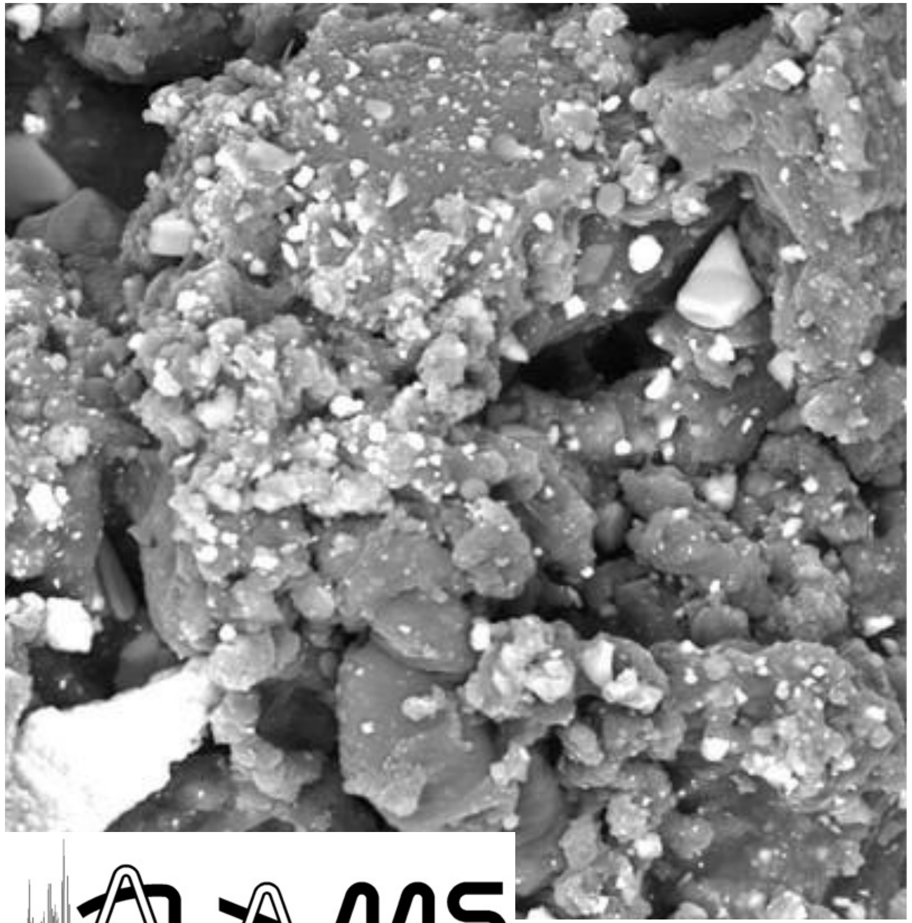
Experimental analysis of cement mortar with varying replacement levels of crumb rubber



Md Salamah Meherier, Rubaiya Rumman, Mohammad Tiznobaik, M. Shahria Alam

Applied Laboratory for Advanced Materials & Structures

Presented by
Rubaiya Rumman
PhD Student, Civil Engineering
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Primary use of rubber

Vehicle tires: Main component rubber (41%)

2020 Statistics

Total rubber production worldwide

27.4m mt

Global consumption of rubber

26.9m mt

Global synthetic rubber market size

19.1 bn USD

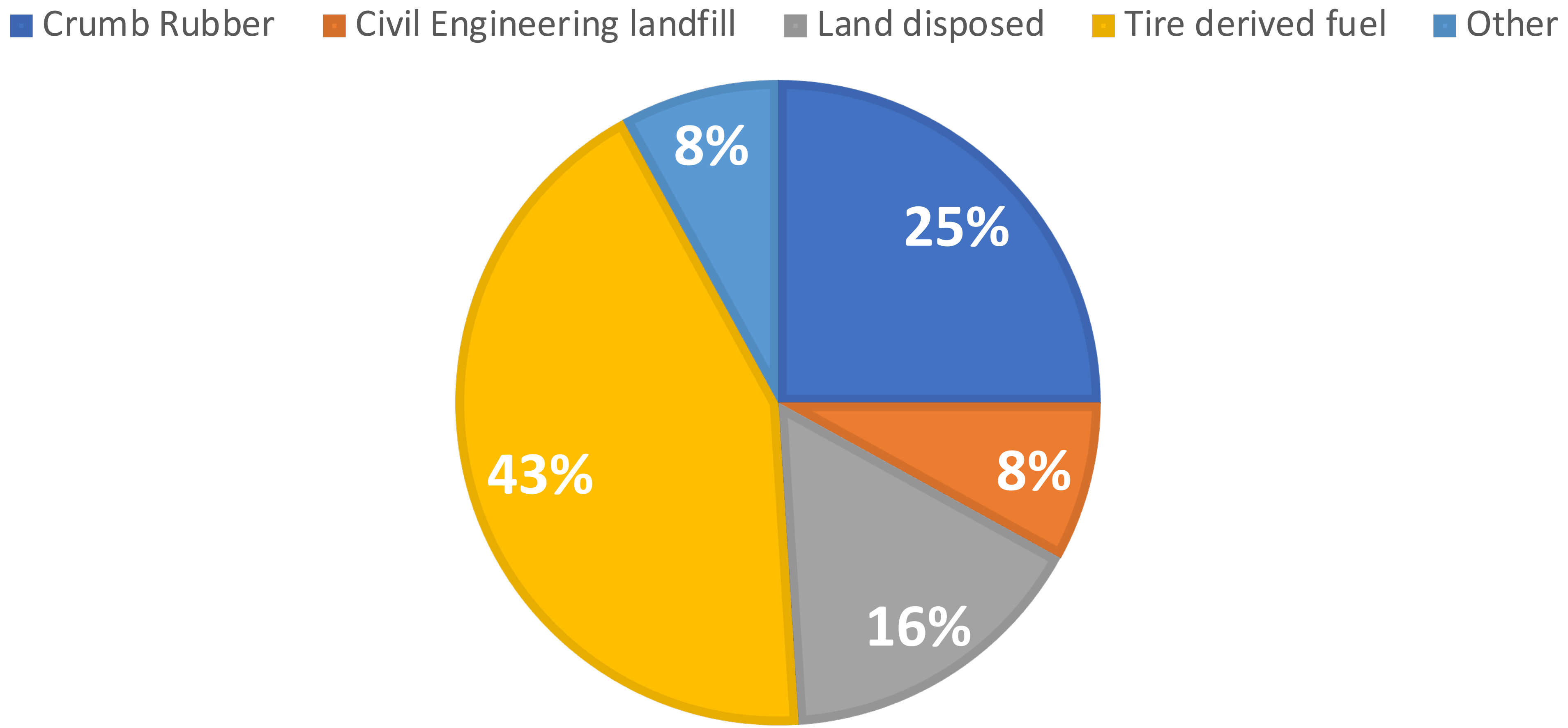
Disposing rubber waste in the landfills

Serious risk to the environment as rubber is non-biodegradable

Breeding ground for mosquitoes, flies, rats and other pests

Fire hazard

Utilization of rubber scraps



U.S. Tire Manufacturers Association, 2018

Crumb rubber in civil engineering

Foundation and trench fills

Flowable fills in bridge abutments

Making aggregate: Non structural forms

Concrete

- Most widely used construction material
- Main ingredient, cement, is responsible for 8% of total global emissions
- Shortage of aggregate is one of the greatest sustainability challenges
- Replacing any component of concrete with recycled material has positive environmental impact

Previous findings

Compressive strength lowered with increasing addition of crumb rubber

Contrasting results on workability

- some researchers found improved workability with crumb rubber addition [1-4]
- some observed the opposite [5-11]

Contrasting results on durability

- some [7] observed a decline in concrete durability
- Some researchers [10] found that concrete performed better in terms of durability

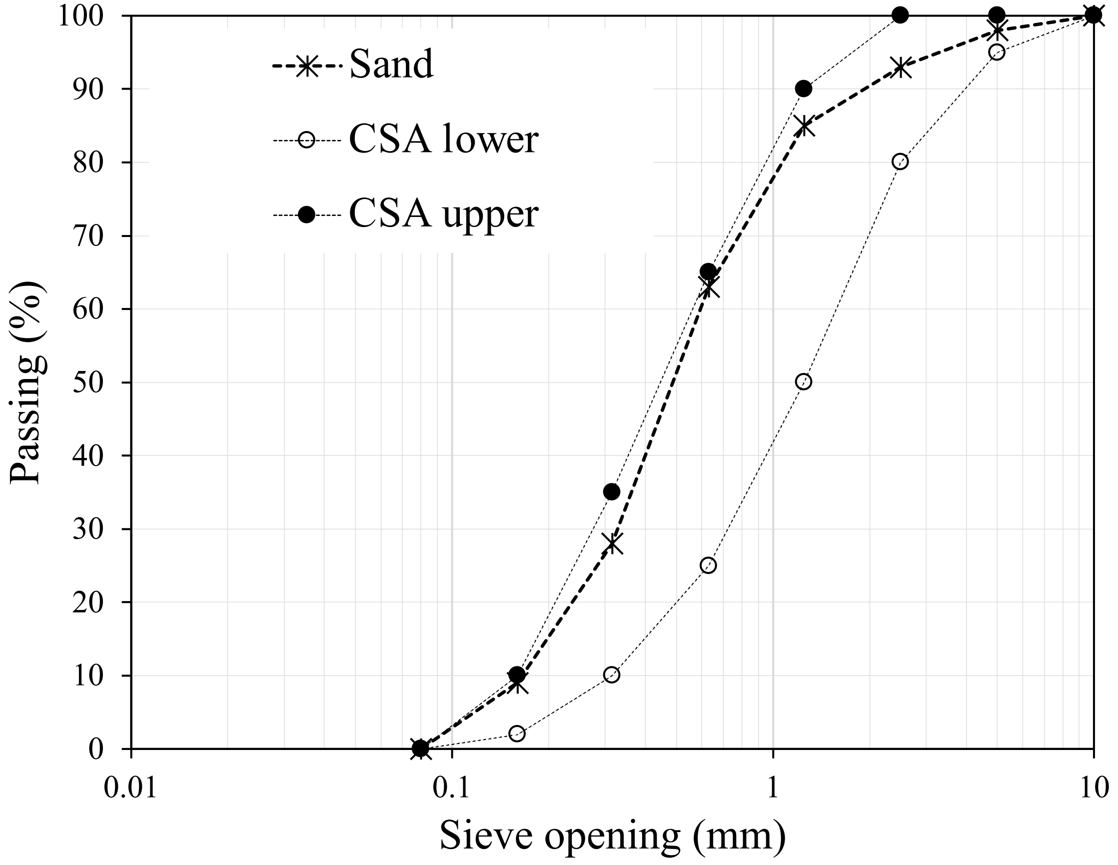
Materials

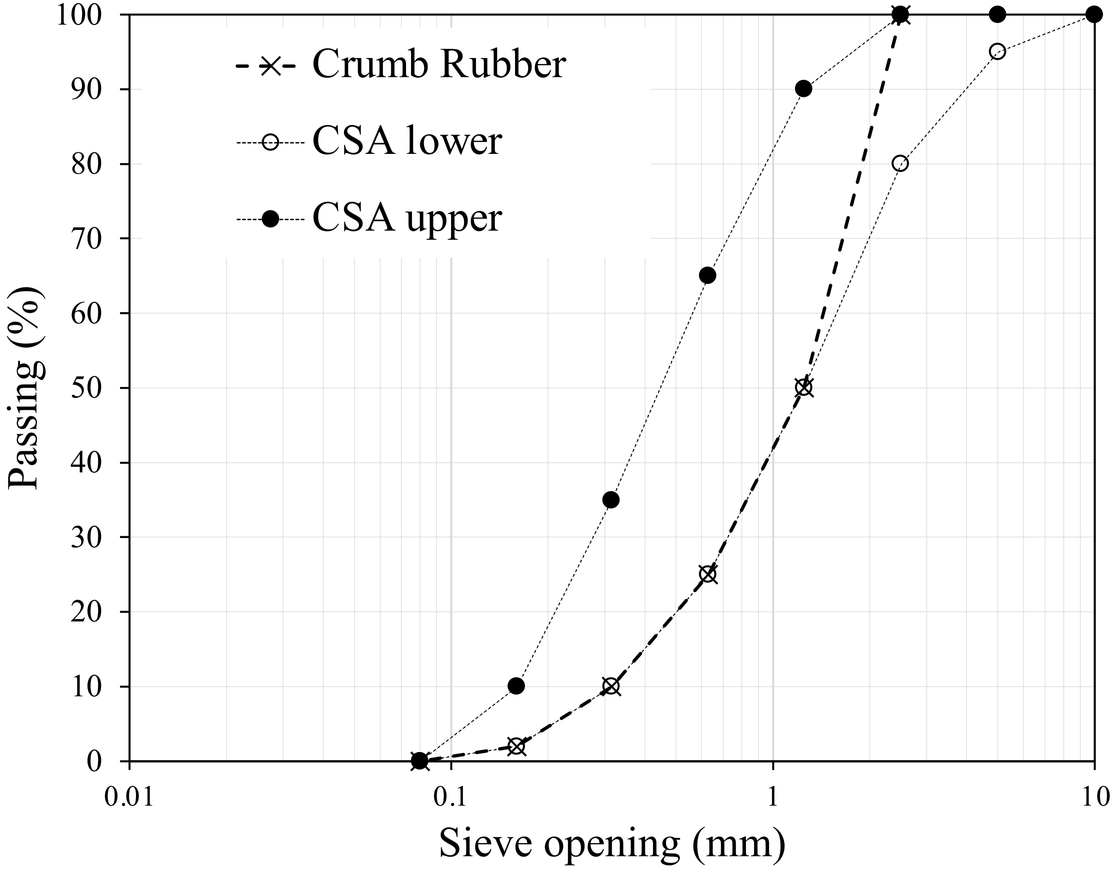
- Cement: GU
- Sand
- Crumb rubber

Sand and crumb rubber properties

Variables	Sand	Crumb Rubber
Bulk dry specific gravity	2.56	1.15
Bulk SSD specific gravity	2.60	
Apparent specific gravity	2.67	
Water absorption capacity (%)	1.52	1.20
Fineness modulus (FM)	2.24	3.68

Gradation of sand and crumb rubber





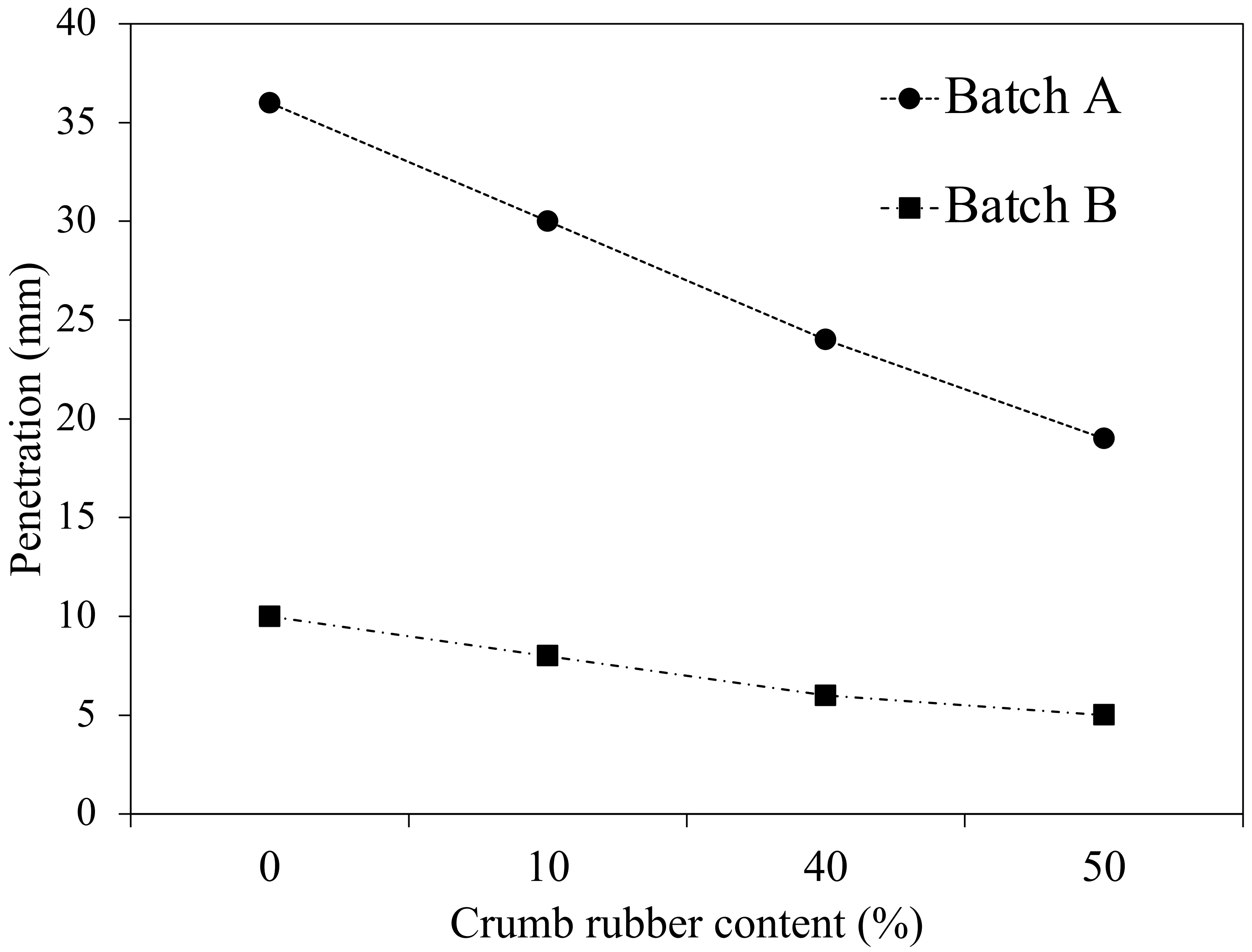
Chemical composition of crumb rubber

Composition of Elements	Percentage
Carbon (C)	69.95
Oxygen (O)	20.93
Sodium (Na)	0.38
Magnesium (Mg)	0.23
Aluminium (Al)	0.71
Silicon (Si)	1.53
Sulfur (S)	1.42
Potassium (K)	0.12
Calcium (Ca)	0.22
Iron (Fe)	2.43
Copper (Cu)	0.15
Zinc (Zn)	1.91
Total	99.98

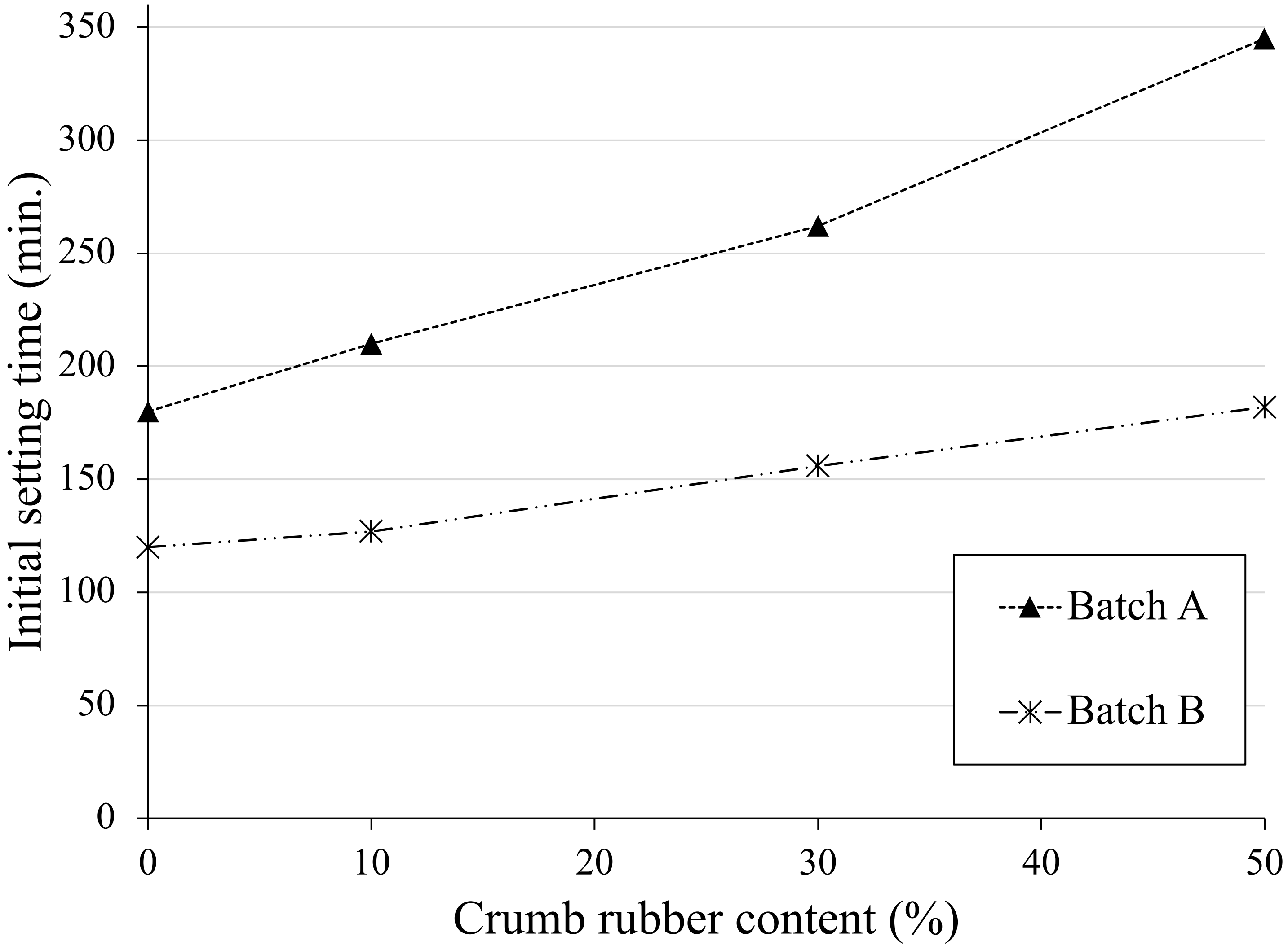
Mortar mix design

Batch	Sample designation	Sand (g)	Crumb rubber (g)	Crumb rubber content
Batch A (1 : 2.5)	A1	2500	0	0%
	A2	2250	109	10%
	A3	1750	327	30%
	A4	1250	545	50%
Batch B (1 : 3)	B1	3000	0	0%
	B2	2700	131	10%
	B3	2100	392	30%
	B4	1500	653	50%

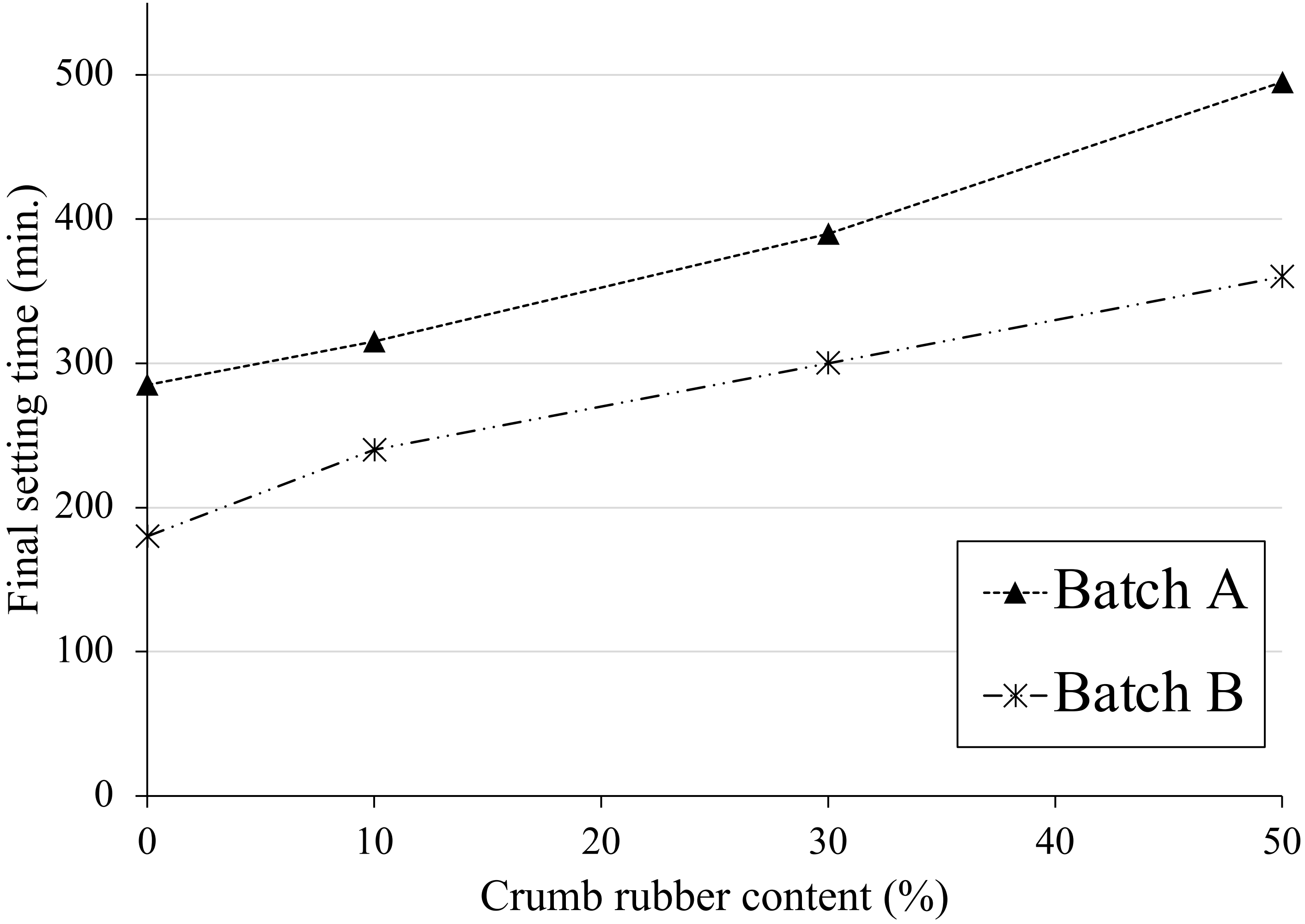
Normal consistency



Initial setting time

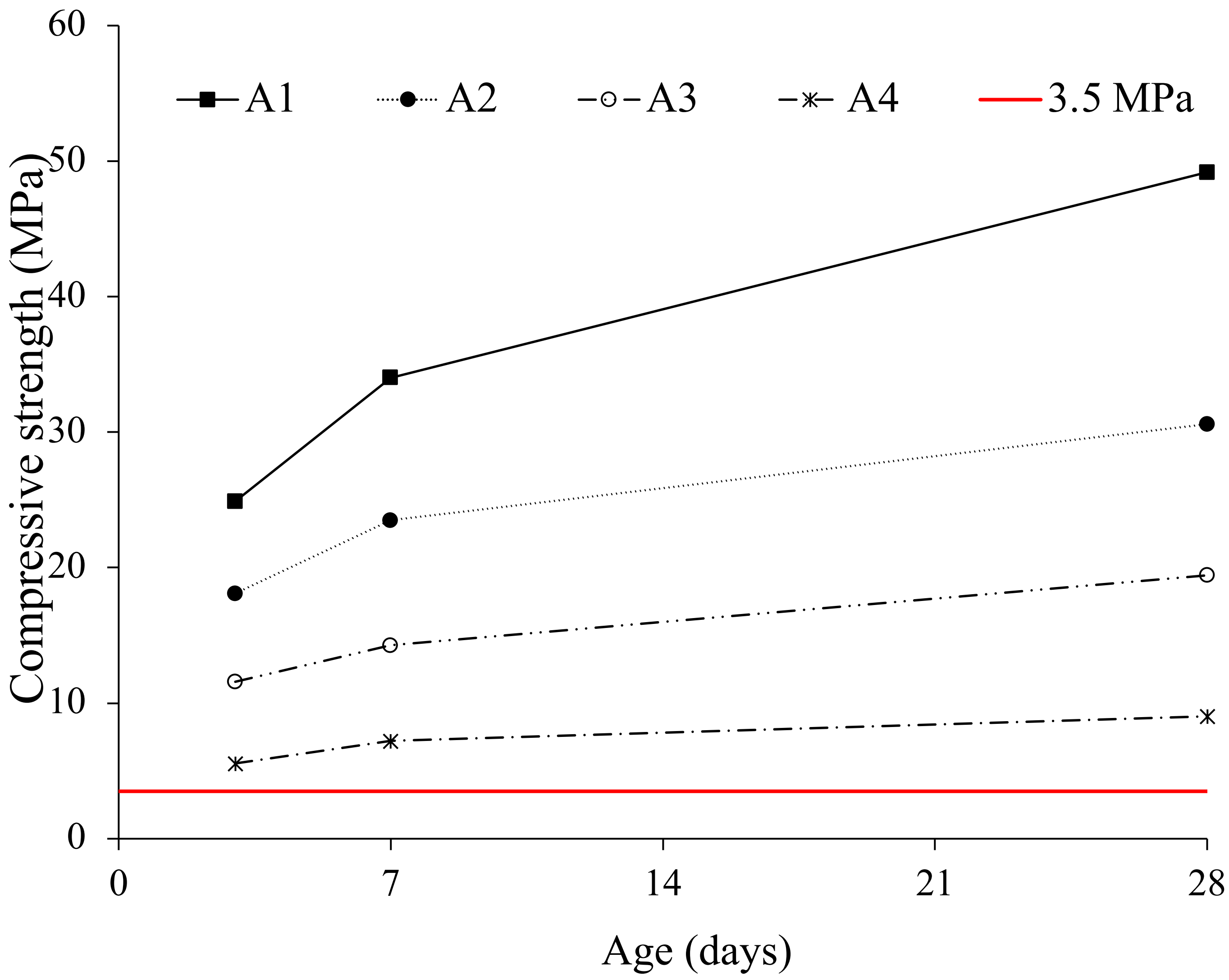


Final setting time



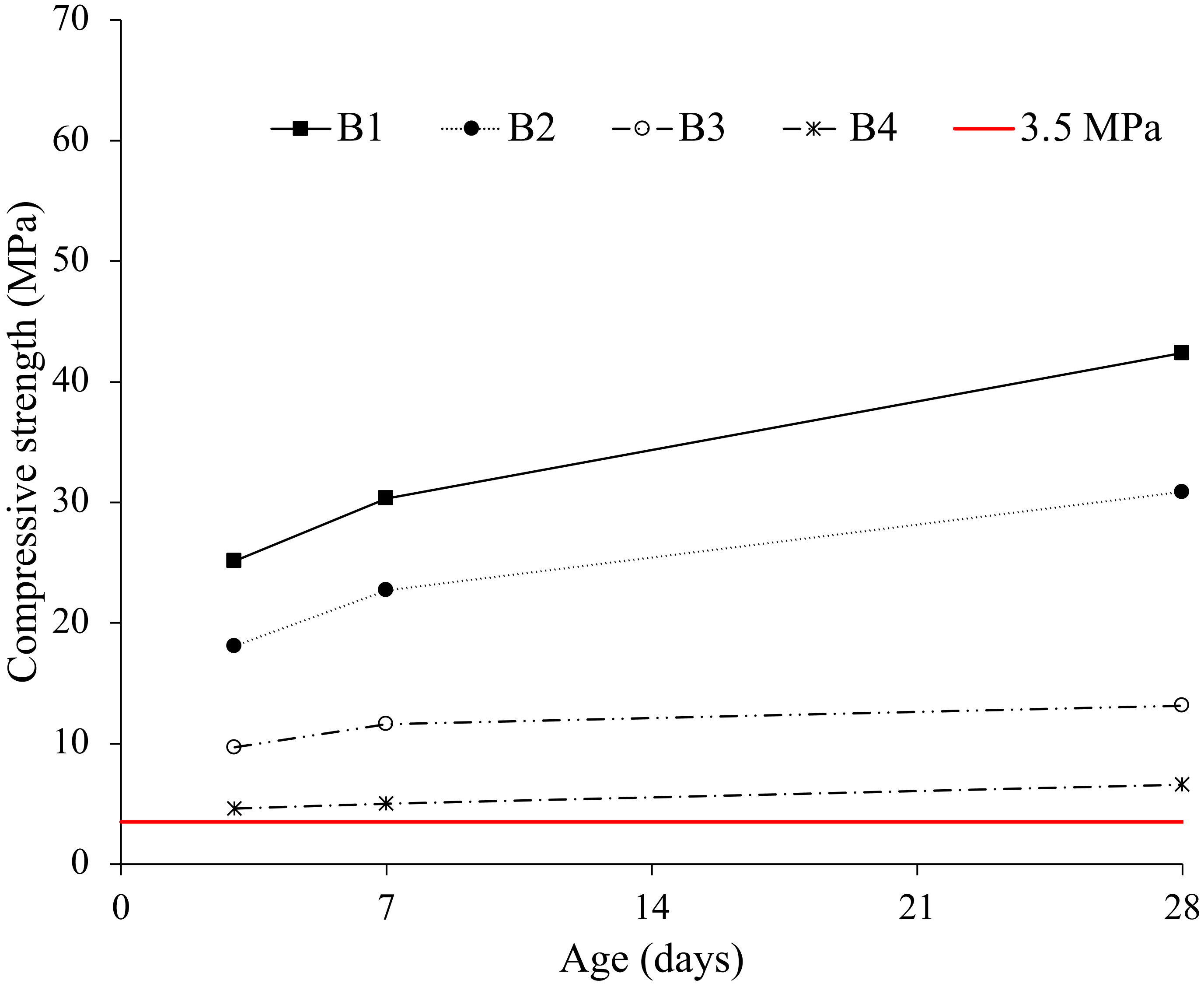
COMOPRESSIVE STRENGTH OF MORTAR CUBES

Compressive strength of batch A mortars

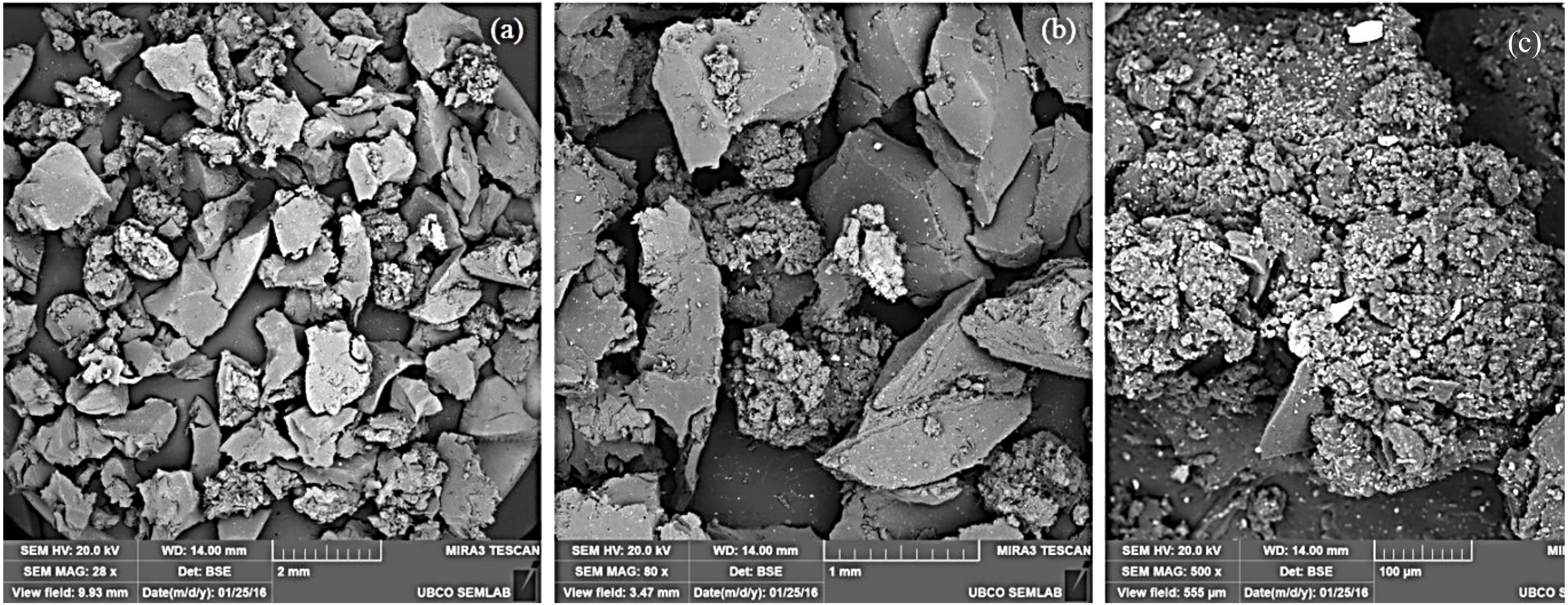


Minimum required strength of non-load-bearing masonry unit is 3.5 Mpa (ASTM C129)

Compressive strength of batch B mortars

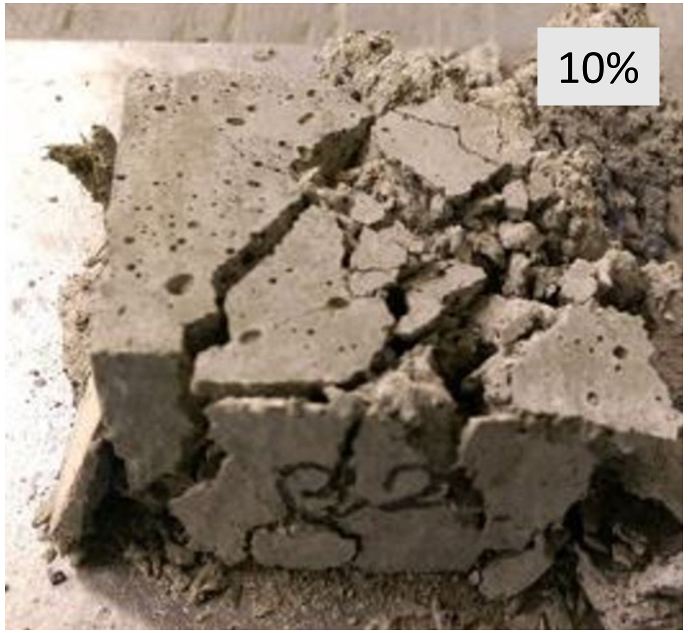


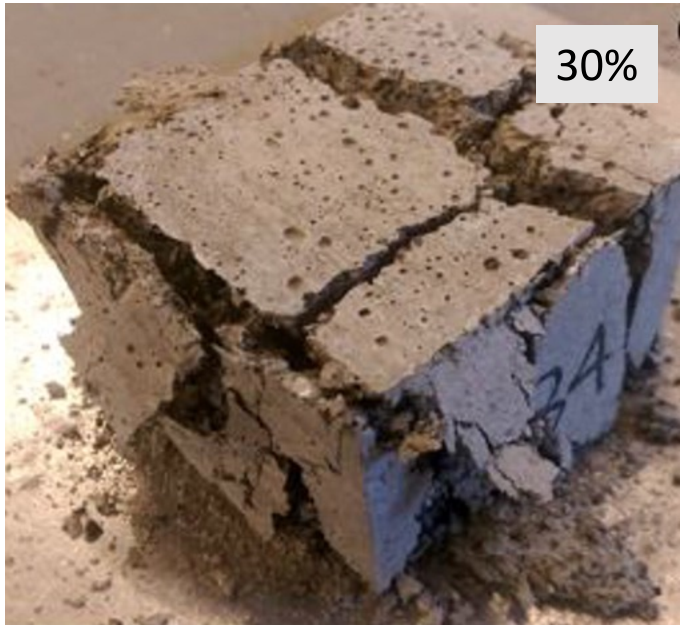
Minimum required strength of non-load-bearing masonry unit is 3.5 Mpa (ASTM C129)



Crumb rubber particles at magnification levels of (a) 28x, (b) 80x, and (c) 500x using Scanning Electron Microscope (SEM)

Failure Pattern





Conclusions

- The incorporation of crumb rubber made the mortar mixtures less workable.
- Increasing rubber crumb delayed both the initial and final setting time of the mortar mixtures.
- The inclusion of crumb rubber in mortar mixtures resulted in an overall decrease in the compressive strength. However, the lowest 28-day compressive strength among all the mixtures was 5 MPa which is more than the minimum value (3.50 MPa) for a **non-load-bearing masonry unit** specified by ASTM C129.
- Incorporating crumb rubber resulted in ductile failure in the mortar mixtures.

ACKNOWLEDGEMENT

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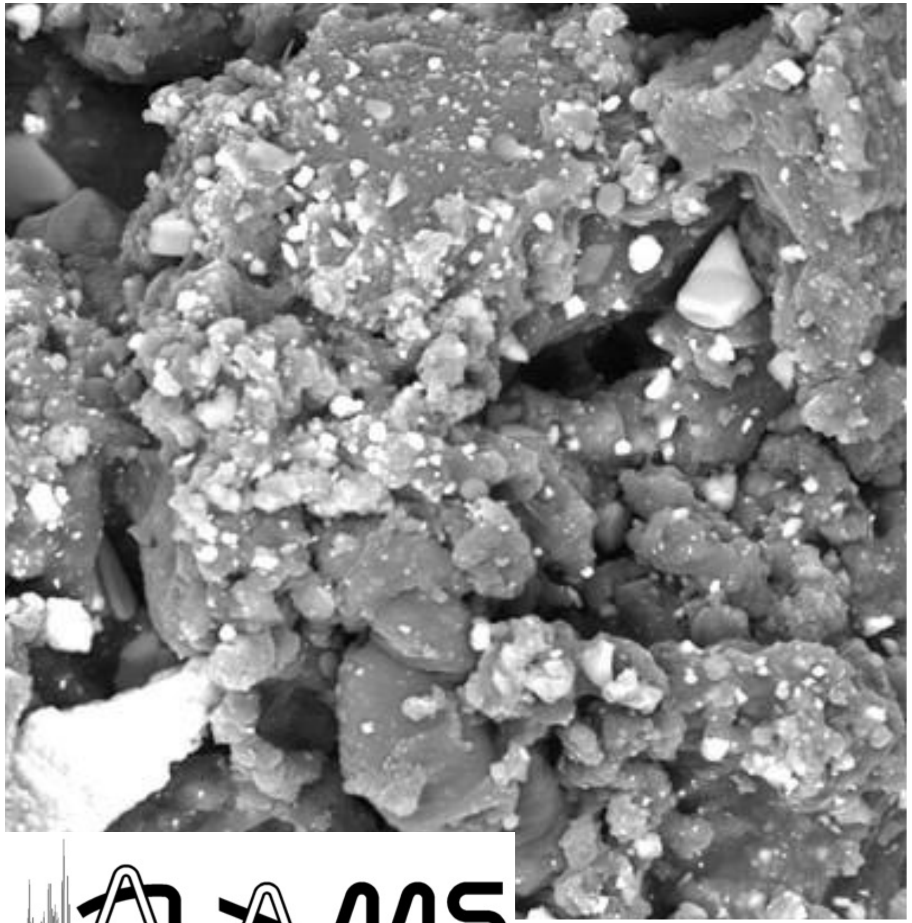

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