ECOPact is the industry's broadest range of low-carbon concrete for high-performing and sustainable construction. *ECOPact features a range of low-carbon levels, from 30% to 100% less carbon emissions compared to standard (OPC) concrete. ECOPact can be used in any type of applications, regardless of performance requirements: from foundations, columns and beams, to walls, driveways and walkways. ECOPact is available in a variety of strength classes and is compliant with industry standards. It can be handled, pumped and finished like conventional concrete.*

In accordance with the sustainability targets of your project, the engineer can either specify ***a desired percentage of Global Warming Potential (GWP) reduction*** *compared to a regional baseline, or indicate a maximum GWP value per class of concrete mix. As a solutions provider, our concrete experts can help find out the GWP targets that can be achieved for any given strength and durability requirement.*

The GWP value of each ECOPact mix is scientifically calculated and third-party verified. The outcome is summarized in a ***product specific Environmental Product Declaration (EPD)*** *that is part of the ECOPact solution and will be provided with each mix.*

This specification language can be included into the project specifications. Below is the typical list of contents in specifications for Cast-in-place concrete. ECOPact specification language should be inserted in the sections identified ***in green bold font****. These sections are pertinent to low-carbon concrete.*

This specification is provided as a courtesy on an as-is basis, and is not intended to substitute for specific design services provided by an architect, engineer, or other design professional. Text underlined and/or red in color must be addressed to complete a final specification document. It is the sole responsibility of the editor to exercise appropriate care and sound professional judgment in the execution of this task.

For more information, contact Holcim (US); 8700 West Bryn Mawr Ave., #300, Chicago, IL 60631; Phone (888) 646-5246; Website: www.holcim.us/ecopact; Email: ask@holcim.com.

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PART 1 – GENERAL

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- Environmental Product Declaration (EPD): Product-specific third-party verified Type III environmental product declaration is required for each mix, for at least 90% by volume or cost of the concrete on the project within 18 months of bid award. EPD must state conformance to ISO 14025 and EN 15804 or ISO 21930, and have at least a cradle-to-gate scope.

- *OPTIONAL:* LEED Recycled content: Submit product data and certification letter from product manufacturers, indicating percentages by weight of postconsumer and preconsumer recycled content for each concrete mix.

- *OPTIONAL:* LEED multi-attribute optimization: Product-specific Type III environmental product declaration is required for each mix, for at least 90% by volume or cost of the concrete on the project within 18 months of bid award. EPD must state conformance to ISO 14025 and EN 15804 or ISO 21930, and have at least a cradle-to-gate scope. EPD must demonstrate impact reduction below industry average in at least three of the following categories:
    - global warming potential (greenhouse gases), in CO2e;
    - depletion of the stratospheric ozone layer, in kg CFC-11;
    - acidification of land and water sources, in moles H+ or kg SO2;
    - eutrophication, in kg nitrogen or kg phosphate;
    - formation of tropospheric ozone, in kg NOx, kg O3 eq, or kg ethene; and
    - depletion of nonrenewable energy resources, in MJ.

  For products meeting the above criteria, submit a letter stating the dollar value of all products that are extracted, manufactured, and purchased (including distribution) within a 100 mile radius of the project site.

PART 2 – PRODUCTS

1.1 CONCRETE MATERIALS

1.1.1 CEMENTITIOUS MATERIALS

- Portland and blended-hydraulic cement: ASTM C150, ASTM C595, or ASTM C1157
- Fly Ash: ASTM C618, Class C or F.
- Slag Cement: ASTM C989/C989M.
- Silica Fume: ASTM C1240 anamorphous silica.
- Metakaolin: ASTM C618, Class N.

1.9 CONCRETE MIXTURES, GENERAL

These specification inserts are performance based. This allows the concrete manufacturer to optimize each ECOPact mix design in order to reach the required strength and durability requirements. At the same time the use of raw materials will be optimized, thus leading to maximal GWP reduction. The engineer should minimize prescriptive requirements on concrete mixtures and construction means and methods and increase the focus on measurable performance attributes when appropriate. The inclusion of both prescriptive and performance requirements in the specification can lead to inherent conflicts.

1.9.1 DESIGN & TESTING

Basis-of-Design Product: Subject to compliance with requirements, provide Holcim (US); **ECOPact** or comparable product.

Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

1.9.2 CEMENTITIOUS MATERIALS

In order to best leverage the available regional SCM and optimize the embodied carbon content of ECOPact mixes, it is preferable not to limit the percentage of cementitious materials other than Portland cement (Option 1). However, if there is a particular project requirement, use Option 2 limits to allow for the entire ECOPact range of low-carbon mixes.

Option 1 (Preferred): Do not limit percentage of cementitious materials other than Portland cement unless there is a particular requirement in local building codes.

Option 2: Limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows:

1. Fly Ash or Other Pozzolans: 50 percent by mass.
2. Slag Cement: 80 percent by mass.
3. Silica Fume: 15 percent by mass.

4. Total of Fly Ash or Other Pozzolans, Slag Cement, and Silica Fume: 70 percent by mass, with fly ash or pozzolans not exceeding 50 percent by mass and silica fume not exceeding 10 percent by mass.
5. Total of Fly Ash or Other Pozzolans and Silica Fume: 60 percent by mass with fly ash or pozzolans not exceeding 50 percent by mass and silica fume not exceeding 10 percent by mass.

1.9.3 ADMIXTURES

1.10 CONCRETE MIXTURES

Maximum GWP allowances per mix can be addressed by two different approaches:

Option 1: Require a reduction percentage for the total GWP of the project's concrete mixes, compared to the regional industry average based on NRMCA table

Option 2: Limit the GWP of each mix to a given value. This value can be derived from a whole-building Life Cycle Analysis depending on the GWP reduction targets of the project, or by comparison with standard mixes with equivalent strength and properties.

1.10.1 Maximum global warming potential (GWP):

OPTION 1: GWP reduction compared to NRMCA regional industry averages

Total GWP of the concrete supplied for the building shall be at least *[insert%]* % lower on a volume-weighted basis, than the amount of GWP using NRMCA industry averages based on strength and weight class for each mix. GWP reduction shall be validated through product-specific Environmental Product Declarations for each mix.
Acceptable product: ECOPact by Holcim (US); or comparable product.
The aggregate reduction is calculated as follows:

$$Reduction = 100\% - \frac{\sum GWP_{a,mix} * V_{mix}}{\sum GWP_{b,mix} * V_{mix}} * 100\%$$

Where

- $GWP_{a,mix}$: actual GWP value of the mix as per product-specific EPD
- $GWP_{b,mix}$: baseline GWP value of the mix based on NRMCA regional averages (see table below)

	Global Warming Potential (GWP) - kg CO_2e / yd^3							
Compressive Strength	**1 - Eastern**	**2 - Great Lakes Midwest Region**	**3 - North Central**	**4 - Pacific North West**	**5 - Pacific South West**	**6 - Rocky Mountains Region**	**7 - South Central**	**8 - South Eastern**
2500 psi	197	192	197	206	210	198	183	200
3000 psi	217	211	216	228	229	217	200	218
4000 psi	261	252	257	275	267	256	235	254
5000 psi	315	304	308	333	314	305	279	298
6000 psi	333	321	327	352	333	323	295	316
8000 psi	395	380	383	420	381	376	341	361
3000 psi Lightweight	399	401	395	422	394	396	378	383
4000 psi Lightweight	446	445	437	470	433	437	415	421
5000 psi Lightweight	493	489	482	519	474	478	453	455

TABLE 1. INDUSTRY AVERAGE GLOBAL WARMING POTENTIAL (GWP) BY REGION AND COMPRESSIVE STRENGTH, AS DETERMINED BY THE NATIONAL READY MIX CONCRETE ASSOCIATION (NRCMA) NOVEMBER 2019 REGIONAL BENCHMARKING STUDY.

Use the following performance criteria for each class of concrete mixture. Ensure that the specified strength is consistent with the most restrictive requirement governed by structural design and the applicable exposure class for each class of concrete. If GWP Option 1 is not selected, use GWP Option 2: Include a maximum GWP value per class of mix. If GWP Option 1 is preferred, remove GWP criteria from all

1.10.2 *[Class A i.e. pile caps, ground slab, etc.]:* Basis of design product: Subject to compliance with requirements, provide Holcim (US); ECOPact or comparable product. Proportion normal-weight concrete mixture as follows:

- Minimum Compressive Strength (f'c): *[xxxx]* psi at *[xx]* days.
- Exposure class: *[xx xx xx]* - in accordance with ACI 318-14
- Maximum Aggregate Size: *[xxx]* inch
- Slump limit: to be selected by Contractor based on ASTM C143, as permitted under ACI 301
- *[GWP Option 2]* Maximum GWP: *[xxx]* kg eq CO2 / *[cy or m3]*

1.10.3 *[Class B i.e. pile caps, ground slab, etc.]:* Basis of design product: Subject to compliance with requirements, provide Holcim (US); ECOPact or comparable product. Proportion normal-weight concrete mixture as follows:

- Minimum Compressive Strength (f'c): *[xxxx]* psi at *[xx]* days.
- Exposure class: *[xx xx xx]* - in accordance with ACI 318-14
- Maximum Aggregate Size: *[xxx]* inch
- Slump limit: to be selected by Contractor based on ASTM C143, as permitted under ACI 301
- *[GWP Option 2]* Maximum GWP: *[xxx]* kg eq CO2/*[cy or m3]*

1.10.4 *[Class C i.e. interior suspended lightweight slabs etc.]:* Basis of design product: Subject to compliance with requirements, provide Holcim (US); ECOPact or comparable product. Proportion lightweight concrete mixture as follows:

- Minimum Compressive Strength (f'c): *[xxxx]* psi at *[xx]* days.
- Exposure class: *[xx xx xx]* - in accordance with ACI 318-14
- Calculated Equilibrium Unit Weight: *[xxxx]* lb/cu.ft, plus or minus *[xxxx]* lb/cu.ft as determined by ASTM C567/C567M.
- Maximum Aggregate Size: *[xxx]* inch
- Slump limit: to be selected by Contractor based on ASTM C143, as permitted under ACI 301
- *[GWP Option 2]* Maximum GWP: *[xxx]* kg eq CO2/*[cy or m3]*

Refer to Appendix A for the definition of Exposure Classes and Requirements for Concrete in accordance with ACI 318-14.

1.11 CONCRETE MIXING

PART 3 – EXECUTION

END OF SECTION

For clarity, it is recommended to include APPENDIX A at the end of the specifications, as the contractor may not be familiar with code defined exposure classes and requirements.

APPENDIX A

Definition of Exposure Classes and Requirements for Concrete in accordance with ACI 318-14

(ACI 318-14) Table 19.3.1.1 – Exposure categories and Classes

Category	Class	Condition	
Freezing and thawing (F)	F0	Concrete not exposed to freezing and thawing cycles	
	F1	Concrete exposed to freezing and thawing cycles with limited exposure to water	
	F2	Concrete exposed to freezing and thawing cycles with frequent exposure to water	
	F3	Concrete exposed to freezing and thawing cycles with frequent exposure to water and exposure to deicing chemicals	
Sulfate (S)		Water-soluble sulfate (SO_4^{2-}) in soil, percent by mass [1]	Dissolved sulfate (SO_4^{2-}) in water, ppm [2]
	S0	$SO_4^{2-} < 0.10$	$SO_4^{2-} < 150$
	S1	$0.10 \le SO_4^{2-} < 0.20$	$150 \le SO_4^{2-} < 1500$ or seawater
	S2	$0.20 \le SO_4^{2-} < 2.00$	$150 \le SO_4^{2-} < 1500$
	S3	$SO_4^{2-} > 2.00$	$SO_4^{2-} > 10{,}000$
In contact with water (W)	W0	Concrete dry in service Concrete in contact with water and low permeability is not required	
	W1	Concrete in contact with water and low permeability is required	
Corrosion protection of reinforcement (C)	C0	Concrete dry or protected from moisture	
	C1	Concrete exposed to moisture but not to an external source of chlorides	
	C2	Concrete exposed to moisture and an external source of chlorides from deicing chemicals, salt, brackish water, seawater, or spray from these sources	

[1] Percent sulfate by mass in soil shall be determined by ASTM C1580
[2] Concentration of dissolved sulfates in water, in ppm, shall be determined by ASTM D512 or ASTM D4130

(ACI 318-14) Table 19.3.2.1—Requirements for concrete by exposure class

Exposure Class	Max w/cm [1]	Min f'_c, psi	Additional Requirements			Limits on SCM
			Air content			
F0	N/A	2500	N/A			N/A
F1	0.55	3500	Table 19.3.1.1			N/A
F2	0.45	4500	Table 19.3.1.1			N/A
F3	0.40 [2]	5000 [2]	Table 19.3.1.1			26.4.2.2(b)
			Cementitious materials [3] - Types			Calcium chloride admixture
			ASTM C150	ASTM C595	ASTM C1157	
S0	N/A	2500	No type restriction	No type restriction	No type restriction	No restriction
S1	0.50	4000	II [4][5]	Types IP, IS, or IT with (MS) designation	MS	No restriction
S2	0.45	4500	V [5]	Types IP, IS, or IT with (HS) designation	HS	Not permitted
S3	0.45	4500	V plus pozzolan or slag cement [6]	Types IP, IS, or IT with (MS) designation plus pozzolan or slag cement [6]	HS plus pozzolan or slag cement [6]	Not permitted
W0	N/A	2500	None			
W1	0.50	4000	None			
			Maximum water-soluble chloride ion (Cl^-) content in concrete, percent by weight of cement [7]		Additional provisions	
			Nonprestressed concrete	Prestressed concrete		
C0	N/A	2500	1.00	0.06		
C1	N/A	2500	0.30	0.06		
C2	0.40	5000	0.15	0.06	Concrete cover [8]	

[1] The maximum *w/cm* limits in Table 19.3.2.1 do not apply to lightweight concrete.

[2] For plain concrete, the maximum *w/cm* shall be 0.45 and the minimum *fc'* shall be 4500 psi.

[3] Alternative combinations of cementitious materials to those listed in Table 19.3.2.1 are permitted when tested for sulfate resistance and meeting the criteria in 26.4.2.2(c).

[4] For seawater exposure, other types of portland cements with tricalcium aluminate (C3A) contents up to 10 percent are permitted if the *w/cm* does not exceed 0.40.

[5] Other available types of cement such as Type I or Type III are permitted in Exposure Classes S1 or S2 if the C3A contents are less than 8 percent for Exposure Class S1 or less than 5 percent for Exposure Class S2.

[6] The amount of the specific source of the pozzolan or slag cement to be used shall be at least the amount that has been determined by service record to improve sulfate resistance when used in concrete containing Type V cement. Alternatively, the amount of the specific source of the pozzolan or slag cement to be used shall be at least the amount tested in accordance with ASTM C1012 and meeting the criteria in 26.4.2.2(c).

[7] Water-soluble chloride ion content that is contributed from the ingredients including water, aggregates, cementitious materials, and admixtures shall be determined on the concrete mixture by ASTM C1218 at age between 28 and 42 days.

[8] Concrete cover shall be in accordance with 20.6.

(ACI 318-14) Table 19.3.3.1—Total air content for concrete exposed to cycles of freezing and thawing

Nominal maximum aggregate size, in	Target air content, percent	
	F1	F2 and F3
3/8	6	7.5
½	5.5	7
¾	5	6
1	4.5	6
1 ½	4.5	5.5
2	4	5
3	3.5	4.5

(ACI 318-14) Table 26.4.2.2(b)—Limits on cementitious materials for concrete assigned to Exposure Class F3

Cementitious Materials	Maximum percent of total cementitious materials by mass
Fly ash or other pozzolans conforming to ASTM C618	25
Slag cement conforming to ASTM C989	50
Silica fume conforming to ASTM C1240	10
Total of fly ash or other pozzolans and silica fume	35
Total of fly ash or other pozzolans, slag cement, and silica fume	50

(ACI 318-14) Table 26.4.2.2(c)—Requirements for establishing suitability of combinations of cementitious materials exposed to water-soluble sulfate

Exposure class	Maximum expansion strain if tested using ASTM C1012		
	At 6 months	At 12 months	At 18 months
S1	0.10 percent	No requirement	No requirement
S2	0.05 percent	0.10 percent [1]	No requirement
S3	No requirement	No requirement	0.10 percent

[1] The 12-month expansion limit applies only if the measured expansion exceeds the 6-month maximum expansion limit.