

Examples of Mixture Proportions and Volume Fraction Calculations

- convert weight of each ingredient to volume
- determine total volume of the mixture
- determine volume fraction of each ingredient
- determine weight of each ingredient needed to achieve a total of one cubic meter (or one cubic yard)
- units and rounding are important

Definitions:

- Density** - ratio of mass to volume of a given substance; can also be calculated from specific gravity
- Specific gravity** - (also called relative density) a dimensionless quantity, ratio of the density of a material to the density of a given reference material at the same conditions of pressure and temperature. Typically the density of water at standard conditions is used (1000 kg/m³ (62.4 lb/ft³, 1684.8 lb/yd³)).
- Volume** - mass/density
- Volume fraction** - ratio of the volume of an individual ingredient in a mixture to the total volume of the mixture expressed as a percentage. Total volume fraction of all ingredients should add up to 100%.

Problem:

Standardize the following mixtures to determine the amounts required to make one cubic meter (or one cubic yard) of concrete.
 Note - these are two separate examples and are not representative of any specific mixture or ingredients; all amounts and densities were randomly chosen.

Metric units - this example shows an OVER yield mixture

ingredient list	amount used	density of ingredient	specific gravity
ingredient A	235 kg	1100 kg/m ³	1.1
ingredient B	465 kg	1420 kg/m ³	1.42
ingredient C	1550 kg	2160 kg/m ³	2.16
ingredient D	95 kg	593 kg/m ³	0.593
ingredient F	10 kg	895 kg/m ³	0.895
Total	2355 kg		

Imperial units - this example shows an UNDER yield mixture

ingredient list	amount used	density of ingredient	specific gravity
ingredient A	259 lb	1775 lb/yd ³	1.05
ingredient B	513 lb	2860 lb/yd ³	1.7
ingredient C	1425 lb	3486 lb/yd ³	2.07
ingredient D	105 lb	1258 lb/yd ³	0.747
ingredient F	13 lb	1425 lb/yd ³	0.846
Total	2315 lb		

Solution:

- Knowing the weight and density (or specific gravity) of each ingredient, determine the volume of each ingredient.
 Volume can be calculated by one of the following as appropriate/desired:

or $\left\{ \begin{array}{l} \text{metric or imperial: } \mathbf{mass / density} \\ \text{metric (m}^3\text{): } \mathbf{mass / (specific\ gravity * 1000)} \\ \text{imperial (yd}^3\text{): } \mathbf{mass / (specific\ gravity * 1684.8)} \\ \text{imperial (ft}^3\text{): } \mathbf{mass / (specific\ gravity * 62.4)} \end{array} \right.$

The volume of each ingredient is shown below, rounded to 6 significant digits just as an example.

ingredient list	volume
ingredient A	0.213636 m ³
ingredient B	0.327465 m ³
ingredient C	0.717593 m ³
ingredient D	0.160202 m ³
ingredient F	0.011173 m ³

ingredient list	volume
ingredient A	0.145915 yd ³
ingredient B	0.179371 yd ³
ingredient C	0.408778 yd ³
ingredient D	0.083466 yd ³
ingredient F	0.009123 yd ³

- Determine total volume of mixture

The total volume of each mixture is:

Metric - 1.430069 m³

Imperial - 0.826653 yd³

3. Determine volume fraction of each ingredient.

Volume fraction is calculated by: volume of ingredient / total volume * 100 (%)

Total volume fraction of all ingredients should equal 100%.

The volume fraction of each ingredient is shown below, rounded to 6 significant digits just as an example.

ingredient list	volume fraction
ingredient A	14.938882 %
ingredient B	22.898526 %
ingredient C	50.178869 %
ingredient D	11.202419 %
ingredient F	0.781304 %

ingredient list	volume fraction
ingredient A	17.651366 %
ingredient B	21.698426 %
ingredient C	49.449782 %
ingredient D	10.096842 %
ingredient F	1.103584 %

4. Determine amount of each ingredient needed to achieve a total of one cubic meter (or one cubic yard) of concrete.

Weight of each ingredient is calculated by: volume fraction of ingredient * ingredient density / 100

The amount per cubic meter (cubic yard) needed of each ingredient is shown below, rounded to 2 significant digits just as an example.

ingredient list	amount for 1 m ³
ingredient A	164.33 kg
ingredient B	325.16 kg
ingredient C	1083.86 kg
ingredient D	66.43 kg
ingredient F	6.99 kg
Total	1646.77 kg

ingredient list	amount for 1 yd ³
ingredient A	313.31 lb
ingredient B	620.57 lb
ingredient C	1723.82 lb
ingredient D	127.02 lb
ingredient F	15.73 lb
Total	2800.45 lb

5. Report amounts per cubic meter (cubic yard) and volume fractions on Submittal sheet being sure to use appropriate significant digits as indicated in the Rules and Submittal example.