

Introduction

- **Problem Statement:** The project goal is to reduce the carbon footprint in concrete, by reducing the cement content used in concrete, and substituting it with admixtures.
- **Target Specifications:**
 1. Reduction of CO₂ footprint by at least 10%.
 2. Have a minimum compressive strength of 30 MPa.
 3. Water to cement ratio equal to 0.4.
 4. Temperature not exceed 35 °C.
- **Constraints:**

Based on Saudi building code (SBC) following constraints are considered

 1. Cement of type V shall be used
 2. Maximum w/c should be between 0.4-0.5
 3. Compressive strength should not be less than 17 MPa
 4. Cylindrical sample is used for compressive strength test
 5. Sample shall be cured for at least 7 days
 6. Temperature of fresh concrete shall not exceed 35°C at the time of placing
 7. Slump of not less than 75 mm at the time of placing

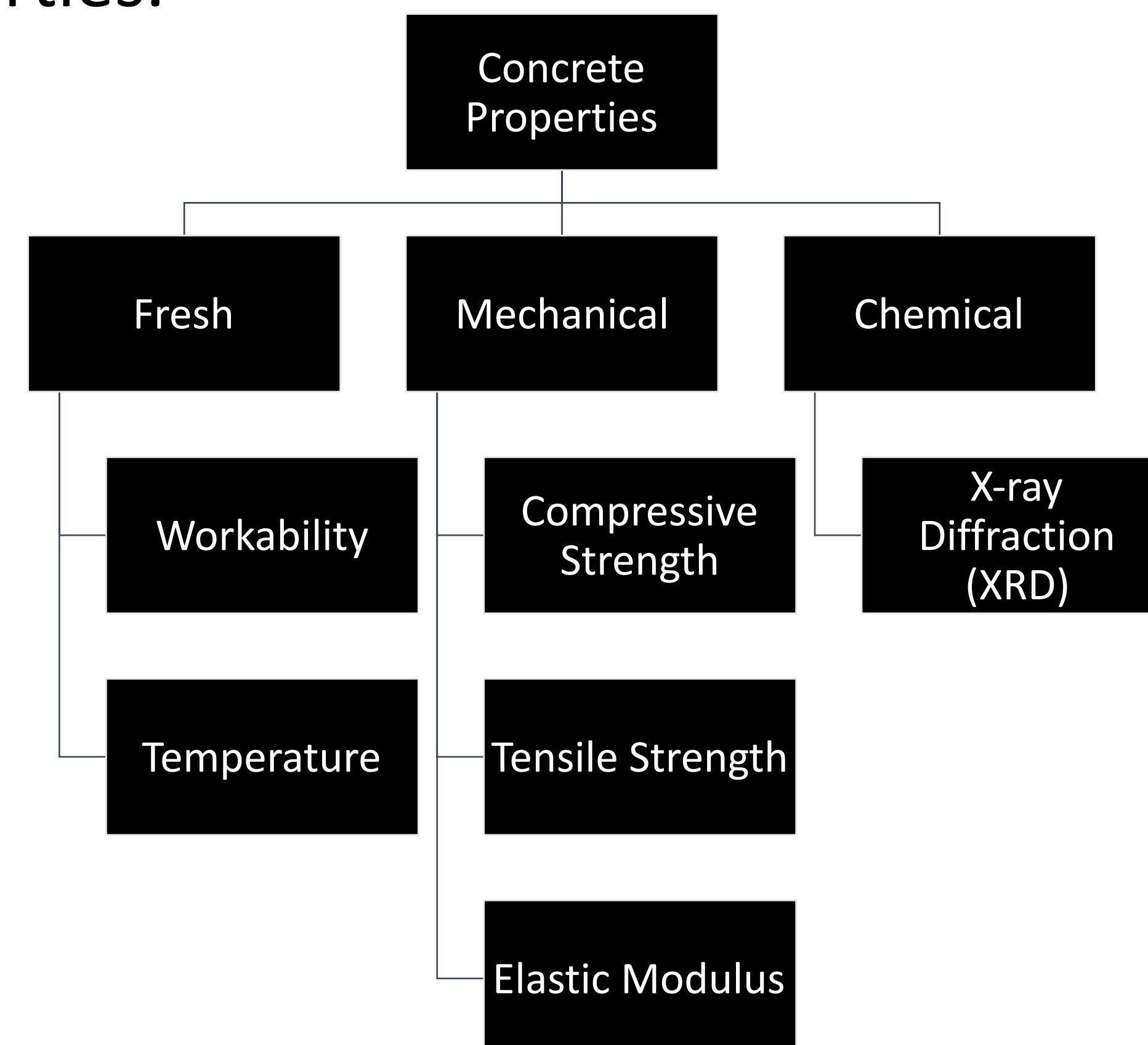
Proposed Solution

In the table below, we have theoretical CO₂ reduction of each mix, as we can see Fly ash & silica fume the highest one in CO₂ reduction

Mix	Cement Content (%)	Admixture Content (% of cement content)	Theoretical CO ₂ Reduction %
Control	100	0	0
Natural Pozzolan (Volcanic Ash)	80	20	20
Fly Ash	85	15	15
Silica Fume	93	7	7
Fly Ash & Silica Fume	78	22	22

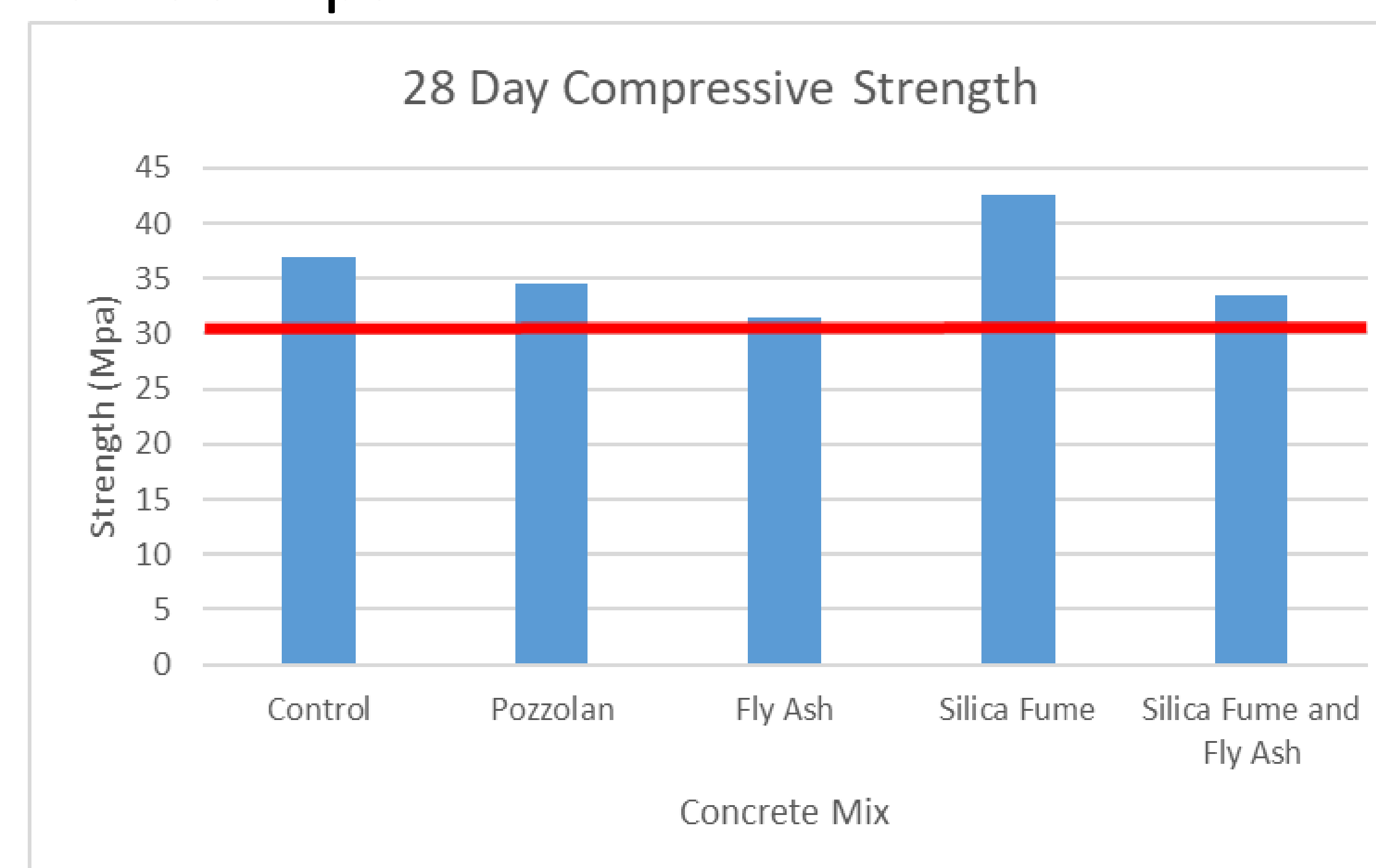
Overview of Analysis

- To analyze the concrete samples, we have to perform multiple tests to evaluate concrete properties.



Results

- All the mixes have greater compressive strength than 30 Mpa.



- w/c in all mixes equal to 0.4
- The temperature of a typical mix is under 35 °C

Sample	Control	Pozzolan Conc.	SF Conc.	FA Conc.	SFFA Conc.
Water (kg)	160	160	160	160	160
Admixture (%)	0	20	7	15	22
Admixture (kg)	0	80	28	60	88
Cement (kg)	400	320	372	340	332
Water to Cement Ratio	0.4	0.4	0.4	0.4	0.4



CO₂ Impact

In the following, we will explain how CO₂ is impacted with calculations:

- Cement = **1 ton**
- Cement with 20% Natural Pozzolan = **800 kg**
- Cement with 15% Fly Ash = **850 kg**
- Cement with 7% Silica Fume = **930 kg**
- Cement with 15% Fly Ash & 7% Silica Fume = **780 kg**
- Since Natural Pozzolan is local, no shipping emission
- CO₂ Reduction in Natural Pozzolan = $1 - 800/1000 \% = 20\%$
- Shipping emission for 1 kg of fly ash = 0.0487 kg
- CO₂ Reduction in Fly Ash = $1 - ((850 + 0.0487*150))/1000 \% = 14.25\%$
- Shipping emission for 1 kg of silica fume = 0.0487 kg
- CO₂ Reduction in Silica Fume = $1 - ((930 + 0.0487*70))/1000 \% = 6.7\%$
- CO₂ Reduction in Fly Ash & Silica Fume = $1 - ((780 + 0.0487*70 + 0.0487*150))/1000 \% = 21\%$

	Control	Natural Pozzolan	Fly Ash	Silica Fume	Fly Ash & Silica Fume
Actual CO ₂ Reduction (%)	0	20	14.25	6.7	21

Cost Impact

- Since we are replacing some of the cement with admixtures, the price will be affected.

	Natural Pozzolan	Fly Ash	Silica Fume	Fly Ash & Silica Fume
Price Change Compared to Control (%)	-2.35	+7.06	+13.59	+20.65

Conclusion

All mixes meet the specifications except silica fume, for less CO₂ reduction. The mix that reduces the CO₂ the most is Fly ash & silica fume. Pozzolan turns out to be the cheapest mix among the others mixes, including the control mix, so Pozzolan is the best one overall for all of the mixes.