

Supplementary materials

Table S1. Results of unconfined compressive strengths of the base formulation.

Basic Formulation	Specimen	Sample 1	Sample 2	Sample 3
C 25/30	Manufacture	04.02.2021	04.02.2021	04.02.2021
	UCS Testing	05.03.2021	05.03.2021	05.03.2021
	UCS [MPa]	30.71	29.90	31.23
	Mean Value σ_D [MPa]	30.61		

Table S2. Results of the unconfined compressive strengths of the base formulation with potential primary m-sand substitutes.

Formulation	Specimen	Base-SR-1	Base-SR-2	Base-SR-3
C 25/30	Manufacture	10.12.2021	10.12.2021	10.12.2021
SR	UCS Testing	07.01.2022	07.01.2022	07.01.2022
	UCS [MPa]	30.11	28.72	29.80
	Mean Value σ_D [MPa]	29.54		
Formulation	Specimen	Base-SB-1	Base-SB-2	Base-SB-3
C 25/30	Manufacture	04.02.2021	04.02.2021	04.02.2021
SB	UCS Testing	05.03.2021	05.03.2021	05.03.2021
	UCS [MPa]	30.71	29.90	31.23
	Mean Value σ_D [MPa]	30.61		
Formulation	Specimen	Base-MA-1	Base-MA-2	Base-MA-3
C 25/30	Manufacture	06.12.2021	06.12.2021	06.12.2021
MA	UCS Testing	03.01.2022	03.01.2022	03.01.2022
	UCS [MPa]	27.46	34.27	31.69
	Mean Value σ_D [MPa]	31.14		
Formulation	Specimen	Base-AM-1	Base-AM-2	Base-AM-3
C 25/30	Manufacture	06.12.2021	06.12.2021	06.12.2021
AM	UCS Testing	03.01.2022	03.01.2022	03.01.2022
	UCS [MPa]	6.87	5.82	9.99
	Mean Value σ_D [MPa]	7.56		
Formulation	Specimen	Base-GD-1	Base-GD-2	Base-GD-3
C 25/30	Manufacture	06.12.2021	06.12.2021	06.12.2021
GD	UCS Testing	03.01.2022	03.01.2022	03.01.2022

	UCS [MPa]	28.52	32.27	29.21
	Mean Value σ_D [MPa]		30.00	
Formulation	Specimen	Base-BA-1	Base-BA-2	Base-BA-3
C 25/30	Manufacture	10.12.2021	10.12.2021	10.12.2021
BA	UCS Testing	07.01.2022	07.01.2022	07.01.2022
	UCS [MPa]	31.62	28.04	26.08
	Mean Value σ_D [MPa]		28.58	

Table S3. Results of the unconfined compressive strengths of the base formulation with potential secondary m-sand substitutes.

Formulation	Specimen	Sample 1	Sample 2	Sample 3
C 25/30	Manufacture	13.04.2022	13.04.2022	13.04.2022
CB + SB	UCS Testing	11.05.2022	11.05.2022	11.05.2022
10 : 90 Vol.-%	UCS [MPa]	24.45	25.53	29.94
	$\emptyset \sigma_D$ [MPa]		26.64	
Formulation	Specimen	Sample 1	Sample 2	Sample 3
C 25/30	Manufacture	13.04.2022	13.04.2022	13.04.2022
CB + SB	UCS Testing	11.05.2022	11.05.2022	11.05.2022
30 : 70 Vol.-%	UCS [MPa]	7.44	11.27	13.91
	$\emptyset \sigma_D$ [MPa]		10.87	
Formulation	Specimen	Sample 1	Sample 2	Sample 3
C 25/30	Manufacture	13.12.2021	13.12.2021	13.12.2021
CB + SB	UCS Testing	10.01.2022	10.01.2022	10.01.2022
50 : 50 Vol.-%	UCS [MPa]	2.71	3.05	4.49
	$\emptyset \sigma_D$ [MPa]		3.42	
Formulation	Specimen	Sample 1	Sample 2	Sample 3
C 25/30	Manufacture	08.03.2022	08.03.2022	08.03.2022
CC + SB	UCS Testing	05.04.2022	05.04.2022	05.04.2022
	UCS [MPa]	21.65	20.07	26.22
10 : 90 Vol.-%	$\emptyset \sigma_D$ [MPa]		22.65	
Formulation	Specimen	Sample 1	Sample 2	Sample 3
C 25/30	Manufacture	08.03.2022	08.03.2022	08.03.2022
CC + SB	UCS Testing	05.04.2022	05.04.2022	05.04.2022
30 : 70 Vol.-%	UCS [MPa]	21.13	17.72	25.65

	Ø σ_D [MPa]	21.50		
Formulation	Specimen	Sample 1	Sample 2	Sample 3
C 25/30	Manufacture	08.03.2022	08.03.2022	08.03.2022
CC + SB	Testing	05.04.2022	05.04.2022	05.04.2022
50 : 50 Vol.-%	UCS [MPa]	8.27	4.17	10.59
	Ø σ_D [MPa]	7.68		

Table S4. Results of the unconfined compressive strengths of the base formulation with various ash shares as cement substitute.

		10% Ash			20% Ash			30% Ash		
Ash 1	Specimen	10%	10%	10%	20%	20%	20%	30%	30%	30%
CA	Manufacture	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1
	UCS Testing	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1
	UCS [MPa]	32,02	35,68	30,47	19,20	16,65	16,19	14,33	12,61	14,14
	Ø σ_D [MPa]	32,72			17,35			13,69		
Ash 2	Specimen	10%	10%	10%	20%	20%	20%	30%	30%	30%
FA	Manufacture	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1
	UCS Testing	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1
	UCS [MPa]	15,70	17,49	16,05	14,88	15,60	14,61	12,50	14,98	15,25
	Ø σ_D [MPa]	16,41			15,03			14,24		
Ash 3	Specimen	10%	10%	10%	20%	20%	20%	30%	30%	30%
LFA 1	Manufacture	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1
	UCS Testing	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1
	UCS [MPa]	30,31	28,40	32,30	24,34	23,28	26,26	21,07	23,78	19,07
	Ø σ_D [MPa]	30,33			24,63			21,31		
Ash 4	Specimen	10%	10%	10%	20%	20%	20%	30%	30%	30%
LFA 2	Manufacture	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1	04.02.2022 1
	UCS Testing	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1	05.03.2022 1
	UCS [MPa]	27,87	27,64	25,18	27,16	22,91	26,64	15,32	19,17	15,08
	Ø σ_D [MPa]	26,90			25,57			16,52		
Ash 5	Specimen	10%	10%	10%	20%	20%	20%	30%	30%	30%

RHA	Manufacture	19.11.2021	19.11.2021	19.11.2021	19.11.2021	19.11.2021	19.11.2021	19.11.2021	19.11.2021	19.11.2021
		1	1	1	1	1	1	1	1	1
	UCS Testing	17.12.2021	17.12.2021	17.12.2021	17.12.2021	17.12.2021	17.12.2021	17.12.2021	17.12.2021	17.12.2021
		1	1	1	1	1	1	1	1	1
	UCS [MPa]	35,47	19,22	29,11	19,32	9,11	14,27	7,23	3,98	8,00
	Ø _{σD} [MPa]	27,94		14,23				6,40		