

Optimization of the Mechanical Formulation of Typha Concrete

It currently occupies more than 3 million hectares with a potential of 520,000 t/year of dry matter [8], a proliferation rate of 15 %/year [9] and a density of 18t/ha [10]. Its invasion constitutes a real brake on the economy and causes many environmental and social problems. Indeed, Typha is a real scourge, which the State has tried through very expensive programs to fight and control its proliferation but without success. Thus, other programs to valorize Typha are being developed in other sectors such as energy as biomass, handicrafts, Industry and construction with the creation of new efficient materials for thermal insulation such as hemp.

The Typha used for the formulation is dried and then chopped before being ground in a mill.

The percentages of passageways obtained during the sieve size analysis are shown in graph 2:

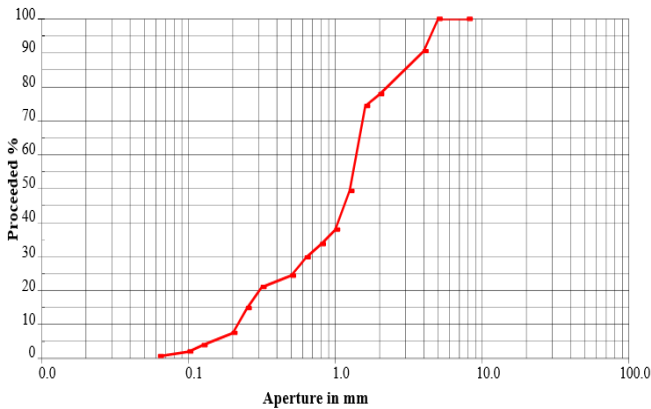


Fig. 2. Typha sieve analysis

B. Formulation method

The determination of the different proportions of the mixture will be done by the method of DreuxGorisse [11], using the Bolomey formula (1):

$$f_c = G * C_E \left(\frac{C}{E} - 0.5 \right) (1)$$

Two series of samples S1 and S2 are used for a desired strength after 28 days for reference concrete greater than or equal to 25MPa and a slump of 7cm for a plastic concrete. On this basis, Typha concrete is obtained by substituting a determined percentage of sand with Typha.

The two formulations differ in their G/S ratio which goes from 1.83 for the first series to 2 for the second series and in the strength class of the cement of 32.5 MPa for series 1 replaced by a cement of 42.5 MPa for series 2 in order to increase the mechanical strength of the concrete [12]. After calculation, the determined amount of sand is substituted by 40, 50 and 60% Typha. The mass quantities required for the composition of one cubic meter of concrete are given in Table III for the S1 series and Table IV for the S2 series.

Table- III: Mass composition of S1 series concretes for 1m³

	Cement (kg)	Sand (kg)	Basalt 3/8 (kg)	Basalt 8/16 (kg)	Typha (kg)	Water (kg)
Control concrete	350	680	329	917	0	197
Concrete with 40% Typha	350	408	329	917	6.17	197
Concrete with 50% Typha	350	340	329	917	7.71	197

Concrete with 60% Typha	350	272	329	917	9.25	197
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Table- IV: Mass composition of S2 series concretes for 1m³

	Cement (kg)	Sand (kg)	Basalt 3/8 (kg)	Basalt 8/16 (kg)	Typha (kg)	Water (kg)
Control concrete	350	680	360	1000	0	185
Concrete with 40% Typha	350	408	360	1000	6.17	185
Concrete with 50% Typha	350	340	360	1000	7.71	185
Concrete with 60% Typha	350	272	360	1000	9.25	185

For each formulation, 6 cylindrical specimens with a diameter of 16 cm and a height of 32 cm are made for the purposes of compression tests of half of the specimens at 7 days and the other half at 28 days according to the NF P 18-404 standard. Fig. 3 shows the samples after preparation, fig. 4 shows the samples 24 hours after removal from the mould and Fig. 5 shows them immersed in water for curing.



Fig. 3. Prepared specimens



Fig. 4. Demolded specimens (Example concrete 50% Typha)



Fig. 5. Sample immersion

The specimens are soaked 24 hours before the determination of the mechanical resistance at 7 and 28 days by the FORDIA type mechanical press as shown in Fig. 6 below:



Fig. 6. Mechanical press

III. RESULTS

The determination of the densities in the fresh state, at 7 and 28 days before crushing allows the following curves to be drawn from Fig. 7 from Table V for the S1 series and Fig. 8 from Table VI for the S2 series for the reference concrete and concretes with Typha:

Table- V: Density of S1 series samples

Age (days)		0	7	28
Control concrete	ρ_1 (kg/m ³)	2479.02	2384.99	2416.85
	ρ_2 (kg/m ³)	2471.25	2402.87	2420.74
	ρ_3 (kg/m ³)	-	2382.66	2423.07
	ρ_{moy} (kg/m ³)	2375.14	2390.17	2420.22
Concrete with 40% Typha	ρ_1 (kg/m ³)	2362.46	2384.22	2385.77
	ρ_2 (kg/m ³)	2440.17	2335.26	2378.00
	ρ_3 (kg/m ³)	-	2354.68	2381.11
	ρ_{moy} (kg/m ³)	2401.31	2358.05	2381.62
Concrete with 50% Typha	ρ_1 (kg/m ³)	2370.23	2333.70	2346.91
	ρ_2 (kg/m ³)	2362.46	2325.15	2340.70
	ρ_3 (kg/m ³)	-	2301.06	2347.69
	ρ_{moy} (kg/m ³)	2366.34	2319.97	2345.10
Concrete with 60% Typha	ρ_1 (kg/m ³)	2331.37	2256.77	2276.97
	ρ_2 (kg/m ³)	2284.74	2262.21	2269.20
	ρ_3 (kg/m ³)	-	2207.81	2266.09
	ρ_{moy} (kg/m ³)	-	-	-

Typha	ρ_{moy} (kg/m ³)	2308.06	2242.26	2270.75
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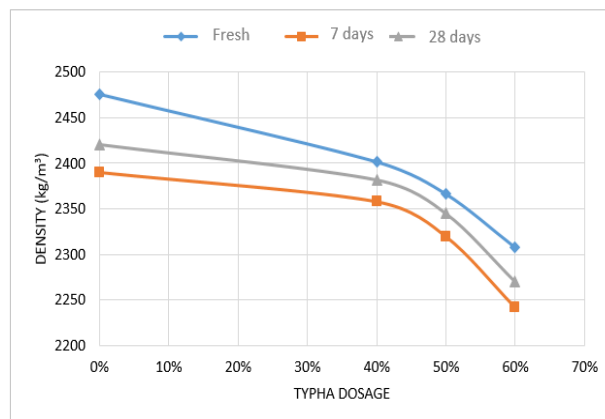


Fig. 7. Evolution of densities of the S1 series

Table- VI: Density of S2 series samples

Age (days)		0	7	28
Control concrete	ρ_1 (kg/m ³)	2578.11	2471.25	2504.67
	ρ_2 (kg/m ³)	2562.18	2453.38	2489.13
	ρ_3 (kg/m ³)	2570.72	2479.80	2481.36
	ρ_{moy} (kg/m ³)	2570.34	2468.14	2491.72
Concrete with 40% Typha	ρ_1 (kg/m ³)	2429.68	2395.09	2402.87
	ρ_2 (kg/m ³)	2400.53	2396.65	2424.63
	ρ_3 (kg/m ³)	2447.16	2409.86	2406.75
	ρ_{moy} (kg/m ³)	2425.79	2400.53	2411.41
Concrete with 50% Typha	ρ_1 (kg/m ³)	2377.61	2343.03	2363.23
	ρ_2 (kg/m ³)	2394.32	2330.59	2352.35
	ρ_3 (kg/m ³)	2416.08	2374.89	2341.47
	ρ_{moy} (kg/m ³)	2396.00	2349.50	2352.35
Concrete with 60% Typha	ρ_1 (kg/m ³)	2389.65	2350.80	2357.02
	ρ_2 (kg/m ³)	2395.48	2331.37	2353.13
	ρ_3 (kg/m ³)	2367.90	2306.50	2350.80
	ρ_{moy} (kg/m ³)	2384.34	2329.56	2353.65

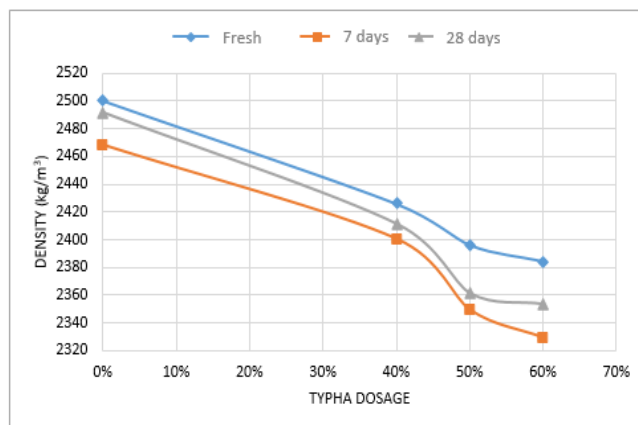


Fig. 8. Evolution of densities of the S2 series

After determining the densities, the breaking force determined by compression is related to the cross-section of the specimens in order to determine the compressive stresses at 7 and 28 days. Table VII lists the stresses for the four formulation categories of the S1 series which are shown in Fig. 9. The compressive results for the S2 series are grouped in Table VIII below and shown in Fig. 10.

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Table- VII: Compression stresses of S1 series samples

Age (days)		7	28
Control concrete	σ_{c1} (MPa)	14.41	24.98
	σ_{c2} (MPa)	14.19	25.41
	σ_{c3} (MPa)	13.69	25.59
	σ_{cmoy} (MPa)	14.10	25.33
Concrete with 40% Typha	σ_{c1} (MPa)	11.77	23.47
	σ_{c2} (MPa)	12.51	23.00
	σ_{c3} (MPa)	13.28	23.11
	σ_{cmoy} (MPa)	12.52	23.19
Concrete with 50% Typha	σ_{c1} (MPa)	12.85	22.90
	σ_{c2} (MPa)	12.35	22.76
	σ_{c3} (MPa)	10.88	23.02
	σ_{cmoy} (MPa)	12.03	22.89
Concrete with 60% Typha	σ_{c1} (MPa)	10.30	18.28
	σ_{c2} (MPa)	10.16	17.97
	σ_{c3} (MPa)	9.63	17.78
	σ_{cmoy} (MPa)	10.03	18.01

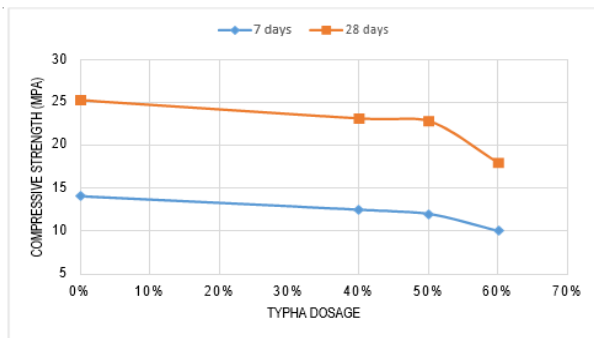


Fig. 9. Evolution of the mechanical resistance of S1 series sample

Table- VIII: Compression stresses of S2 series samples

Age (days)		7	28
Control concrete	σ_{c1} (MPa)	16.35	28.11
	σ_{c2} (MPa)	16.00	27.29
	σ_{c3} (MPa)	14.04	26.97
	σ_{cmoy} (MPa)	16.46	27.46
Concrete with 40% Typha	σ_{c1} (MPa)	14.95	25.08
	σ_{c2} (MPa)	15.40	26.45
	σ_{c3} (MPa)	15.74	25.79
	σ_{cmoy} (MPa)	15.36	25.77
Concrete with 50% Typha	σ_{c1} (MPa)	14.39	24.94
	σ_{c2} (MPa)	13.83	24.36
	σ_{c3} (MPa)	15.04	24.11
	σ_{cmoy} (MPa)	14.42	24.47
Concrete with 60% Typha	σ_{c1} (MPa)	12.92	22.30
	σ_{c2} (MPa)	12.65	21.87
	σ_{c3} (MPa)	12.42	21.48
	σ_{cmoy} (MPa)	12.66	21.88

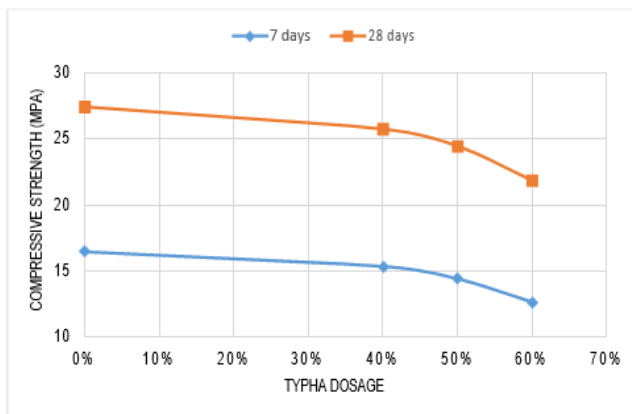


Fig. 10. Evolution of the mechanical resistance of S2 series sample

IV. DISCUSSION

The results of the experimental measurements showed that the density of the concretes decreases with the percentage of addition of Typha. This is explained by the fact that the density of Typha is lower than the density of substituted sand. Nevertheless, these concretes cannot be considered as light concretes because their density remains higher than 2000 kg/m³ (NF EN 206-1, Eurocode 2 - 1992). They then remain lightweight concretes with normal density.

In addition, the compressive strength of concretes with Typha decreases in an inversely proportional way with the amount of Typha added. The strength decreases compared to the reference concrete by about 8 to 29% for the S1 series and 6 to 20% for the S2 series. This small drop in strength for the S2 series compared to the S1 series is explained by the increase in the G/S ratio and the cement class.

The Typha concretes obtained can be used for the dimensioning of the load-bearing structure of a building depending on their use and the resistance classes of C20/25 or C25/30 according to the exposure class of the NF EN 206-1 standard. In fact, for the S1 series, concretes with 40% Typha allow to have a compression strength at 28 days of 23.19 MPa and a resistance of 22.89 MPa for concretes with 50% Typha. For the S2 series, the 40, 50, and 60% Typha concrete formulations provide compressive strengths of 25.77 MPa, 24.47 MPa, and 21.88 MPa respectively. Therefore, they can be used in load-bearing parts of buildings with desired minimum strengths of 20 MPa at 28 days.

V. CONCLUSION

Typha Australis is locally available in large quantities, with a relatively low operating cost and ease of implementation. This work allowed us to valorize it in concrete as a building material. Its valorization in a cementitious matrix, with a progressive reduction of the quantity of sand to the detriment of Typha Australis, allows concrete to be lightened while keeping a normal density (higher than 2000 kg/m³). The mechanical compressive strengths also obtained are all higher than 20 MPa for the 40 and 50% Typha concretes of the S1 series and for all Typha concretes of the S2 series. In short, all these Typha concretes can be used to dimension the load-bearing parts of buildings according to their uses and exposure classes.

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