PCC MIX DESIGN SOFTWARE TUTORIAL

Version 2.5 (CMMS)

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

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!!! IMPORTANT !!! This spreadsheet utilizes macros.

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.

Buttons are provided for ease of navigation, and their use is recommended as they ensure proper operation throughout the design process. Using the worksheet tabs, found at the bottom of the Excel screen, will also work.

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 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 righthand 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.

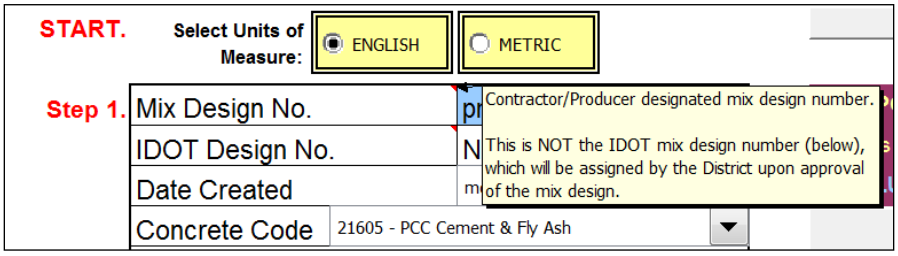


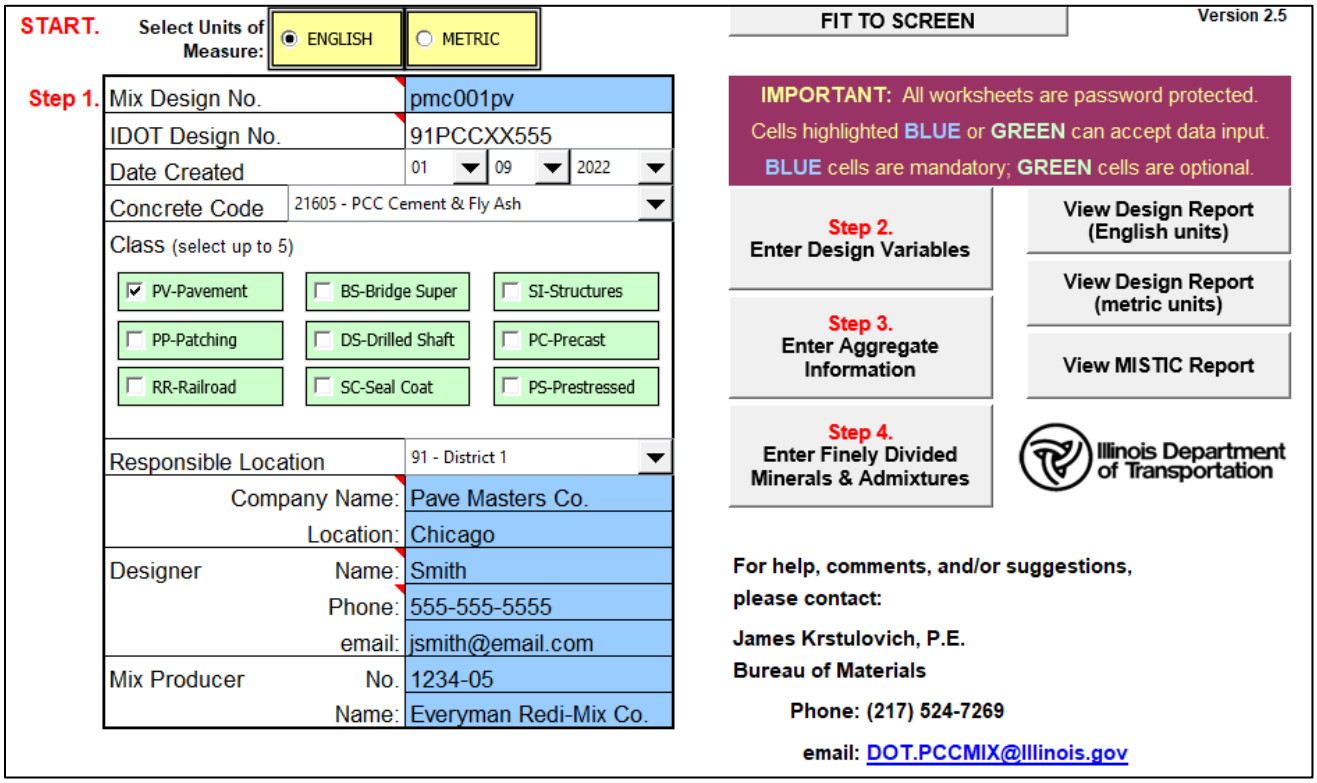
Figure 1. Example of a comment; note red flag, which indicates the cell has a comment.

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.



Fit to Screen [button]: Click this button to optimize each page of the mix design spreadsheet for viewing on your screen.

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.: 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 IL 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 producer/contractor/consultant responsible for creating the mix design.

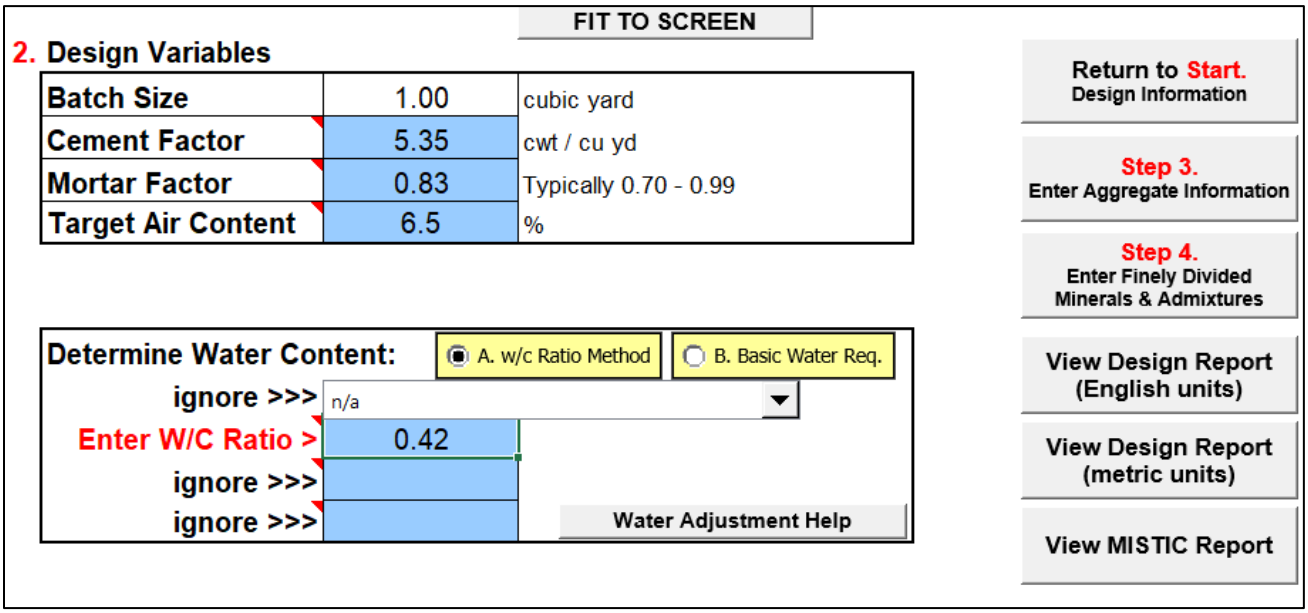
Location: Nearest municipality to Company.

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

Mix 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%**.

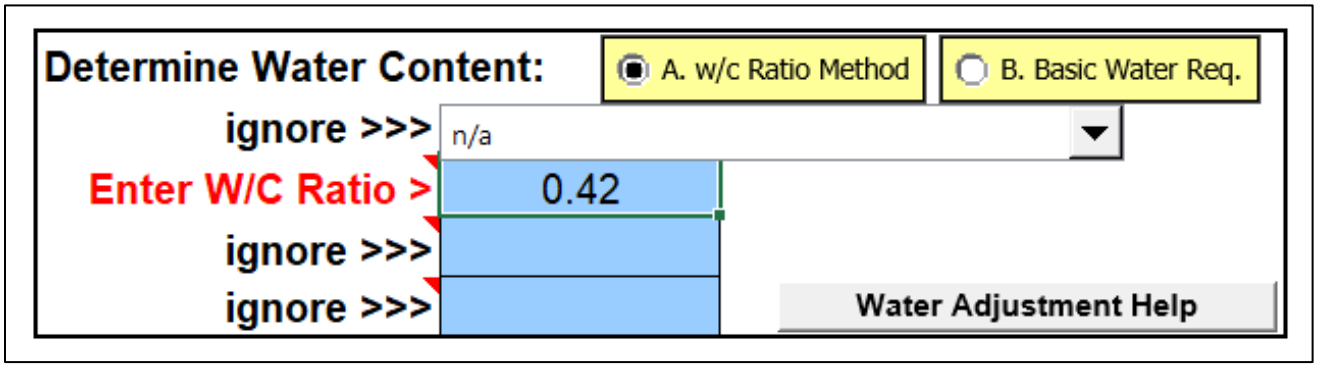
Step 2. **Design Variables** (continued)

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.**

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

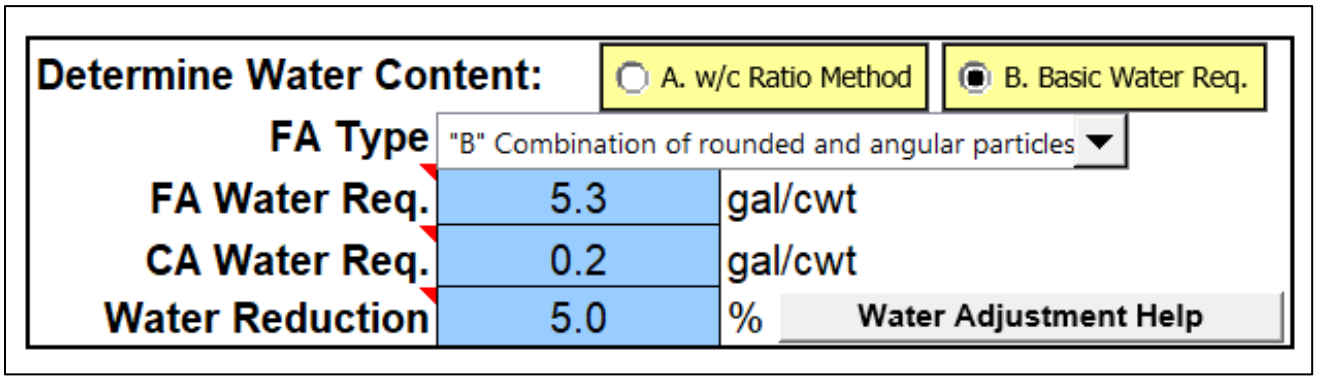


Enter W/C Ratio: When *w/c Ratio Method* is toggled, this field appears. Enter the target w/c ratio that the design water content will be based on; for example, 0.42.

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**.

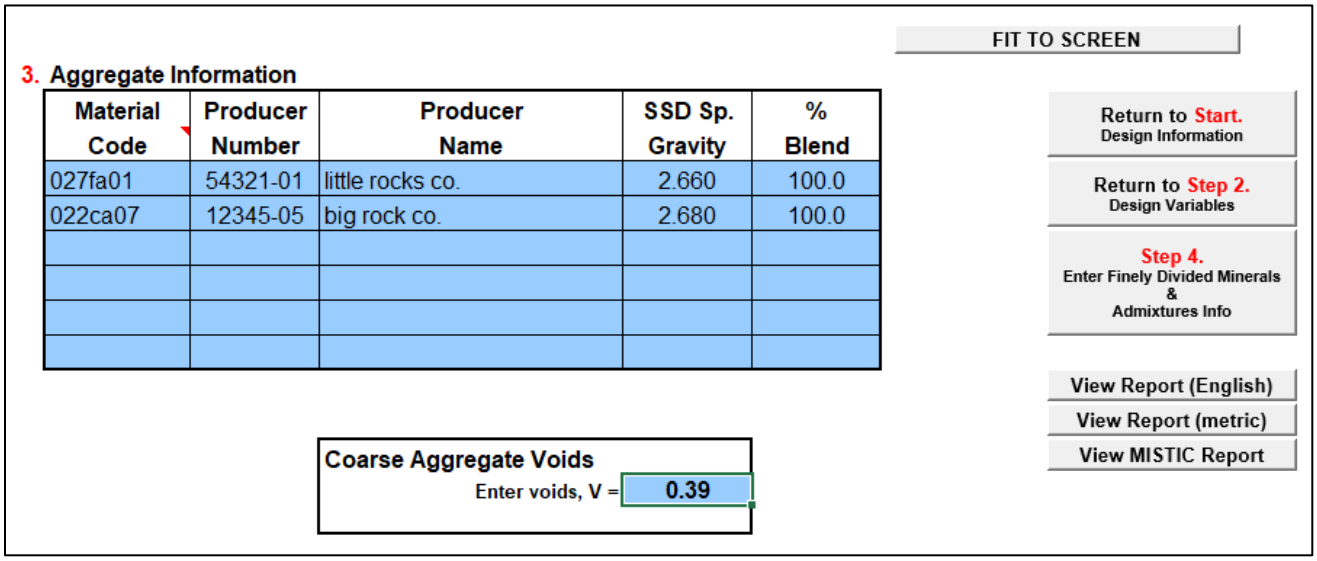
Water Reduction: Percentage of water adjustment (typically a reduction) accounting for various factors, such as admixture use, cement and finely divided mineral content, air content, etc. Note that because this input is referred to as a "reduction," the value entered may seem counter-intuitive; that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



Material: Aggregate material codes. Coarse and fine aggregates may be entered in any order, except as required by your District. For more information regarding aggregate material codes, refer to form BMPR MI504 "Field/Lab Gradations".

EXAMPLE PROBLEM	• Fine aggregate: Enter **027FA01** as given in the Course Manual. 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** as given in the Course Manual. 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 as given 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.

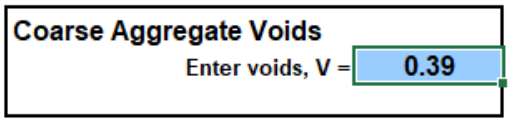
EXAMPLE PROBLEM	Because this mix is utilizing one coarse aggregate component and one fine aggregate component (and the mix is not CAM II), enter **100** for coarse aggregate and **100** for fine aggregate.

Step 3. **Aggregate Information** (continued)

Voids in Coarse Aggregate

Refer to the District office verifying your mix design for guidance on what value to use for Voids. For example, some Districts may provide a value for general aggregate types, such as "0.36" for gravels, or one value for all aggregates.

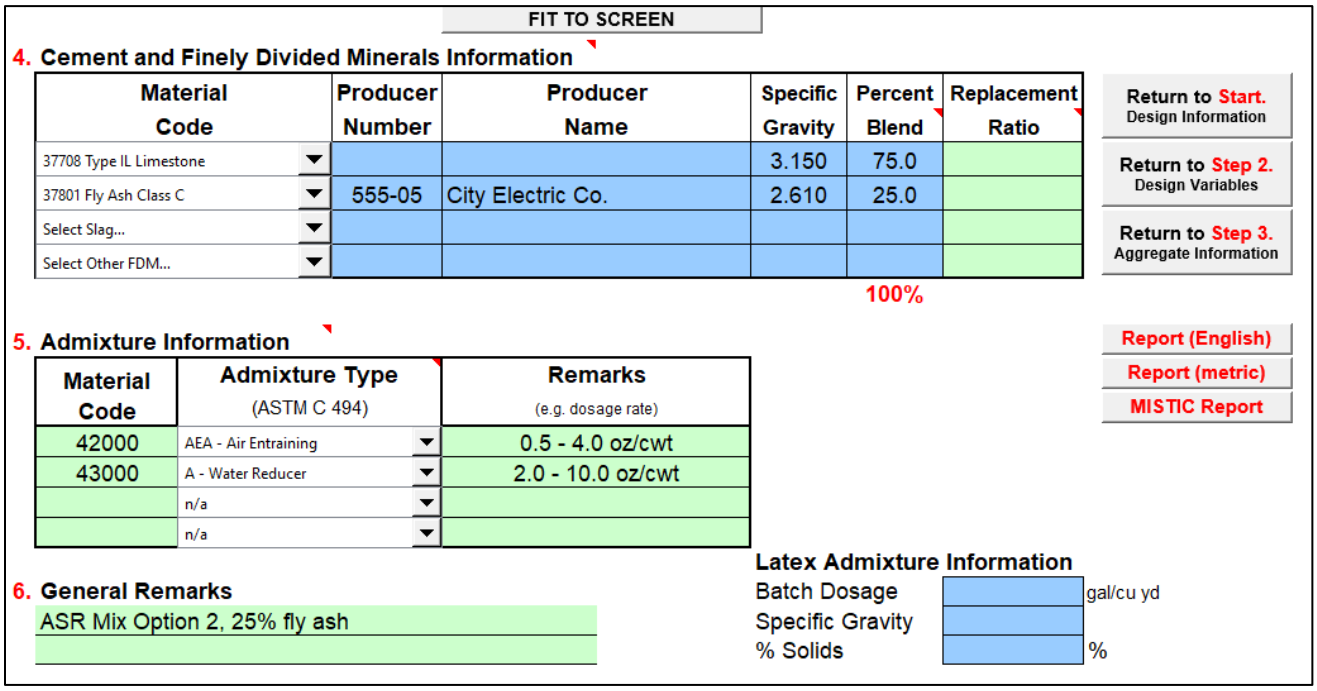
Important: *Enter* "1.00" *for any mix design that does not contain coarse aggregate.*



EXAMPLE PROBLEM	The example problem as given 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.).



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: Because this mix is utilizing a Type IL cement, select **37708 Type IL, Limestone** from the drop-down list. • Fly ash: Because this mix is utilizing a Class C 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. However, for a blended cement (except Type IL cement), 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**. Although no specific gravity is given for the cement component, from Section 2.3 in the Course Manual, the specific gravity of portland cement and portland limestone cement is normally 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. Thus, it is decided to use **25 percent** fly ash. 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.

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. Three design reports are generated: one in English units of measure, one in metric (SI), and one formatted per the Department's MISTIC database requirements. Please consult your District for which report(s) to submit for approval.

ENGLISH UNITS DESIGN REPORT

IDOT MIX #: 91PCCXX555 MATERIAL: 21605 CONCRETE PC FLYASH EFFECTIVE:
CONTR MIX #: PMC001PV CLASS: PV
RESP: 91 DISTRICT 1 REVIEWED BY: JONES

BATCH CU YD	ADX	H2O% RED	FINE MOD	% AIR	VOIDS	(Z) CEMENT	MORTAR FACTOR	{TYPE} ASH	FA	{GAL/CWT} FA	CA	{ABS. VOL} CA,B	FA,A
1.00	--	5.0	--	6.5	.39	5.35	0.83	C	B	5.30	0.00	0.4236	0.2690

MATERIAL	PROD NO	PROD NAME	SP G	% BLEND	%MOIST / REPL	[LBS / CU YD] SSD	[LBS / CU YD] ADJ	[KG / CU M] ADJ
027FA01	54321-01	LITTLE ROCKS CO.	2.660	100.0	--	1205	1205	718
022CA07	12345-05	BIG ROCK CO.	2.680	100.0	--	1912	1912	1135
37708			3.150	75.0	1.00	405	405	240
37801	555-05	CITY ELECTRIC CO.	2.610	25.0	1.00	135	135	80
					ADJ. H2O (gal : lbs)	27.3	227	135
					TOTAL BATCH WT (lbs)		3884	2308
					THEO. H2O (gal : lbs)	27.2	227	

{FA + CA} MIX-H2O: 5.30 W/C RATIO: 0.42
TOTAL CEMENTITIOUS MATL: 5.40

PRODUCER: 1234-05 PROD NAME: EVERYMAN REDI-MIX CO.
REMARKS: ASR Mix Option 2, 25% fly ash
REMARKS:

ADDITIONAL INFORMATION: Lab: PAVE MASTERS CO. Location: CHICAGO
Designer: SMITH Created: 01/09/22

Adx(s):	Matl Code	Type	Remarks
	42000	AEA	
	43000	A	

Designer Phone: 555-555-5555
Designer email: jsmith@email.com

Printed 8/10/2022

METRIC UNITS DESIGN REPORT

IDOT MIX #: 91PCCXX555 MATERIAL: 21605M CONCRETE PC FLYASH EFFECTIVE:
CONTR MIX #: PMC001PV CLASS: PV
RESP: 91 DISTRICT 1 REVIEWED BY: JONES

BATCH CU M	ADX	H2O% RED	FINE MOD	% AIR	VOIDS	(Z) CEMENT	MORTAR FACTOR	{TYPE} ASH	FA	{L / KG} FA	CA	{ABS. VOL} CA,B	FA,A
1.00	--	5.0	--	6.5	.39	320	0.83	C	B	0.4420	0.0000	0.4236	0.2700

MATERIAL	PROD NO	PROD NAME	SP G	% BLEND	%MOIST / REPL	[KG / CU M] SSD	[KG / CU M] ADJ	[LBS / CU YD] ADJ
027FAM01	54321-01	LITTLE ROCKS CO.	2.660	100.0	--	718	718	1205
022CAM07	12345-05	BIG ROCK CO.	2.680	100.0	--	1135	1135	1912
37708M			3.150	75.0	1.00	240	240	405
37801M	555-05	CITY ELECTRIC CO.	2.610	25.0	1.00	80	80	135
					ADJ. H2O (L : kg)	134.4	134	226
					TOTAL BATCH WT (kg)		2308	3883
					THEO. H2O (kg : lbs)	134.4	226	

{FA + CA} MIX-H2O: 0.4420 W/C RATIO: 0.42
TOTAL CEMENTITIOUS MATL: 320

PRODUCER: 1234-05 PROD NAME: EVERYMAN REDI-MIX CO.
REMARKS: ASR Mix Option 2, 25% fly ash
REMARKS:

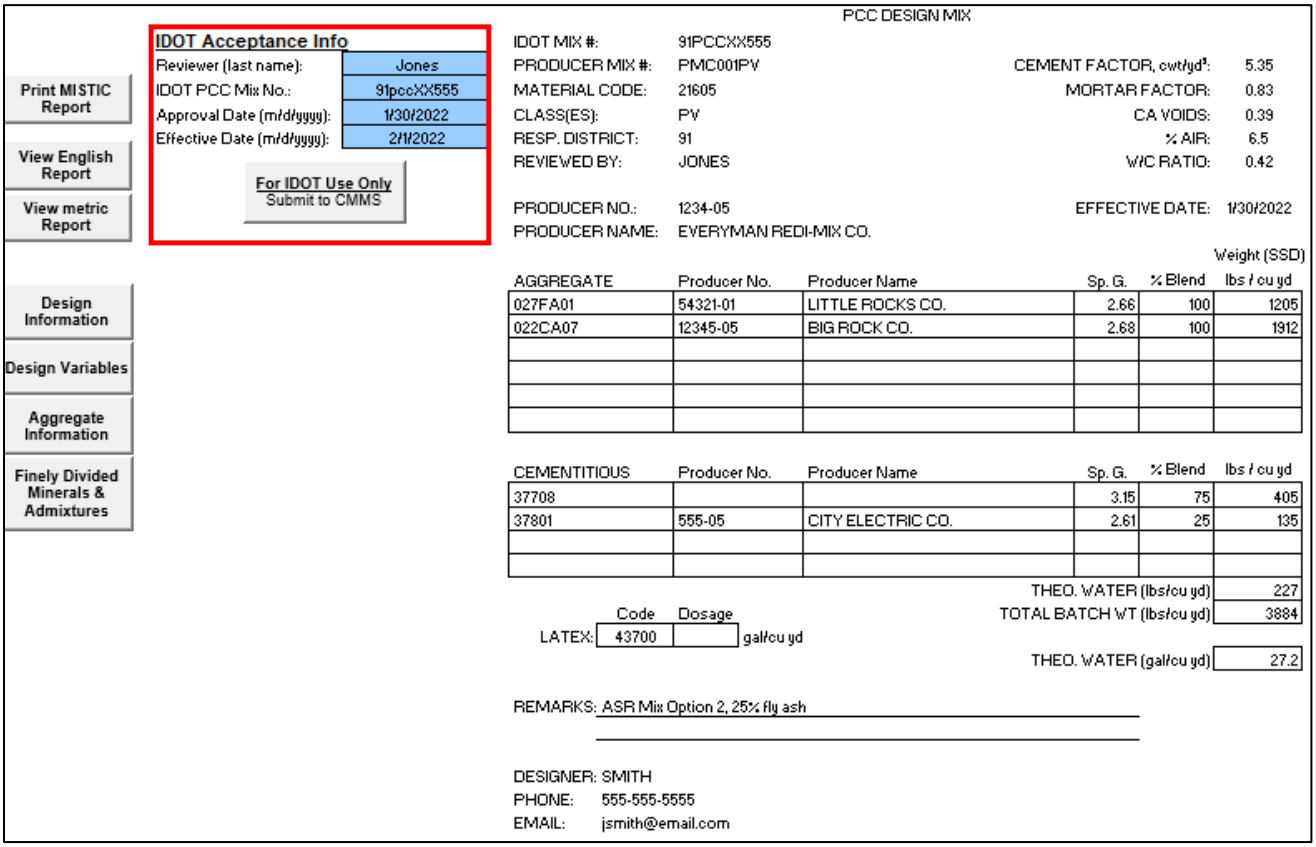
ADDITIONAL INFORMATION: Lab: PAVE MASTERS CO. Location: CHICAGO
Designer: SMITH Created: 01/09/22

Adx(s):	Matl Code	Type	Remarks
	42000	AEA	
	43000	A	

Designer Phone: 555-555-5555
Designer email: jsmith@email.com

Printed 8/10/2022

CMMS DESIGN REPORT



Print MISTIC Report
View English Report
View metric Report
Design Information
Design Variables
Aggregate Information
Finely Divided Minerals & Admixtures

IDOT Acceptance Info

Reviewer (last name):	Jones
IDOT PCC Mix No.:	91pccXX555
Approval Date (m/d/yyyy):	1/30/2022
Effective Date (m/d/yyyy):	2/1/2022

For IDOT Use Only
Submit to CMMS

PCC DESIGN MIX

IDOT MIX #:	91PCCXX555		
PRODUCER MIX #:	PMC001PV	CEMENT FACTOR, cwt/yd³:	5.35
MATERIAL CODE:	21605	MORTAR FACTOR:	0.83
CLASS(ES):	PV	CA VOIDS:	0.39
RESP. DISTRICT:	91	% AIR:	6.5
REVIEWED BY:	JONES	W/C RATIO:	0.42
PRODUCER NO.:	1234-05	EFFECTIVE DATE:	1/30/2022
PRODUCER NAME:	EVERYMAN REDI-MIX CO.		

AGGREGATE	Producer No.	Producer Name	Sp. G.	% Blend	Weight (SSD) lbs / cu yd
027FA01	54321-01	LITTLE ROCKS CO.	2.66	100	1205
022CA07	12345-05	BIG ROCK CO.	2.68	100	1912

CEMENTITIOUS	Producer No.	Producer Name	Sp. G.	% Blend	lbs / cu yd
37708			3.15	75	405
37801	555-05	CITY ELECTRIC CO.	2.61	25	135

THEO. WATER (lbs/cu yd)	227
TOTAL BATCH WT (lbs/cu yd)	3884

	Code	Dosage	
LATEX:	43700		gal/cu yd

THEO. WATER (gal/cu yd) 27.2

REMARKS: ASR Mix Option 2, 25% fly ash

DESIGNER: SMITH
PHONE: 555-555-5555
EMAIL: jsmith@email.com

Note for IDOT Users: The CMMS Report has four input fields ***to be completed by the District when approving a mix design***. Once a mix design is approved, click the "Submit to CMMS" button to export the file to CMMS.