# Predicting Concrete Strength

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W203

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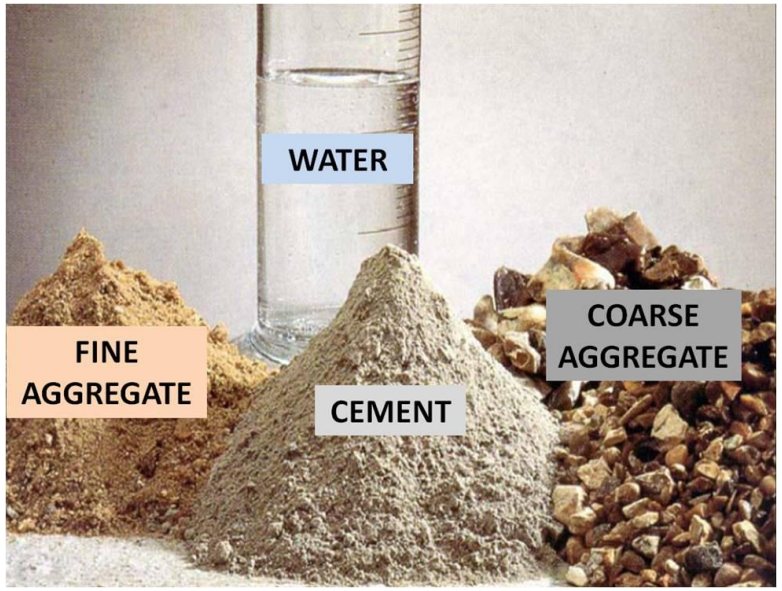
# Overview

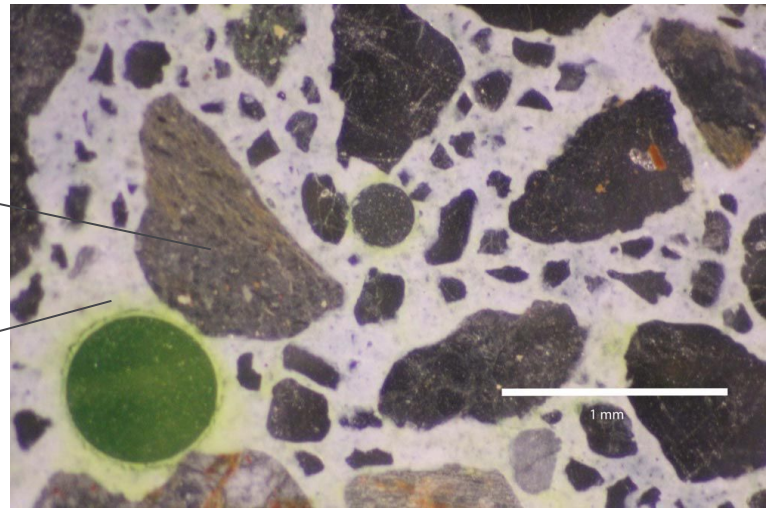
## What is Concrete?

concrete = (cement + water) + aggregate

binder filler

$$2\ Ca_3SiO_5 + 7\ H_2O \rightarrow 3\ CaO{\cdot}2SiO_2{\cdot}4H_2O + 3\ Ca(OH)_2 + 173.6kJ$$




Thin section showing concrete microstructure

# Research Question

Concrete strength is controlled by the Water-Cement (WC) ratio and curing conditions

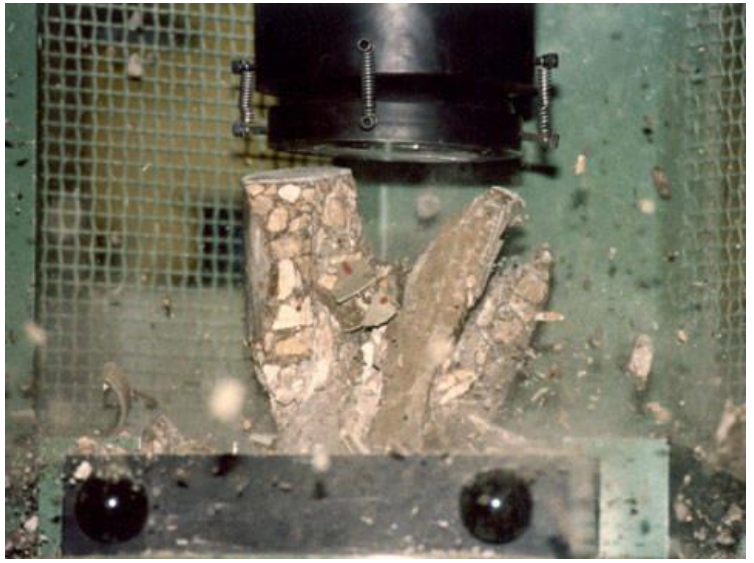
WC = mass of water/ mass of cement

Low WC ratio → High strength, low workability
High WC ratio → Low strength, good workability

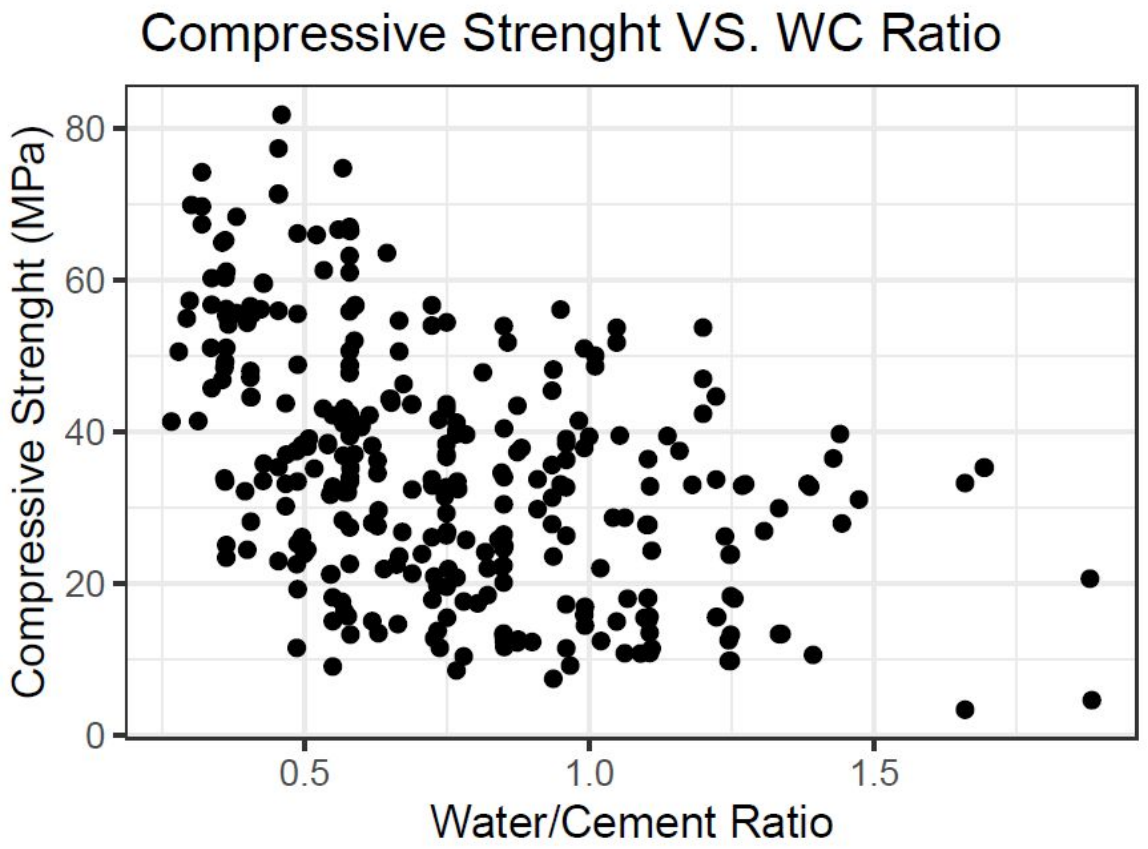
**We need a model for compressive strength of concrete**

# Dataset

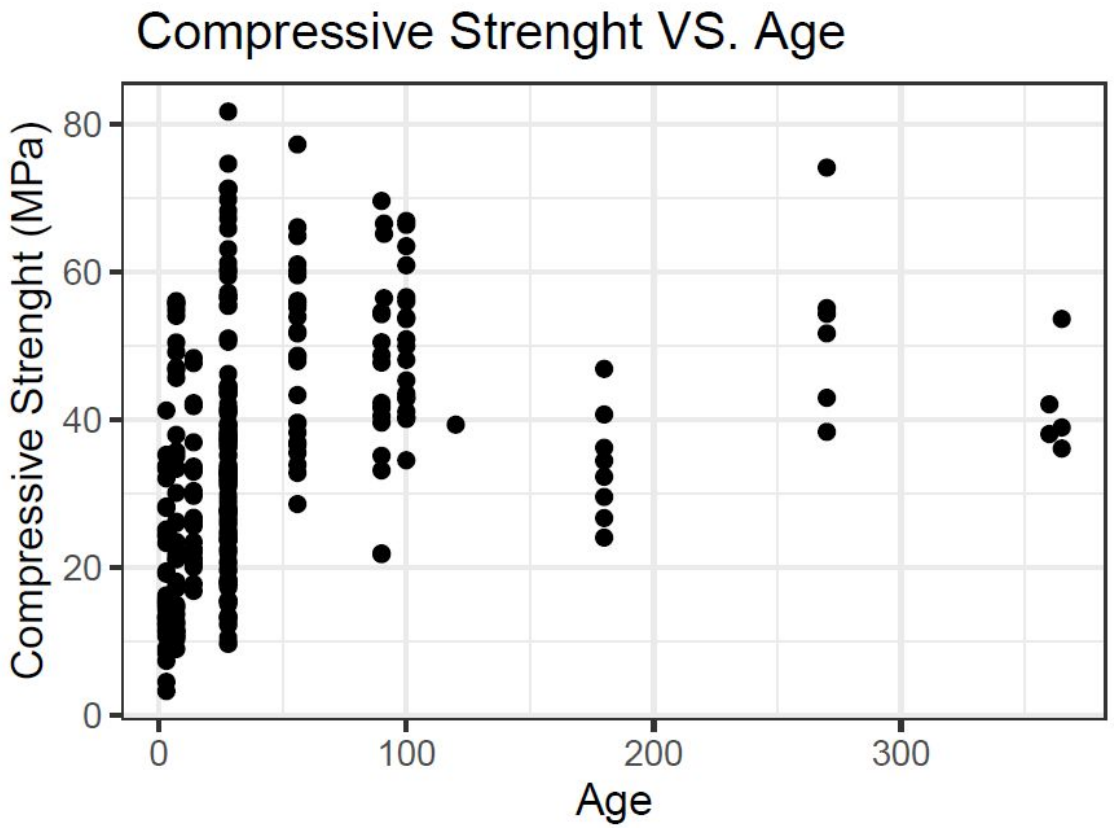
UC Irvine - 1030 observations



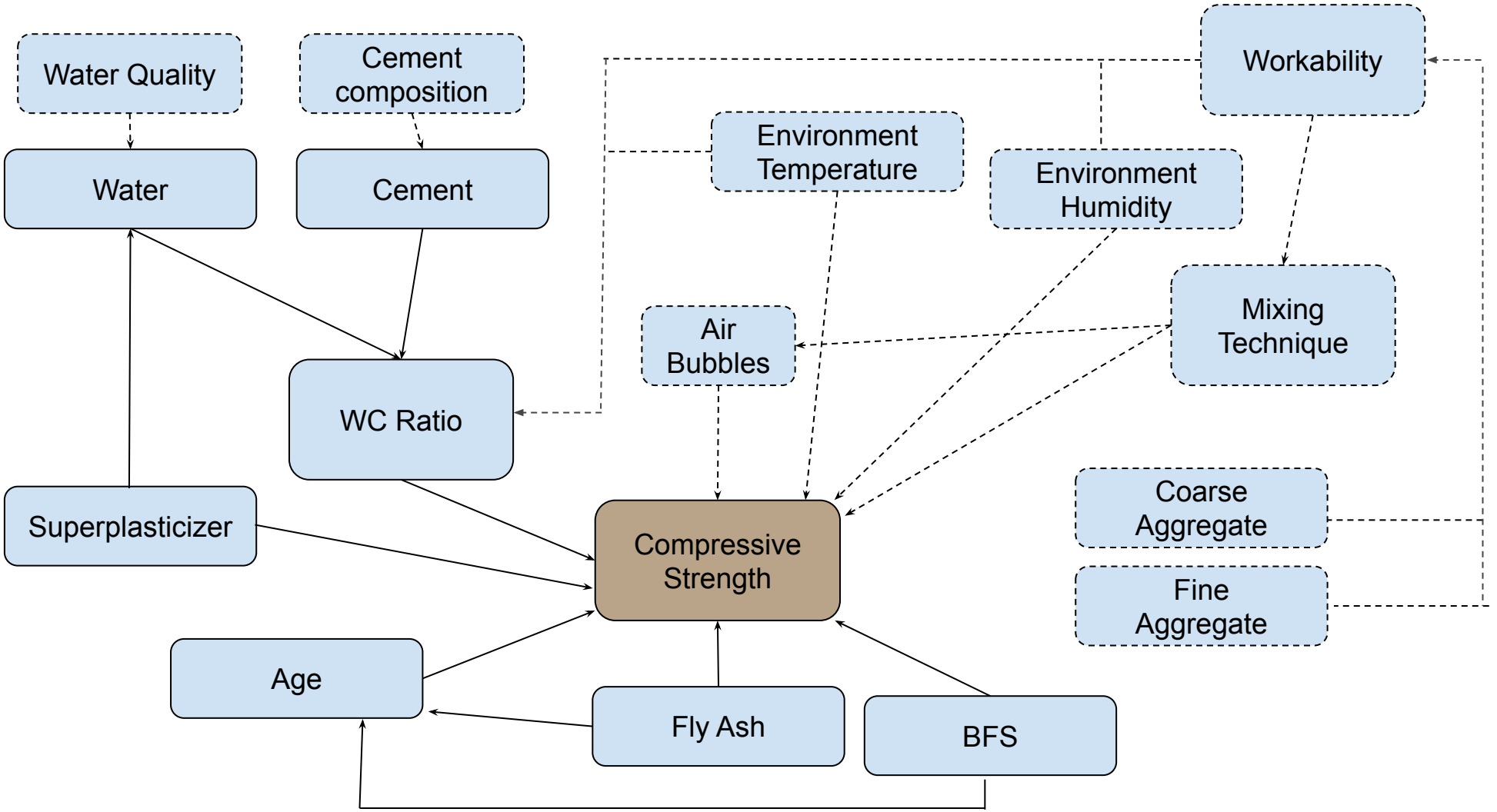
# Water Content VS. Workability



# Concrete Strengthens as it Dries



# Causal Graph



# Best Model

- Practical ranges:

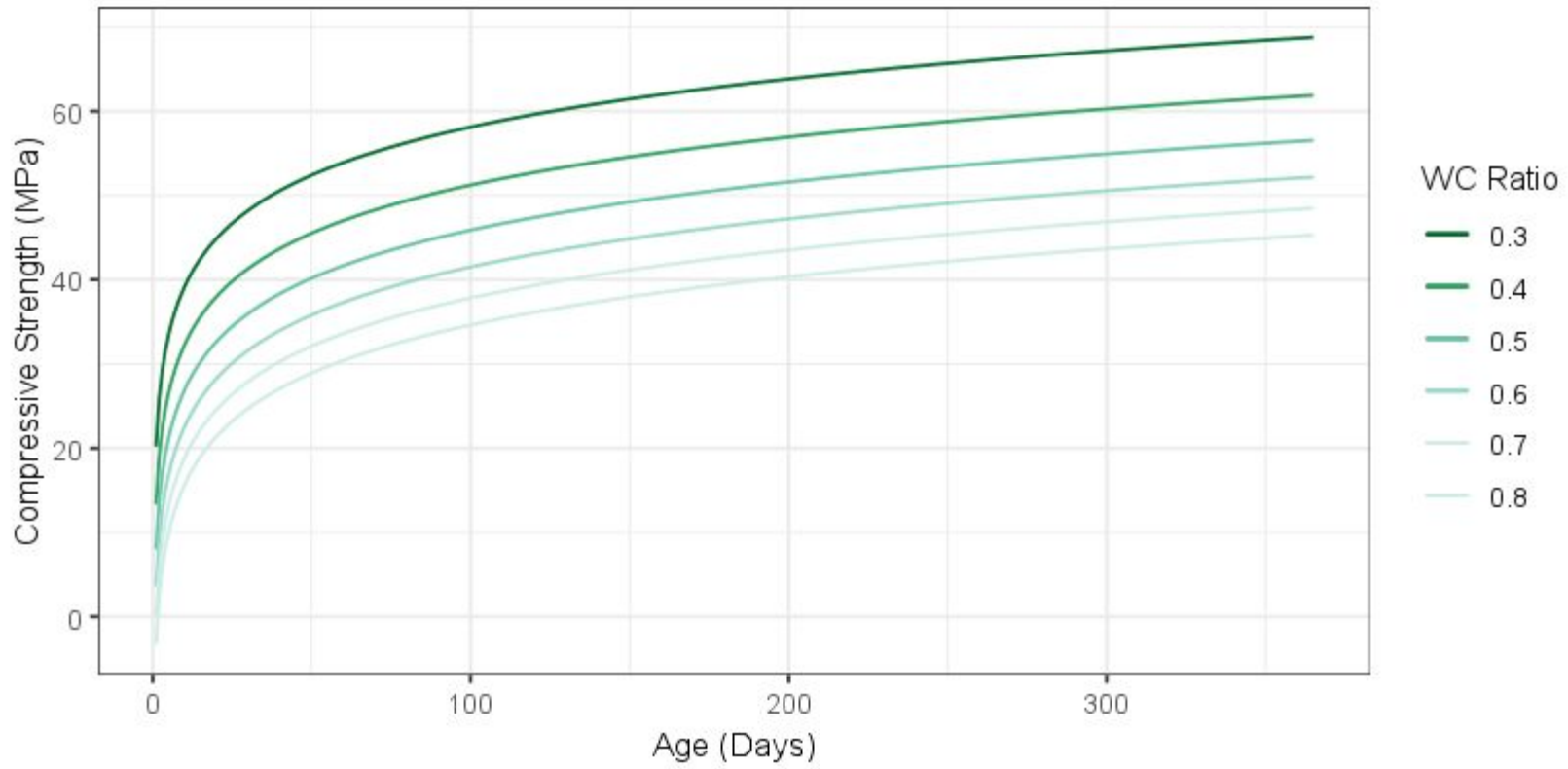
  0.3 < WC ratio < 0.8

- Categorical: Slag, Superplasticizer, Ash

| | Compressive Strength |
|---|---|
| log(WC ratio) | −23.948*** |
| | (0.922) |
| log(age) | 8.233*** |
| | (0.240) |
| Slag | 8.995*** |
| | (0.652) |
| Superplasticizer | 9.267*** |
| | (1.135) |
| Ash | −2.354** |
| | (1.130) |
| Constant | −8.633*** |
| | (0.849) |
| Observations | 721 |
| $R^2$ | 0.798 |
| Adjusted $R^2$ | 0.796 |
| Residual Std. Error | 7.596 (df = 715) |
| F Statistic | 563.924*** (df = 5; 715) |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 |

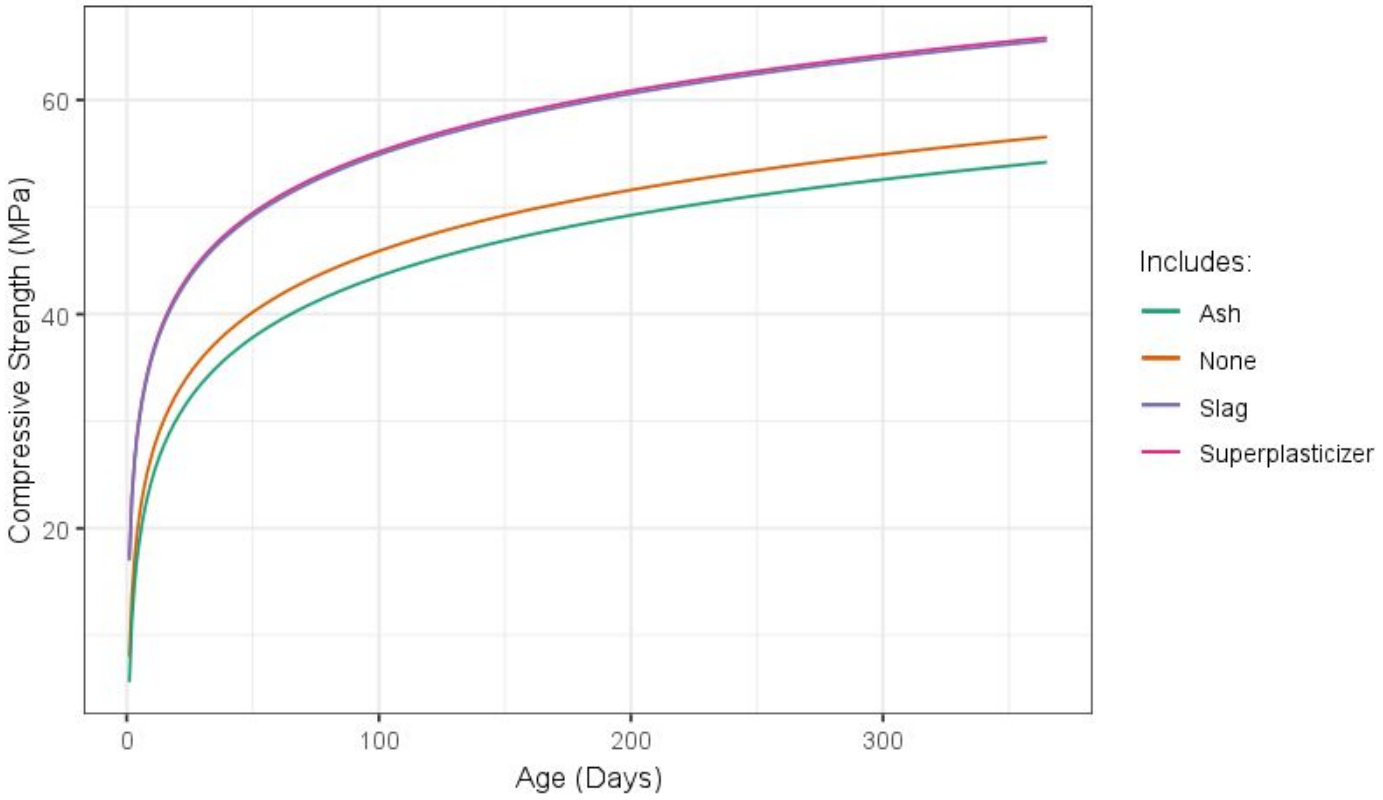
# Application of the Model

Given a specific mixture, when can construction continue?



# Application of the Model

How do additives affect compressive strength?



# Conclusion

- **With our model we can design a concrete recipe to meet customer specifications, avoiding waste of materials.**

- Our model is consistent with the physics of concrete compressive strength within practical limits.
  - The compressive strength is controlled by the quality of the binder and age.
  - The use of admixtures show an impact on the compressive strength of the concrete

- Even though the key parameter controlling the strength of concrete has been known for over 100 years, there is still debate about the mechanisms for it.

# Thanks for listening!