Washington State Department of Transportation
Bridge and Structures Office

Design Memorandum

TO: All Design Section Staff
FROM: Bijan Khaleghi
DATE: September 23, 2016
SUBJECT: Concrete Class 5000P in Bridge Foundations

This design memorandum allows the use of Concrete Class 5000P for piles, shafts, and deep foundations for bridges and other structures. Concrete Class 5000P should be called out in the Plans by designers for use in deep foundations for bridges and may be specified in other locations where Concrete Class 4000P would otherwise be specified.

The typical 0.85 strength reduction factors for non-vibrated Class P concrete, which may or may not be placed in the wet, are no longer required for structural design using Class P concrete.

Background:
Concrete Class 4000P has historically achieved 28-day compressive strengths that usually exceed 6000 psi and sometimes exceed 9000 psi. Because the mixes are driven by the need for working properties as well as hardened properties, the compressive strengths are inherently higher than 4000 psi at 28 days. Based on discussion with Washington Aggregate and Concrete Association (WACA) representatives, it is anticipated that most, if not all, of the approved concrete class 4000P mixes can satisfy the requirements for Concrete Class 5000P with no further modification. This presents an opportunity to realize more economical foundation designs with little or no added cost.

For structural design using Class P concrete, a compressive strength reduction factor of 0.85 has historically been required to account for potential construction defects such as inadequate concrete consolidation, slurry being mixed into the concrete, and necking or soil inclusions due instability of the excavation. As the construction and inspection practices for deep foundations have improved, this reduction factor has become less economical. Large defects in deep foundations will still require remediation as before, while small defects or anomalies may be addressed without remediation using other sources of conservatism. These sources of conservatism include target concrete strength in excess of design concrete strength, reduced structural demands in locations away from the peak structural demands, and concrete strength gain with time.

If you have any questions regarding this policy memorandum, please contact Anthony.Mizumori@wsdot.wa.gov at 360-705-7228 or Bijan.Khaleghi@wsdot.wa.gov at 360-705-7181 or.

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Bridge Design Manual Revisions:

Section 5.1.1 B5 shall be revised as follows:

*4. **Class 4000P and 5000P***

Used for CIP piles, ~~and~~ shafts, and deep foundations where vibration is not feasible or practical.

Section 5.1.1 B7 shall be revised as follows:

"Used in CIP post-tensioned concrete box girder construction, deep bridge foundations, or in other special structural applications if significant economy can be gained or structural requirements dictate.

The specified 28-day compressive strengths (f'_c) are equal to the numerical class of concrete. The ~~28-day~~ compressive ~~design~~ strengths (f'_c) for design are shown in Table 5.1.1-1.

Table 5.1.1-1 shall be revised as follows:

Classes of Concrete	Design Compressive Strength ~~f'c~~ (psi)
COMMERCIAL	2300
30004000, 4000A	3000
4000, 4000A, 4000D	4000
4000W	2400*
4000P	4000~~**~~
5000P	5000
5000	5000
6000	6000

* 40 percent reduction from Class 4000.

~~** 15 percent reduction for piles and shafts.~~

Section 7.1.5 shall be revised as follows:

"Shafts and cast-in-place piles shall be Concrete Class ~~4000P~~ 5000P. Concrete Class 4000P may be used for elements other than bridge foundations."

Section 7.2.3 B shall be revised as follows:

"For a soft substructure response:

1. *Use ~~0.85~~ f'_c to calculate the modulus of elasticity. ~~Since the quality of shaft concrete can be suspect when placed in water, the factor of 0.85 is an estimate for decrease in stiffness.~~"*

Section 7.8.2 B shall be revised as follows:

"Concrete Class ~~4000P~~ 5000P shall be specified for the entire length of the shaft for wet or dry conditions of placement."

Section 7.8.2 D shall be revised as follows:

"The assumed concrete compressive strength may be taken as ~~0.85~~$f'c$ for structural design of shafts. ~~A reduction in concrete strength is used to account for the unknown shaft concrete quality that results.~~ For seismic design, the expected compressive strength may be taken as 1.3 times this ~~reduced~~ value in accordance with AASHTO Seismic Section 8.4.4."

Section 7.9.6 A shall be revised as follows:

"Concrete Class ~~Concrete~~ 5000P shall be specified for CIP concrete piles. The top 10' of concrete in the pile is to be vibrated. Use 1.0 f'_c for the structural design."

Section 7.10.2 A1 shall be revised as follows:

"The concrete for CFT and RCFT shall be Concrete Class ~~4000P~~ 5000P. ~~A reduced compressive design strength of 0.85f'_c shall be used for wet placed concrete.~~"

Section 15.7.7 B2 shall be revised as follows:

"Concrete Class ~~4000P~~ 5000P shall be specified for the entire length of the shaft for wet or dry conditions of placement."

Section 15.7.8 D1 shall be revised as follows:

"Concrete Class ~~4000P~~ 5000P ~~Concrete~~ shall be specified for CIP concrete piles. The top 10' of concrete in the pile shall be vibrated."

Section 15.5.2 A1 shall be revised as follows:

"Cast-in-place (CIP) concrete shall meet the requirements of Table 5.1.1-1:"

Component or Application	Minimum Numerical Class and Minimum Compressive Strength at 28 days	Letter Suffix	Compressive Strength for use in Design = f'c (psi)

	(psi)		
Commercial Concrete; Non-structural Concrete; Sidewalks: Curbs: Gutters	3000	-	Numerical Class
General Structural Concrete including Spread footings; Walls; Columns; Crossbeams; Box Girders; Slabs; Barriers; etc.	4000	-	Numerical Class
Bridge Approach Slabs	4000	A	Numerical Class
Bridge Decks	4000	D	Numerical Class
Piles and Shafts	4000	P	~~0.85 times~~ Numerical Class
Underwater Seals	4000	W	0.6 times Numerical Class

Section 15.7.2 B2 shall be revised as follows:

"For a soft substructure response:

1. *Use ~~0.85~~ f'_c to calculate the modulus of elasticity."*

Section 15.7.7 B4 shall be revised as follows:

"The assumed concrete compressive strength <u>may</u> ~~shall~~ be <u>taken as</u> ~~0.85~~f'c for structural design of shafts. For seismic design, the expected compressive strength may be taken as 1.3 times this ~~reduced~~ value in accordance with AASHTO Seismic Section 8.4.4."