HAHN READY MIX

Water-Cement Ratios

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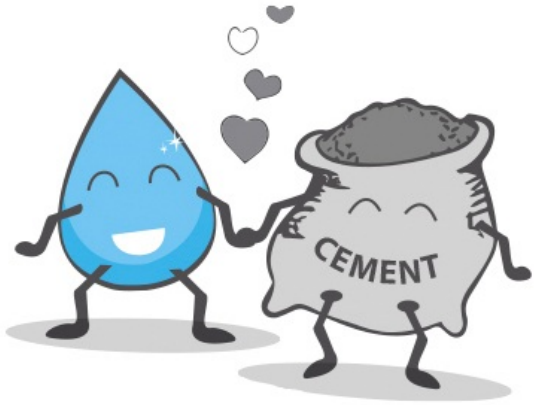


Most of you have probably seen it... you're getting ready to pour a floor, or perhaps some exterior flatwork, and then specs or drawings are brought up that limit the slump of your concrete to a 4" maximum. Which makes sense, right? How else could one tell if the concrete was of sufficient quality before it is placed?

WRONG.

You are likely seeing specifications that have been copied and pasted for nigh on generations at this point. Before the advent of water reducing admixtures (Stay tuned for next month!), slump was the best way to judge the water content of a mix design and therefore it's acceptability. That, however, is not the world we live in today. Slump is merely a measurement of the concrete's consistency. It tells us next to nothing about the quality of the concrete.

Class	Specified 28 day Compressive Strength	Maximum W/cm Ratio	Minimum Cementitious Content	Maximum Slump	Air Content
SOG	3000psi	0.5	500lbs	4"	3% Max
Footings	3000psi	0.55	450lbs	4"	N/A
Foundations	4000psi	0.45	564lbs	4"	6% +/- 1%
Ext. Paving	4500psi	0.45	564lbs	4"	6% +/- 1%

Of course, the factors that lead to a quality concrete mix are beyond

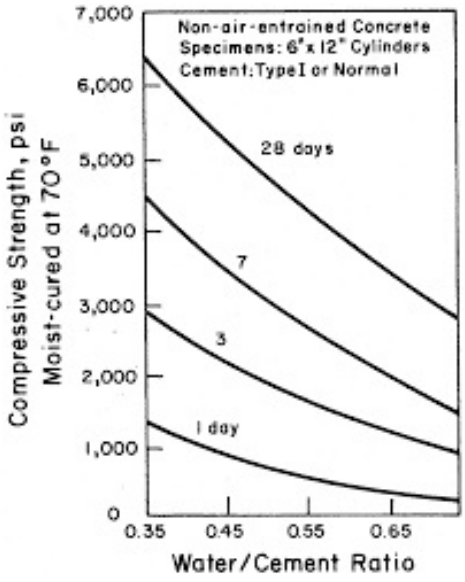
numerous: aggregate quality, supplementary cementitious qualities, cementitious quantities, aggregate proportioning, proper use of admixtures, etc, etc. However, *the simplest and most accurate way to evaluate a mix design or load of concrete is by looking at the* **Water-Cement Ratio**, or in the case of the use of supplementary cementitious materials, the water-cementitious ratio (w/cm). This ratio is easy to calculate:

Total Weight of Water / Total Weight of Cementitious Materials

It's also often found right on the batch weights of a concrete ticket and one of the key numbers in a mix design submittal. It is typically a value somewhere between .30 - .60. The lower the value, the lower the w/cm ratio and, all else being equal, the stronger the concrete. Lower w/cm ratios also indicate lower permeability, higher resistance to freeze-thaw attacks, higher durability, and higher resistance to salts and sulfates.

All of this happens because there is a bit of a love-hate relationship between cement and water. Cement needs water to hydrate. Without water, cement can never hydraulically activate to grow C-S-H crystals and gain strength. The water needed to hydrate the cement particles can be called “The Water of Necessity”, and will vary by cementitious materials and quantities, but is often around a .30 w/cm ratio. Cement and water of necessity have a very solid romantic relationship.

Beyond this, additional water raises the w/cm ratio and could be referred to a “Water of Convenience". This extra water forces the cement grains further apart creating a less dense paste. The result of the extra water is lower strengths, higher permeability, etc. That's not the end of the world, much of this decreased strength is typically accounted for in the mix design process as it is beyond rare that concrete is poured with exactly the water of necessity. The excess water also has the benefit of increasing consolidation, workability, finishability, and pumpability. Too much water, however, can make the negative effects significantly outweigh the positive. Adding 70+ gallons on site, for example, is almost certainly compromising the quality of a load of concrete from a strength, durability and permeability perspective. Cement's relationship with water of convenience is definitely a bit toxic.



Okay Jerry Springer, what w/cm ratio should I be targeting?
That, of course, depends on what you are pouring, how you are placing, and what your budget is for admixtures. Here's some helpful guidelines

though:
Slipform Paving - Sub .40, Highest durability for streets and low water content provides the necessary slump for a paving machine.
Exterior Flatwork - .45, Exterior flatwork is especially susceptible to freeze-thaw damage and salts. A .45 will give you adequate strength (4500psi+) and permeability to withstand those forces.
Interior floors - .50-.55, For floors, strength is rarely a concern. A more typical concern is curling, which results from drying shrinkage. Lowering the cementitious contents will help with curling, even if it drives up the w/cm ratio.
Walls - .55, freeze thaw concerns are markedly reduced on vertical surfaces, and sufficient water to eliminate bug holes and honeycombing is desired. A lower w/cm ratio may be needed if the structural load on the wall is high.

Many other requirements of a concrete mix might necessitate a lower w/cm ratio, such as sulfate resistance, durability requirements, water intrusion resistance, and salt or chemical resistance.

And in case you we're wondering, water is the ideal curing material for hardened concrete. Our C-S-H crystals will continue to grow as long as water is present. And so, our love story between cement and water ends happily ever after.

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Hahn Ready Mix
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