

## 5.3 MIX DESIGN METHODS

### 5.3.1 CONCRETE MIX DESIGN

#### 1. Scope.

This method covers the procedure for designing concrete mixes and is based on the absolute volumes of the various components of the mix, i.e.: the absolute volumes of cement (plain, blended or fly ash modified), aggregate, water and air in one cubic yard of concrete.

#### 2. Procedure.

**2.1.** Specifications govern the following elements of concrete mixtures:

**2.1.1.** Minimum Cement Content or "Cement Factor" (CF) expressed as pounds per cubic yard of concrete.

**2.1.2.** Maximum allowable water content or water-cement ratio (W/C) expressed as pounds of water per pound of cement.

**2.1.3.** When air entrained concrete is specified, the air content is expressed as percent of the volume of the concrete.

NOTE: When air entrained concrete is not specified, a percentage of entrapped air is used during design. Experience has shown that the entrapped air is usually between 2% and 4%.

Since the quantities of cement, water and air are limited by specifications, the volumes occupied by each of these elements are calculated. Calculations are then made to determine the quantity of aggregate required, when added to the combined volumes of other ingredients, to result in a cubic yard of mixed concrete.

#### 3. Calculations.

**3.1.** Secure one or more copies of **KDOT Form No. 694**, WORK SHEET - CONCRETE MIX DESIGN. (See Example.)

**3.2.** Complete Part I of the form. This includes the class of concrete, the water-cement ratio, specified minimum cement factor, percent air, and the specific gravity (Bulk, Saturated Surface Dry Basis) of each aggregate.

The specific gravity is determined by tests conducted on samples obtained from project stockpiles. Due to differences in processing and gradation, there may be an appreciable difference between the specific gravity of the aggregate submitted to the Laboratory and the specific gravity of the aggregate in the project stockpiles.

When designing concrete mixes composed of sweetened mixed aggregate, the percentage of each aggregate may be determined by specification requirements, or the contractor may elect to use certain aggregate combinations to produce the required gradation.

When designing a "coarse-fine" mix, equal parts of coarse aggregate and fine aggregate are normally used. This portion has proven to be satisfactory and should be changed only to improve the

characteristics of the mix and not as a convenience to the producer or contractor. Deviation from these proportions shall not be made without prior approval from the District Materials Engineer.

**3.3.** Complete Part II of the form by calculating the volume, in cubic feet, occupied by the cement, water and air in a cubic yard of the mixture. Then subtract the sum of these values from 27 to determine the volume of aggregate that must be added to produce a cubic yard of concrete.

NOTE: If the specific gravity of Type II cement is not known, a value of 3.20 will be assumed. For Type I cement use a value of 3.15.

**3.4.** Complete Part III as follows:

**3.4.1.** Calculate the volume occupied by 100 lbs. of combined aggregate.

**3.4.2.** Using simple proportioning, calculate the number of pounds of combined aggregate required to produce the volume of aggregate determined in Part II.

NOTE: The basic formula in Parts II and III is:

$$\text{Absolute volume (cu. ft.)} = \frac{\text{Weight (lbs.)}}{\text{spec. grav.} \times 62.4}$$

**3.5.** Complete Part IV to determine the weight in pounds of each ingredient in one cubic yard of concrete.

Calculate the saturated, surface dry weight of each individual aggregate in the batch by multiplying the total weight of aggregate as determined in Part III by the design percentage for each aggregate.

**3.6.** If the aggregate contains free moisture, as determined by **KT-24**, the initial batch weight is multiplied by the percent of free moisture in the aggregate and this quantity is added to the initial batch weight. An equivalent amount must then be deducted from the pounds of water computed under Part IV. If the aggregate is absorptive, as determined by **KT-24**, the aggregate weight must be reduced by the percent of absorption and the computed water requirement must be increased by a like amount. Since moisture conditions of aggregates may change throughout a given pour, the initial moisture conditions will govern only as long as the moisture content remains the same. The batch weights thus determined can easily be converted from pounds per cubic yard to pounds per sack or any other convenient unit required for the batching operation.

**3.7.** At the option of the contractor, fly ash from an approved source and meeting the specified requirements may be used as a partial replacement for Portland Cement. Calculations for fly ash substitution are to be made on the back of **KDOT Form No. 694**.

ENTER INFORMATION IN THE SHADED AREAS

Designed by:		
Date:		
Mix Design No.:		
Class Concrete:		
Project No.:		
W/C Max:		
W/C Design:		
Specified Min. CF: (use English units)	Metric value:	#N/A
Design CF: (use English units)	Metric value:	0
Designed for	% Air	
Admixture		
Aggregate type:		
Cement Sp. Gr.		
Agg. No. 1 Sp. Gr.		
Agg. No. 2 Sp. Gr.		
Agg. No. 3 Sp. Gr.		
Agg. No. 1 % of mix:		
Agg. No. 2 % of mix:		
Agg. No. 3 % of mix:		
Cement Source		
Water Source		
Agg. No. 1 type		If using CA - list if crushed or uncrushed
Agg. No. 1 Source		
Agg. No. 2 type		
Agg. No. 2 Source		
Agg. No. 3 type		
Agg. No. 3 Source		
Air Entraining Agent		
Air Entraining Agent Source		
Calculated by: (use initials)		
Checked by: (use initials)		
Design Slump:	Metric value:	0 mm
Agg. No. 1 W1:		
Agg. No. 2 W1:		
Agg. No. 3 W1:		

After you have entered all info., click on the tab you want to print (U.S. or SI), then click on the PRINT icon.

D.O.T. Form 694

Source of Fly Ash: \_\_\_\_\_ (Distributor)

Power Plant Location: \_\_\_\_\_ Class: \_\_\_\_\_

Test Report or Certification Identification: 87-0001

specific Gravity of Fly Ash, Sp.Gr. <sub>fa</sub> 2.55 substitution rate 1.0

- a. Percent cement to be replaced = 15 %
- b. Weight of cement being replaced =  $cf \times a.$  =  $\frac{620 \times 15}{100}$  = 93 lbs.
- c. Weight of cement remaining =  $CF - b.$  =  $620 - 93$  = 527 lbs.
- d. Volume of cement remaining =  $\frac{c.}{Sp.Gr. \times 62.4}$  =  $\frac{527}{3.20 \times 62.4}$  = 2.639 Cu. Ft.
- e. Weight of Fly Ash =  $b. \times$  substitution rate =  $93 \times 1.0$  = 93 lbs.
- f. Volume of Fly Ash =  $\frac{e.}{Sp.Gr. \times 62.4}$  =  $\frac{93}{2.55 \times 62.4}$  = 0.584 Cu. Ft.
- g. Volume of cement plus Fly Ash =  $d. + f.$  =  $2.639 + 0.584$  = 3.223 Cu. Ft.
- h. Volume gain due to Fly Ash =  $g. -$  original cement volume =  $3.223 - 3.105$  = 0.118 Cu. Ft.
- I. Revised volume of Fine Agg. ( No. 1 ) =  $\frac{orig. wt. agg. No. 1 - h.}{Sp.Gr. \times 62.4}$  =  $\frac{19.97 - 0.118}{2.60 \times 62.4}$  = 12.191 Cu. Ft.
- j. New weight of Agg. No.1 per Cu. Yd. =  $I. \times Sp.Gr. \times 62.4$  =  $12.191 \times 2.60 \times 62.4$  = 1978 Cu.Ft.
- k. Compute revised batch weights.

- (c.) Cement ( revised ) ----- 527 lbs.
- (e.) Fly Ash ----- 93 lbs.
- Water----- 291 lbs.
- (j.) Agg. No. 1 ( Fine Agg. - revised )----- 1978 lbs.
- Agg. No. 2----- 856 lbs.
- Agg. No. 3----- 0 lbs.

m. Revised Weight for one cubic yard 3745 lbs.

n. Revised lbs./Cu.Ft.; Design air content  $\frac{m.}{27}$  = 138.70 lbs./Cu.Ft.

o. Revised lbs./Cu.Ft.: Air Free  $\frac{m.}{27.000 - vol. air}$  =  $\frac{3745}{27.00 - 1.620}$  = 147.56 lbs./Cu.Ft.

Calculated By \_\_\_\_\_ Checked \_\_\_\_\_ Approved \_\_\_\_\_ Date \_\_\_\_\_

(c) CMS - Concrete Mix design

**CMS [Mainframe]** DTMT252 PCC Design Mix READ MATERIAL

PC Mix#: 5P00001A  E  M Matl Code: PCC000143 Name: CONC (MA)(GR 31)(AE) W/C Max: 0.40

Spec Min CF: 639 Design CF: 639 % Air: 6.5 Design Slump: 2.17 Design: 0.40

Water Source: CITY OF GREENSBURG Eff Date: 01 10 00 Term Date: 01 01 05

Material	Name	Prod #	Prod Name	spg	%Blend
001070019	BASIC SSG FOR MA-1	00815801	SEACAT AND HEFT(049)	2.60	70.0
001050017	CA-6(CRSH LIMESTONE)	00809402	DOLESE STONE CO (OK)	2.69	30.0
Cement	Name	Prod #	Prod Name	spg	%Blend
161060100	CEMENT TY 1/2 BL/BAG	00003401	BUZZI UNICEM (063)	3.17	100.0

Kg Per Cubic Meter

Material	Name	Prod #	L/m3
Agg1= 2,056	Water= 256	AEA 041000000	AIR-ENTRAINING AGENT 00000801 2.6
Agg2= 882	Cmnt1: 639	ADMIX1	
Agg3=	Cmnt2:	ADMIX2	
Agg4=	Cmnt3:	ADMIX3	
Total: 3,831	Conc unit wt: 141.89	Air Free Unit Wt: 151.75	

Remarks: PRODUCER:HEFT & SONS, LLC 00838502

Error/Status

Help Exit Clear

## PCC DESIGN MIX DTMT252

### General

The function of this screen is to itemize the specific components and sources of materials used in a mix. Additionally, some physical characteristics of the components as well as the mixed material is recorded. The data of a mix design is used by the DTMT300 "Daily PC Air Slump" to calculate component quantities and specific mix properties of the material being produced.

### Assignment of Materials

This screen does not have the ability to make materials assignments.

### Unique Features

1) When 'Create' is the operation mode, two additional fields show on the screen and require entry. They appear in the lower right hand corner of the screen. They are '# Mixes to Create' and 'W/C Increment'. Multiple mixes can be created by just entering a number other than '1' in the space following the '# Mixes to Create' label. Normally no more than 8 – 10 mixes would be created at one time. The second field, 'W/C Increment', is the increment decrease in the water/cement ratio the system will use when

calculating the multiple mixes. The increment decrease will start with the 'Design' water/cement ratio of the first mix in the multiple sequence.

2) All of the component materials must be 'tied' in the Producer/Product table to the producer entered for each one on the screen to be acceptable for use in this program.

### **Screen Prints**

All of the mix designs have a "screen print" feature, right 'click' on the bottom margin of the screen display. A "drop-down" will give you the option of 'print screen data' or 'print image'. The print image will print, to your net work printer, what you see on the screen. The 'print screen data' will print the data on the entire CMS data screen in the proper order.

### **INDIVIDUAL FIELD INFORMATION**

**PC Mix #** - A user entered number which uniquely identifies a PCC Mix Design to the system. The first digit should be the district of origin for the mix design and the second digit must be a 'P' for the system to recognize this number as being for a portland cement concrete mix. The remaining five (5) digits can be any combination of letters and/or numbers. The system will generate the number in the initial "Create" with an 'A' on the end. The SI indicator field is not labeled, but must be entered after the "PC Mix#". Must be 'M' or 'E'.

**Matl Code** – The number which identifies the PCC mix being designed.(numbers start PCC.....)

**NAME** – System display for the material code entered previous December 19, 2008 156

**W/C Max** – The maximum water/cement ratio allowed by the current specification.

**Spec Min CF** – The minimum lbs. (kg) of cement allowed in a CuYd (cu m) by current specification, also called the minimum 'cement factor'.

**Design CF** – The actual lbs. (kg) of cement to be used in a CuYd (cu m) of concrete for this design, known as the 'design cement factor'.

**% Air** – The design volume of air in the mix by percent of the total volume (CuYd or cu m).

**Design Slump** – The design target for the slump of the mix. This value usually has a range established in the current specification.

**Design** – The design water/cement ratio to be used for this Mix Design, must be equal to or less than the 'W/C Max'.

**Water Source** – The mix water source.

**Eff Date** – The first day on which the mix design may be used. Must be a valid date, format MM DD YY.

**Term Date** – The last day on which the mix design may be used. Must be a valid date, format MM DD YY.

**Material** – Column header for the listing of the aggregate components included in this mix design. The number must exist in the materials code table and be active. Up to four different aggregates may be entered.

**NAME** – System display for the material code entered previous.

**Prod #** - The column header for the list of the numbers which identify the individual or company responsible for the manufacture of the aggregate listed to the left of this column. The number must exist in the Producer/Product table, be ‘tied’ with the materials code entered previous and be active.

**NAME** – System display for the producer code entered previous.

**Spg** – The specific gravity of the aggregate listed on the line of the screen.

**% Blend** – The amount of each component used in the final mixture. The total of the aggregate percentages in this column must equal 100%.

**Cement** – Column header for the listing of the cement component(s) included in this mix design. The number must exist in the materials code table and be active. Up to Three cements can be entered.

**NAME** – System display for the material code entered previous.

**Prod #** - The column header for the list of the numbers which identify the company responsible for the manufacture of the cement listed to the left of this column. The number must exist in the Producer/Product table, be ‘tied’ with the materials code entered previous and be active.

**NAME** – System display for the producer code entered previous.

**Spg** – The specific gravity of the aggregate listed on the line of the screen.

**% Blend** – The amount of each component used in the final mixture. The total of the cement percentages in the column must equal 100%.

**Lbs per Cubic Yard (E) or kg per cubic meter (M)** – All values below this column header are system calculated based on the information entered previously.

**Material (AEA, ADMIX 1, 2 & 3)** – Column header for the listing of the admix components included in this mix design. The number must exist in the materials code table and be active.

**NAME** – System display for the material code entered previous.

**Prod #** - The column header for the list of the numbers which identify the individual or company responsible for the manufacture of the Admix listed to the left of this column. The number must exist in the Producer/Product table, be ‘tied’ with the materials code entered previous and be active.

**oz/cy (l/cu m)** – The application rate for the air entraining agent or the Admix.

**# Mixes to Create:** Open only when in ‘Create’ mode, multiple mixes can be created by entering the number of mixes wanted to create.

**W/C Increment:** Open only when in ‘Create’ mode, used to reduce the W/C ratio on multiple mixes. The system decreases the W/C by this amount on each additional mix from the “A” mix design W/C ratio

**Remarks** – Free form information about the mix design.