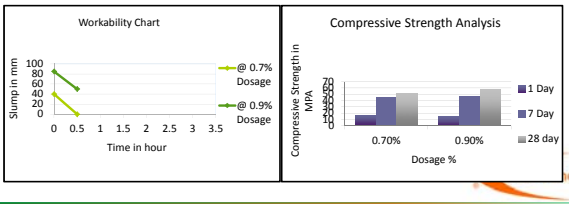


Sample 10

Admixture Formulations	
Test Mix	(%)
Na Ligno	12.8
SNF (42%)	66.8
Water	20.4
Total	100

Physical Properties	
% NVM	39.98
SG @ 25^{0}C	1.2
pH @ 25^{0}C	6.15
VISCOSITY FCB4 25^{0}C	17

Compatibility	
Viscosity After 24 Hrs at 25 ^{0}C	17
Viscosity After 7 Days at 25 ^{0}C	18
Viscosity After 30 Days at 25 ^{0}C	18

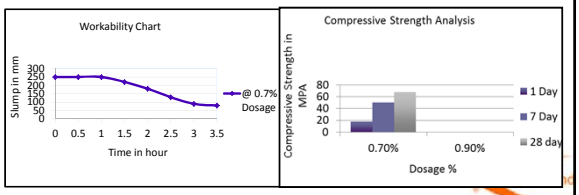


Sample 11

Admixture Formulations	
Test Mix	(%)
PC-WR1	80
Water	20
Total	100

Physical Properties	
% NVM	40.2
SG @ 25^{0}C	1.1
pH @ 25^{0}C	6.5
VISCOSITY FCB4 25^{0}C	51

Compatibility	
Viscosity After 24 Hrs at 25 ^{0}C	51
Viscosity After 7 Days at 25 ^{0}C	51
Viscosity After 30 Days at 25 ^{0}C	51

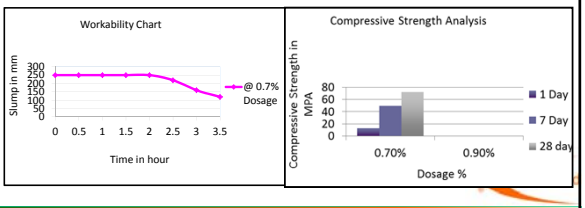


Sample 12

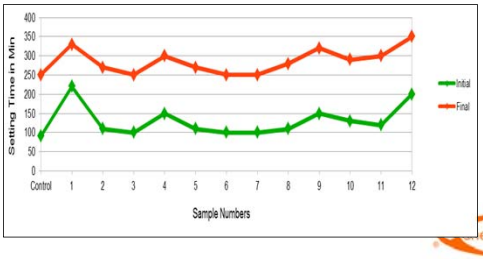
Admixture Formulations	
Test Mix	(%)
PC-SR1	80
Water	20
Total	100

Physical Properties	
% NVM	40.01
SG @ 25^{0}C	1.1
pH @ 25^{0}C	6.51
VISCOSITY FCB4 25^{0}C	38

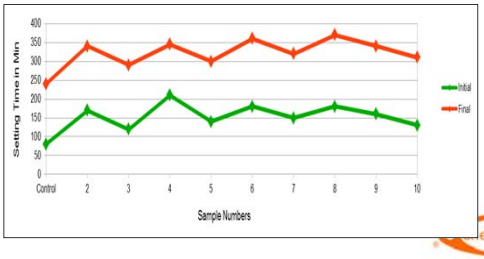
Compatibility	
Viscosity After 24 Hrs at 25 ^{0}C	38
Viscosity After 7 Days at 25 ^{0}C	38
Viscosity After 30 Days at 25 ^{0}C	38



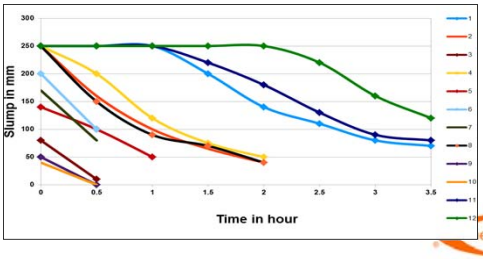
SETTING TIMES
AT 0.7% DOSAGE



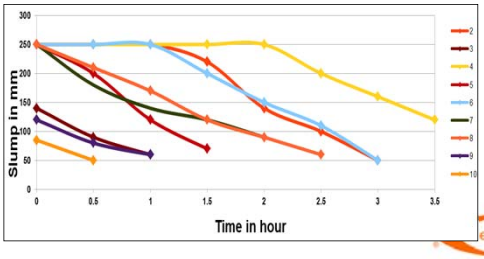
SETTING TIMES
AT 0.9 % DOSAGES



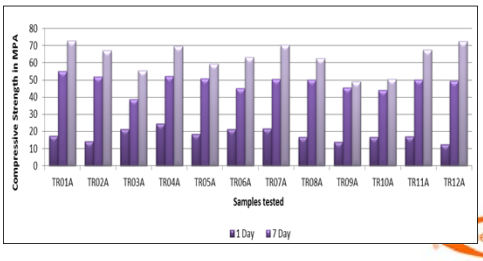
WORKABILITY
AT O.7 % DOSAGE



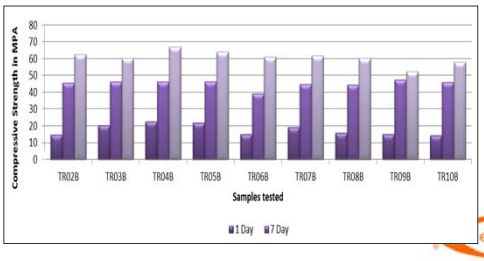
WORKABILITY
AT 0.9% DOSAGE



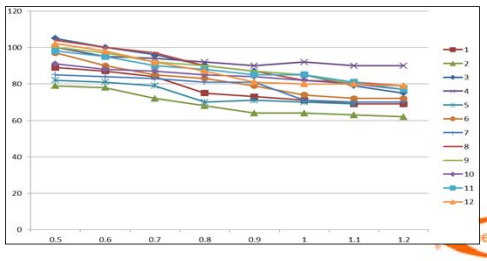
COMPRESSIVE STRENGTHS
AT 0.7% DOSAGE



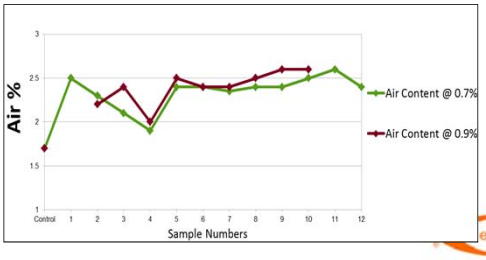
COMPRESSIVE STRENGTHS
AT 0.9 % DOSAGE



MARSH CONE RESULTS



AIR CONTENT



RESULTS & DISCUSSION

COMPATIBILITY, SETTING TIME AND WORKABILITY

- Compatibility of PC-WR and LS combinations has been established.
- At 25^{0}C, all formulations at 0.7 and 0.9 % dosages are near to the requirement of ASTM C-494 type G, for setting time.
- As the dosage is low retardation is under control.
- At 0.7% PC-WR : PC-SR and their combination, gives good workability retention.
- 50 : 50 combinations of PC-WR and NAL's give good initial workability but the slump drops quickly after 30 minutes.

COMPATIBILITY, SETTING TIME AND WORKABILITY

- PC-WR : NAL's 75:25 combination retains slightly better than 50:50 combination.
- At 0.9% both PC-WR and Na-LS as well as Ca-LS provide good retention.
- Na-LS combination gives better retention.
- PC-WR and Na-LS 75:25 combination provides best slump retention.
- It is obvious that the retention of SNF : Na-LS combinations is no way near PC-WR : Na-LS combination. This could be due to a very low W/B ratio of 0.3.

COMPRESSIVE STRENGTH AND AIR CONTENT

- Best compressive strength achieved @ 0.7% dosage.
- Compressive strengths
  - At 0.7% dosage
    - Pure PCE's > 75:25 PCE : LS > 50:50 PCE : LS.
  - At 0.9% dosage
    - 75:25 PCE : Na-LS > 50:50 PCE : Na-LS
    - 25:75 PC-WR : Na-LS > 75:25 SNF : Na-LS
- Air content of all the mixes has not varied much due to lower dosages.

CONCLUSIONS

- Combinations of PCEs with LS will add a significant value to concrete sustainability.
- LS has good compatibility, with all the PCE molecules used in this study.
- PCE : LS combination are most desirable where SNF:LS combinations fail or require higher dosages.
- The synergy of PCE: LS combinations, have opened up an excellent option for Admixture formulators.
- Good workability retention and comparatively higher strengths achieved, suggest that significant cost and material savings may be obtained, using PCE : LS combinations.

PATH FORWARD

- Work In Progress
  - Study involving GGBFS and different cement brands.
  - To check other PCE molecules.
- Further Studies
  - Long term compatibility and compatibility with various cement types.
  - At higher dosages and higher W/B ratios.

ACKNOWLEDGEMENTS

- ACI INTERNATIONAL
- My Organization - CHEMBOND CHEMICALS LIMITED
- My colleagues across the organization at Chembond for supporting my study in various capacities
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THANK YOU

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