Mixing Information

This appendix is a consolidation of information for use when preparing block mix for a particular operation. Type of material, material composition, desired number of blocks per sack of cement, and block purpose (load bearing, partition, etc.) are variables to be considered when planning the mixing procedures and the type and amount of aggregate to be used.

PREMIXING

Lightweight Aggregates: If porous or lightweight aggregates that display high absorption characteristics are used, it is recommended that 1/2 to 2/3 of the total mixing water be pre- mixed with the aggregate for 11/2 to three minutes. Premix ing fills the pores of cellular particles before cement is added, preventing dry cement from being wasted in the pores.

Heavy Aggregates: Before water is added, it is good practice to dry mix heavy aggregates with cement for approximately one minute, or until the mass is uniform in color.

WATER

In general, the correct amount of water is indicated when a compressed handful of mix will stay together in a ball while displaying a trace of moisture. A further check of processed blocks is also a good indicator of water content.

If occasional fine streaks of web like water marks appear on the block sides, the amount of water in the mix is very close to ideal. However, a mix that is too wet will display slumping and a generally poor appearance. A mix that is too dry will not contain enough water for efficient cement hydration, requiring that manufactured blocks be handled carefully to avoid cracking. So that uniformity of water content can be maintained, always measure the amount of water used, preferably by meter.

MIX TIME

The relatively dry mixtures used in the manufacture of concrete masonry units require longer mixing than ordinary concrete. Since the units are stripped immediately after being molded, the mix must be considerably under the slump point. Despite this, the watercement ratio still applies, and adequate strength can be obtained only if the mixing time is sufficiently long to coat each particle of aggregate with cement.

Some plants mix material for as long as 15 to 20 minutes. Others, however, feel that the increase in strength achieved by mixing over eight minutes is not sufficient to be economically justifiable. This time should be measured after all material is in the mixer.

YIELD

One sack of cement should yield approximately 20 203x203x406 mm (8x8x16in.) blocks of a compressive strength exceeding 70 kg/sq.cm (1000 psi) at 28 days. The finer the aggregate used, the lower the per sack yield. The largest aggregate should not exceed 9.5mm (3/8in.) diameter, or 1/3 of the thinnest segment of the block. Depending on the compressibility of the aggregate used, one cubic yard of mix will yield approximately 70 blocks.

RECOMMENDED MIXING PROCEDURE FOR SAND & GRAVEL AGGREGATE

1. Charge mixer with all aggregate.
2. Add all cementitious materials (Cement, Fly Ash, Lime, Etc.).
3. Dry mix combined materials (1 minute).
4. Add all required mixing water.
5. Continue mixing. Absolute minimum mixing time is 2-4 minutes
6. When tempering water is required to bring mix to consistency, mix an additional 1 minute.

MIXING SEQUENCE FOR AGGREGATES

Following is the mixing sequence that you should use for heavyweight and lightweight materials:

1. Load mixer with the total amount of materials that is needed for one batch.
2. Let the material mix for thirty to forty five seconds.
3. Add sixty percent of total water.
4. After sixty percent of total water is added, let material mix for thirty to fortyfive seconds.
5. Dump cement into mixer along with Addmix. Let material, cement, and Addmix mix for sixty seconds.

6. After mixing sixty seconds, dump the color pigment and add the balance of water.

7. After color pigment and balance of water is added, let complete batch mix for no less than two minutes.

This mixing sequence will improve your strength, as well as the color of your product.

RECOMMENDED MIXING PROCEDURE

Light Aggregates:

1. Charge mixer with all lightweight aggregate .

2. Add 1/2 of the total mixing water and mix 1 1/2 to 2 minutes. Premixing fills the pores of cellular particles before cement is added, preventing dry cement from being wasted in the pores.

3. Add all cementitious material (cement, fly ash, lime, etc.)

4. Add balance of mixing water.

5. Continue mixing for a minimum of 3 to 4 minutes.

6. When tempering is required to bring mix to right consistency, mix an additional 1/2 to 1 minute.

The subject of mixing lightweight aggregates for the products industry has long held the attention of the best informed people in the business.

The question of how much water, when this water should be added, when and how to add the cement, should the fines be placed in the mixer first, etc., have been some of the major controversial points of this problem. A great deal of research has been done on the subject with the end result being very close or exactly the same as the recommended procedure above.

Because of the high attraction of lightweight aggregates to water, it is the opinion of experts that the thirst of aggregate should be satisfied as indicated by step number two (2). Onehalf (1/2) of the total required mixing water will in most cases completely saturate all particles of lightweight aggregate.

So far as the time element is concerned, ft is the same as for sand and gravel mixing procedure. Keep in mind the important point of a minimum of 3 to 4 minutes for the socalled finish mixing time.

Another point relative to lightweight aggregates and one that has distinct bearing on the properties of the finished block is the resistance of the aggregate to attrition and

breakage during the mixing operation. Very often the actual gradation spread of material from which lightweight block are made may be somewhat lower from an F.M. (fineness modulus) standpoint because of the yielding nature of some lightweights.

This mixing procedure is also applicable to various highly absorbent limestones and other similar type aggregates.

Heavyweight Aggregates:

1. Charge mixer with all aggregate
2. Add all cementitious material (cement, fly ash, lime, etc.)
3. Dry mix combined materials 1 minute.
4. Add all required mixing water
5. Continue mixing for a minimum of 3 to 4 minutes.
6. When tempering watering is required to bring mix to consistency, mix an additional 1/2 to 1 minute.

The mixing phase of the concrete products business is one of the major factors which determines to a degree the makings of a good or bad end product.

In covering the six (6) steps for mixing sand and gravel and other types of hard aggregate, the procedure is explained in a relatively simple manner. The number three (3) and five (5) steps could be termed the most important part of the six (6) steps, although each is important in their respective sequence order.

It may be possible that your current mixing procedure is due for a check against this recommended step by step outline.

Adherence to the general sequence of this plan may also bring about marked improvements in the different quality characteristics of your block.

Strength, appearance, and the possibility of increased production are three of the major improvements that may be accomplished.

The above are only guidelines and will vary with the type of product to be produced, i.e., ready mix, block, brick, pavers, etc.

Water

In general, the correct amount of water is indicated when a compressed handful of mix will stay together in a ball while displaying a trace of moisture. A further check of processed blocks is also a good indicator of water content.

IMPORTANT FACTORS FOR MAKING QUALITY BLOCK

1. Source of raw material. Good clean aggregate.
2. Evaluation and Testing of aggregate.
3. Correct Grading and Proportioning.
4. Maximum amount of clean water. Batch design.
5. Adequate Mixing Time.
6. Block material vibrated to maximum density in the mold.
7. Steam curing in moist air for uniformity and high strength.
8. Covered storage for thorough drying.

CHARACTERISTICS OF A HIGH QUALITY BLOCK

1. Strength and design to withstand abnormal stresses when laid in the wall.
2. Sufficient impermeability to withstand serious wetting by heavy rain and the ability to dry out quickly afterwards.
3. Adherence to consistent quality, uniform size and accurate dimensions.
4. Finished unit dried to a minimum of moisture content.
5. Freedom from discoloration, popping or staining.
6. Pleasing appearance eliminating the necessity of painting except for decoration.

AGGREGATE, DEFINED: A collection of particles to form a mass or whole

The true Webster definition of Aggregate is only part of the meaning as applied to the concrete products. We must go deeper into Webster and add any hard inert material that when graduated and mixed with a cementitious material to form concrete or similar product.

The importance of Aggregate is emphasized by the fact that approximately 90-95% of the concrete block is Aggregate, the remaining percentage is cement. The percentages stated here are based on the average dry weight of sand and gravel blocks.

Quality block can be produced most readily with properly “graded” Aggregate. The judgement of a quality block is first on appearance, which should be watertight and dense and of uniform shape and exacting dimensions. The painting of walls though not mandatory, should not be essential in having a water proof wall.

The denseness of texture of a unit being acceptable, the minimum load and tensile strength requirements must also be met. The minimum standards are usually not enough and for many areas the general unit is not adequate. A loose texture may be desired in one area while a very tight and exacting unit is needed in others. The higher quality block is the most desired and can be produced with very little additional cost; this is usually offset by a premium price.

There are additional characteristics of a high quality block which are of prime importance. High rise structures now being built need a high strength and density unit to withstand the abnormal stresses imposed when laid in the wall.

The uniformity of size and accuracy of dimensions is extremely critical when the units are placed in modern construction. The appearance of the finished building is governed by the building units used and discoloration, staining and popping results from poor quality units and raw materials. These problems cannot often times even be covered by paint.

The addition of paint is often times hampered by units improperly dried or not dried at all which will take on rain and dampness, further the denseness of the units will affect the ability to paint properly for decorative purposes as well as the ability to dry out after heavy rains. Sufficient impermeability can only be assured by proper Aggregate graduation, mixing which produces quality units.

Aggregate and its source proves to be a problem in some areas, (that is, a suitable Aggregate). The supply of Aggregate you will be using and needing, consistently must be carefully assessed to assure a good supply for the uninterrupted production of top quality units. The source must be carefully analyzed to assure its availability for several years of operation. The availability of a good source of Aggregate is a factor in the savings in cement and a reduction in production costs to you.

The other factors greatly contributing to a good source of Aggregate are the reliability of the supplier and the operation he maintains as well as his equipment. A periodic check on the gradation of the Aggregate delivered to your yard will assure you of the proper material as you originally required.

FINENESS MODULUS (F.M.), DEFINED

Fineness Modulus (FM) is an index number which is roughly proportional to the average size of the particles in a given aggregate; thus the coarser the aggregate the higher the fineness modulus will be.

Fineness modulus is computed by adding the cumulative percentages retained on each sieve (pan excluded) and dividing the sum by 100.

CLASSIFICATION OF SAND

Fine Drift Sand:
Or beach sand graded up to the No. 30 (1.19mm) sieve with an F.M. of 1.50-2.50.

Medium Sand:
Graded up to the No. 8 (2.38mm) sieve with an F.M. of 2.50-3.00.

Coarse Sand:
Graded up to the No. 4 (4.76mm) sieve with an F.M. of 3.00-3.25

IMPORTANT CHARACTERISTICS OF AGGREGATE

1. CLEANLINESS: Free from clay, loam silt and organic matter such as bark, sticks, leaves, coal or other deleterious material.

2. DURABILITY: Free from soft friable particles which will disintegrate under exposure to weather conditions.

A low percentage will not effect strength of concrete but will give objectionable appearances.

CLAY TEST

The Clay Test determines the cleanliness of aggregate. Follow these simple three steps below using a 1 Quart (1 liter) glass container:

1. Put 2” of aggregate in container.

2. Add water until container is 3/4 full.

3. Shake well and let stnad 1 hour. If over 1/8’ (3mm) clay layer material must be washed before using.

RANGE OF MOISTURE CONTENT IN SAND

Sand may be in any of the 4 states shown below:

1. OVEN DRY: No moisture on surface or in interior of particles.
2. AIR DRY: Dry at surface but containing some interior moisture, less than amount required to saturate the particles.
3. SATURATED & SURFACE DRY: Dry at surface but wet inside.
4. DAMP OR WET: Wet on surface as well as inside.

HEAVYWEIGHT AGGREGATE MOISTURE COMPENSATION

The figure above provides figures which substantiate the value of compensating for surface moisture in heavyweight type aggregate.

Under normal conditions, the batch as shown is typical of the average block plant. The 133 lbs. figure in the right hand column on the bottom of the batch data page gives the approximate loss in aggregates.

If the normal condition calls for adding twenty (20) gallons of water to the batch when it is known that this typical batch on a dry weight basis would require 36 gallons, then we know that 16 gallons of water is present with the aggregate. Similarly the sixteen (16) gallons of surface moisture times (8 1/3 lbs.*).), equals 133 lbs. The 133 lbs. divided by forty (40 lbs. or the weight of the block, then represents 3.3 less block per batch).

For a more impressive concept of this, multiply this 3.3 less block per batch by 50 batches per day and the alarming figure of approximately 165 block is found.

In order to drive home this point, consider the fact that there is a loss of block per batch and that each block which is produced has a higher cement content.

Assuming cement to be one cent (.01) per pound and 3 3/4 Ibs. as the standard per sand and gravel block requirements, then $6.20 worth of cement was used in the 50 batch day. Using $6.20 per day, times a 250 day year starts to make a producer conscious of the approximate $1,550 per year worth of cement used in making less block than expected.

This cost figure becomes greater if carried out on the LIGHTWEIGHT block basis where the per block cement requirement is higher.

Producers who operate two (2) or more machines and two (2) or more shifts can effect real savings if compensation is made for the moisture content in the various types of aggregate.

A survey in your plant may reveal some startling facts that will put you on the road to substancial savings and greater yield.

Water as such when weighed across the scales and assumed to be aggregate will not make block. -

*One gallon of water weighs approximately 8 1/3 lbs. at 62 degrees F.

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 should be done to assure quality.

   C. Cementacious substitutes (Fly Ash) in various ratios i.e. Fly Ash, Micro Silica, can act as a cement substitute to various degrees

3. Mix Design.

   A. Aggregate blend (Fineness Module FM)

      i. Consistency of aggregate size and shape

      ii. Strength of aggregate used

      iii. 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.

iv. Cost and availability of aggregate in the area of the plant.

v. How clean the aggregate is i.e. no clay, or organic

vi. What is the percent of PAN in the mix design. Remember a finer mix design has more surface area than a course 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 weigh batching the water content in the sand can alter this ratio... we are weighing water and not sand and aggregate.)

C. Additives... plastizers, styrates, etc.

D. Moisture...

i. Wet mix vs. Dry mix ...

ii. How clean is the water

iii. Is water hard or soft (chemical content)

4. Curing...

A. Time available for turn around through cuber

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. ManagementWhat margin of safety do they require

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

        i. Cement chemistry

        ii. Product strength, (Compressive, Flexural)

        iii. Aggregate sieve analysis (mix design)

        iv. Abrasion resistance, water absorption, freezelthaw, 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.

Cement to Aggregate Ratlo (by Weight) for various types of Aggregate:

Type of Aggregate	Cement to Aggregate	% Cement
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.

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:

1. 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
2. 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

Wisconsin Brick and Block:

- They use an aggregate 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. 14200 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.

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    - This is approximately 4.70 lbs. (2.1 kg) per block

Cement:

- Sand possesses greater surface area to coat
- Stone less surface area to coat
- Proper blend will effect savings in reduction of cement required to bind mass together