IDOT PCC MIX DESIGN SOFTWARE TUTORIAL

Version X1.0

For help, comments, and/or suggestions, please contact:

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General

This spreadsheet is designed to calculate and report PCC mix designs for submittal to IDOT. The spreadsheet is comprised of data inputs based on the mix design methodology provided in the PCC Level III Technician course manual.

The spreadsheet is organized across a series of tabs. To navigate from one input screen to another, please use the tabs found at the bottom of the Excel screen.

The blue-shaded areas are cells which require data input, green-shaded areas are optional (unless required by your District), and white cells are calculation fields, which are password protected from accidental overwriting.

Throughout the spreadsheet, comments have been interspersed to offer hints on where to find relevant information. To view comments, hold the cursor over the red tags found in the upper right-hand corner of commented cells, as shown below. These comments generally refer to sections of the Course Manual; however, it should be noted that the Department's Standard Specifications and Special Provisions take precedence.

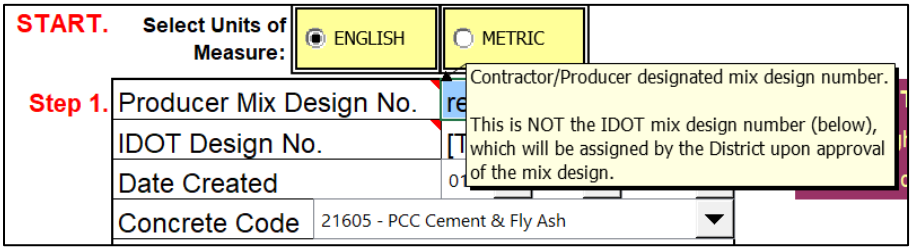


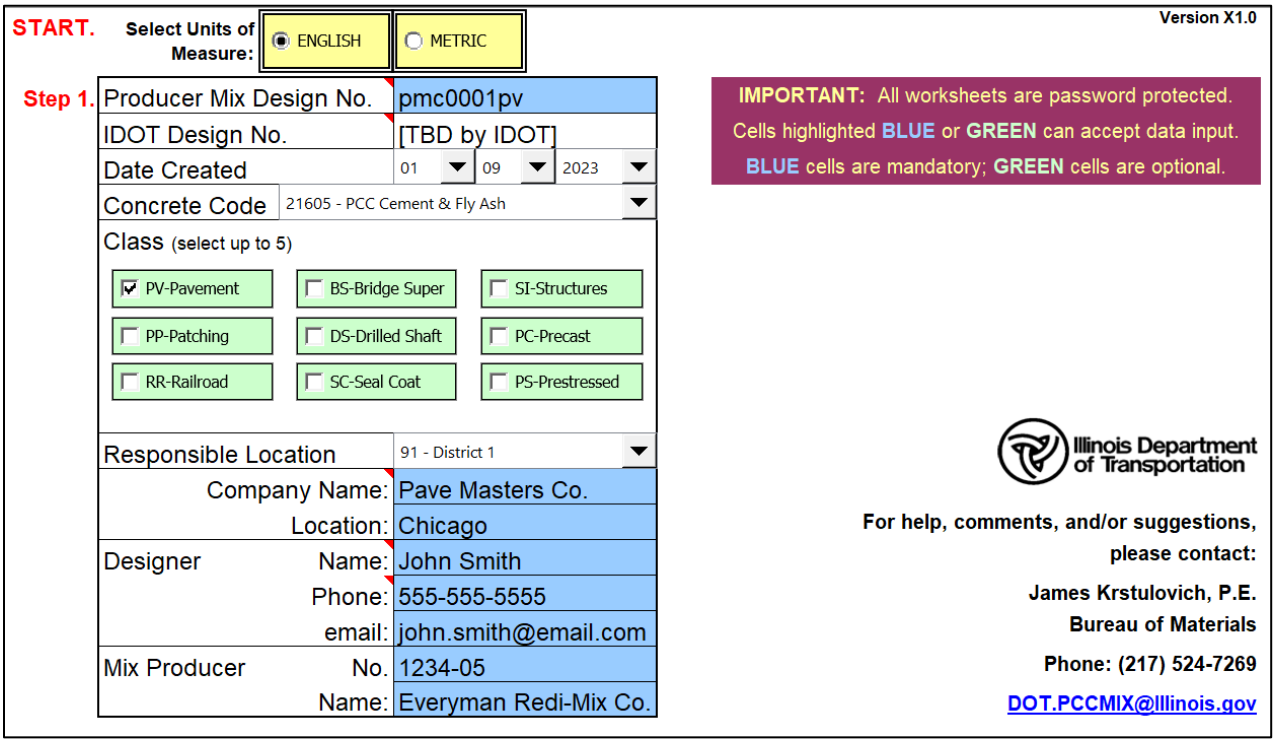
Figure 1. Example of a comment; note red flag, which indicates the cell has a comment.

Tutorial Mix Design

This tutorial also includes notes for how to input the example mix design discussed in Section 2.8 of the Course Manual. If you follow the notes in order as they are presented herein, you should successfully create a basic PCC paving mix design while also being introduced to all of the spreadsheet's functions and capabilities.

Step 1. Design Information

The Design Information page is important to establish the who-what-where of the mix design. This is where the designer decides in which units of measure the mix will be designed, what type of concrete it is, for what Classes of concrete it is valid, and those responsible for the mix design.



English/Metric [toggle]: Toggle button for selecting the units of measure for the mix design's inputs. All data inputs will have to be entered in the chosen units of measure. However, the design will be reported in **both** units of measure on the different final mix design reports generated.

EXAMPLE PROBLEM	Assuming most of us are more comfortable using English units of measure (lbs, yd^3, etc.), the example mix design will be designed using English units. Click on the **ENGLISH** toggle button.

Mix Design No.: Alphanumeric designation (up to nine characters in length). This is the Producer's or Contractor's self-designated mix design number; this is not the mix design number assigned by IDOT, see "IDOT Mix Design No." below.

EXAMPLE PROBLEM	Because this is the Producer's or Contractor's mix design number, any reasonably succinct and unique identifier can be used here, as long as it is no more than nine characters long. For this example, we will use **PMC0001PV** (i.e., Pave Masters Co. paving mix #1).

IDOT Mix Design No.: Nine-character alphanumeric mix design number reported to the Department's CMMS database. This number will be assigned by your District to an approved mix design.

EXAMPLE PROBLEM	Because this mix design number is assigned by the District upon approval, this cell reads **Not yet assigned**.

Date Created: The date the mix design was created.

Step 1. **Design Information** (continued)

Concrete Code: Select the appropriate material code. This code is used by the Department's CMMS database to designate the type of concrete.

EXAMPLE PROBLEM	Because this mix will utilize Type I portland cement and Class C fly ash, the appropriate Concrete Code to select from the drop-down list is **21605**.

Class: Select up to five Classes of concrete.

EXAMPLE PROBLEM	Because this mix will be used for a continuously reinforced portland cement concrete pavement, the appropriate Class to select is **PV**.

Responsible Location: District responsible for mix design's use; for example, "91" for District 1.

EXAMPLE PROBLEM	Select one of the nine IDOT Districts with which you typically work; for example, select **91** if you often work with District 1 in the Chicago area.

Company Name: Name of laboratory responsible for creation and/or testing of mix design.

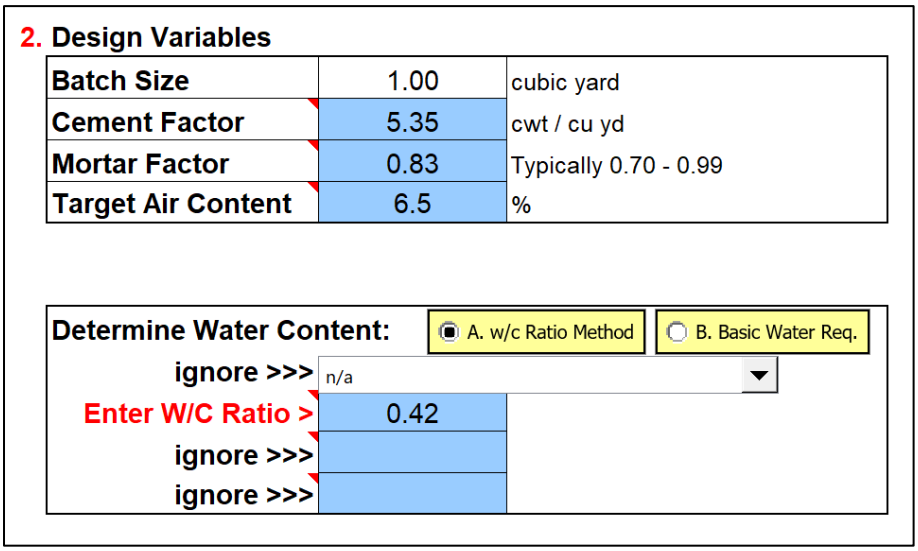
Location: Nearest municipality to Lab/Company.

Designer: Name, phone number, and email of person that created the design.

Mix Design Producer: IDOT-assigned producer number and name of producer.

Step 2. Design Variables

The Design Variables page is where the designer first begins to determine the mix design's parameters that factor into the mix design calculations.



Batch Size: Batch size in cubic yards (cubic meters). All mix designs are created per 1 yd^3 (1 m^3).

Cement Factor: Cement quantity in hundredweight per cubic yard (kilograms per cubic meter).

EXAMPLE PROBLEM	From Table 2.2.1 in the Course Manual, the cement factor for Class PV concrete from a central mixed plant is **5.65 cwt/yd^3**. Also, from Section 2.2.2, a cement factor reduction of **0.30 cwt/yd^3** can be applied because a water-reducing admixture will be used. Thus, the final, adjusted cement factor is reduced to **5.35 cwt/yd^3**.

Mortar Factor: Refer to Table 2.7.2.2 *Design Mortar Factor* in the Course Manual.

EXAMPLE PROBLEM	From Table 2.7.2.2 in the Course Manual, a mortar factor can be selected for Class PV concrete. Enter **0.83** as a reasonable starting point.

Target Air Content: Percentage of entrained air in the concrete to improve durability. Refer to Table 2.6 *Air Content* in the Course Manual.

EXAMPLE PROBLEM	From Table 2.6 in the Course Manual, the midpoint of the air content range for Class PV concrete is **6.5%**.

Step 2. Design Variables (continued)

Determine Water Content

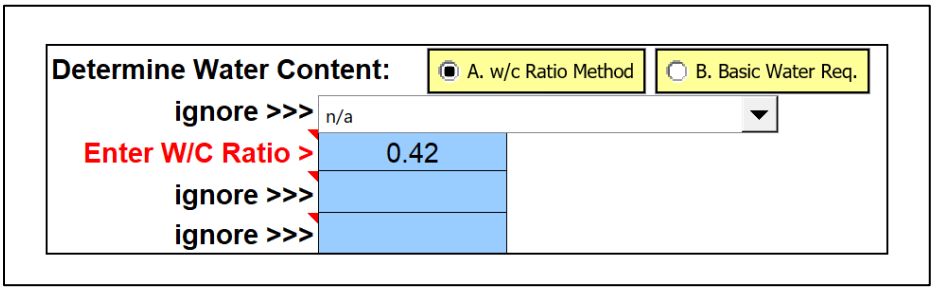
First, using the toggle switch, select either the *w/c Ratio Method* or the *Basic Water Requirement Method* .

The *w/c Ratio Method* will determine water content based on the w/c ratio entered and the total content of cement and finely divided minerals. No water adjustment needs to be entered as it will be back-calculated based on the w/c ratio and assumed aggregate water requirements (see Note).

Alternatively, the *Basic Water Requirement* method requires the fine and coarse aggregate water requirements, as well as percent water reduction. Refer to Appendix Q *Basic and Adjusted Water Requirement Method* in the Course Manual for more information. **See next page for when using the *Basic Water Requirement* method.**

> Note: Because the Department's original method for determining water content used the *Basic Water Requirement* Method, its MISTIC database requires data related to the basic water requirement method. Thus, when the "w/c Ratio Method" is selected, the spreadsheet will provide 'dummy' values in the design reports assuming a Type B fine aggregate with basic water requirement of 5.3 gal/cwt (0.44 L/kg).

If the* W/C Ratio Method *has been selected:

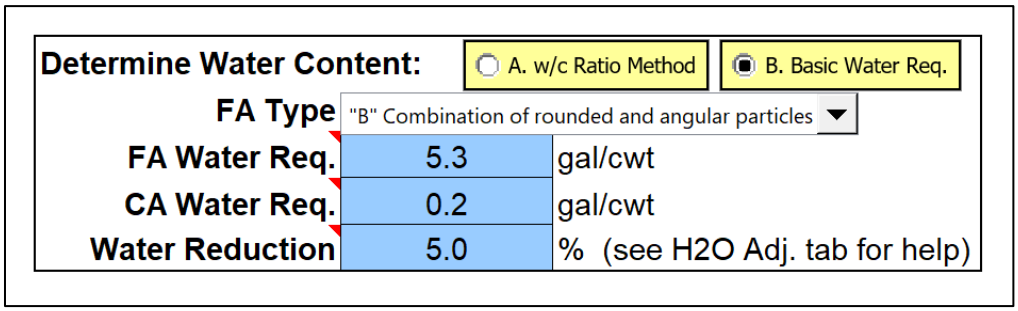


Enter W/C Ratio: When *w/c Ratio Method* is toggled, this field appears. Enter the target w/c ratio that the design water content will be based on; for example, 0.42.

EXAMPLE PROBLEM	In this example, per **Table 2.5** in the Course Manual, the maximum w/c for Class PV concrete is **0.42**.

Step 2. **Design Variables** (continued)

If the* Basic Water Requirement Method *has been selected:



FA Type: Select fine aggregate type.

EXAMPLE PROBLEM	Assume this mix will utilize a Type "B" fine aggregate, select **B** from the drop-down list.

FA Water Req.: Water requirement for fine aggregate in gallons per hundredweight (liters per kilogram) of cement and finely divided minerals. This value is based on the type of fine aggregate.

EXAMPLE PROBLEM	Assuming this mix will utilize a Type "B" fine aggregate, enter **5.3 gal/cwt**.

CA Water Req.: Water requirement for coarse aggregate in gallons per hundredweight (liters per kilogram) of cement and finely divided minerals material. This value is based on the type of coarse aggregate.

EXAMPLE PROBLEM	Because this mix will utilize a crushed stone, enter **0.2 gal/cwt**.

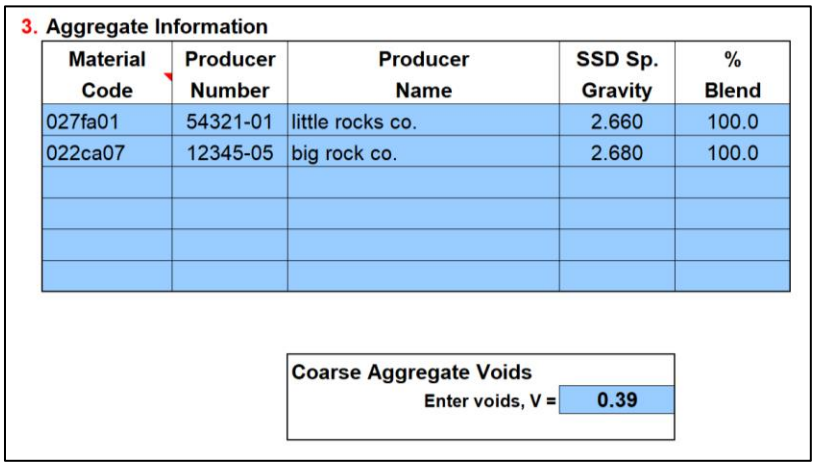
Water Reduction: Percentage of water adjustment (typically a reduction) accounting for various factors, such as admixture use, cement and finely divided mineral content, air content, etc. Note that because this input is referred to as a "reduction," the value entered may seem counter-intuitive; that is, a water reduction should be entered as a positive value, while a water addition should be entered as a negative value. For example, enter "10.0" for a 10 percent water reduction, and enter "-10.0" for a 10 percent water addition.

For help determining a reasonable water adjustment, refer to Appendix Q *Basic and Adjusted Water Requirement Method* in the Course Manual.

EXAMPLE PROBLEM	Because this mix will utilize a water-reducing admixture to provide a target water reduction of 10%, enter **10.0**. Note: If for some reason this mix needed a 10 percent water addition, you would have entered -10.0.

Step 3. Aggregate Information

The Aggregate Information worksheet is where the designer enters all fine and coarse aggregate information.



3. Aggregate Information

Material Code	Producer Number	Producer Name	SSD Sp. Gravity	% Blend
027fa01	54321-01	little rocks co.	2.660	100.0
022ca07	12345-05	big rock co.	2.680	100.0

Coarse Aggregate Voids
Enter voids, V = 0.39

Material: Aggregate material codes. Coarse and fine aggregates may be entered in any order, except as required by your District.

EXAMPLE PROBLEM	• Fine aggregate: Enter **027FA01**. This material code is for an "A" quality natural sand meeting the gradation criteria for FA 1 per Article 1003.01(c). • Coarse aggregate: Enter **022CA07**. This material code is for an "A" quality crushed stone meeting the gradation criteria for CA 7 per Article 1004.01(c).

Producer Number: Aggregate producer number. This field is required for all aggregate components.

Producer Name: Aggregate producer name.

Specific Gravity: Saturated Surface Dry (SSD) specific gravity of each aggregate.

EXAMPLE PROBLEM	The example problem in the Course Manual indicates that the saturated surface-dry specific gravities for the fine and coarse aggregate components are **2.66** and **2.68**, respectively.

% Blend: Percent blend for aggregate components. If only using one coarse aggregate and one fine aggregate material, enter "100" for each. On the other hand, if blending coarse aggregate materials, say, CA 11 and CA 16 at 75 and 25 percent, respectively, enter a "75" for the CA 11 and a "25" for the CA 16. Similarly, if blending fine aggregate materials. Do not blend coarse and fine aggregate, except as noted below for CAM II:

Note for CAM II designs *only*—Recommended % Blend of coarse-to-fine aggregate: 50-50 when using CA 7, CA 9, or CA 11; 75-25 when using CA 6; and 100-0 (i.e., no fine aggregate) when using CA 10. For example, when using CA 6 and FA 1, enter "75" for the CA 6 and "25" for the FA 1.

EXAMPLE PROBLEM	Because this mix is utilizing one coarse aggregate and one fine aggregate (and the mix is not CAM II), enter **100** for coarse aggregate and **100** for fine aggregate, as well.

Coarse Aggregate Voids: Voids in coarse aggregate. Refer to the District office verifying your mix design for guidance on what value to use. **Important:** Enter "1.00" for any mix design that does not contain coarse aggregate.

EXAMPLE PROBLEM	The example problem in the Course Manual notes that the Voids for the coarse aggregate is **0.39**.

Step 4. Finely Divided Minerals & Admixtures Information

This worksheet is where the designer enters all information pertaining to cement and finely divided minerals, as well as chemical admixtures (e.g., air-entraining water-reducing admixtures, etc.).

4. Cement and Finely Divided Minerals Information

Material Code	Producer Number	Producer Name	Specific Gravity	Percent Blend	Replacement Ratio
37708 Type IL Limestone	555-01	Big Cement, Co.	3.150	75.0	
37801 Fly Ash Class C	43215-01	Ash Marketers, Inc.	2.610	25.0	
Select Slag...					
Select Other FDM...					
				100%	

5. Admixture Information

Material Code	Admixture Type (ASTM C 494)	Product Name	Remarks (e.g. dosage rate)
42000	AEA - Air Entraining	Air Plus X	
43000	A - Water Reducer	Water Reducto 2000	
	n/a		
	n/a		

6. General Remarks

ASR Mix Option 2, 25% fly ash

Latex Admixture Information

Batch Dosage		gal/cu yd
Specific Gravity		
% Solids		%

Material: Cement and finely divided mineral (FDM) material codes. Each line is dedicated to a specific material: Line 1 for cement, Line 2 for fly ash, Line 3 for GGBF slag, and Line 4 for miscellaneous (e.g., microsilica, high-reactivity metakaolin, etc.).

EXAMPLE PROBLEM	Because this mix will utilize a Type IL cement and Class C fly ash, Lines 1 and 2 will be used. • Cement: select **37708 Type IL Limestone** from the drop-down list. • Fly ash: select **37801 Fly Ash Class C** from the drop-down list.

Producer Number: Material producer number. This field is required for all finely divided minerals.

Producer Name: Material producer name.

Specific Gravity: Specific gravity of each material. The specific gravity of cement is normally assumed to be 3.15 for ordinary portland cement or portland-limestone cement. However, for portland-pozzolan or portland-slag cements, this value should be verified with the District. Specific gravity values for finely divided minerals can be obtained from the Qualified Producer List of Finely Divided Minerals.

EXAMPLE PROBLEM	The example problem as given in the Course Manual notes that the specific gravity for the fly ash component is **2.61**. The specific gravity of cement is assumed to be **3.15**.

Step 4. **Finely Divided Minerals & Admixtures Information** (continued)

Percent Blend: The blend percentage must be entered for each material, totaling 100. For example, when blending fly ash and cement at 20 and 80 percent, respectively, enter "20" for the fly ash and "80" for the cement.

EXAMPLE PROBLEM	First, we have to determine if we need to mitigate for alkali-silica reaction (ASR): From Section 2.4.3 in the Course Manual, it is determined that the component aggregates are **Group II** (fine aggregate expansion in the **>0.16% - 0.27%** range and coarse aggregate expansion **≤0.16%**). Thus, we are required to use Mix Option 1, 2, 3, 4, or 5. Because the example problem as given notes that the mix will utilize a cement with alkali content >0.60% and a Class C fly ash, we will use **Mix Option 2**. Mix Option 2 requires a minimum 25.0 percent Class C fly ash. Furthermore, from Section 2.4.1.1 in the Course Manual, the Class C fly ash component can replace up to 30 percent of the cement. Thus, it is decided to use **25 percent** fly ash since a larger replacement would reduce the portland cement content below 400 lb/yd^3. Because the total Percent Blend must equal 100, enter **75.0** for the cement and **25.0** for the fly ash.

Replacement Ratio: (Optional) Enter the replacement ratio for each finely divided mineral, if applicable. If left blank, the default value of "1.00" will be used.

Step 5. **Admixtures Information**

Material Code: Enter admixture material codes here. The 5-digit material code for admixtures can be found on the Approved/Qualified Product List of Concrete Admixtures.

Admixture Type: Choose admixture type.

Product Name: Enter admixture product name here.

Remarks: Enter key information regarding proposed dosage rates, dosing procedures, etc.

Step 6. **General Mixture Remarks**

Remarks: Enter any pertinent information not already covered. When required to mitigate for alkali-silica reaction (ASR), indicate the mixture option selected.

EXAMPLE PROBLEM	Because we are required to mitigate for alkali-silica reaction, we must indicate the mixture option selected. Enter **ASR Mix Option 2, 25% fly ash**.

Latex Admixture Information (only required for mix designs using a latex admixture)

Batch Dosage:	Enter latex admixture dosage in terms of gallons per cubic yard (liters per cubic meter).
Specific Gravity:	Enter manufacturer's specific gravity for the latex admixture.
% Solids:	Enter manufacturer's percent solids for the latex admixture.

Design Report

Given the inputs, the mix design proportions are calculated and reported. Two design reports are generated: one in English units of measure and one in metric (SI).

ENGLISH UNITS DESIGN REPORT

PCC DESIGN MIX

IDOT MIX #:	[TBD by IDOT]	CEMENT FACTOR, cwt/yd^3:	5.35
PRODUCER MIX #:	PMC0001PV	MORTAR FACTOR:	0.83
MATERIAL CODE:	21605	CA VOIDS:	0.39
CLASS(ES):	PV	% AIR:	6.5
RESP. DISTRICT:	91	W/C RATIO:	0.44

AGGREGATE	Producer No.	Producer Name	Sp. G.	% Blend	Weight (SSD) lbs / cu yd
027FA01	54321-01	LITTLE ROCKS CO.	2.66	100	1183
022CA07	12345-05	BIG ROCK CO.	2.68	100	1912

CEMENTITIOUS	Producer No.	Producer Name	Sp. G.	% Blend	lbs / cu yd
37708	555-01	BIG CEMENT, CO.	3.15	75	405
37801	43215-01	ASH MARKETERS, INC.	2.61	25	135
				THEO. WATER (lbs/cu yd)	235
				TOTAL BATCH WT (lbs/cu yd)	3869

PRODUCER NO.: 1234-05

PRODUCER NAME: EVERYMAN REDI-MIX CO. THEO. WATER (gal/cu yd) 28.2

REMARKS: ASR Mix Option 2, 25% fly ash

DESIGNER: JOHN SMITH

PHONE: 555-555-5555

EMAIL: john.smith@email.com

ADMIXTURES:

Code	Type	Name	Remarks
42000	AEA	AIR PLUS X	
43000	A	WATER REDUCTO 2000	

METRIC UNITS DESIGN REPORT

PCC DESIGN MIX

IDOT MIX #: [TBD by IDOT]
PRODUCER MIX #: PMC0001PV
MATERIAL CODE: 21605M
CLASS(ES): PV
RESP. DISTRICT: 91

CEMENT FACTOR, kg/m^3: 320
MORTAR FACTOR: 0.83
CA VOIDS: 0.39
% AIR: 6.5
W/C RATIO: 0.44

AGGREGATE	Producer No.	Producer Name	Sp. G.	% Blend	Weight (SSD) kg / cu m
027FAM01	54321-01	LITTLE ROCKS CO.	2.66	100	702
022CAM07	12345-05	BIG ROCK CO.	2.68	100	1135

CEMENTITIOUS	Producer No.	Producer Name	Sp. G.	% Blend	kg / cu m
37708M	555-01	BIG CEMENT, CO.	3.15	75	240
37801M	43215-01	ASH MARKETERS, INC.	2.61	25	80

THEO. WATER (kg/cu m): 140
TOTAL BATCH WT (kg/cu m): 2297

PRODUCER NO.: 1234-05
PRODUCER NAME: EVERYMAN REDI-MIX CO.

THEO. WATER (L/cu m): 139.6

REMARKS: ASR Mix Option 2, 25% fly ash

DESIGNER: JOHN SMITH
PHONE: 555-555-5555
EMAIL: john.smith@email.com

ADMIXTURES:

Code	Type	Name	Remarks
42000	AEA	AIR PLUS X	
43000	A	WATER REDUCTO 2000	

Additionally, there is a tab for help determining the percent water adjustment taking into account various factors. However, this table is for informational purposes only. The water adjustment calculated using this table is not referenced by any of the spreadsheet's mix design calculations. To use the water adjustment calculated using this table, **the value *must be entered* on the *Design Variable* tab**.

There are many factors that can be taken into account when determining a mix's water requirement. The table below allows you to estimate the percentage of water adjustment (typically a reduction) based on the mix's constituent materials. **IMPORTANT:** This table is for informational purposes only. The water adjustment calculated here is not referenced by any mix design calculations. **To use the water adjustment calculated here, it must be entered on the Design Variables tab.**

Water Adjustment		Suggested Range	Adjustment Percentage
Combined aggregate grading:			
	Well-graded	(-10 to 0%)	
	Gap-graded	(0 to +10%)	
Admixture(s):			
Air entraining admixture	1 to 3% air content	(0%)	
Minimum air content specified:	4 to 5% air content	(-5%)	
	6 to 10% air content	(-10%)	
	Normal water-reducing admixture	(-10 to -5%)	
	Mid-range water-reducing admixture	(-15 to -8%)	
	High range water-reducing admixture (Note 1)	(-30 to -12%)	
Finely Divided Minerals:			
	Fly Ash (Note 2)	(-10 to 0%)	
	Microsilica	(0 to +15%)	
	High-Reactivity Metakaolin (HRM)	(-5 to +5%)	
	Ground Granulated Blast Furnace (GGBF) Slag	(0%)	
Other factors:			
	Coarse cement, water/cement ratio > 0.45, and concrete temperature < 60 °F (27 °C)	(-10 to 0%)	
	Fine cement, water/cement ratio < 0.40, and concrete temperature > 80 °F (27 °C)	(0 to +10%)	
		Cumulative Adjustment (%)	0
Reference: Appendix Q, Table 1.2 "Adjustment to Basic Water Requirement" in the PCC Level III Technician Course Manual.			**0 %**

Note 1: A polycarboxylate superplasticizer may reduce the water content up to 40%.

Note 2: For each 10% of fly ash, it is recommended to allow a water reduction of at least 3%.