MIXTURE:

Aggregate 2, agg2			C	EMI	ENTITIO	us M	ATERIA	LS				
Comentitions Material I, cm; fi² lb/yd² lb/yd² cem ratio, by mass	Component				Volume			Amount of CM				
Cementitious Material 1, cm; fri lbydi Cementitious Material 2, cm; fri lbydi Cementitious Material 3, cm; fri lbyd	Cement, c					j	ft ³		lb/yd³	Total on	(inaludas a)	
Cementitious Material 2, cm2 ft² lb/yd² ft² lb/yd² lb/	•					ft ³			lb/yd³	Total cm	lb/yd^3	
Tibers Fibers	· · · · · · · · · · · · · · · · · · ·					v			lb/yd³	c/cm ra		
Component Specific Gravity Volume Amount of Fibers	•					ft ³			lb/yd³			
Fiber 1, f_1 f_1^3 f_2^3 f_3^3					Fi	BERS		ļ				
Fiber 2, f_2 f_3 f_3 f_3 f_3 f_3 f_3 f_4 f_4 f_5 f_5	Component			ecific	Gravity	Volume			Amount of Fibers			
Fiber 2, f_2 f_{1^2} f_{1}^{1} f_{2}^{1}	Fiber 1, f_1					ft³			lb/yd³	Total Am	Total Amount of Fibers	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Fiber 2, f_2					ft³			lb/yd³		· ·	
Aggregates RCA' Abs (%) SGoD SGSSD Woo WSSD Vegs. SSD Aggregate 1, agg1, Yes /No % lb/yd^1 lb/yd^1 ft^2 Aggregate 2, agg2 Yes /No % lb/yd^2 lb/yd^2 ft^2 Aggregate 3, agg3, agg3, Yes /No % lb/yd^2 lb/yd^2 ft^2 Aggregate 3, agg3, agg3, agg3 Yes /No % lb/yd^2 lb/yd^2 ft^2 Aggregate 3, agg3, agg3, agg3, agg3 Yes /No % lb/yd^2 lb/yd^2 lb/yd^3 ft^2 Aggregate 3, agg3, a	AGGREGATE	es (Exc	CLUE	OING	MINER	RAL FI	LLERS	PA	SSING NO. 2	200 SIEVE)		
Aggregate 1, agg 1	ASTM								D O C H		Volume,	
Aggregate 2, $agg2$ Yes /No % $ bb/yd^2 $ $ bb/yd^3 $ $ ft^3 $ Aggregate 3, $agg3$ Yes /No % $ bb/yd^3 $ $ bb/yd^3 $ $ ft^3 $ Admixture Ib/ US gal Oscape (fl. az / cwt) % Solids Amount of Water in Admixture Liquid Dye, ld % $ bb/yd^3 $ Total Water from Admixture 1, $admx_1$ % $ bb/yd^3 $ $admx_1$ $admx_1$ % $ bb/yd^3 $ $admx_2$ $admx_2$	Aggregates	RCA ¹			ADS (%)	SG _{OD}	SGSSI	D	Wod	W_{SSD}		
Admixture lb/US gal lb/yd^3 lb	Aggregate 1, agg1	Yes	/ No		%				lb/yd³	lb/yd³	ft³	
	Aggregate 2, agg ₂	Yes / No			%				lb/yd³	lb/yd³	ft ³	
Admixture lb/US gal Dosage (fl. oz / cwt) % Solids Amount of Water in Admixture Liquid Dye, ld % lb/yd³ Total Water from Liquid Admixtures, $\sum w_{admix}$ Admixture 1, admx ₁ % lb/yd³ Liquid Admixtures, $\sum w_{admix}$ Admixture 2, admx ₂ % lb/yd³ Liquid Admixtures, $\sum w_{admix}$ SOLIDS (DYES, POWDERED ADMIXTURES, AND MINERAL FILLERS) Component Solid Component of Liquid Dye, S_{ld} fi³ lb/yd³ Total Solids. S_{loud} Powdered Admixture, S_p admix fi³ lb/yd³ Total Solids. S_{loud} WATER WATER Water, w_i [= S_p (w_{pree} + w_{admix} + w_{banch})] w_i and w_i	Aggregate 3, agg ₃	Yes	/ No		%				lb∕yd³	lb/yd³	ft ³	
Admixture lb/US gal Dosage (fl. oz / cwt) % Solids Amount of Water in Admixture Liquid Dye, ld % lb/yd³ Total Water from Liquid Admixtures, $\sum w_{admix}$ Admixture 1, admx ₁ % lb/yd³ Liquid Admixtures, $\sum w_{admix}$ Admixture 2, admx ₂ % lb/yd³ Liquid Admixtures, $\sum w_{admix}$ SOLIDS (DYES, POWDERED ADMIXTURES, AND MINERAL FILLERS) Component Solid Component of Liquid Dye, S_{ld} fi³ lb/yd³ Total Solids. S_{loud} Powdered Admixture, S_p admix fi³ lb/yd³ Total Solids. S_{loud} WATER WATER Water, w_i [= S_p (w_{pree} + w_{admix} + w_{banch})] w_i and w_i												
Admixture 1, adm x_1	Admixture	lb/US	Ib/ US gal Do						Amount of Water in Admixture			
Admixture 1, admx ₁ % lb/yd³ Liquid Admixtures, \sum wadmix Admixture 2, admx ₂ % lb/yd³ Liquid Admixtures, \sum wadmix SOLIDS (DYES, POWDERED ADMIXTURES, AND MINERAL FILLERS) Component Specific Gravity Volume (ft³) Amount (lb/yd³) Solid Component of Liquid Dye, S_{ld} ft³ lb/yd³ Total Solids. S_{total} Powdered Admixture, $S_{p admix}$ ft³ lb/yd³ lb/yd³ Ib/yd³ Mineral Filler (Passing No. 200 sieve), mf ft³ Amount Volume Volume WATER Water, w. [=\sum_{lb/yd³} (Pree+wadmx + wbaach)] w/c ratio, by mass lb/yd³ ft³ ft³ Total Water from All Aggregates, \sum_{wline} w/c ratio, by mass lb/yd³ ft² ft³ Batch Water, w_baach DENSITIES, AIR CONTENT, RATIOS, AND SLUMP Values for 1 cy of concrete cm Fibers Aggregate (SSD) Solids, Stotal Water, w Total Mass, M lb lb lb lb lb lb lb pf³	Liquid Dye, ld					%			lb/yd³	lb/yd³ Total Water from		
SOLIDS (DYES, POWDERED ADMIXTURES, AND MINERAL FILLERS) Component Specific Gravity Volume (ft^3) ft^3	Admixture 1, admx ₁					g /	%		lb/yd³	Liquid Admixtures, $\sum w_{adm}$		
Component Specific Gravity Volume (ft³) Amount (lb/yd³) Solid Component of Liquid Dye, S_{ld} $ft³$ $lb/yd³$ $lb/yd³$ Powdered Admixture, $S_{p admix}$ $ft³$ $lb/yd³$ $lb/yd³$ Mineral Filler (Passing No. 200 sieve), mf $mf³$ mf	Admixture 2, admx ₂					%			lb/yd³	lb/yd³		
Solid Component of Liquid Dye, S_{lid} Powdered Admixture, $S_{p \ admix}$ Mineral Filler (Passing No. 200 sieve), mf WATER Water, w, $[=\sum (w_{free} + w_{admx} + w_{batch})]$ Total Notal Free Water from All Aggregates, $\sum w_{free}$ Batch Water, w _{batch} DENSITIES, AIR CONTENT, RATIOS, AND SLUMP Values for 1 cy of concrete Mass, M Ib I	SOLIDS (DYES, I	POW	DER	ED ADM	IIXTUF	RES, AN	ID N	MINERAL FII	LLERS)		
Powdered Admixture, $S_{p \ admix}$	Component			Specific Gravity			Volume (ft³)		Amount (lb/yd³)			
Powdered Admixture, S_{p} admix Mineral Filler (Passing No. 200 sieve), mf	Solid Component of Liquid Dye, Sld						ft ³		lb/yd³			
Mineral Filler (Passing No. 200 sieve), mf ft³ lb/yd³ Volume Water, w, $[= \sum (W_{free} + W_{admx} + W_{batch})]$ w/c ratio, by mass lb/yd³ ft³ Total Free Water from All Aggregates, $\sum w_{free}$ w/c ratio, by mass lb/yd³ lb/yd³ DENSITIES, AIR CONTENT, RATIOS, AND SLUMP Values for 1 cy of concrete cm Fibers Aggregate (SSD) Solids, Stotal Water, w Total Mass, M lb lb <th c<="" th=""><td colspan="3">Powdered Admixture, S_{p admix}</td><td colspan="3"></td><td colspan="2">ft³</td><td>lb/yd³</td><td>Total S</td></th>	<td colspan="3">Powdered Admixture, S_{p admix}</td> <td colspan="3"></td> <td colspan="2">ft³</td> <td>lb/yd³</td> <td>Total S</td>	Powdered Admixture, S _{p admix}						ft ³		lb/yd³		
Amount Volume Water, w , $[= \sum (w_{free} + w_{admx} + w_{batch})]$ w/c ratio, by mass $ b/yd^3 $ $ b/yd^3 $ Total Water from All Admixtures, $\sum w_{admx}$ w/c m ratio, by mass $ b/yd^3 $ $ b/yd^3 $ $ b/yd^3 $ Batch Water, w_{batch} DENSITIES, AIR CONTENT, RATIOS, AND SLUMP Values for 1 cy of concrete cm Fibers Aggregate (SSD) Solids, Stotal Water, w Total Mass, M b b b b b b b b Absolute Volume, V fi^3 fi^3 fi^3 fi^3 fi^3 fi^3 fi^3 V fi^3 Theoretical Density, T , $(= \sum M/\sum V)$ b b a	Mineral Filler (Passing No. 200 sieve), mj					ft ³			lb/yd³	107 yu		
Water, w, $[= \sum (w_{free} + w_{admx} + w_{batch})]$ W/c ratio, by masslb/yd³ft³Total Free Water from All Aggregates, $\sum w_{free}$ W/c ratio, by masslb/yd³DENSITIES, AIR CONTENT, RATIOS, AND SLUMPValues for 1 cy of concretecmFibersAggregate (SSD)Solids, StotalWater, wTotalMass, Mlblblblblblb $\sum M$: lbAbsolute Volume, Vft³ft³ft³ft³ft³ft³ $\sum M$: lbTheoretical Density, T, $(=\sum M/\sum V)$ lb/ft³Air Content, Air, $[=(T-D)/T \times 100\%]$ %Measured Density, Dlb/ft³Air Content, Air, $[=(27-\sum V))/27 \times 100\%]$ %Total Aggregate Ratio² $(=V_{agg,SSD}/27)$ %Slump, Slump flow, Spread (as applicable)in.					W	ATER				•		
Total Free Water from All Aggregates, $\sum w_{free}$ Total Water from All Admixtures, $\sum w_{admx}$ Batch Water, w_{batch} DENSITIES, AIR CONTENT, RATIOS, AND SLUMP Values for 1 cy of concrete cm Fibers Aggregate (SSD) Solids, S_{total} Water, w Total Mass, M lb lb lb lb lb lb lb lb $SM:$ lb Absolute Volume, V Theoretical Density, $T_{t} = \sum M / \sum V$ Theoretical Density, $T_{t} = \sum M / \sum V$ Belieft ³ Air Content, Air, $T_{t} = \sum M / \sum V$ Total Aggregate Ratio ² (= $V_{agg.SSD}/27$) Slump, Slump flow, Spread (as applicable) in.						Amoun				V	Volume	
Total Free Water from All Aggregates, $\sum w_{free}$ Ib/yd³ Batch Water from All Admixtures, $\sum w_{admx}$ Ib/yd³ Batch Water, w_{batch} DENSITIES, AIR CONTENT, RATIOS, AND SLUMP Values for 1 cy of concrete cm Fibers Aggregate (SSD) Solids, Stotal Water, w Total Mass, M lb M: lb Absolute Volume, V ft³ ft³ ft³ ft³ ft³ ft³ ft³ ft³ w Theoretical Density, w Theoretical Density, w Theoretical Density, w Theoretical Density, w Air Content, w Air Content, w Air Content, w Air Content, w Fig. (SD) w Total Aggregate Ratio² (=Vagg,SSD/27) w Slump, Slump flow, Spread (as applicable) in.	Water, w , $[=\sum (w_{free} + w_{admx} + w_{batch})]$				w/c 1	mass		lb/yd³		ft³		
Batch Water, w_{batch} DENSITIES, AIR CONTENT, RATIOS, AND SLUMPValues for 1 cy of concretecmFibersAggregate (SSD)Solids, S_{total} Water, w TotalMass, M lb lb lb lb lb lb Absolute Volume, V ft^3 <	Total Free Water from All Aggregates, $\sum w_{free}$						_		lb/yd³			
DENSITIES, AIR CONTENT, RATIOS, AND SLUMPValues for 1 cy of concretecmFibersAggregate (SSD)Solids, StotalWater, wTotalMass, MlblblblblblbAbsolute Volume, Vft3ft3ft3ft3ft3ft3ft3ft3Theoretical Density, T , $(=\sum M/\sum V)$ lb/ft3Air Content, Air, $[=(T-D)/T \times 100\%]$ %Measured Density, Dlb/ft3Air Content, Air, $[=(27-\sum V))/27 \times 100\%]$ %Total Aggregate Ratio2 (= $V_{agg,SSD}/27$)%Slump, Slump flow, Spread (as applicable)in.	Total Water from All Admixtures, $\sum w_{admx}$								lb/yd³			
Values for 1 cy of concretecmFibersAggregate (SSD)Solids, S_{total} Water, w TotalMass, M lb lb lb lb lb lb lb lb lb Absolute Volume, V ft^3	Batch Water, w _{batch}								lb/yd³			
Mass, MlblblblblblblbAbsolute Volume, V ft^3 <th>]</th> <th>DENSIT</th> <th>TIES,</th> <th>AII</th> <th>R CONTI</th> <th>ENT, R</th> <th>RATIOS</th> <th>, Al</th> <th>ND SLUMP</th> <th></th> <th></th>]	DENSIT	TIES,	AII	R CONTI	ENT, R	RATIOS	, Al	ND SLUMP			
Absolute Volume, V ft^3 <	Values for 1 cy of concret	te	c	m	Fib	ers			Solids, Stotal	Water, w	Total	
Theoretical Density, T , $(=\sum M/\sum V)$ lb/ft^3 Air Content, Air, $[=(T-D)/T \times 100\%]$ % Measured Density, D lb/ft^3 Air Content, Air, $[=(27-\sum V))/27 \times 100\%]$ % Total Aggregate Ratio ² $(=V_{agg,SSD}/27)$ % Slump, Slump flow, Spread (as applicable) in.	Mass, M	·		lb lb		,	lb		lb	lb	$\sum M$: lb	
Measured Density, Dlb/ft3Air Content, Air, $[=(27 - \sum V))/27 \times 100\%]$ %Total Aggregate Ratio² $(=V_{agg,SSD}/27)$ %Slump, Slump flow, Spread (as applicable)in.	Absolute Volume, V		f	ft^3 ft		3	ft ³		ft ³	ft^3	$\sum V$: ft^3	
Total Aggregate Ratio ² (= $V_{agg,SSD}/27$) % Slump, Slump flow, Spread (as applicable) in.				lb/ft³			Air Content,		Air, $[=(T-D)/T \times 100\%]$		%	
	Measured Density, D	• • • • • • • • • • • • • • • • • • • •			lb/ft³		<i>Air Content, Air,</i> $[=(27-\sum V))/27 x$			())/27 x 100%]	%	
$(C330+RCA\ Ratio^{3}(=V_{C220+RCA}/V_{enc}))$	Total Aggregate Ratio ² (= $V_{agg,SSD}$ /	(27)			%	,	Slump, Slump flow, Spread (as applicable)				in.	
(C330+RCA / agg,35D/)	C330+RCA Ratio ³ (= $V_{C330+RCA}/V_{C330+RCA}$	$J_{agg,SSD}$)			%							

- 1. Indicate if aggregate is ASTM C330 compliant (C330) or recycled concrete aggregate (RCA).
- 2. Ratio of total aggregate volume (in percent) compared to the total volume of concrete (min. allowable is 30%)
- 3. Ratio of combined volume of C330 and RCA ($V_{C330+RCA}$ (in percent)) compared to the total aggregate volume of aggregate in SSD condition ($V_{agg,SSD}$); (min. allowable is 50%)

TERMS AND FORMULAS

Abs = absorption of an aggregate, whether taken as a whole, the coarse, or the fine aggregate, %.

admx = admixtures

air = gravimetric air content, per ASTM C138, %.

agg = aggregate c = cement

cm = cementitious materials (including cement)

c/cm = ratio of cement to cementitious materials, by mass, *dimensionless*

cwt = hundred weight of cementitious material (example 750 lb/yd³ of cm is 7.5 cwt)

f = fibers ld = liquid dyes M = mass, lb.

 MC_{total} = total moisture content referenced to the oven-dried condition of the aggregate, %.

 MC_{free} = free moisture content, referenced to the saturated, surface-dry condition (SSD), of the aggregate, %.

mf = mineral fillers (i.e., aggregate-like materials passing the No. 200 sieve (75µm) D = measured density (wet, plastic) of concrete test cylinders, per ASTM C138, lb/ft^3 .

T = theoretical density of concrete (zero air voids), per ASTM C138, lb/ft^3 .

 S_{ld} = solids in liquid dyes

 $S_{p admx}$ = solids of powdered admixtures

 S_{total} = total solids of liquid dyes, powdered admixtures, and mineral fillers, lb/yd^3 .

 SG_{SSD} = specific gravity, in the saturated, surface-dry condition, of aggregate, dimensionless.

 SG_{OD} = specific gravity, in the oven-dried condition, of aggregate, dimensionless.

V = volume, ft^3 .

 $V_{agg,SSD}$ = volume, in the saturated, surface-dry condition, of aggregate, ft^3 .

C330 = aggregate that is ASTM C330 compliant

RCA = recycled concrete aggregate

 $V_{C330+RCA}$ = volume, in the saturated, surface-dry condition, of aggregate classified as ASTM C330 compliant or as recycled concrete aggregate, ft^3 .

 W_{SSD} = mass, in the saturated, surface-dry condition, of aggregate per unit volume of concrete, lb/vd^3 .

 W_{OD} = mass, in the oven-dried condition, of aggregate per unit volume of concrete, lb/yd^3 .

 W_{stk} = mass, in the stock moisture condition, of the aggregate per unit volume of concrete, lb/yd^3 .

 w_{admx} = the mass of water in the admixtures, per unit volume of concrete, lb/yd^3 .

 w_{batch} = the mass of water to be batched per unit volume of concrete when the aggregates are in a stock moisture condition, lb/yd^3 .

 w_{free} = free water carried into the batch by a wet per unit volume of concrete, lb/yd^3 .

w/c = water to cement ratio, by mass, dimensionless.

w/cm = water to cementitious material ratio, by mass, dimensionless.

TERMS AND FORMULAS

Each one of these formulas should be applied to each aggregate source:

$$Abs = \frac{W_{ssd} - W_{od}}{W_{od}} \times 100\%$$

$$MC_{total} = \frac{W_{stk} - W_{od}}{W_{od}} \times 100\%$$

$$MC_{free} = MC_{total} - Abs$$

$$W_{SSD} = \left(1 + \frac{Abs}{100\%}\right) * W_{OD}$$

$$W_{free} = W_{OD} \times \left(\frac{MC_{free}}{100\%}\right)$$

Note that w_{free} can be a negative number indicating a dry and absorptive aggregate.

$$W_{stk} = W_{SSD} + w_{free}$$

Then, for the mixture as a whole:

$$w_{batch} = w - \left(w_{free} + \sum w_{admx}\right)$$

The following formula should be applied to all admixtures in liquid form:

 $w_{admx} = dosage (fl \ oz/cwt) * cwt \ of \ cm * water \ content \ (\%) * 1 \ gal/128 \ fl \ oz * lb/gal \ of \ admixture$

The following formula should be applied to liquid dyes only:

 $S = dosage (fl \ oz/cwt) * cwt \ of \ cm * solid \ content \ (\%) * 1 \ gal/128 \ fl \ oz * lb/gal \ of \ admixture$