

PEM State Specification Review

No.	Date of call	Strength	Shrinkage	Freeze-thaw	Oxychloride	Transport	Aggregate	Workability	Other	Notes/Recommendations	Specification year	Specifications Link	Summary of spec. changes as a result of PEM (based on calls and TAC meetings)
1	Iowa	6/21/2019	No requirement, no testing	Paste volume is typically less than 25%, no testing for pavement, may consider a ring test for bridge decks	8 ± 2% air, continue to evaluate SAM, likely focus on mix design rather than acceptance.	Looking at adopting a 0.15 CaOHX limit	0.42 max w/c	No concerns with D-cracking or ASR, state has effective approach	Gradation requirements deliver acceptable workability. If minimum cement contents are removed then V-Kelly or Box prequalification would be required.	A tool is needed to calculate voids in aggregate rather than having to measure it in the lab. If there is a good correlation between CaOH and CaOHX, this will be cheaper to measure and specify. Looking at resistivity. Performed shadow projects in 2018 & 2019 with 4 PEM tests. One PEM shadow project in 2020.	2020	https://iowadot.gov/en/	Have been using optimized aggregate gradation for over 20 years. Working on mixes with reduced cement content and validating at mix design phase with box test and SAM.
2	Illinois	7/9/2019	650 psi flexural @ 14 days, 3500 psi @ 28 days compressive (either testing is allowed)	Paste volume typically 24-26%, but is not measured. Shrinkage requirement likely to come in a few years for bridge decks	5.5 - 8.0% air. Illinois has stringent air testing; every truck is tested before and after pump for bridge deck	Typically 25-30% SCM. Calcium chloride used on bridge decks, only sodium chloride on pavement for deicers	No testing in spec but interested in resistivity. Have NCHRP research project. w/c 0.32-0.42	No concerns with D-cracking or ASR, state has effective approach	Considering a V-Kelly or Box test at mix design stage. No desire to mandate a tarantula curve, would rather have contractor come up with own mix.	Interested in a spec to include payment for performance to be similar to HMA. Will likely have a lengthy statewide shadow testing phase once they determine their PEM tests. Want to avoid conflict between contractor and producer. Concerns with the SAM used for acceptance, Illinois is measuring hardened air and getting good results. Regular SAM testing in the field is unlikely but may be used as a periodic check. SAM has a lot of potential but DOT is going to have to incorporate troubleshooting tools into its QC/QA training program.	2016	http://dot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Construction/Standard-Specifications/Standard%20Specifications%20for%20Roads%20and%20Bridges%20Construction%202016.pdf	Considering V-Kelly or Box test in mix design phase, will start collecting data with SAM on bridge decks. Specs have max. and min. cement and w/c ratios. Performed shadow project in 2019 with 4 PEM tests
3	Tennessee	8/2/2019	3,000 psi compressive @ 28 days, acceptance monitor with coring	No testing but emphasize curing and w/c for bridge decks	Started using SAM internally	Calcium chloride used for decking	Max 0.49 w/c, mixes allow for SCMs, interested in resistivity	No concerns, but researching how to mitigate ASR if encountered	Interested in V-Kelly	Communication with industry is encouraged, looking to expand exposure with future association. Looking for future shadow test candidate. Will investigate spec on fly ash temperature language.	2015	https://www.tn.gov/dot/dot-construction-division/transportation-construction-division-resources/transportation-construction-2015-standard-specifications.html	No Change
4	Wisconsin	8/13/2019	650 psi @ 28 days flexural, 3000 psi @ 28 days compressive	No testing	7 ± 1.5% air. SAM on lab qualified mixes since Dec 2017 (mix design), considering SAM in 2021 specs (acceptance)	Not Tested	Interested in resistivity testing, max. 0.42 w/c ratio	No concerns	Slump < 2.5 inches. Allows for optimized mix (3% incentive), V-Kelly and Box likely will be utilized during mix design phase in future projects	Shadow project in Racine April 2020	2020	https://wisconsin.gov/Pages/doing-business/eng-consultants/cnsl-sources/rwa/strdspec.aspx	SAM shadow testing in mix design phase (and once per lot) since Dec 2017. Considering adding SAM for pavements acceptance testing in 2021. Spec allows for 3% incentive with optimized aggregate gradation allowing cement reduction from 564 pcy to 520 pcy
5	Colorado	8/26/2019	4500 psi compressive @ 28 days, 650 psi flexural	Unrestrained shrinkage shall not exceed 0.050% at 28 days when tested by CP-L 4103.	No SAM in new spec. 4-8% air	20% fly ash or 30% slag. Class C fly ash allowed if oxychloride <15g/100g paste (AASHTO T 365)	max w/c ratio 0.45, Max. 2500 coulombs @ 56 days or surface resistivity of at least 12 kW-cm @ 28 days (AASHTO T 358).	Some ASR issues regionally, been testing for over 25 years, mitigating with F.ash. Used modified 1260 but now 1567.	Edge slump less than 0.25 inch, & ranking of 2 or better on box test	Information reviewed is from 8-23-19 draft spec that will be implemented this fall. Changes in new draft spec: Eliminated max and min cement content. Includes max shrinkage.	2019	https://www.codot.gov/business/designsupport/cdot-construction-specifications/2019-construction-specifications/rev-ssr/rev-sec600/rev-sec601sc/view	Revised specification in October, 2019. Removed max. and min. cement requirements, allow optimized gradation, box test in mix design (<0.25" edge slump and ranking of 2 or less). Mix permeability < 2,500 coulombs, @ < 56 days (ASTM C1202) or surface resistivity > 12 kW-cm @ 28 days (AASHTO T358), unrestrained shrinkage < 0.05 % @ 28 days (CP-L 4103)
6	Michigan	9/4/2019	650 psi flexural @ 28 days, 3500 psi compressive @ 28 days	No testing	5-8.5% air. Have 19 SAMs, concerns with equipment performance and durability	25-40% SCM replacement allowed. Typically use 25-30% slag	0.45 max w/c, wants to encourage to lower. Have seen variability in resistivity based on change of only aggregate	ASR testing on fine aggregates, mitigated with slag. Vacuum saturate coarse aggregate test for D-cracking since 1950s.	Optimizing aggregates since 1998 based on shilstone	Slag is preferred SCM and not fly ash due to: 1) reliable and consistent availability, 2) variability in air content (air content is PWL pay factor)	2012	https://www.michigan.gov/mdot/0,4616,7-151-9622_11044_11357_00.html	Have been using optimized aggregate gradation for over 20 years, considering use of SAM in the mix design phase, performed SAM testing on 2 shadow projects
7	New York	9/24/2019	600 psi flexural @ 28 days (mix design), 3000 psi compressive @ 28 days for opening using 4" cylinders	25% max paste per AASHTO (mix design)	5-10% air, SAM max. 0.2 (mix design). SAM < 0.25 acceptable, >0.25 to <0.3 action required, >0.3 reject	No testing	0.40 max. Resistivity > 16.5 kWh-cm (4" x 8" cylinders) AASHTO T158 (mix design). Resistivity during paving for information only	Some absorptive aggregate. Some ASR mitigated with F.ash.	Slump as desired by contractor. Tarantula curve, Shilstone or 818 method	Ready mix plants supplying majority of mixes. There is a need to get PEM training to industry. Industry may benefit from box test and V-Kelly exposure. Contractor has Quality Control plan. Contractor sampling and testing plastic PCC (not for acceptance). Contractor provides ACI Certified Concrete Field Testing Technician, Grade I or higher (sampling, temp, slump, air and in the future possibly SAM)	2020	https://www.dot.ny.gov/main/business-center/engineering/specifications/updated-standard-specifications-us	Performed 2 shadow projects in 2019. SAM, resistivity, paste volume were mix design requirements. One project had SAM acceptance testing. Standard concrete spec revised by structural engineers with SAM, pilot project with SAM on structural project.
8	Minnesota	9/26/2019	No strength testing for acceptance, just for opening	No testing, paste volume is around 25%	7% +2% to -1.5%. SAM for shadow testing 0.25 to 0.3.	No testing	0.40 max (fly ash), 0.42 max (ternary) w/c with incentives for less. Min 5 SCM (ash/slag/ternary) (33/35/40). Consultant doing resistivity testing on shadow projects	No concerns with D-cracking or ASR, have spec limit for carbon	No slump requirement. V-Kelly done in the lab, box test during mix design in D-B project	Had a design-build project with PEM testing. Shadow project will start spring 2020. They will send shadow test data. Incentives/Disincentives for w/c ratio, aggregate quality and well-graded aggregate for paving plant and certified ready mix plant. Experienced some leaking problems with SAM. Interested in SAM training as part of PEM pooled fund.	2018	http://www.dot.state.mn.us/pre-letting/spec/	Have optimized aggregate gradation, includes 0.40 max w/c ratio (0.42 max w/c for ternary mixes) with incentives, performed 2 shadow projects in 2019 with PEM tests
9	Idaho	10/3/2019	4500 psi @ 28 days, 3500 psi for opening, 660 pcy min. cement	No testing	4 - 7% air	Use fly ash & slag SCM	0.42 max. w/c, resistivity testing utilized lime water prep	Have ASR risk areas, mitigated with F.ash. Eastern region uses lithium	2" max slump, interested in box and V-Kelly test	Min. 660 pcy cement	2019	https://apps.frd.idaho.gov/Apps/manuals/SpecBook/SpecBook18.pdf	Shadow project in 2019 accepted optimized aggregate gradation with lower cement content. Considering allowing this into future specification
10	California	10/5/2019	570 psi Mod. Of Rupture @ 28 days (acceptance test)	Revised spec is 0.032 for bridge decks. Modified T160 is to take initial reading at 7 days after casting. Demold at 24 hrs and keep in lime water until initial reading.	4 + 1.5% for low mountain areas; + 1.5% for high mountain and high desert areas. For other areas, air is not specified and max air must be 4% in average of 3 tests and each test must be less than 5.5%.	SCMs must be used in FT and corrosive areas. For corrosive areas, SCMs must be used by one of the following: (1) 25% natural pozzolan or fly ash; (2) 20% natural pozzolan or fly ash + 5% silica fume, (3) 12% silica fume, metakaolin, or UFFA, or (4) 50% GGBFS.	No testing for resistivity/formation factor, no w/c requirements.	D-cracking not an issue. ASR is mitigated with SCMs	For paving concrete, mix design requirement is max. 1.5" Kelly ball penetration.	Min. 590 pcy cement in F-T areas, min. 675 pcy in corrosive environments	2018	https://dot.ca.gov/programs/design/ccs-standard-plans-and-standard-specifications	No Change
11	Kansas	10/10/2019	4000 psi @ 28 day, 4" cylinders	No testing	5% air & max spacing of 0.01 inch after paver using AWA. Close to implementing SAM with associated internal training regimen	No testing	Testing permeability since 2007. 0.45 max w/c, resistivity by Rapid Chloride, boil or Surface test	ASR not an issue, some eastern aggregate sources have durability challenges	Using V-Kelly, interesting in comparing SAM and V-Kelly	Min. 517 pcy (QC/QA mix)	2015	https://www.ksof.org/bureaus/bur/ConsMain/Specpro/2015Specpro.aspx	Have had optimized aggregate gradation for 10 years, testing resistivity for 5 years. Considering SAM requirements in mix design or acceptance for 2021. Performed shadow project in 2019 with PEM tests
12	South Dakota	10/18/2019	600 pcy, 575 pcy w/optimized gradation, opening strength: 4000 psi new construction, 3000 - 3500 psi for full depth repairs, 3000 for spall repair (2000 to 2500 being considered)	No testing but looking into proper test, limits and best methods for bridge deck	Consider SAM in mix design, not ready for field testing	unsure how to deal with Oxychloride other than using ash	0.42 max, 0.39-0.42 is typical, resistivity testing planned for mix design phase and possibly field testing	No issues with absorption or D-cracking, ASR mitigated with Type F Ash (20 - 25%), use a Modified 1260 test for ASR	Concern for V-Kelly - amount of time for test. Prefers Box Test	Industry needs exposure to new tests	2015	https://dot.sd.gov/doing-business/contractors/standard-specifications	Considering SAM, tarantula curve and box test in mix design phase. Performed shadow project in 2018 with PEM tests
13	Oklahoma	11/1/2019	3000 psi compressive @ 28 days, 650 psi flexural @ 28 days, 700 psi flexural @ 56 days	No testing	6 % ± 1.5%	No testing	0.48 max w/c, fly ash max 20%, max SCM 50%	No testing	slump 2± 1 in	min. 517 pcy	2019	https://www.odot.org/Manuals/SpecBook/2019%20FULL-SPEC-Web-Version.pdf	No Change
14	Georgia	11/13/2019	3,000 psi compressive @ 28 days	No testing	air requirement, northern area gets freezing temps	No testing	max 0.53, 15% max fly ash, 30%-50% slag replacement	few reactive sources	slump max 2.5 inches	DOT has plans to review their mainline paving specification section 430 to incorporate PEM.	2013	http://www.dot.ga.gov/PartnerSmart/BusinessSource/Specs/DOT2013.pdf	No Change
15	Ohio	1/27/2019	4000 psi @ 28 days compressive, 400 psi flexural. May lower to 300 psi	No testing, but allow tarantula curve to optimize aggregate; reduce paste	Completed SAM trials. Looking at SAM for mix submittal phase. 7% ± 2% air. Have seen some air loss and air gain through concrete pumps	Have joint deterioration, use brines, do not seal joints, may be interested in oxychloride test	2000 coulombs @ 28 days permeability for pavement, 1500 coulombs for bridge deck, max 0.45 w/c, 20% max fly ash, max slag 30%, max combination 50%, wants to do resistivity testing	well graded aggregates, good spec. Not the best gravel, concern on limestone, allow tarantula curve, ASR not a concern, good aggregate availability a concern, seen limestone polishing on bridge decks. Have good testing program	max slump 4 in, industry wants to get rid of slump test, have done box test and V-Kelly test	min 520 pcy	2019	http://www.dot.state.oh.us/Divisions/ConstructionMet/OnlineDocs/Pages/2019-Online-Spec-Book.aspx	No Change
16	Pennsylvania	2/21/2020	All testing is compressive. 2000 - 3600 psi compressive for opening to traffic based on slab thickness and size (Table D, section 501), 4000 psi @ 28 days mix design strength. Maturity testing is allowed but contractors are not typically using unless for opening strength on patches. DOT tests cylinders for acceptance.	AASHTO T 160 utilized for bridge decks and pavements. AASHTO T 334 utilized on bridge decks. 28-day max. is 500 microstrain (unless approved up to 550 microstrains by the DME/DMM per ASTM C157).	Air content 7.0 % +/- 1.5%. They have 4 SAMs and using on larger paving projects. Requiring 30% SCMs on bridge decks, may look at requiring SCMs for pavements, may look at requiring sealants.	No testing, may look at in future	Max. w/c 0.42 (slip form), 0.45 (form paving). Permeability of 2,000 coulombs after 56 day curing (AASHTO T 277 or AASHTO T 358), not to exceed 2,800 coulombs. Not to exceed 15.6 kd-cm for 4-inch by 8-inch cylinders and 12.3 kd-cm for 6-inch by 12-inch cylinders. For 6-inch by 12-inch cylinders. max. fly ash 15%, max. GGBFS 25%-50%, max combination 50%.	Not concerned with D-cracking, following AASHTO R80 for ASR testing.	Have used the Box Test, have not worked with V-Kelly. Prefer to remove slump test.	Slip form paving 517 pcy to 611 pcy cement content	2020	http://www.dot.state.pa.us/public/PubsForms/Publications/Pub_408/408_2020/408_2020_IE/408_2020_IE.pdf	Lowered w/c ratio to 0.42 (slip form) and 0.45 (hand placed). Permeability & shrinkage now tested on pavements and allowing use of reopod in lieu of rapid chloride penetration (April 2020)
17	North Carolina	4/30/2020	3000 psi opening strength, 4500 psi compressive, 650 psi flexural acceptance @ 28 days. Min 526 pcy cementitious	Paste volume is 29-30% (based on mix design)	Air content 5 +/- 1.5%. Have lots of SAM data. Future SAM number could be 0.3	No testing	w/c ratio typically 0.4 to 0.5. Good results with shadow project resistivity testing. Lime water sample prep used.	ASR mitigated with fly ash. ASTM C1260 used.	1.5 in. max slump (slip form) & 3 in. (hand placed). Box test used in shadow project.	Future shadow project on bridge deck and deck overlay.	2018	https://connect.ncdot.gov/resources/specifications/StandSpecLibrary/2018%20Standard%20Specifications%20for%20Roads%20and%20Structures.pdf	Working on pilot project with resistivity requirements (bridge deck). Performed shadow project in 2019 with PEM tests
18	Arkansas	6/4/2020	4000 psi @ 28 days, 3000 psi for traffic	No testing, have seen shrinkage cracks in bridge decks	6% ± 2%, have done some SAM testing in the lab	No testing, northern roads aggressive with deicers	max 0.45 w/c, max fly ash 20%, max slag 25%	have some areas of ASR, Univ of Arkansas has research	slump max 2 inches, no exposure to V-Kelly or Box test	2014 Spec date. They typically get 1k- 3k psi over the spec for strengths.	2014	https://www.arkansashighways.com/standard-specifications.aspx	No Change
19	Maine	3/3/2020	4000 - 5000 psi @ 28 days	Mortar bar expansion testing	6% - 9%	No testing	no specified w/c ratio, max 2400 coulombs (bridge deck), 2000 coulombs (low perm mix)	Some ASR sources, have some absorptive aggregates, mortar bar expansion testing	Slump (QC test) by contractors, No DOT slump testing)	Primarily using concrete specification for bridge deck application. No concrete paving specifications.	2014	https://www.maine.gov/mdot/contractors/publications/standard-spec-hnd-ex2014.shtml	

States seeing variability in resistivity due to aggregate porosity: Iowa, Michigan, Illinois and Kansas.