Concrete Materials

Concrete Ingredients

Portland Cement

Water

Fine Aggregate

Coarse Aggregate

Supplementary Cementitious Materials

Chemical Admixtures

Important Aggregate Properties

Crushing strength

Deleterious substances

Shape and texture

Hardness

Soundness

Chemical stability

Gradation / Fineness Modulus

Relative density and absorption

Dry-rodded unit weight

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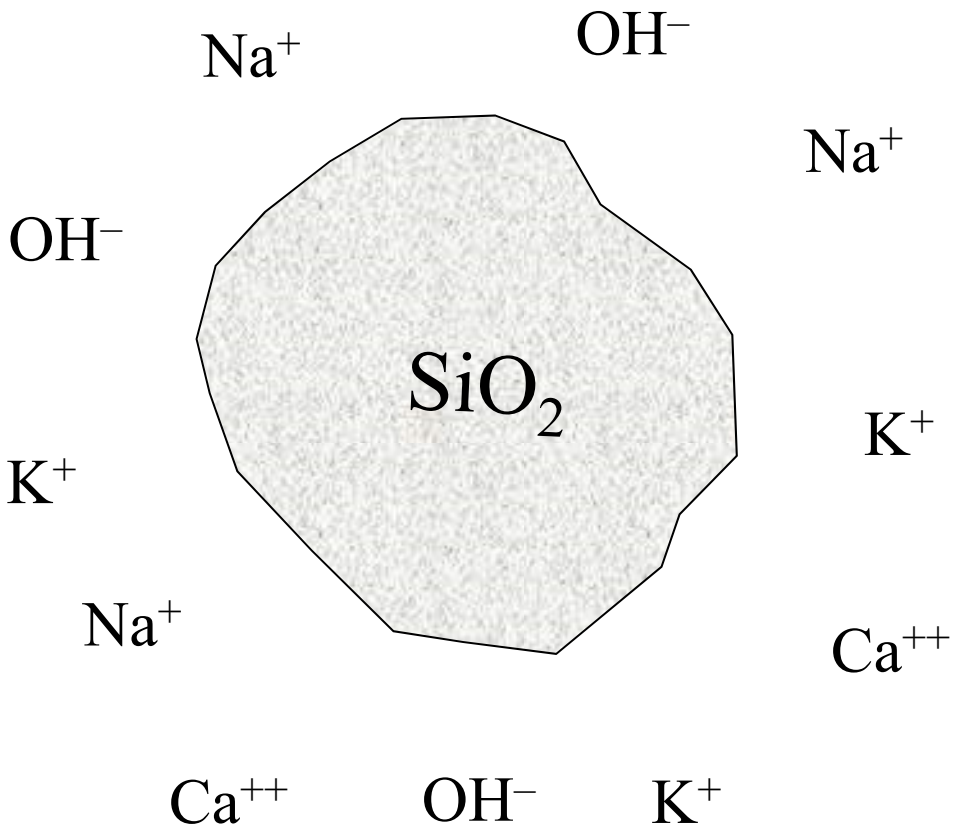
Reactive Aggregate (ASR)

Map Cracking

Alkali-Silica Reaction

Alkali-silica reaction occurs when aggregates containing non-crystalline (amorphous) silica react with alkali hydroxide in cement paste to form a gel that swells as it adsorbs water from the surrounding cement paste or the environment. These gels can induce enough expansive pressure to damage the concrete.

What is ASR?



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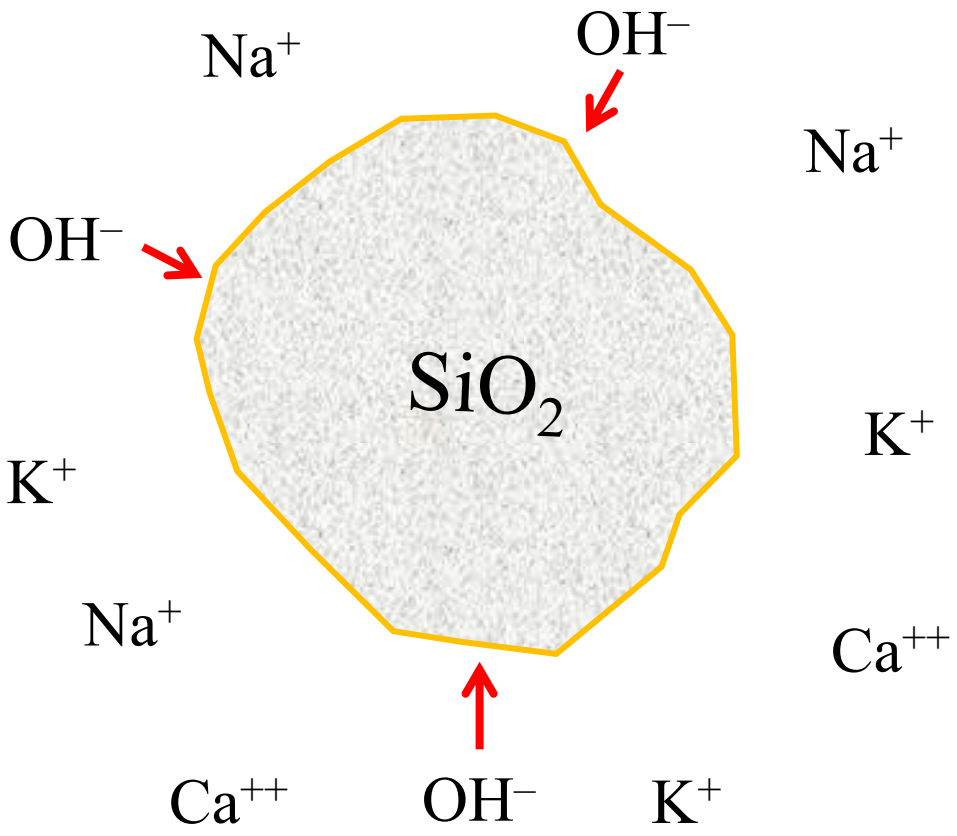

Hydroxyl ions are attracted to the reactive silica

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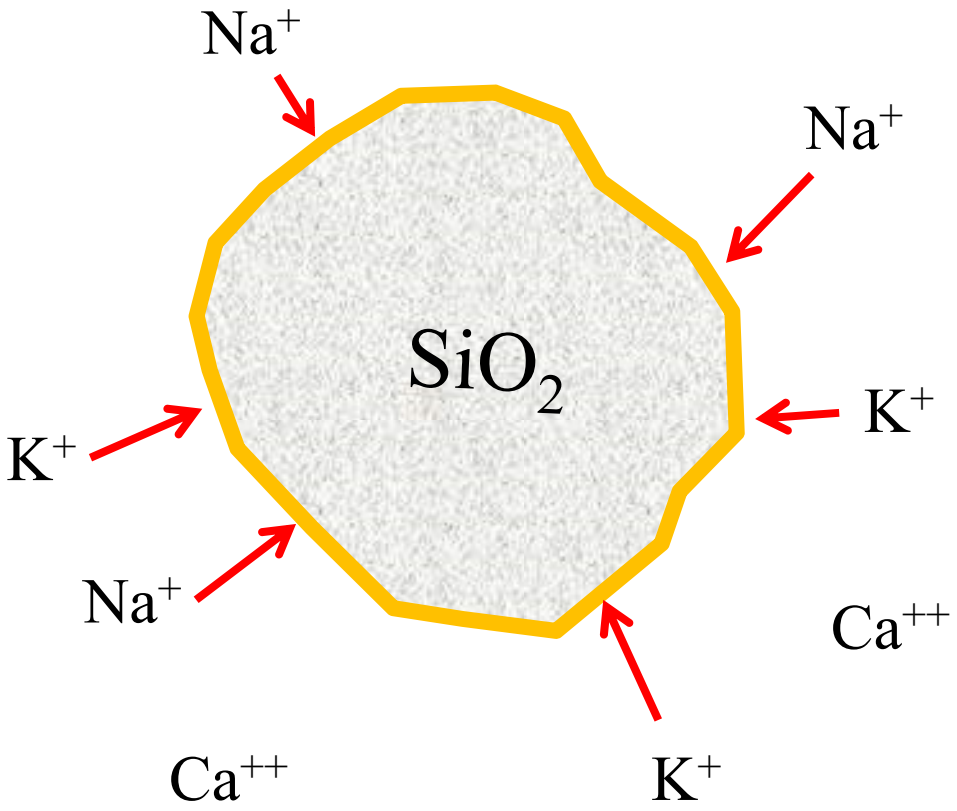

C-N-S-H and C-K-S-H gel forms from alkali in the cement

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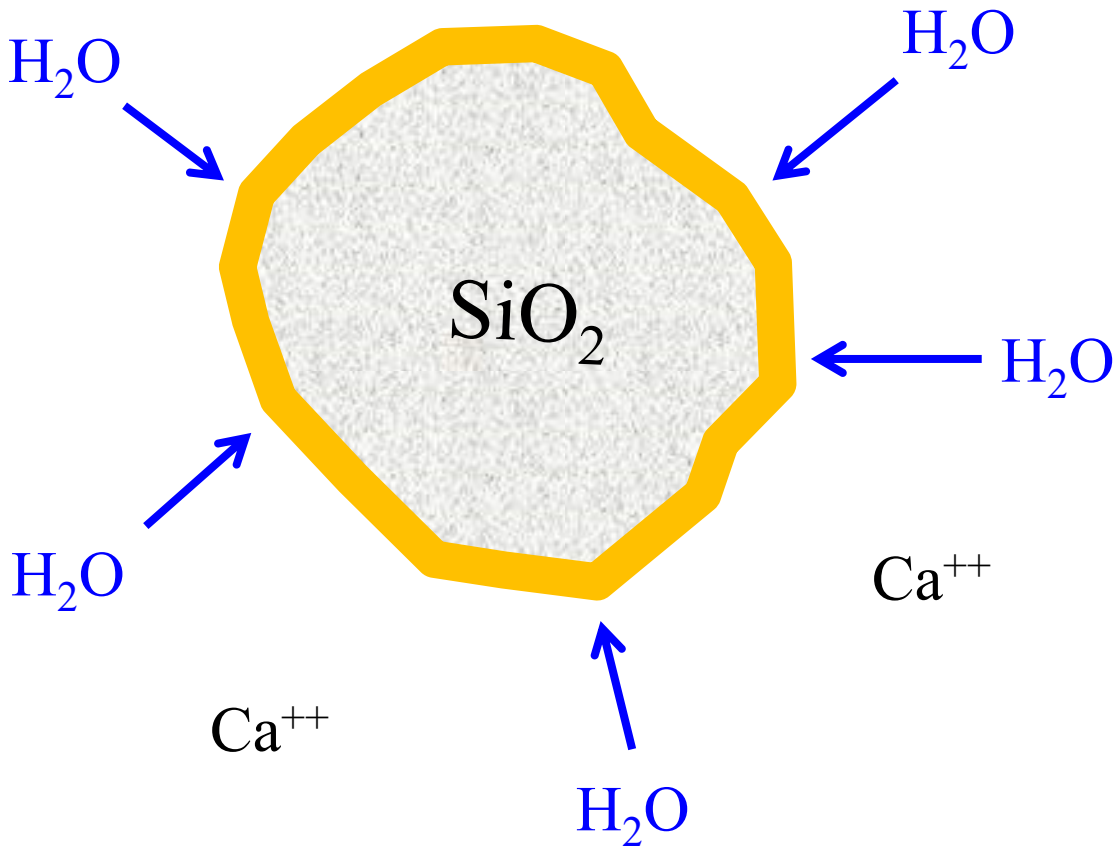

C-N-S-H and C-K-S-H gel attracts water

Alkali-Silica Reaction

Alkali-silica reaction can be controlled using certain supplementary cementitious materials. In the proper proportions, silica fume, fly ash, and ground granulated blast-furnace slag can significantly reduce or eliminate expansion due to alkali-silica reactivity. Lithium compounds have also been used to reduce ASR.

Important Aggregate Properties

Crushing strength

Deleterious substances

Shape and texture

Hardness

Soundness

Chemical stability

Gradation / Fineness Modulus

Relative density and absorption

Dry-rodded unit weight

Coarse Aggregate

TDOT Specs for Concrete Coarse Aggregate

Application	Size No.
Concrete Pavement	467
Concrete Base Course	467
Cement Treated Base Course	57
Structural Concrete	57
Prestressed Concrete	57 or 67
Precast Concrete	57 or 67

Coarse Aggregate

TDOT Specs for Concrete Coarse Aggregate

Application	NMAS
Concrete Pavement	2"
Concrete Base Course	2"
Cement Treated Base Course	1½"
Structural Concrete	1½"
Prestressed Concrete	1½" or 1"
Precast Concrete	1½" or 1"

Coarse Aggregate

$$\text{NMAS} \leq \frac{\text{depth of slab}}{3}$$

$$\text{NMAS} \leq \frac{\text{narrowest dimension}}{5}$$

$$\text{NMAS} \leq \frac{3}{4} \times \text{clear space}$$

Coarse Aggregate

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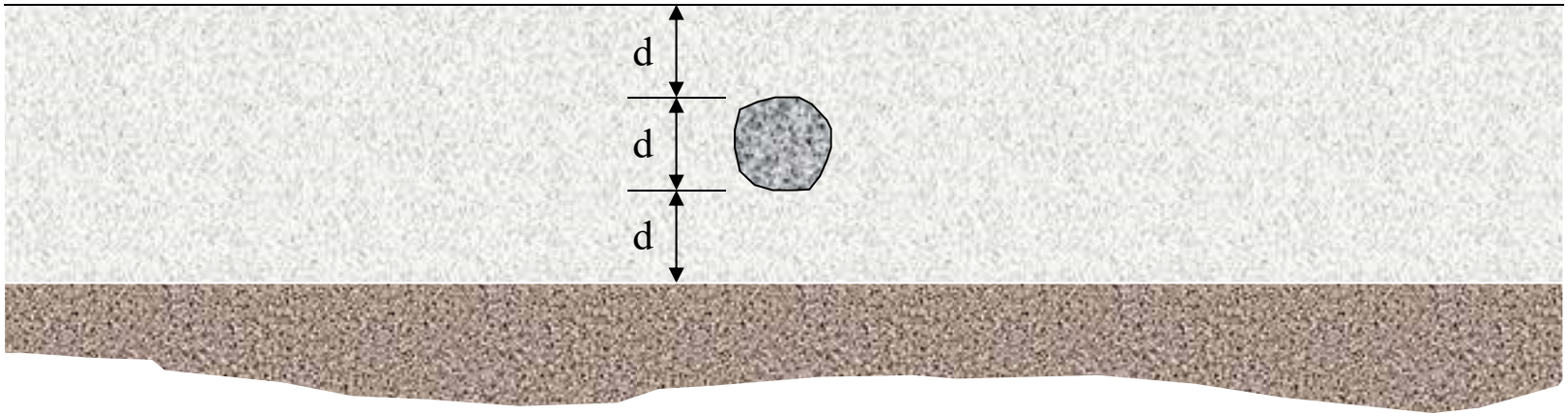
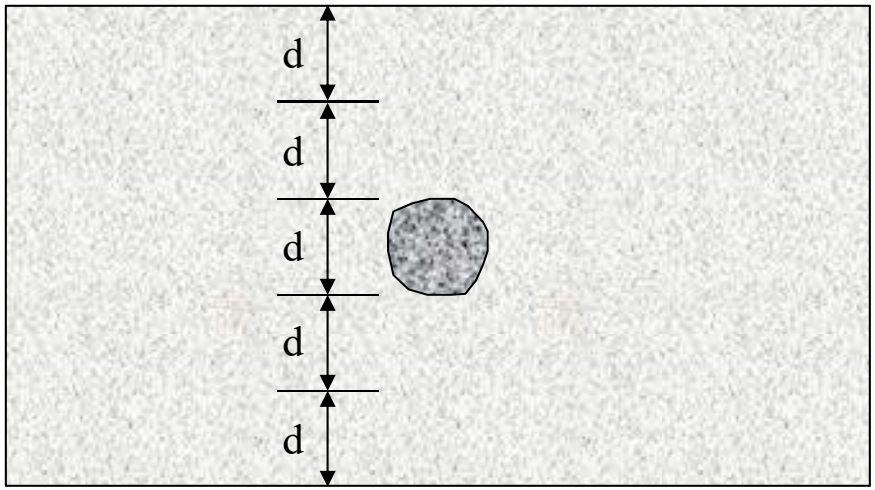


Coarse Aggregate

$$\text{NMAS} \leq \frac{\text{narrowest dimension}}{5}$$



Coarse Aggregate

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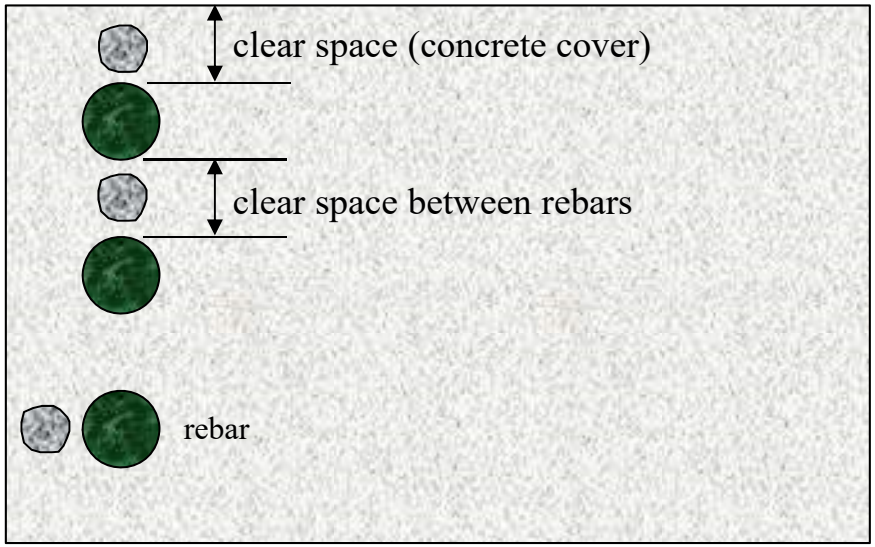


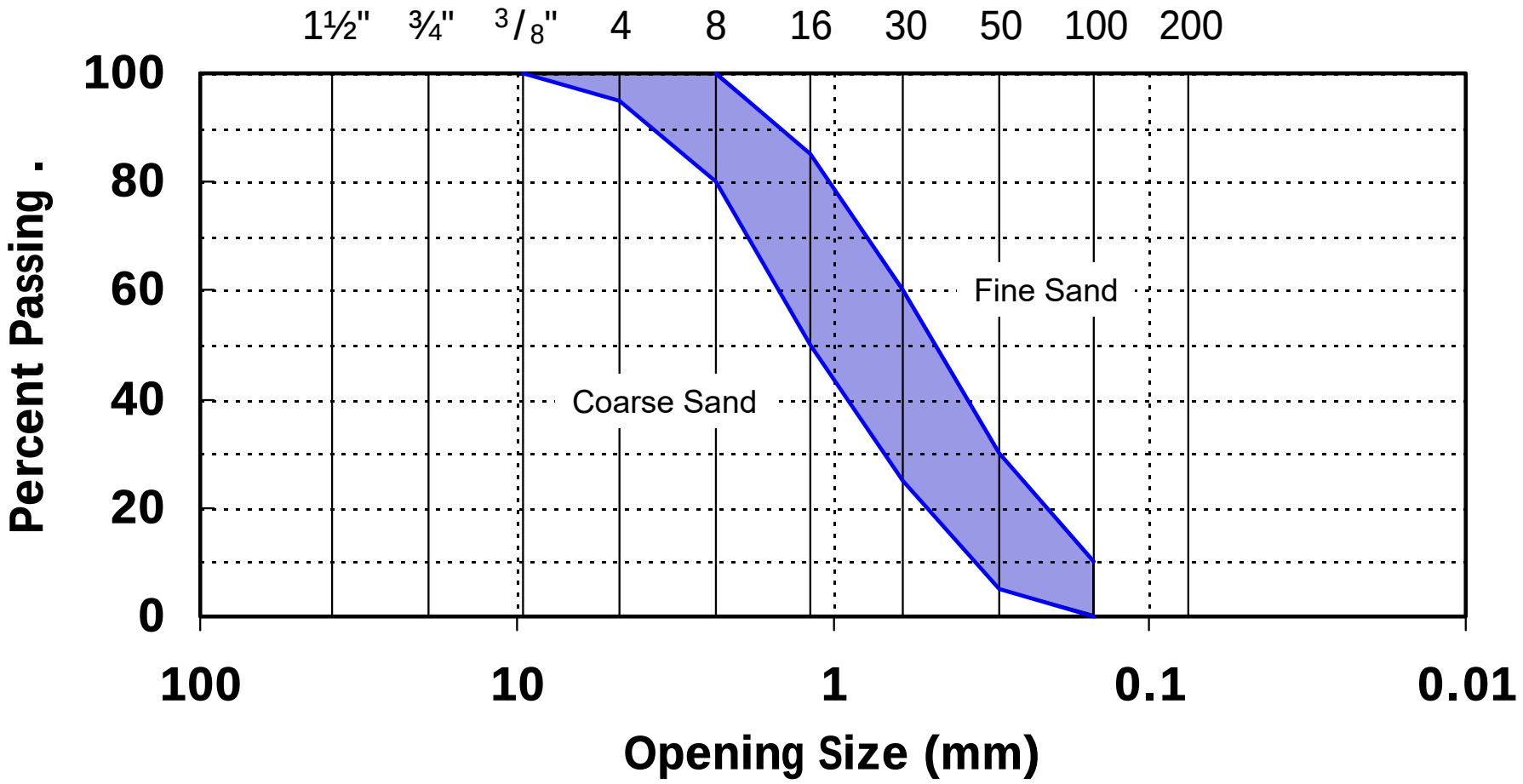
Fine Aggregate

Table 5-3. Fine-Aggregate Grading Limits (ASTM C 33/AASHTO M 6)

Sieve size		Percent passing by mass	
9.5 mm	(⅜ in.)	100	
4.75 mm	(No. 4)	95 to 100	
2.36 mm	(No. 8)	80 to 100	
1.18 mm	(No. 16)	50 to 85	
600 µm	(No. 30)	25 to 60	
300 µm	(No. 50)	5 to 30	(AASHTO 10 to 30)
150 µm	(No. 100)	0 to 10	(AASHTO 2 to 10)

Source: Design and Control of Concrete Mixtures (PCA, 2007)

ASTM C-33 Sand



Fineness Modulus

Fineness modulus (*n.*) an index of the coarseness or fineness of an aggregate; it is computed as the sum of the fraction retained on each full series sieve starting from the No. 100 sieve.

Fineness Modulus Example

Sieve Designation	Cumulative Weight Retained (g)	Cumulative Percent Retained (%)	Cumulative Percent Passing (%)
1/2 in.	0	0	100
3/8 in.	0	0	100
No. 4	0	0	100
No. 8	99.0	10	90
No. 16	317.4	32	68
No. 30	575.4	58	42
No. 50	793.6	80	20
No. 100	932.5	94	6
No. 200	972.2	98	2
Pan	992.5	100	0

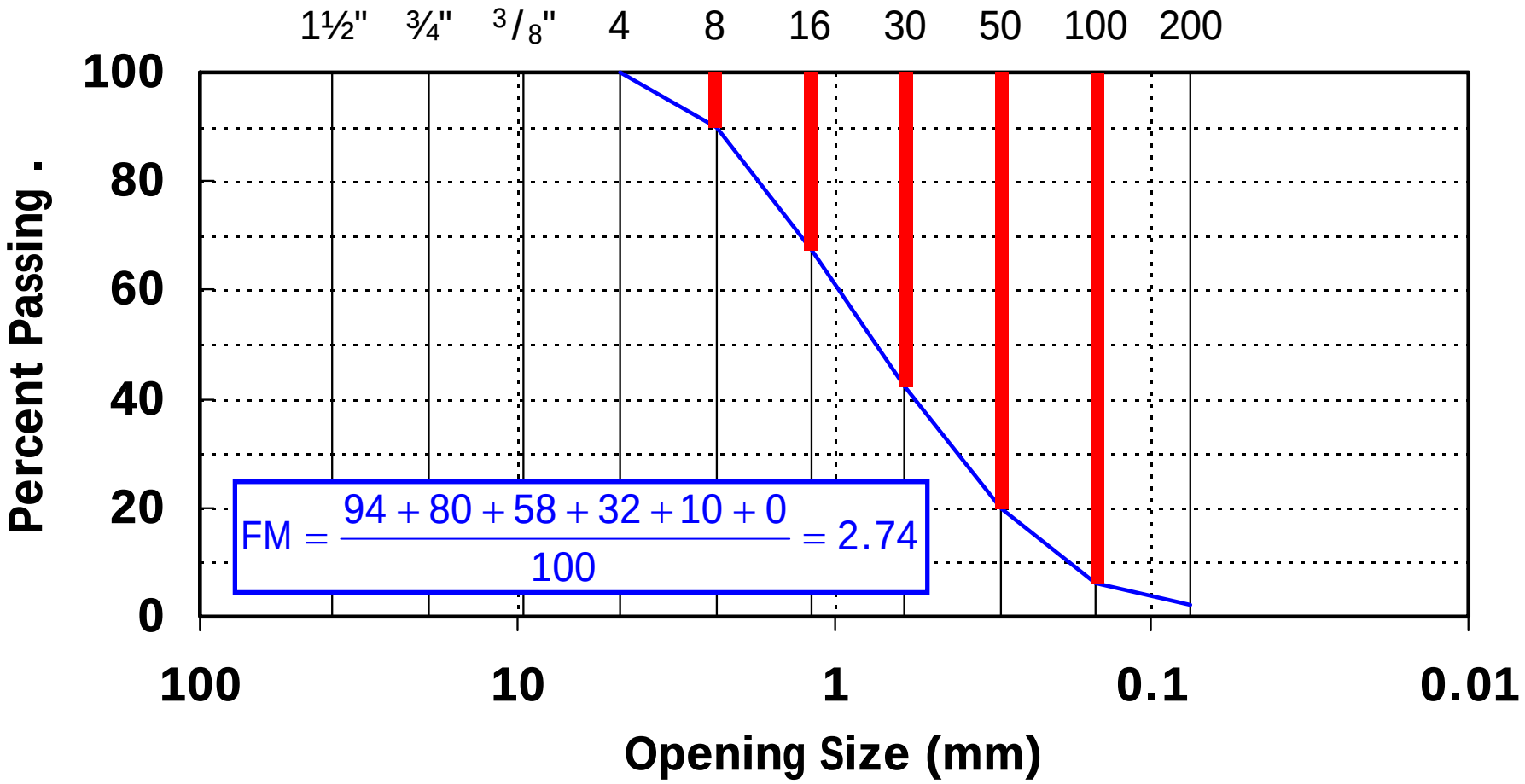
$\Sigma = 274\% \therefore FM = 2.74$

Fineness Modulus

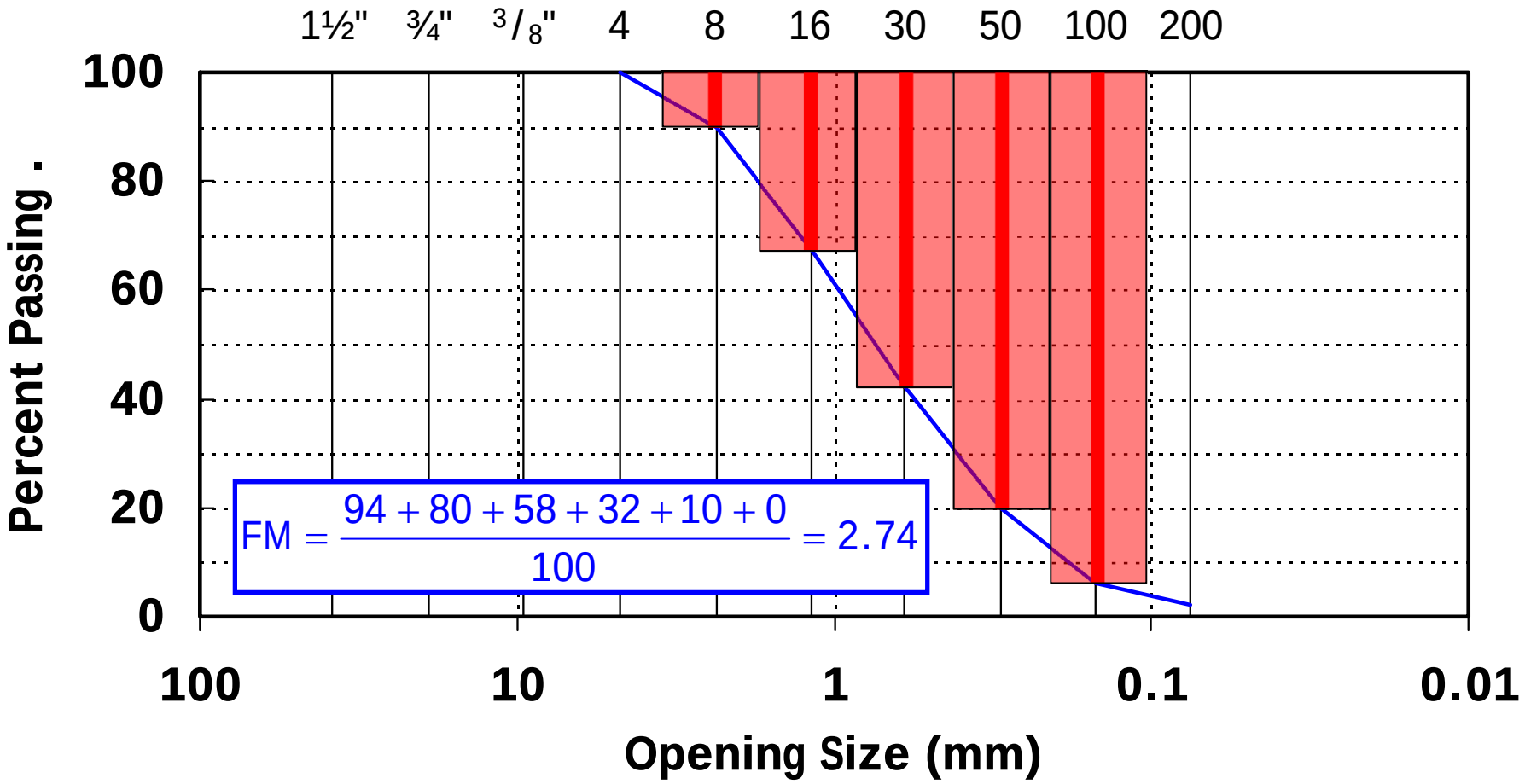
So what is the fineness modulus trying to tell us?

If you plot the gradation curve, the percent retained is the length of a line drawn from the curve to the top of the plot. Since we only use full series sieves, the data points are equally spaced along the opening size axis. If you assign a relative width of one to each line, the fineness modulus is really an approximation of the area above the gradation curve. The greater the area, the coarser the sand.

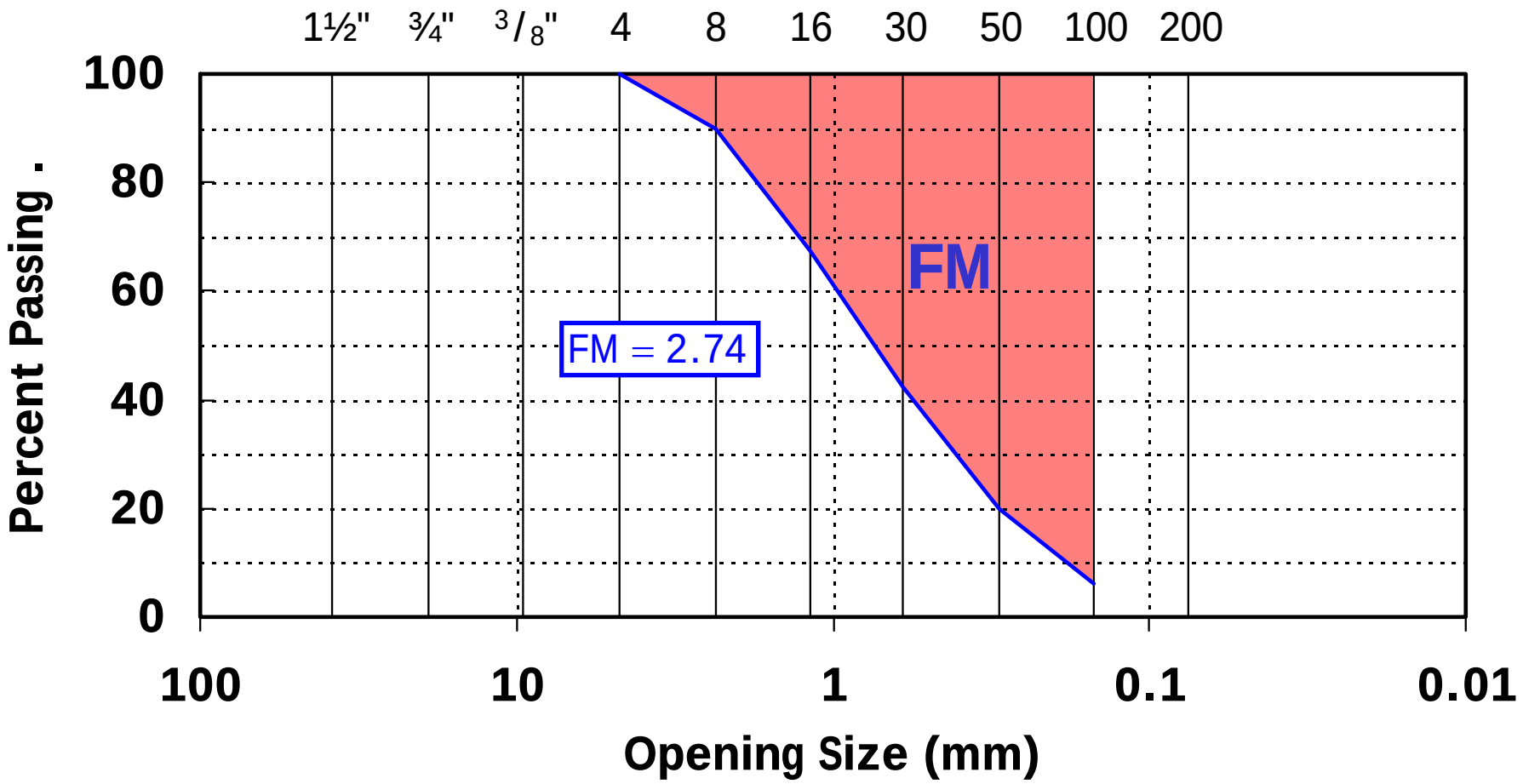
Fineness Modulus



Fineness Modulus



Fineness Modulus

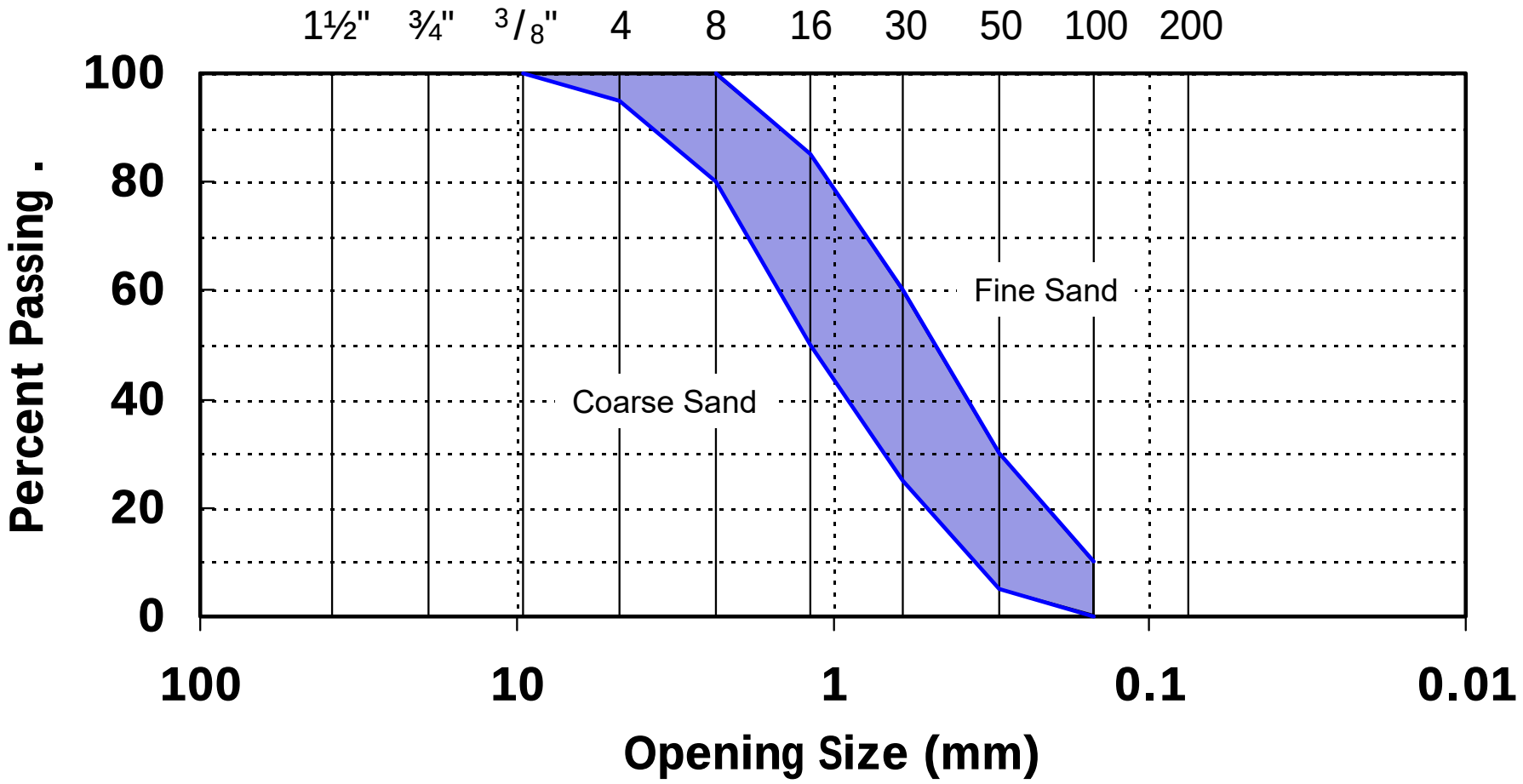


Fineness Modulus

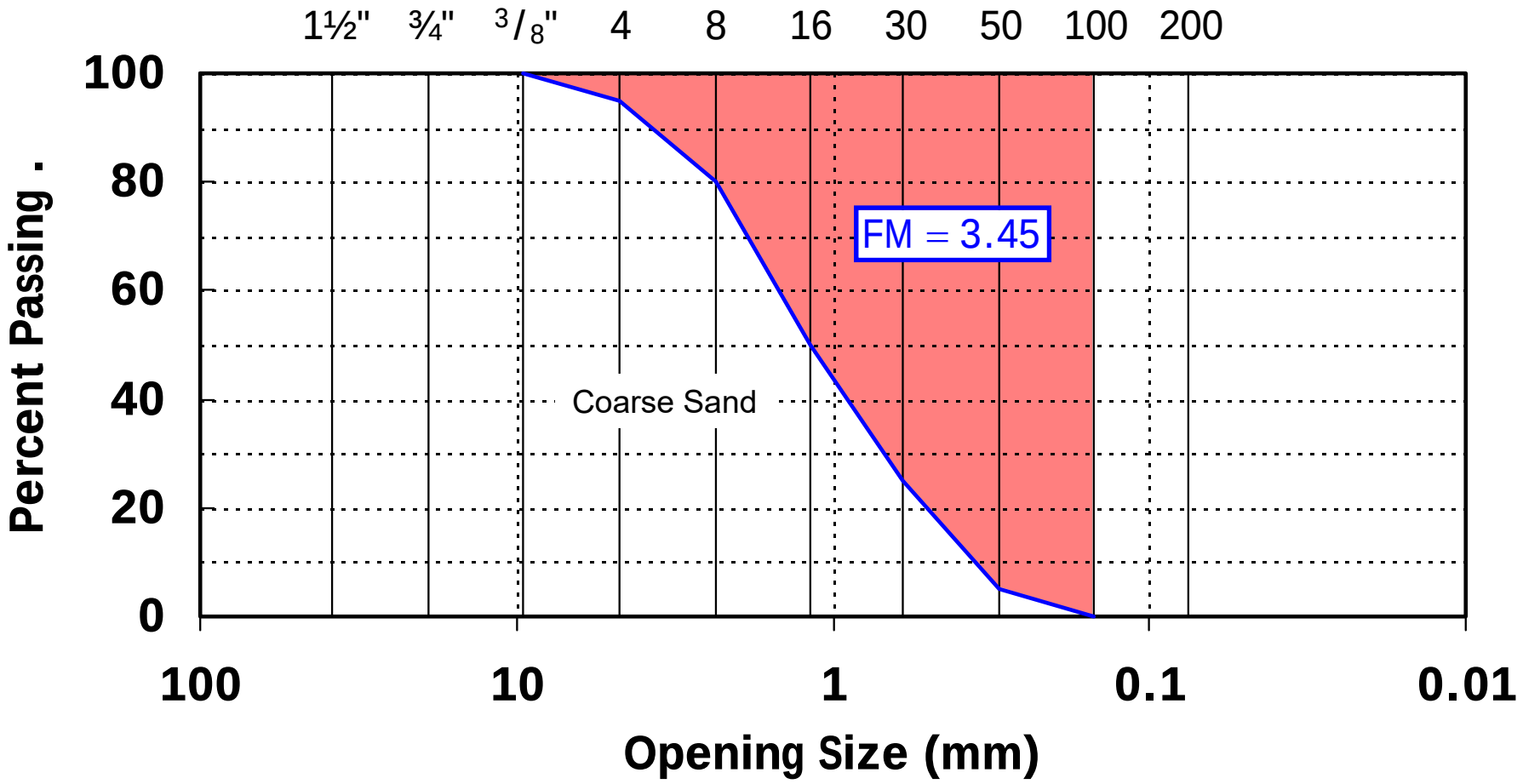
If we examine the ASTM specification for concrete sand, the lower bound of the gradation specification represents the coarsest possible sand you could use and the upper bound of the specification represents the finest possible sand.

The fineness moduli of those two gradations are 3.45 and 2.15, respectively. So, despite the name, fineness modulus is an index measurement of the coarseness of the sand!

ASTM C-33 Sand



ASTM C-33 Coarse Sand



ASTM C-33 Fine Sand