

Concrete Mix Design

Table 1 illustrates the reasons why we used the composite materials of the concrete mix design.

Table 1: Reason for Composite Material Use

Spirit Mix	Reason for Use
Lime Type S	-Shrinkage reduction -Improve workability
Portland Cement	-Key cementitious material
Poraver .5mm-1mm	-Lightweight aggregate to reduce weight of canoe -Sustainability (recycled glass)
Mortar Sand	-Aggregate (structural filler) -Increase strength
Fibermesh ® 150	-Control cracking -Aid in tensile strength

Table 2 shows the desired strength, unit weight, and slump that Team *Spirit* desired.

Table 2: Concrete Mix Design Goal

Characteristics	Set Criteria	Mix #5	Mix #11
Strength (psi)	> 3,000	4,436	4,536
Unit Weight (lb/ft ³)	< 2/3 normal concrete	104	81.1
Workability – "Slump" (in)	< 2"	1	1

Table 3 depicts the resulting unit weight (psf), strength (psi), and slump (in). The first mix is Team *Night Fury*'s; as iterations continued, the proportions of the materials listed in Table 1 above were altered until the desired parameters were met. The final mix is highlighted in gold.

Table 3: Results of Mix Design

Mix Number	1	2	3	4	5	6	7	8	9	10	11	12
Unit Weight (psf)	58	5	60	61	104	75	104	77	84	68	81.1	131
Strength (psi)	1,154	1,353	4,775	915	4,436	955	2,944	1,989	2,149	589	4,536	1,592
Slump (in)	9.00	9.00	9.00	9.00	1.00	1.50	0.50	1.00	3.00	2.50	1.00	5.00

Table 4 details the mixture proportions used in the final concrete mix design of *Spirit*.

Table 4: Mixture Proportions

				Design Proportions (Non SSD)		Actual Batched Proportions		Yielded Proportions			
Y _D	Design Batch Size (ft ³):										
Cementitious Materials				SG	Amount (lb/yd ³)	Volume (ft ³)	Amount (lb)	Volume (ft ³)	Amount (lb/yd ³)	Volume (ft ³)	
CM1	Portland Cement			3.15	1142.50	5.812	29.45	0.150	1311.75	6.674	
Total Cementitious Materials:					1142.50	5.81	29.45	0.15	1311.75	6.67	
Fibers											
F1	Fiber 1			1.10	2.50	0.036	0.06	0.001	2.90	0.042	
Total Fibers:					2.50	0.00	0.06	0.00	2.90	0.04	
Aggregates											
A1	Poraver .5-1 mm	Abs:	25	0.44	193.75	7.057	5.00	0.182	220.50	8.031	
A2	Mortar Sand		12	2.60	479.00	2.952	12.33	0.076	544.31	3.355	
Total Aggregates:					672.75	10.01	17.33	0.26	764.81	11.39	
Water											
W1	Water for CM Hydration (W1a + W1b)			1.00	342.75	5.493	11.00	0.176	336.11	5.386	
	W1a. Water from Admixtures		33.60			2.70		35.20			
	W1b. Additional Water		342.75			11.00		336.11			
W2	Water for Aggregates, SSD			1.00	105.92		2.73		121.55		
Total Water (W1 + W2):					448.67	7.19	13.73	0.22	457.66	7.33	
Solids Content of Latex, Dyes and Admixtures in Powder Form											
S1	Lime Type S			2.60	84.00	0.518	2.16	0.013	96.43	0.594	
Total Solids of Admixtures:					84.00	0.52	2.16	0.01	96.43	0.59	
Cement-Cementitious Materials Ratio					1.000		1.000		1.000		
Water-Cementitious Materials Ratio					0.30		0.374		0.256		
Slump, Slump Flow, <i>in.</i>					1.00		1.000		1.000		
M	Mass of Concrete, <i>lbs</i>			2350.42		62.73		2633.55			
V	Absolute Volume of Concrete, <i>ft³</i>			23.53		0.64		26.03			
T	Theoretical Density, <i>lb/ft³</i> = (M / V)			99.88		97.73		101.17			
D	Design Density, <i>lb/ft³</i> = (M / 27)			87.05							
D	Measured Density, <i>lb/ft³</i>					94.800		98.180			
A	Air Content, % = [(T - D) / T x 100%]			12.84		3.00		2.96			
Y	Yield, <i>ft³</i> = (M / D)			27		1		27			
R _y	Relative Yield = (Y / Y _D)					1.000					