Guide to Selecting Proportions for Pumpable Concrete

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This guide addresses methods for selecting proportions for hydraulic-cement concrete placed by pumping. Specific numerical guidelines are given as applicable to mixture component proportions that lead to the most efficient concrete pumping results. Comments are also included in this guide on how pumping affects the supplied concrete and how the proportions affect the concrete's pumpability. This guide complements ACI 304.2R and is also intended as a supplement to ACI 211.1 and ACI 211.2.

The mass of an object is defined as the amount of matter that is present. Mass is independent of any other property; weight is the force arising from specific gravitational field or other acceleration acting on a mass. The weight is thus dependent on both the mass and the acceleration due to gravity rotation. In the common engineering system, a pound of mass is accelerated by gravity to be 1 lb of force. There is no need for distinction, and mass and weight are often used interchangeably in that the numerical values are the same. A mass of 1 lb exerts a weight of 1 lb. There is a hidden gravitational constant. In the SI system, mass is expressed in grams and weight in Newtons. A mass of 1 kg exerts a weight of 9.81 N. It is correct, therefore, to use the term "mass" when determining how much material is being loaded into the plant, and when the mixtures are designed and proportioned. The industry, however, conventionally uses weight for these items. In the common measurement system, this creates no confusion. Thus, the vernacular term for the massing

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elements of the concrete plant is the weigh hopper. The batch record showing masses of materials in the concrete mixture are collectively referred to as batch weights. In an acknowledgement of this widespread industry practice, and to make the document as widely useable as possible, the term "weight" is used throughout to represent mass in the text. This is technically incorrect but is in line with common practice. In all conversions, both mass and weight are given (kilograms and Newtons).

Keywords: admixtures; aggregate; cementitious material; concrete mixture design; fiber; grading; fineness modulus; lightweight aggregate; mass concrete; normalweight aggregate; pumpability; unit weight.

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

As construction projects grow more sophisticated, concrete placement by pumps has become one of the most widely used practices in construction. To meet the demand of the industry, concrete mixture proportions need to be designed considering pumpability requirements. However, when proportioning a mixture, pumpability is only one of several factors. Because hardened properties determine the durability and serviceability of concrete, the professional responsible for design of concrete mixtures should also consider exposure conditions, strength, curing characteristics, flowability, sustainability, delivery, and placement. In some cases, where these are in direct conflict, a compromise or alternative solution is required. Given the prevalence and benefits of placement by pumping, it is sometimes critical to certain applications that the components and their mixture proportions be designed with consideration to pumpability. The extent to which attention should be given to the components and proportions in a mixture depends on the application and equipment being used.

1.2—Scope

This guide addresses methods for selecting proportions specific to hydraulic-cement concrete to be placed by pumping. The primary focus of this document is to discuss the principles of mixture proportioning for normalweight and lightweight concrete. Any specific information regarding pumping equipment and field practices are covered elsewhere (ACI 304.2R). The methods provided for selecting proportions for hydraulic cement begin with an approximation of the proportions intended to be checked by trial batches in the laboratory or field, which will then be adjusted as necessary to produce the desired pumpability characteristics while confirming it meets the other performance requirements such as durability and strength. Selection of the mixture proportions should be done by considering both fresh and hardened properties required for a given application. The size of the pump and pump line should be evaluated to accommodate the volume of coarse aggregates and nominal maximum aggregate size used in the mixture. This guide does not address slump because concrete of all slumps and slump flows can be successfully pumped, provided the proper equipment and mixture proportions are used. Slump or slump flow should meet other project and application requirements, as discussed in ACI 211.1.

CHAPTER 2—DEFINITIONS

Please refer to the latest version of "ACI Concrete Terminology" for a comprehensive list of definitions.

CHAPTER 3—AGGREGATE GRADING

3.1—Considerations

Quality concrete proportioning begins with the appropriate combined aggregate grading. This is also true for pumpable concrete. Consistency in grading promotes consistency in the pumpability of any mixture. Thus, aggregate grading should be monitored and blends adjusted when required to assure consistency in the combined aggregate grading.

3.2—Normalweight aggregate

3.2.1 *Coarse normalweight aggregate*—The nominal maximum size (NMS) of coarse aggregate is limited to one-third of the smallest inside diameter of the pipeline. The NMS required should be specified and provisions made for the elimination of oversized particles in the concrete by use of finish screening (ACI 304R; ASTM C33/C33M) or by careful selection of coarse aggregate.

The NMS has a significant effect on the volume of coarse aggregate that may be efficiently used. The quantity of coarse aggregate should be reduced as the NMS is reduced