

Investigations on Cement-free Pigmented Geopolymer Mortar Grouted Open Graded Friction Course

Sandeep Kumar Guddu and Dr. Anush K. Chandrappa

Presented by

Dr. Anush K. Chandrappa
Associate Professor
School of Infrastructure
IIT Bhubaneswar
akc@iitbbs.ac.in

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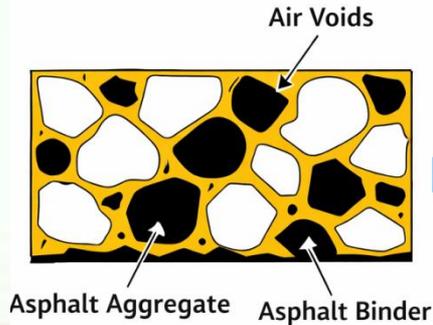
**Global Road Infratech
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BACKGROUND

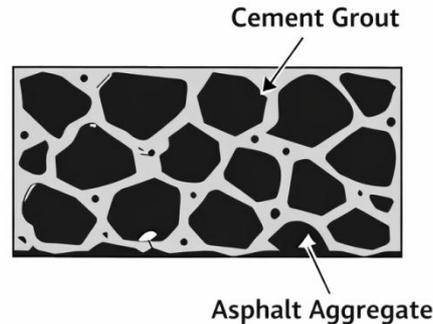
- Cement grouted bituminous mixture (CGBM) involves grouting highly porous bituminous mixture with cement mortar

Before Grouting



Porous Asphalt Mix

After Grouting



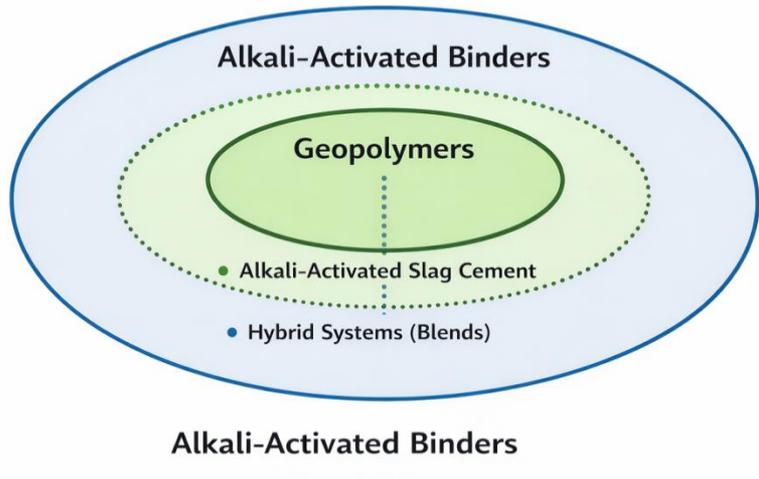
Cement Grouted Composite

- Porous bituminous layer provides flexibility and load distribution
- Cement grout provides high stiffness, strength, and rut resistance
- Depicts semi-flexible behavior

BACKGROUND

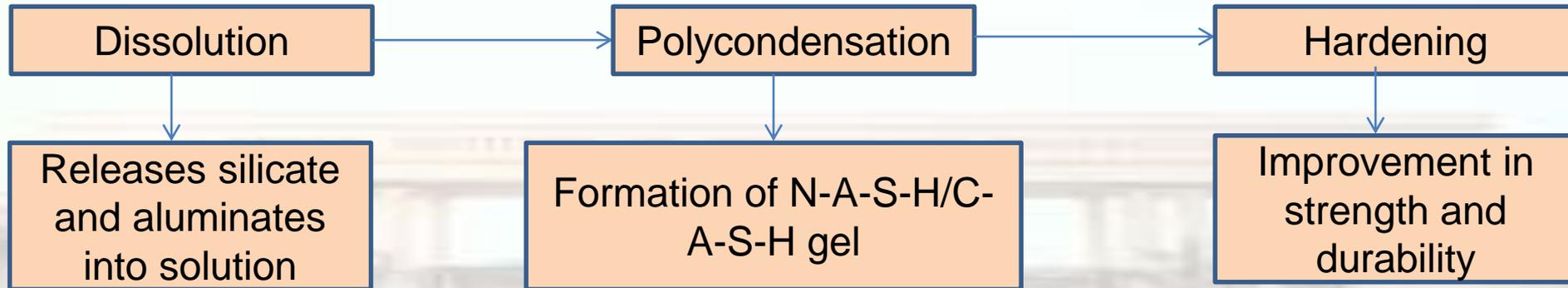
- CGBM requires 25-35% porosity in bituminous mixture
- One lane-km of CGBM requires 50-80 tonnes of cement
- Each ton of cement emits 0.8-0.9 ton of CO₂
- Significantly increases carbon footprint
- Sustainable alternatives required to reduce carbon footprint
- Alkali-activated binders

- Alkali-activated binders (AABs) – sustainable alternative for cement
- AABs uses alumino-silicate rich industrial byproducts instead of cement for binding



- Geopolymer – low calcium and produces sodium alumino-silicate hydrate (N-A-S-H) [Fly ash, RHA, Silica fume]
- Alkali-activated slag cement – high calcium and produces calcium alumino-silicate hydrate (C-A-S-H) [GGBFS]
- Hybrid blends

- AABs produce N-A-S-H / C-A-S-H in alkaline environment
- Alkaline environment is created by sodium hydroxide (NaOH)/ potassium hydroxide (KOH) and sodium silicate or potassium silicate solutions



OBJECTIVE and SCOPE

Objective: to investigate the potential of cement-free geopolymer mortar as a grouting material for open graded friction course (OGFC)

Scope

Design of Geopolymer grout as a function of Molarity of NaOH

Investigate setting and flowability characteristics of geopolymer grout

Investigate strength characteristics of geopolymer mortar

Materials:

- Precursor: **GGBFS** and **Fly ash**
- Alkali Activator:
NaOH (3M to 15 M) and Na_2SiO_3
- Water
- Aggregates
- Pigments (Red and Green)
- VG40 bitumen

OGFC gradation

IS Sieve	Grade-1	Grade-2	Grade-3
26.5	100		
19.0	92.5	100	100
13.2	20	92.5	95
9.5	3.5	20	45
6.3	-	3.5	-
4.75	-	-	12.5
2.36	1	1	11.5
0.075	0.75	0.75	5

Methods: Design of GP Mortar

Material	% By Wt.	Specific gravity	Volume %	Volume % w.r.t GGBFS	Volume (dm ³)	Density (kg/m ³)	Weight (in gm)
GGBFS	25	2.846	8.784	1.00	0.200	2846	569.9
Fly Ash	25	2.066	12.101	1.38	0.276	2066	569.9
Sand	50	2.703	18.498	2.11	0.422	2703	1139.8
Alkali Activator	30	1.433	20.935	2.38	0.477	1433	683.9
Water	15	1	15.000	1.71	0.342	1000	342.0
Pigment	1.5	4.28	0.350	0.04	0.008	4280	34.2
			Sum	8.61	1.725		3339.7
AA/Binder	0.6	Na ₂ SiO ₃ /NaOH	2				
Water/Binder	0.3	Sodium Silicate	455.94				
Pigment/Binder	0.03	Sodium Hydroxide	227.97				
Volume of GGBFS	0.200	Calculate for volume	1.725	Average Density	1.94		

Methods



Grade-1



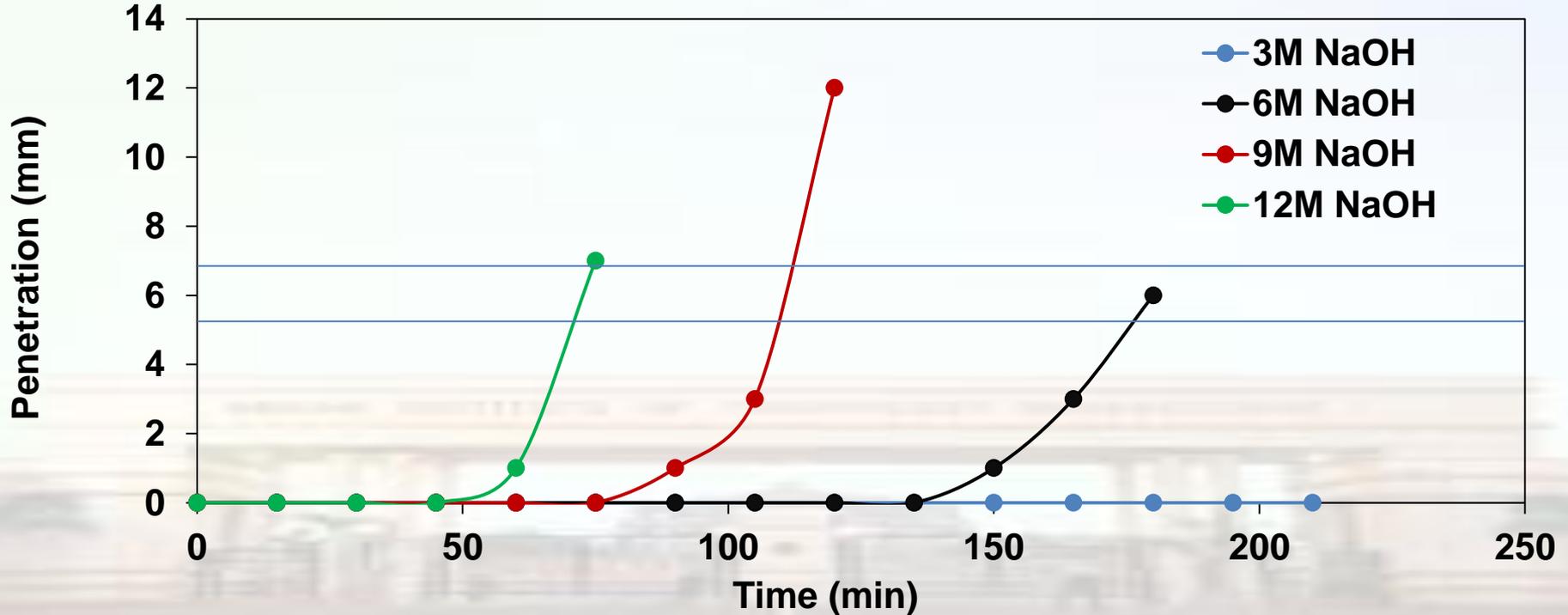
Grade-2



Grade-3

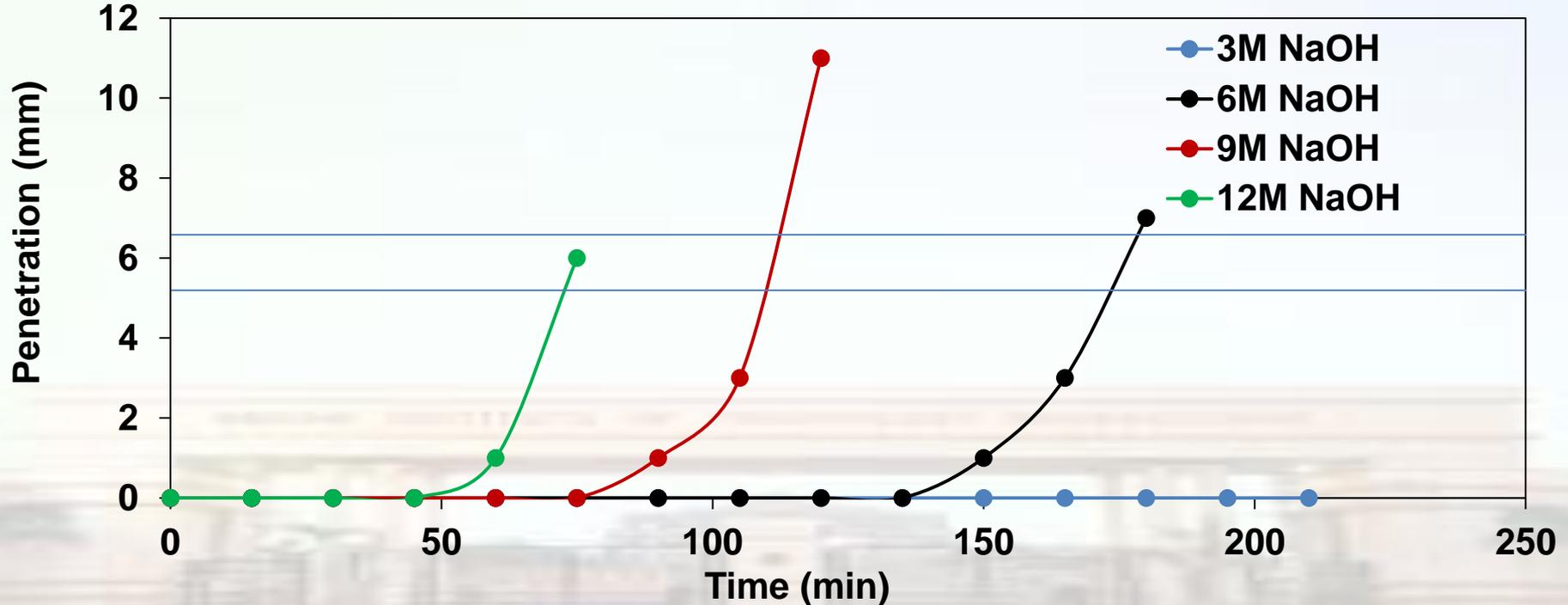
RESULTS & ANALYSIS

Initial setting time of GP Mortar with Red Pigment

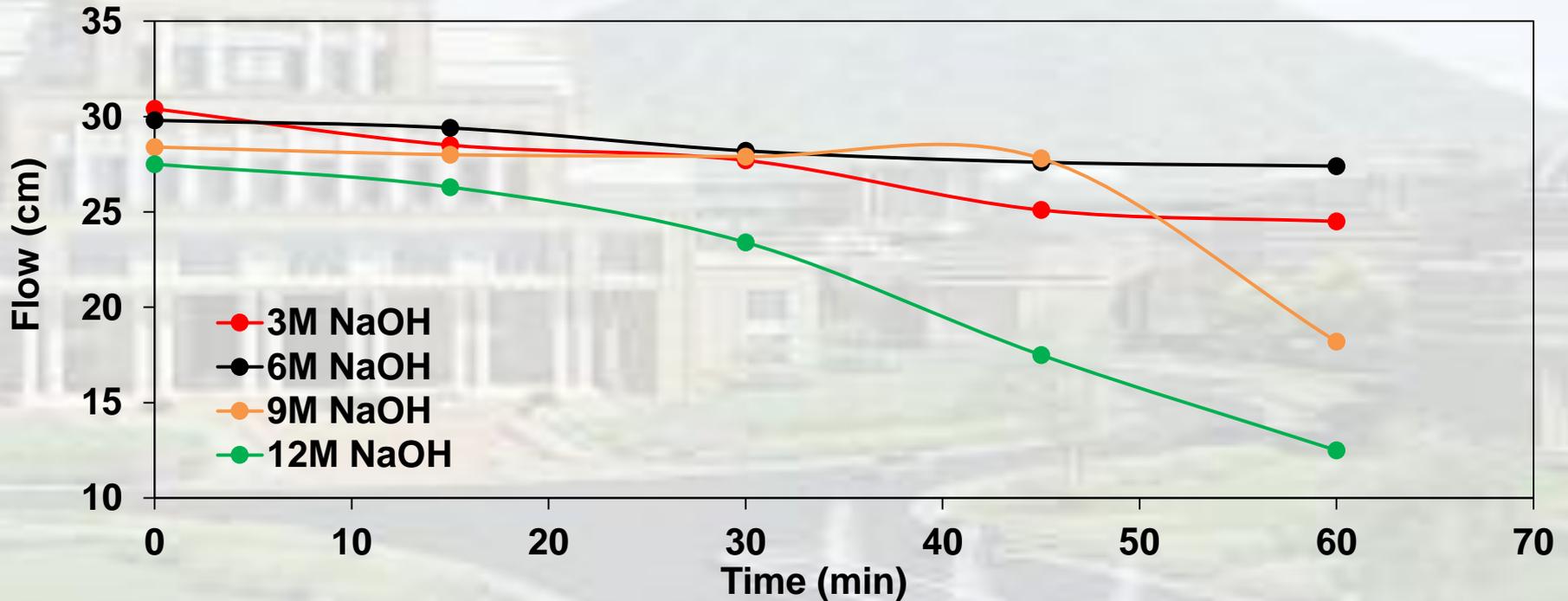


RESULTS & ANALYSIS

Initial setting time of GP Mortar with green pigment

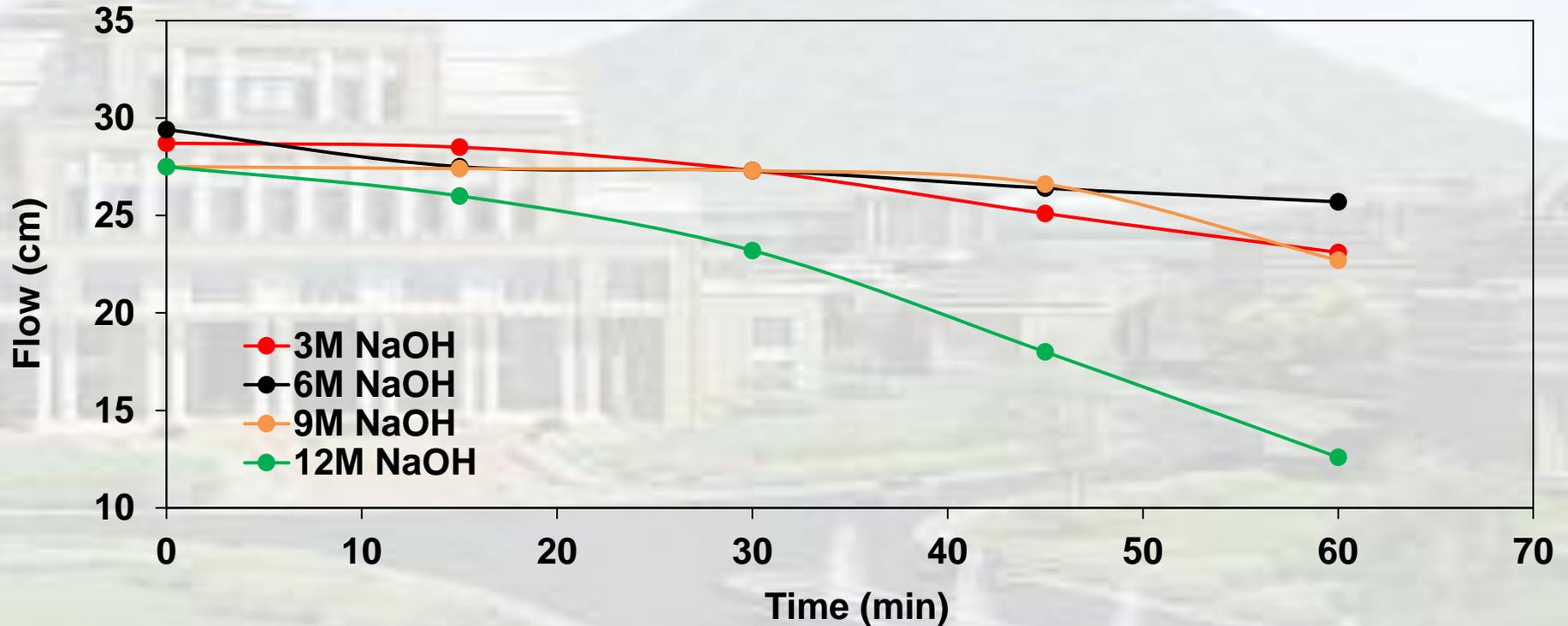


Flow Value of GP Mortar with Red Pigment



RESULTS & ANALYSIS

Flow Value of GP Mortar with Green Pigment



RESULTS & ANALYSIS

Mix 6M NaOH	3-Day Strength (MPa)	7-Day Strength (MPa)	14-Day Strength (MPa)	28-Day Strength (MPa)
M1	7.56	12.78	16.62	24.01
M2	6.67	13.39	17.06	24.04
M3	7.46	12.04	16.67	23.65
Average	7.23	12.74	16.78	23.90

Mix 9M NaOH	3-Day Strength (MPa)	7-Day Strength (MPa)	14-Day Strength (MPa)	28-Day Strength (MPa)
M1	16.63	27.97	33.83	35.86
M2	16.42	30.74	32.97	34.45
M3	17.07	27.53	29.91	36.25
Average	16.71	28.75	32.24	35.52

RESULTS & ANALYSIS



Grade-2



Grade-1



Grade-3

RESULTS & ANALYSIS



Efflorescence at high molarity
($> 12M$) geopolymer mortar
grout

CONCLUDING REMARKS

- Grouting characteristics are significantly affected by molarity of NaOH
- Flow and setting time decreased significantly at higher molarity providing less window for construction operation
- Increase in molarity increases the strength of mortar
- 9M GP mortar ensured sufficient flowability and strength
- Bus stops, truck lay-bays, Highway nest areas, etc.

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THANK YOU