ceEntek

ce200-120D™

ce200-120D™ is an Ultra-High Performance Steel Fiber Reinforced Concrete (UHPSFRC) developed at ceEntek Pte Ltd, Singapore, containing OPC cement, finely graded sand, carbon nanofibers, steel fibers and other carefully selected components.

MIX COMPONENTS

1. ce200-120D™ premix
2. Steel fibers
3. (CNF paste)
4. Potable water

MIX COMPONENTS QUANTITIES

Table 1 outlines the weight of each mix component used in the mixing of ce200-120D™, for a typical batch sized in an IMER Mortaman 750 planetary mixer or equivalent planetary mixer.

The values below have been determined in order to simplify the weighing of components, as much as possible. In order to ensure the batch is mixed properly, a single batch requires a given weight of ce200-120D™, based on the mixing capacity of the high-shear mixer used and the desired plastic properties of ce200-120D™. When mixing a different volume than the volume in Table 1, each substituent weight is to be adjusted and verified by a ceEntek Technical Representative.

Table 1: Material quantities per 300 kg batch of ce200-120D™

Mix Component	kg/m³	lbs/yd³	kg	lbs
ce200-120D™ premix	1920.1	3236.4	254.9	562.0
Steel fibers	35.0	59.0	4.64	10.23
cePA1-116D	12.5	21.1	1.66	3.66
Potable water	292.4	492.9	35.8	78.9

STORAGE AND SHELF LIFE

ce200-120D™ Premix: Premix bags must be protected from moisture, freezing, and kept dry at all times. Unopened bags of ce200-120D™ Premix have a shelf life of 6 months.

Steel fibers: Steel fibers must be kept in dry conditions to prevent oxidation. Minor oxidation of the fibers is acceptable and can improve bond to the matrix. Any fibers showing signs of rust that cause clumping or balling of the fibers must not be used.

cePA1-116D: cePA1-116D must be stored in a dry place and be protected from sun and freezing. Unopened pail of cePA1-116D has a shelf life of 6 months.

PROCEDURES

Mixing: Mixing ce200-120D™ requires a high shear mixer and qualified personal on-site. The number of mixers should be adjusted to reduce the waiting time between batches, depending on the volume of material to be placed. Since a wheelbarrow or buggy will be used to transport the fresh material to the pouring location, the mixers must be raised high enough to ensure that it discharges properly. A platform can also be used next to the mixer to allow workers to batch properly and safely. The mixer should be kept as clean as possible between batches in order to guarantee the performance of subsequent batches.

Mixing Sequence: The following mixing procedure has been developed and tested thoroughly at an ambient temperature of 25 ± 1 ℃ when using an IMER Mortaman 750 planetary mixer or equivalent planetary mixer. The mixing procedure may be adjusted to better suit the temperature conditions, based on the recommendations of a ceEntek Technical Representative. Prior to the batching operation, the mixer must be inspected and cleaned so that no foreign material impacts the fresh ce200-120D™ mixing.

Different models of high-shear mixer have successfully been used to batch ce200-120D™. Refer to ceEntek Technical Representative to use a different high-shear mixer.

Table 2: Mixing procedure for ce200SF-t™

Step	Component to Introduce	Action	Mixer Speed	Start (mm:ss)	End (mm:ss)
1	ce200-120D™ premix	Introduce ce200-120D™ premix the mixer			
2	cePA1-116D and potable water	Dilute cePA1-116D with potable water to form CNF suspension			
3	CNF suspension	Slowly introduce the CNF suspension into the mixer during mixing	Medium	00:00	00:45
4	-	Mix	Medium	00:45	05:00
5	Steel fibers	Slowly introduce the steel fibers	Medium	05:00	7:00
6	-	Mix	Medium	7:00	9:30

Table 3: Precautionary measures

Cautions
1. All personnel involved in mixing operations are required to adhere to the PPE requirements as below.  Hard Hat Safety Glasses Hand Protection Foot Protection Dust Mask
2. Make sure that the inside of the mixer has been pre-dampened slightly (remove any excess water) prior to the preparation of every batch on each batching day.
3. The time to complete steps 1 to 6 outlined in the mixing sequence of Table 2 above may vary and must be validated by a ceEntek Technical Representative.
4. Cover the mixer with plastic during mixing to help control dust emissions or alternately, use a dust collector mounted over the mixer.
5. Clean and dry the mixer as best as possible between batches in order to help ensure consistency between batches. Remove any build up excess material on the mixer or mixing blades.

CURING

The curing of ce200-120D™ is essential in obtaining the necessary mechanical and physical material properties. In order to properly cure the material, the contractor must cover the fresh material with formwork plywood, or plywood wrapped in a plastic film, immediately after pouring. Covering the material quickly after pouring prevents the top surface of the material from drying out. The ce200-120D™ is demolded after 24 hours of casting and water-cured at approximately 23 °C (73 ℉) in a humidity-controlled chamber.

MECHANICAL, DURABILITY AND TIME DEPENDENT PROPERTIES OF ce200-120D™

The following data is representative of typical values achievable under laboratory conditions. Results in the field may vary.

Table 4: Mechanical properties of ce200-120D™

Mechanical properties	Curing ages (day)	Parameter	Mean values (Standard deviation)	
			SI Unit	US Unit
Compressive strength[1]	1	$f_{c,1}$	26 MPa (1.8 MPa)	3770 psi (261.1 psi)
	7	$f_{c,7}$	89 MPa (0.5 MPa)	12908 psi (71.1 psi)
	28	$f_{c,28}$	102 MPa (0.9 MPa)	14793 psi (132.0 psi)
Limit of Proportionality (LOP) [2]	10	$f_{r,10}$	8.4 MPa	1221 psi
	28	$f_{r,28}$		
$f_{R,1}$ value[2]	10	$f_{r,10}$	8.9 MPa	1292 psi
	28	$f_{r,28}$		
$f_{R,4}$ value[2]	10	$f_{r,10}$	9.3 MPa	1344 psi
	28	$f_{r,28}$		
Tensile Splitting Test[3]	7	$f_{t,10}$	9.6 MPa (2.3 MPa)	1393 psi (333.6 psi)
	28	$f_{t,28}$		

Table 5: Durability properties of ce200-120D™ (without Steel Fibers)

Durability properties	Mean values (S.D.)
Volume of Permeable Voids[4]	7.81% (0.45%)
Chloride ion penetration[5]	264 coulombs (53 coulombs)
Pressure Penetration[6]	7.0 mm (1.0 mm)
Shrinkage[7]	-0.0166% (-0.0014%)
Water absorption[8]	1.10% (0.04%)
Permeability Coefficient[9]	4.5×10^{-13} m/s (0.058×10^{-13} m/s)
Microbiological Influenced Corrosion Test (12 months)[10]	2.40 mm (0.1 mm)
Chloride Migration Coefficient[11]	0.25×10^{-12} m^2/s (0.026×10^{-12} m^2/s)
Freeze-Thaw Durability (56 cycles)[12]	188 g/m^2 (26.5 g/m^2)

Notes	
1	Compressive strength tests in accordance to ASTM C109
2	Flexural tensile strength tests in accordance to EN 14651:2000
3	Tensile splitting test in accordance to EN 12390-6:2000
4	Volume of permeable voids test in accordance to ASTM C642
5	Pressure penetration tests in accordance to EN 12390-8:2009
6	Chloride ion penetration test in accordance to ASTM C1202
7	Shrinkage test in accordance to ASTM C157
8	Water absorption test in accordance to BS 1881: Part 122
9	Permeability coefficient test in accordance to HDB Permeability Coefficient Test
10	Microbiological influenced corrosion test in accordance to Kiwa-Hausverfahren: QMA P Bau 923 “ODOCO Pilot Plant”
11	Chloride migration coefficient test in accordance to Kiwa-Hausverfahren: QMA P Bau 923/ BAW-Merkblatt “Chlorideindringwiderstand von Beton, 2012”
12	Freeze-thaw durability test in accordance to Kiwa-Hausverfahren: QMA P Bau 923/ DIN EN ISO 11358:2014-10