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ESSENTIALS FOR DURABLE CONCRETE

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Concrete is the mass formed by combining cement, sand, gravel, and water. It hardens because of the chemical reaction between the cement and the water. Each particle of sand and gravel is coated with a cement-water film, which upon setting, forms a bond tying the particles together. The aggregate thus acts only as a filler.

In making concrete, consideration must be given a number of factors if the finished product is to give satisfactory service. Concrete mixes are generally designed to withstand specific exposure conditions, rather than to meet certain strength requirements.

Materials Should Be of Good Quality

Little need be said here about the cement since all portland cements must conform to standard specifications. Cement that is exposed to dampness for any length of time becomes lumpy and is unsuitable for important concrete work. Under certain exposure conditions, such as alkali, the selection of a cement high in resistance to sulphate waters is important.

A sand in which much dirt, shale, or foreign material of any kind is present is undesirable for concrete, although small quantities of finely divided silt and clay may or may not affect its concrete-making qualities. Gravel in which any appreciable quantity of shale is found should be avoided.

The proportions of sand and gravel should be combined to give the densest mixture possible and such that the combination of materials can be made plastic with as little mixing water as possible. The maximum size of the gravel is governed by the type of construction, and in no case should aggregate be used larger than one-fifth the thickness of the section, or larger than three-quarters the size of opening between reinforcing rods. If there is any doubt about the quality of the aggregate, have it tested. Generally it will be more satisfactory to buy well graded aggregate from a local commercial concern known to sell good material.

Most any water that is fit for drinking is suitable for concrete work. The presence of oils, acids, vegetable matter, and salts may be injurious to concrete.

Do Not Use Too Much Mixing Water

One of the principal factors affecting the durability of concrete is the amount of mixing water used with each bag of cement. Remember that the less water used, the better the concrete, provided

the concrete can be properly placed. Use only enough water to make the mix workable.

The cement-water film between the aggregate particles can be thought of as a paste. The more water you add, the more you dilute the paste, and this weakens the concrete very appreciably. A thin, wet paste upon hardening will not form the strong, dense binding medium so essential to durable concrete.

Five and one-half gallons of water per bag of cement will make concrete that will resist the severest weathering conditions, such as exposure to alternate wetting and drying, and freezing and thawing. The amount of moisture in the sand and gravel must be included in the total water. The following figures give the approximate quantities of surface water carried by an average aggregate.

Very wet sand.....	7/8 gal. per cu. ft.
Moderately wet sand.....	1/2 " " " "
Moist sand.....	1/4 " " " "
Moist gravel.....	1/4 " " " "

Following is a table giving the materials required for one cubic yard of concrete, using two sizes of aggregate, a one-inch maximum aggregate and a two-inch maximum aggregate. The total water used is 5 1/2 gallons per bag of cement. The surface moisture in the aggregate is included in the 5 1/2 gallons. One cubic foot of dry sand will weigh about 110 pounds and one cubic foot of dry gravel will weigh about 100 pounds. Due to bulking, one cubic foot of damp sand will weigh less, ordinarily 90 to 100 pounds.

The water, sand, and gravel should be accurately measured. Cement is sold in sacks weighing 94 pounds and equal in volume to one cubic foot.

Mixing

It is important to mix the materials thoroughly. If using a mixer do not overload, and run mixes at least one minute after all materials are added. Longer periods of mixing will somewhat increase the strength of the concrete.

Placing

Concrete must be placed in the forms with some care to prevent the materials from separating. The layers should not be over one to two feet thick, and each layer should be spaded to remove all air pockets and settle the concrete, thus making a smooth surface. To avoid checking or cracking do not trowel or finish surface of concrete until it has hardened long enough to be quite stiff. If the mix is very dry it will be stiff enough when placed to trowel almost immediately, but if wet one must wait one-half hour or longer before troweling.

Curing

The chemical reaction between cement and water is dependent upon moisture and temperature. In the presence of moisture this chemical reaction goes on indefinitely. When the water used in mixing evaporates the reaction ceases. Therefore, it is important to protect the concrete from early drying by covering exposed surfaces with damp materials which should be sprinkled regularly to insure no drying out of the concrete. This outside moist curing should start as soon as concrete has hardened enough to prevent marring and should continue for at least seven days with regular portland cement. In freezing weather the temperature of the concrete should be kept about 70° F. for three days or above 50° F. for five days.

Quantities of Materials for One Cubic Yard of Concrete
Using 5 1/2 Gallons of Water

Consistency	Mix—Dry, Loose			Quantities for 1 Cu. Yd.—Measured Dry				Quantities for 1 Cu. Yd.—Measured Damp				
	Cement sacks	Sand cu. ft.	Coarse aggregate cu. ft.	Cement sacks	Sand		Coarse aggregate		Sand		Coarse aggregate	
					Cu. ft.	Cu. yd.	Cu. ft.	Cu. yd.	Cu. ft.	Cu. yd.	Cu. ft.	Cu. yd.
1-Inch Maximum Aggregate												
Stiff	1	2	3	6.2	12.4	.46	18.6	.68	14.9	.55	19.8	.73
Medium	1	1 3/4	2 1/2	7.0	12.2	.45	17.4	.64	14.6	.54	18.5	.68
Wet	1	1 1/2	2	7.9	11.9	.44	15.8	.58	14.2	.53	16.8	.62
2-Inch Maximum Aggregate												
Stiff	1	2	3 1/2	5.8	11.6	.43	20.3	.76	13.9	.52	21.5	.81
Medium	1	1 3/4	3	6.5	11.3	.42	19.4	.72	13.6	.51	20.6	.76
Wet	1	1 1/2	2 1/2	7.3	11.0	.41	18.1	.67	13.2	.49	19.2	.71