Project #2, Written Report

Automation of NDOT Concrete Mix Design Prepared for NDOT

Written by: Justin Witcofski

Date: February 23, 2026

Introduction/Background

In collaboration with the Nebraska Department of Transportation (NDOT). This written report outlines the steps taken and the process to transition from a manual, spreadsheet based concrete mix design to a standardized Python automated process. The primary objective that was followed was to eliminate calculation errors in volumetric conversions and provide a tool for rapid analysis of different NDOT concrete classes. (NDOT, 2024)

The Goals:

1. **Standardize Logic:** To translate excel-based mix design formulas into Python functions.
2. **Automate the scenarios:** Run and compare four different mix designs, in this report, 47B, 47BR, High Strength, and 47B-Air all simultaneously
3. **Validate the Process:** Ensure that every generated mix results in exactly 27 cubic feet.
4. **Export the Data:** Output a profession CSV for use by the NDOT engineers

Methods

This project utilized the absolute volume method, that was implemented through Jupyter Notebook. This method ensures that the sum of all the volumes of all the individual components equals exactly 27 cubic feet, or one cubic yard. The primary transition involved in converting the logic and formulas in the NDOT excel into a working python function. In the original excel file an engineer would have to manually update the cells, in this version on python, the script calculates the water weight first based on the water to cementitious ratio and then determines the remaining volume available for aggregates. Most importantly, the mass to volume conversion was made standardized for all materials by dividing the weight of the material product by its specific gravity and the unit weight of water. This Python tool allows for any variety of concrete mixes, such as ones involving fly ash or silica fume, while it contains a consistent volumetric number. To use the tool, there are several input and output parameters to guide users. The input parameters include the weights of cement, fly ash, silica fume, and other various cementitious materials, the

design water to cement ratio, target air content percentage, desired percentages for coarse and fine aggregates, and the specific gravity for each respective material. The tool also outputs various parameters. It generates the required weight of water in pounds, the final batch weights for coarse and fine aggregates, and the validation of the total remaining volume that is left.

Results/Discussion

This section details the findings from the automated mix design process and analyzes the relationships between the four NDOT-specified scenarios.

Summary of the Batch Weights:

Scenario	Water (Q)	Fine Agg (Y)	Coarse Agg (Z)	Total Cementitious
1: NDOT 47B	279 lb	1004 lb	1865 lb	620 lb
2: NDOT 47BR	260.4 lb	872 lb	2034 lb	620 lb
3: High Strength	276.5 lb	1035 lb	1688 lb	790 lb
4: 47B-Air	253.8 lb	1171 lb	1756 lb	564 lb

Analysis of Results:

1. **Comparison of 47B and 47BR:** Both the mixes have the same total cementitious weight; the 47BR scenario uses a lower W/C ratio. Looking at the results, this reduction in water volume requires a significant increase in coarse aggregate to maintain the 27 cubic feet of yield. This stays consistent with the NDOT standards for applications where there's lower permeability and higher rock content is preferred.
2. **High Strength:** Scenario 3 has the highest cementitious total and the lowest W/C ratio. The automation tool managed the paste volume increase by reducing the coarse aggregate weight. This demonstrates that as cementitious content increases to achieve higher psi, the aggregate volume must be lowered to prevent too much yielding of material. (UNL CIVE 202, 2026)
3. **Impact of Air:** In the fourth scenario, the air content was increased to 8%. Due to air occupying 2.16 feet cubed without adding weight, the python tool correctly reduced the cementitious material. To just state how accurate the tool was in the absolute volume method, it ensured that air entrained in mixes for freeze thaw durability that did not exceed the 27 cubic feet limit.

References

- Nebraska Department of Transportation (NDOT). (2024). *Standard Specifications for Highway Construction*.
- Witcofski, J. (2026). *Project-2 GitHub Repository*.
- UNL CIVE 202. (2026). *Project 2 - Client Prompt*.
- Nebraska Department of Transportation. (2024). *Materials Sampling Guide*.