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Durability Evaluation of Hemp Fibers and Recycled Aggregates Concrete

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1 Introduction and Background

Concrete production consumes large quantities of natural aggregates causing significant damage to the environment. To reduce the amount of natural aggregates used in concrete HRAC is proposed. This is a concrete mix where hemp fibers are incorporated in the mix, the amount of natural coarse aggregates (NCA) is reduced by 20%, and where 50% of NCA are replaced by RCA. HRAC also helps in reducing the problem of construction and demolition wastes (CDW) which are a mixture of surplus materials generated during new construction, renovation, and demolition of buildings, roads, bridges, and other structures (Cheng *et al.,* 2013). A sustainable concrete should be also durable; therefore, it is important to study the effect of the incorporation of hemp fibers and RCA on the durability properties of concrete.

Ramli *et al.* (2013) studied the durability of coconut-fiber-reinforced concrete in aggressive environments. Results showed that the damaging effects of aggressive environments on concrete can be lowered with fiber-reinforced. Awwad *et al.* (2014) investigated the long-term behavior of concrete incorporating hemp fibers and concluded that at an age of 1.5 years hemp fibers did not have a negative effect on concrete strength. In this paper, the durability of the proposed HRAC is investigated by evaluating its mechanical performance at the age of 2 years and by studying its resistance to freeze-thaw cycles.

2 Materials and Experimental Procedures

Sixteen different mixes were prepared: The control mixes with no hemp fibers and no coarse aggregate reduction are referred to as N10 and N20. R10 and R20 are two mixes with 50 percent replacement of NCA with RCA, no hemp fibers, and also no reduction of coarse aggregate content**.** The other twelve mixes with hemp fibers are identified by a three-part notation. The first part is N (100% NCA) or R (50% replacement of NCA with RCA) and 10 or 20 mm are the MSA. The second part of the notation refers to the length of the hemp fibers (H20 is 20 mm and H30 is 30 mm). The third part is the type of fiber treatment where T1 is alkali treatment and T2 is acetyl treatment. A total of 7 HRAC mixes were used.

To study the long-term mechanical performance of HRAC, compressive strength tests, flexural strength tests and modulus of elasticity tests were performed at an age of 2 years for 14 of the 16 mixes and the results were compared to the results at 28 days presented in previous studies (Ghosn *et al.,* 2019). The resistance to freeze-thaw cycles was also studied.

3 Results

Table 1. Test results.

	Mix ID	Compressive strength 2 years / 28 days ratio	Flexural strength 2 years / 28 days ratio	RDME after 144 cycles (%)
Group 1; MSA = 10 mm	N10 (Control10)	1.11	1.35	83.50
	R10	1.1	1.41	77.00
	N10-H20-T1	1.28	1.16	77.00
	R10-H20-T1	1.19	1.25	88.50
	R10-H20-T2	1.08	1.45	79.50
	N10-H30-T1	1.09	1.4	90.40
	R10-H30-T1	1.15	1.53	90.40
Group 2; MSA = 20 mm	N20 (Control20)	1.13	1.47	51.00
	R20	1.09	1.6	31.00
	N20-H20-T1	1.21	1.19	42.00
	R20-H20-T1	1.26	1.24	-
	N20-H20-T2	-	-	55.00
	R20-H20-T2	-	-	53.20
	N20-H30-T1	1.06	1.35	-
	R20-H30-T1	1.2	1.48	56.50
	R20-H30-T2	1.31	1.38	-

4 Conclusion

Results showed that at the age of 2 years HRAC mixes had an improved mechanical performance compared to the age of 28 days, as the compressive strength and the flexural strength improved by up to 31%, 53% respectively. Furthermore, the resistance to freeze-thaw cycles of HRAC was similar to that of normal concrete mixes after 144 cycles and mixes with an MSA of 10mm had a better resistance than mixes with an MSA of 20mm. Based on these results, it can be concluded that HRAC is a durable concrete that has a reliable long-term performance and it also can be used in cold climates as it has a freeze/thaw durability comparable to that of ordinary concrete mixes.

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