



How Much Cement should I use in my Mix Design?

A common Question asked by many. Some items to consider when trying to determine the proper Cement to Aggregate Ratio are as follows:

- 1. Compressive strength requirements (Mpa PSI)
- 2. Quality and type of Cement used
 - A. Ordinary Portland Cement (OPC type I)
 - B. Type III - High early strength is the other type generally used for concrete products. Overseas may have different standards?? Chemical analysis is a part of lab. tests that should be done to assure quality.
 - C. Cementitious substitutes (Fly Ash) in various ratios i.e. Fly Ash, Micro Silica, ... they can act as a cement substitute to various degrees
- 3. Mix Design.
 - A. Aggregate blend (Fineness Module FM)
 - 1. Consistency of aggregate size and shape
 - 2. Strength of aggregate used
 - 3. Type of aggregate used i.e. heavy wt. Vs light wt.
 - crushed gravel and sand, natural gravel and sand cinders,
 - expanded clay, limestone, pumice, expanded slag, air cooled slag, etc.
 - 4. Cost and availability of aggregate in the area of the plant.
 - 5. How clean the aggregate is...i.e. no clay, or organic
 - 6. What is the percent of PAN in the mix design. Remember a finer mix design has more surface area than a coarse mix design. Increased surface area will require increased amounts of cement to coat the aggregate surface area.
 - B. Consistency of aggregate to cement ratio
 - (especially if weighing batching the water content in the sand can alter this ratio
 - ... we are weighing water and not sand and aggregate.)
 - C. Additives... plastizers, stybrates, etc.
 - D. Moisture...
 - 1. wet mix Vs dry mix ...
 - 2. How clean is the water
 - 3. Is water hard or soft .. (chemical content)



- 4. Curing...
 - A. Time available for turn around through curber
 - B. Curing cycle Time, Temperature, Moisture
 - C. Maximum temperature achieved, and hold time at 100 % Humidity
 - D. Low pressure curing Vs high pressure curing (autoclave)
- 5. Management...What margin of safety do they require
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- 6. Type of mixer, mixing time available either too long of too short
 - A. Inconsistent mixing time, inconsistent mixing
 - B. Pan Vs ribbon blade
- 7. Flexure Strength required (Curbes)
- 8. Abrasion resistance required
- 9. Water absorption test requirements
- 10. Freeze/Thaw test requirements
- 11. Block machine type
 - A. Even texture top to bottom as produced on the Columbia equipment
 - B. Or tight band top and bottom and loose mid section as produces by some competitive equipment that tries to squeeze mix together rather than vibrate it together.
- 12. Type of product being manufactured
 - A. Block Vs Paver Vs Retaining Wall Vs Curbs etc.
 - B. Shape of product, tall thin, 300 mm Vs short wide 40 mm
- 13. Type of green product handling system.. how smooth it operates. Some pallet handling systems require a higher green strength for handling green product from machine to kilns. Some producers add cement to help bind the mix together to prevent cracking during handling in the green state. The minimum strength they get is 2,500 PSI but if cement is removed from the mix to lower the strength the cull rate goes up and there is a negative savings.



- 14. Product Testing
 - A. Proper equipment
 - 1. Cement chemistry
 - 2. Product strength, (Compressive, Flexural)
 - 3. Aggregate sieve analysis (mix design)
 - 4. Abrasion resistance, water absorption, freeze/thaw, etc.
 - B. Frequency of testing for strength and mix design
 - C. Consistency of test results
 - D. Record keeping of test results

- 15. ASTM (C129 - 95) Nonloadbearing Concrete Masonry Units
 - Compressive Strength Requirements:
 - (average net area, min.)
 - Average of 3 Units 600 PSI, 4.14 Mpa
 - Individual unit 500 PSI, 3.45 Mpa

 - Note: Few is the US product this type of unit. Its difficult to produce, and have it hold together during the green strength process of pallet handling.

- 16. ASTM (C90 - 95) Feb. 15, 1995 Loadbearing Concrete Masonry Units
 - Compressive Strength Requirements:
 - (average net area, min.)
 - Average of 3 Units 1,900 PSI, 13.1 Mpa
 - Individual unit 1,700 PSI, 11.7 Mpa

 - This is the specification most US producers use for Concrete Masonry Units.

Wisconsin Brick and Block:

- They use a agg:cemt ratio of 10.5:1 9.5%
- This produces a block that has a compressive strength of 2,200 PSI (15.2 Mpa). They do have a fine mix with a lot of sand and fine material. The crushed aggregate and sand they use must have the cement to hold it together during the green block handling.

- The other plant they have uses limestone and pumice and can work with less cement due to the "stickiness" of their material.



Westblock CPM40: Dupont, Washington

- Jim Hammer uses 500 lbs. /4200 lb. of agg this is a 11.9% a ratio or 8.4:1. The blocks test at a strength of 2,500 PSI (17.24 Mpa). This is above the 1900 PSI (13.1 Mpa) required due to safety factor and green product handling.

WMK, Las Vegas, Nevada

- Jerry Shoebach advises that the mix design used in the Columbia and the Besser are the same. He runs "Scoria" a cinder mix for light weight product. His cement ratio is :
 - Scoria Mix. 7.5 : 1 13.3%... This material requires this much cement due to its strength and porosity.
 - He also advises that at other plants he has run that with:
 - Expanded Shale 10 : 1 10%... is used
 - Sand and Gravel 11.5 : 1 8.7% but never lower
 - with either Besser or Columbia equipment, for load bearing product.
- They do not make non load bearing products.... Even the wall block for wind barriers are of the 7.5 : 1 ratio due to green strength handling, type of material, and management.

Columbia Training Manual, General Information

- By U.S. Standards:
 - A sack of Cement Weighs 94 pounds (43 Kg.)
 - A barrel of Cement equals 4 sacks x 94 lbs. or 376 pounds (170 kgs.)
 - A sack of Cement (94 lbs. 43 Kg.), equals 1 cu ft.
 - A sack of Cement in absolute volume equals .478 cu. ft.
- Rule of thumb:
 - For Heavy Weight Sand and Gravel, Standard 8" x 8" x 16"
 - (200 mm x 200 mm x 400 mm) cored block
 - A sack of Cement (94 lbs. 43 Kg.) will produce Approximately 25 Units,
 - This is approximately 3.75 lbs. (1.7 kg) per block
 - For Light Weight Aggregate, Standard 8" x 8" x 16"
 - (200 mm x 200 mm x 400 mm) cored block
 - A sack of Cement (94 lbs. 43 Kg.) will produce Approximately 20 Units,
 - This is approximately 4.70 lbs. (2.1 kg) per block



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**Columbia Training manual, Cement to Aggregate Ratio
(by Weight) for various types of Aggregate:**

<u>Type of Aggregate</u>	<u>Cement to Aggregate</u>	<u>% Cement</u>
• Sand and Gravel	1-8 to 1-12	12.5% to 8.3%
• Cinders	1-6 to 1-8	16.7% to 12.5%
• Clay (Expanded)	1-8 to 1-9	16.7% to 11.1%
• Limestone	1-7 to 1-12	14.2% to 8.3%
• Pumice	1-4 to 1-6	25% to 16.7%
• Slag (Expanded)	1-5 to 1-7	20% to 14.3%
• Slag (Air Cooled)	1-8 to 1-12	12.5% to 8.3%

The only way to know for sure is to test actual product on a regular basis.

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