Flow Diagram: Automated Concrete Mix Design

Process of Converting the NDOT Excel Workbook to a Python-Based System

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Phase 1 — Excel Logic Analysis & Formula Mapping

1.1 Download NDOT Mix Design Excel workbook; identify the Mix Design tab
1.2 Locate all shaded (user-editable) input cells and map to variables A-P
1.3 Trace every formula and document calculation dependencies between cells
1.4 Establish sequential calc order: Inputs -> Q -> R,S,T,U -> V,W -> X -> Y,Z,AA

Phase 2 — Python Function Development (Excel -> Python)

2.1 Define constants: unit_weight_water = 62.4 lb/ft³, cubic_yard_ft3 = 27.0 ft³
2.2 Write calculate_water_weight_Q(): Q = (A + B + C + D) x E
2.3 Write cementitious volume functions (R, S, T, U): Vol = Weight / (SG x 62.4)
2.4 Write air_volume_V(): V = (F/100) x 27 and water_volume_W(): W = Q / 62.4
2.5 Write total_aggregate_volume_X(): X = 27 - R - S - T - U - V - W
2.6 Write aggregate weight functions (Y, Z, AA): Wt = (%/100) x SG x 62.4 x X
2.7 Unit-test each function; verify R+S+T+U+V+W+X = 27.000 ft³

Phase 3 — Sequential User Input Implementation

3.1 Design input() prompt sequence mirroring Excel worksheet fill-in order
3.2 Collect 16 parameters: weights (A-D), W/C ratio (E), air (F), agg % (G-I), SGs (J-P)
3.3 Wrap each input in float() for type conversion with descriptive labels and units

Phase 4 — Execute 5-Step Calculation Chain

Step 1: Compute water weight Q from cementitious weights and W/C ratio
Step 2: Compute cementitious volumes R, S, T, U from weights and specific gravities
Step 3: Compute air volume V from target air %, and water volume W from Q
Step 4: Compute total aggregate volume X = 27 - (sum of all other volumes)

Phase 5 — Generate Formatted Weight Chart Output

5.1 Print weight chart: all component weights and total weight (lb/yd³)
5.2 Format to 3 decimal places; match NDOT Excel "Weights for 1 yd³" format

Phase 6 — Verification & Validation (4 Mix Scenarios)

6.1 Research 4 realistic mix designs from NDOT, other DOTs, and ACI references
6.2 Run each scenario through the Python program and record outputs
6.3 Enter the same inputs into the original NDOT Excel spreadsheet
6.4 Compare Python vs. Excel results; if discrepancy found, trace and fix the error

Model Inputs & Outputs Summary

INPUTS (16 Parameters Collected via Sequential Prompts)

A	= Weight of Cement	lb/yd³	**I**	= Target % Other Aggregate	%
B	= Weight of Fly Ash	lb/yd³	**J**	= Specific Gravity, Cement	—
C	= Weight of Silica Fume	lb/yd³	**K**	= Specific Gravity, Fly Ash	—
D	= Weight of Other SCM	lb/yd³	**L**	= Specific Gravity, Silica Fume	—
E	= Target Water/Cement Ratio	—	**M**	= Specific Gravity, Other SCM	—
F	= Target % Air Content	%	**N**	= Specific Gravity, Fine Agg.	—
G	= Target % Fine Aggregate	%	**O**	= Specific Gravity, Coarse Agg.	—
H	= Target % Coarse Aggregate	%	**P**	= Specific Gravity, Other Agg.	—

Basis of calculation: 1 cubic yard of concrete = 27 ft³ | Unit weight of water = 62.4 lb/ft³

OUTPUTS (Contractor Target Mix Design Weights for 1 yd³)

Cement Weight	(A)	lb/yd³	*user input*
Fly Ash Weight	(B)	lb/yd³	*user input*
Silica Fume Weight	(C)	lb/yd³	*user input*
Other SCM Weight	(D)	lb/yd³	*user input*
Water Weight	(Q)	lb/yd³	*calculated*
Fine Aggregate Weight	(Y)	lb/yd³	*calculated*
Coarse Aggregate Weight	(Z)	lb/yd³	*calculated*
Other Aggregate Weight	(AA)	lb/yd³	*calculated*
Total Weight	(sum)	lb/yd³	*calculated*

All values formatted to 3 decimal places via Python f-strings