Nebraska Department of Transportation's Automation of Concrete Mix Design

Concrete Mix Design Report

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Nebraska Department of Transportation Final Deliverable

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Introduction

The NDOT (Nebraska Department of Transportation) would like us to migrate an existing concrete mix design from an Excel-based workflow to a Python-based system. The intention of this is to replicate and automate the logic contained in the “Mix Design” so that it can be used to enter material specifications and design parameters. It also has to have a structured step-by-step manner. The output should automatically generate a weight chart for one cubic yard of concrete. NDOT would like to increase the reliability of the concrete design process by ensuring logic is fixed, transparent, and repeatable. The tasks of this project are (1) Translate the Excel logic to Python, (2) Implement sequential user inputs, (3) Generate a final mix design output, and (4) Prepare and evaluate four concrete mix scenarios.

Scope of Work

Project goals

The goal of this project is to migrate an existing concrete mix design model from an Excel-based workflow to a Python-based system. The client for this project is NDOT (Nebraska Department of Transportation). They would like us to replicate and automate the logic of the “ Mix Design” worksheet so that the user can enter material properties and automatically generate the weight chart for one cubic yard of concrete. The client requests (1) A translation of the Excel logic into Python code. All of the calculations need to be replicated, and each major calculation should be clearly defined as a Python function. (2) Implement sequential user inputs. The client would like for the program to prompt the user to enter a required design input in a step-by-step fashion, an example of this is cement content, water–cement ratio, air content, and aggregate proportions. The inputs should be collected in a logical order and mirror the Excel worksheet. (3) Generate a final mix design. The program must produce a clearly formatted weight chart for one cubic yard of concrete.

The output values should be labeled and presented in a professional manner that is readable to the client. (4) Evaluation of 4 concrete mix scenarios. In order to test the program, the client has requested 4 scenarios. The scenarios that are run are based on our own research.

Project Tasks

Task #1 – translate Excel logic to Python

Coding tasks:

- Get equations used in Excel
- Translate equations to Python
- Organize in a similar fashion to an Excel workbook

Research:

No research needed for this task

Task #2 – implement sequential user inputs

Coding tasks:

- Draft code to request user inputs
- Ensure all inputs are included
- Ensure all inputs have the correct set up

Research:

No research needed for this task

Task #3 – Generate a final mix design output

Coding tasks:

- Organize code so clearly formatted
- Produce a weight chart for one cubic yard
- Label output values

Research:

No research needed for this task

Task #4 – Prepare to evaluate four concrete mix scenarios

Coding tasks:

- Must be evaluated using an automatic workflow

Research:

- Use DOT references and other external sources to obtain 4 concrete mix scenarios.
- Ensure the mixes are expressible using the inputs required

Project Deliverables

Deliverable	File	Due Date
GitHub	GitHub Repository + README	2/24/26
Scope of work	Scope of work	2/24/26
Gantt Chart	Gantt Chart	2/24/26
Mix Scenarios	Research + Documentation	2/24/26
Python Code	Python Code	2/24/26
Annotated code document	Annotated code document	2/24/26
Written Technical Reprot	Written Technical Reprot	2/24/26

Methods

A Python code was created, which included equations from the Excel workbook translated into automated logic, and sequential user prompts for input and four mix design runs. For task number 1, all of the necessary equations and calculations were evaluated and transferred into Python to create a replica of the Excel workbook. All necessary parts of the equations were defined. For Task 2, all prompts were transferred and combined with parts from the previous task to create a seamless workflow. Code was organized in a way that is understandable to the user and mirrors the Excel Workbook. For task 3, code was created to produce a weight chart for one cubic yard of concrete; the output values were labeled. For task 4, four scenarios were researched and created. The four scenarios were fun in the program to ensure proper automation.

Results

Task #1

Task 1 requested that the calculations on the Excel Worksheet be transformed into clearly defined Python code. This task was completed.

This is a sample of the code created using the Excel calculations. This code calculates the volume of the variable R using Cement A and the sample gravity of Cement J

```
Define a function to calculate the volume of cement (R)\n\ndef
calculate_volume_R(cement_A,sg_cement_J):\n    volume_R = cement_A/
(sg_cement_J * unit_weight_water)\n    return volume_R\n\n# Example input
values for demonstration\n\ncement_A = 600\nsg_cement_J = 3.5\n   \n# Use
them in the function\n\nR = calculate_volume_R(cement_A, sg_cement_J)\n\n#
Print\n\nprint(f\"Cement volume (R): {R:.3f} ft&3\")",
```

Task #2

Task 2 requested that there be user inputs; these inputs were to be in a logical order that mirrored the Excel workbook. This task was completed.

Here is an example of the code for the inputs that would create an organized and logical workflow.

```
": "Enter project number:  404222\nEnter class of concrete (e.g., 47B,
47BR):  47B\nEnter cement weight A (lb per cubic yard):  600\nEnter fly
ash weight B (lb per cubic yard):  100\nEnter silica fume weight C (lb per
cubic yard):  30\nEnter other SCM weight D (lb per cubic yard):  70\nEnter
target water-cement ratio E:  0.42\nEnter target air content F (%):
6.0\nEnter percent fine aggregate G (%):  45\nEnter percent coarse
aggregate H (%):  50\nEnter percent other aggregate I (%):  5\nEnter
specific gravity of cement J:  3.15\nEnter specific gravity of fly ash K:
2.30\nEnter specific gravity of silica fume L:  2.20\nEnter specific
gravity of other SCM M:  2.60\nEnter specific gravity of fine aggregate N:
2.69\nEnter specific gravity of coarse aggregate O:  2.70\nEnter specific
gravity of other aggregate P:  2.60\n"
        },
```

Task #3

Task 3 requested that the program produce a clearly formatted weight chart for one cubic yard of concrete. This step can be seen in the code. This step was completed

Task #4

Task 4 was to prepare and evaluate four concrete mix designs. This step required that the first 3 steps be completed. This step was completed.

Here is an example of the first scenario used to test the workflow of our code

```
"#Scenario 1:\nproject_number = int(input(\"Enter project number:
\"))\nclass_of_concrete = input(\"Enter class of concrete (e.g., 47B,
47BR): \")\n\ncement_A = float(input(\"Enter cement weight A (lb per cubic
yard): \"))\nfly_ash_B = float(input(\"Enter fly ash weight B (lb per
cubic yard): \"))\nsilica_fume_C = float(input(\"Enter silica fume weight
C (lb per cubic yard): \"))\nother_scm_D = float(input(\"Enter other SCM
weight D (lb per cubic yard): \"))\n\nwater_cement_ratio_E =
float(input(\"Enter target water-cement ratio E: \"))\nair_content_F =
float(input(\"Enter target air content F (%): \"))\n\npercent_fine_G =
float(input(\"Enter percent fine aggregate G (%): \"))\npercent_coarse_H =
float(input(\"Enter percent coarse aggregate H (%): \"))\npercent_other_I
= float(input(\"Enter percent other aggregate I (%): \"))\n\nsg_cement_J =
float(input(\"Enter specific gravity of cement J: \"))\nsg_fly_ash_K =
float(input(\"Enter specific gravity of fly ash K: \"))\nsg_silica_fume_J
= float(input(\"Enter specific gravity of silica fume L:
\"))\nsg_other_scm_M = float(input(\"Enter specific gravity of other SCM
M: \"))\n\nsg_fine_N = float(input(\"Enter specific gravity of fine
aggregate N: \"))\nsg_coarse_O = float(input(\"Enter specific gravity of
coarse aggregate O: \"))\nsg_other_P = float(input(\"Enter specific
gravity of other aggregate P: \"))\n\nQ calculate_water_weight_Q(\n
cement_A, fly_ash_B, silica_fume_C, other_scm_D, wc_ratio_E\n)\n\nR =
calculate_volume_R(cement_A, sg_cement_J)\nS =
calculate_volume_S(fly_ash_B, sg_fly_ash_K)\nT =
calculate_volume_T(silica_fume_C, sg_silica_fume_L)\nU =
calculate_volume_U(other_scm_D, sg_other_scm_M)\n\nV =
calculate_air_volume_V(air_content_F)\nW =
calculate_water_volume_W(water_weight_Q)\n\nX =
calculate_total_aggregated_volume_X(R, S, T, U, V, W)\n\nY =
calculate_total_fine_aggregated_weight_Y(target_percent_fine_aggregate_G,s
g_aggregate_N,total_aggreagated_volume_X)\nZ =
calculate_total_coarse_aggregated_weight_Z(percent_coarse_H, sg_coarse_O,
total_aggreagated_volume_X)\nAA =
calculate_total_coarse_aggregated_weight_AA(percent_other_I, sg_other_P,
total_aggreagated_volume_X)\n\nprint(\"\\n-------------------------------
-------------\")\nprint(\" NDOT Concrete Mix Design ,Äì Weight
Summary\")\nprint(\"         (1 Cubic Yard of Concrete)\")\nprint(\"------
---------------------------------------\")\nprint(f\"Project Number:
{project_no}\")\nprint(f\"Class of Concrete:
{concrete_class}\")\nprint(\"----------------------------------------------
\")\nprint(f\"Cement (A):  {cement_A:8.1f} lb\")\nprint(f\"Fly Ash (B):
{fly_ash_B:8.1f} lb\")\nprint(f\"Silica Fume (C):  {silica_fume_C:8.1f}
lb\")\nprint(f\"Other SCM (D):  {other_scm_D:8.1f} lb\")\nprint(\"--------
-----------------------------------\")\nprint(f\"Fine Aggregate (Y):
{Y:8.0f} lb\")\nprint(f\"Coarse Aggregate (Z): {Z:8.0f}
lb\")\nprint(f\"Other Aggregate (AA):  {AA:8.0f} lb\")\nprint(\"----------
---------------------------------\")\nprint(f\"Water (Q): {Q:8.0f}
```

```
lb\")\nprint(\"-----------------------------------------------
\")\nprint(\"End of Mix Design Summary\")",
```

References

Optimized Aggregates Gradations for Portland Cement Concrete Mix Designs Evaluation

Standard Specifications for Highway Construction 2017 Edition

Nebraska.gov, 2026, dot.nebraska.gov/media/jp3paote/mix-design-submittal.xlsx