The Effects of Composition, Curing, and Rebar Placement on the Flexural Strength of Engineered Concrete

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A B S T R A C T

The engineered concrete slab is a fundamental structure in construction with its mechanical properties influenced by the rebar placement, curing process, and the ratios of its primary components aggregate, cement, and sand. This study investigates how variations in rebar placement, concrete composition and curing methods affect the flexural strength of the sample. In ENGR 30014, 18 engineering teams produced their best sample of concrete with different ratios, rebar patterns, and different types of curing. The results provide insights into optimizing the concrete ratios, rebar placement, and methods for curing and their effect on flexural strength.

PROPERTIES

MIX RATIOS

To determine the strength, workability, and durability (Cement:Sand:Aggregate)

Mortar (1:3:0): Smooth, proper bonding and easy to work. Not very strong (***Plot 2***)

Concrete Mix 1 (1:2:2): Non-structural applications, it has good strength and durability (***Plot 1***)

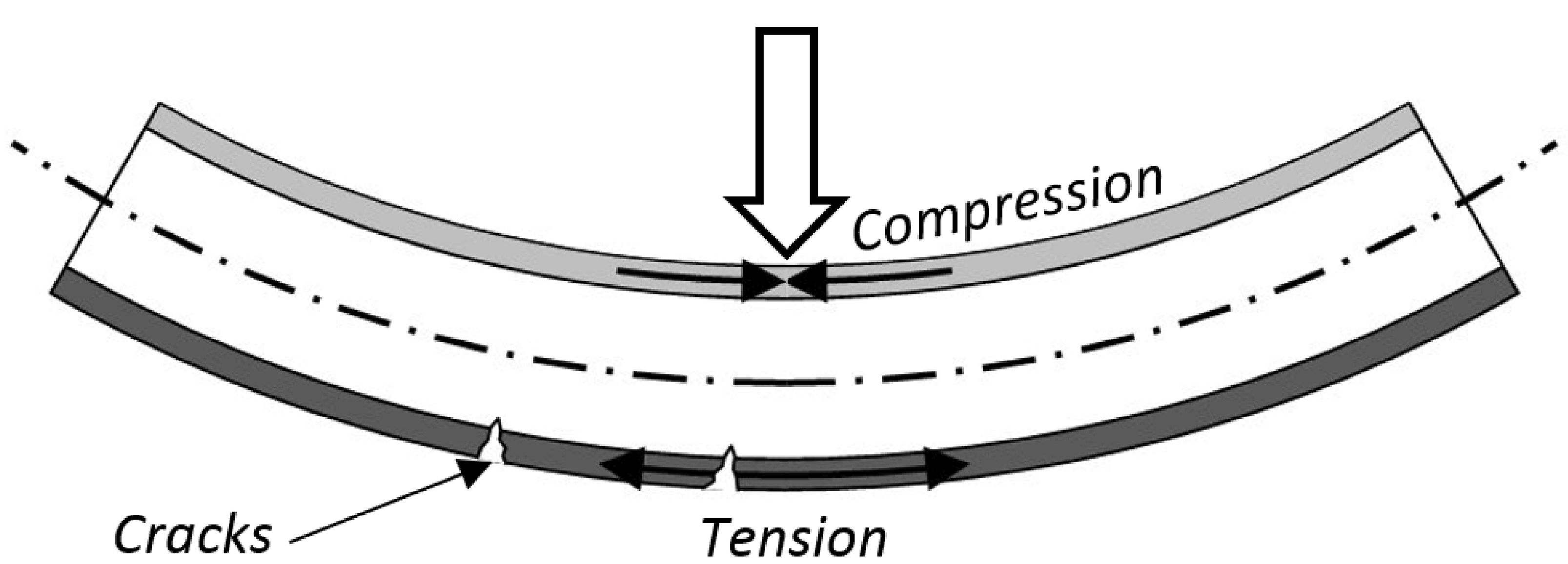
Concrete Mix 2 (1:2:4): Used for beams and columns. Highest strength (***Plot 3***)

REBAR PLACEMENT

Bear heavier loads, resist cracking less prone to failure

Compressive and Tensile Forces: Without rebar, the neutral axis is in the middle of the beam. Concrete can handle compression (forces pushing down) above this axis but struggles with tension (pulling forces) below it. Placing rebar in the bottom half of the beam allows the concrete to handle the compression, while the rebar takes the tension, making the beam stronger.

Cracks: Without rebar, cracks in the concrete propagate rapidly, leading to the beam's swift failure. With rebar, the cracks propagate more slowly, providing stabilization and enhancing the overall strength of the concrete.



CURING PROCESS

Properly maintaining concrete requires controlling moisture and temperature

Dry Curing: Cement reacts with water to form a chemical bond with the sand and aggregates surrounding it. When the concrete is left out in the air to cure, the water will evaporate quickly and leave some of the cement unreacted.

Wet Curing: The curing process is slower because the water does not leave the system quickly and has time to react will most or all of the cement. This results in a longer cure and a stronger final concrete

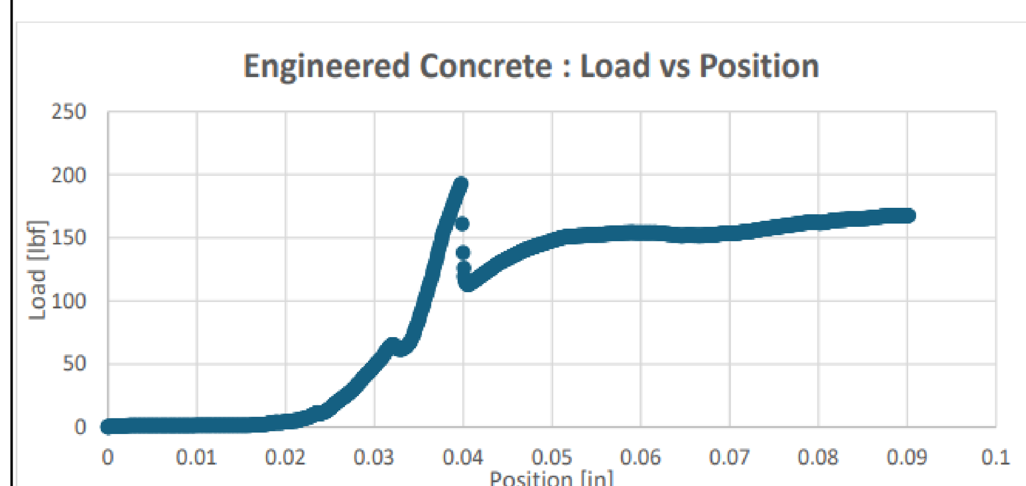
RESULTS

The flexural strength of 54 concrete samples varied significantly, underscoring the importance of mix design, rebar configuration, and curing methods on structural performance. Most samples displayed strengths between 400–700 psi, with cracking initiating on the tension side. A few samples, however, showed notably higher strengths, suggesting superior design and execution

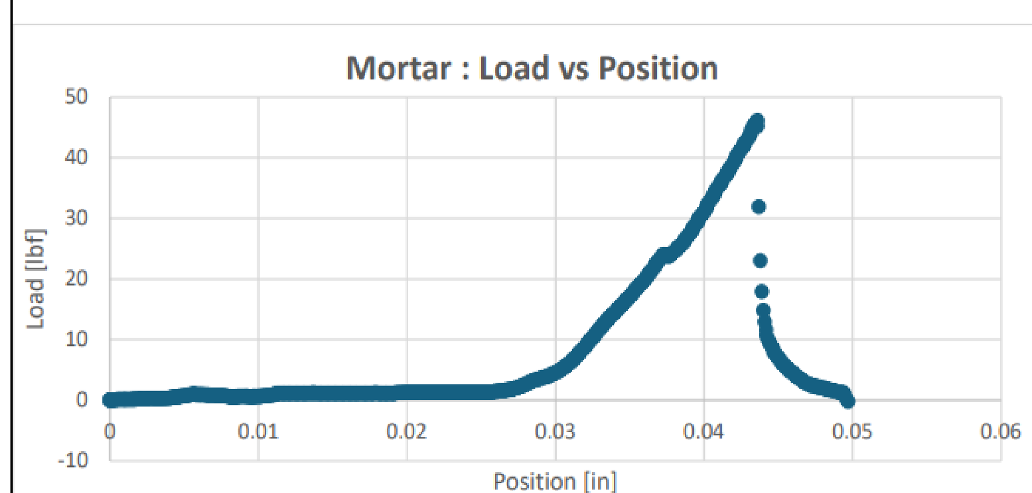
DIFFERENCES BETWEEN STRONG AND WEAK SAMPLES

The weakest samples often exhibited issues such as poor or uneven curing, insufficient reinforcement, improper rebar placement (e.g., near or above the neutral axis), or inconsistent cement, sand, and aggregate ratios. These beams typically failed quickly under load, with wide cracks and brittle fractures.

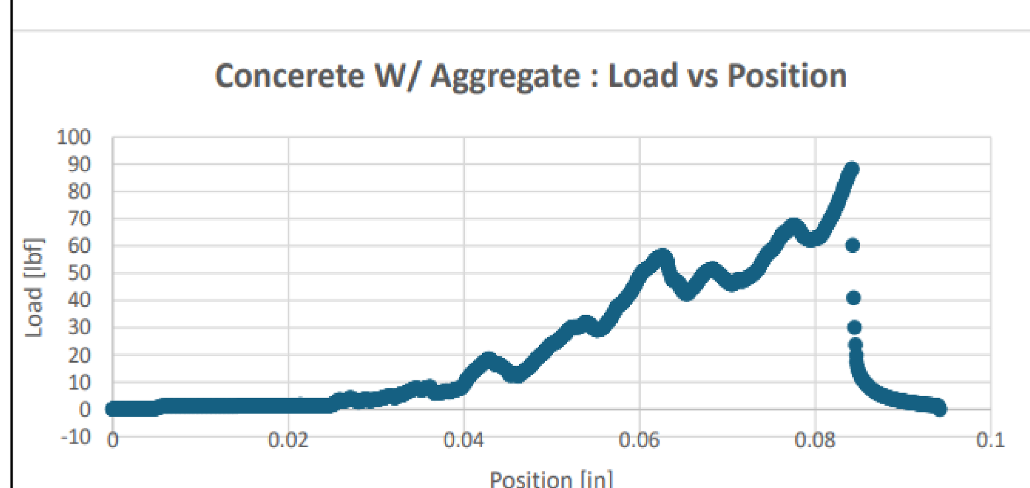
In contrast, the best-performing sample exhibited exceptional strength, due to strategic rebar placement and careful curing, allowing it to surpass expectations and resist cracking beyond the average. Additionally, as shown in Table 1, one key factor contributing to the strong performance of the best beam was its thickness



Plot 1. Engineered Concrete; Max force = **192.6 lbf**



Plot 2. Mortar mix; Max force = **46.1 lbf**



Plot 3. Concrete with aggregate; Max force = **88.3 lbf**

Figure 1. Three Point Bending Test on Instron

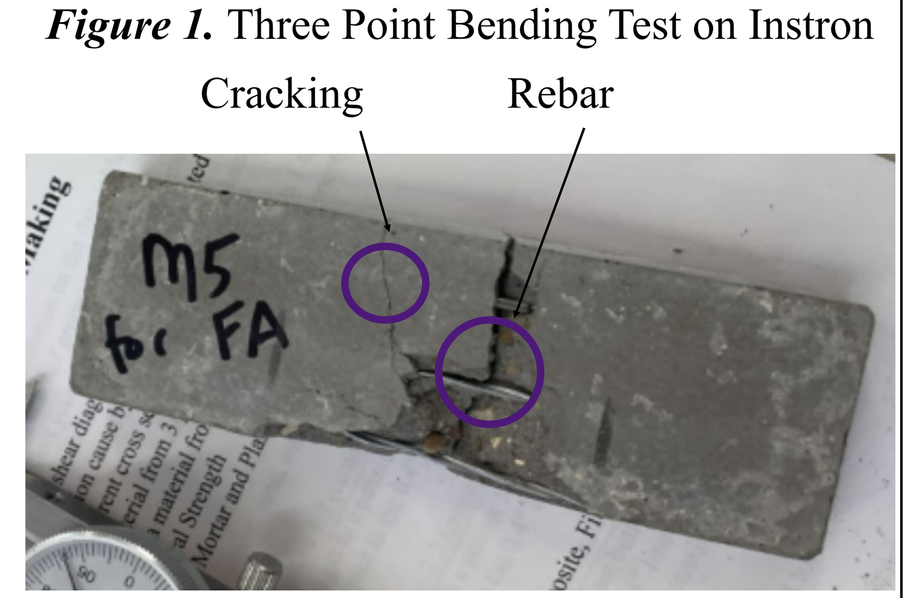


Figure 2. Concrete Sample after 3 point

FLEXURAL STRENGTH

FLEXURAL STRENGTH

Material's ability to resist bending forces before failure

Three point Bending Test: Flexural strength is measured by placing a beam on two supports with a central load, assessing the refractory product's resistance to bending, or cracking under pressure.

P = Maximum Load

L = Length between supports

b = Width

h = Thickness

$$MOR = \frac{3PL}{2bh^2}$$

Flexural Strength (Modulus of Rupture)

Width (in)	Thickness (in)	Force (lbf)	MOR (psi)
1.51	0.62	364.5	1883.9
1.536	0.589	297.3	1673.8
1.553	0.576	98	570.6
1.596	0.728	196.2	695.9
1.435	0.742	423	1606.2
1.535	0.585	135	771.0
1.568	0.673	181.5	766.7
1.588	0.636	121.9	569.3
1.558	0.501	363.4	2787.8
1.556	0.487	127.4	1035.7
1.639	0.734	117.8	400.2
1.643	0.695	192.6	728.1
1.647	0.765	241	750.1
1.676	0.674	94.9	373.9
1.587	0.658	153.9	671.9
1.824	0.665	138	513.3

Table 1. Flexural Strength Results for Various Samples

Strongest Sample