IN-LB	Inch-Pound Units
SI	International System of Units

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Guide for Use of Volumetric-Measuring and Continuous-Mixing Concrete Equipment

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This guide includes a short history of and information on the basic design and operation of equipment, frequently called mobile mixers, used to produce concrete by volumetric measurement and continuous mixing (VMCM). Definitions, applications, and quality assurance testing are discussed. The use of this equipment is compared with weigh-batch-mixing equipment to highlight some of the limited differences.

Keywords: batcher; continuous mixer; flowing (self-consolidating) concrete; fresh concrete; grout; high-early-strength concrete; latex; mixer; no-fines (pervious) concrete; overlay; precast concrete; shotcrete.

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

This document offers guidance on volumetric-measurement and continuous-mixing (VMCM) concrete production. The original and most common use of VMCM equipment is as mobile (either truck- or trailer-mounted) equipment. Because of its compact size, ability to produce mixed concrete, and versatility, a significant number of stationary units have been produced. This configuration provides a free-standing base and is typically powered by electrical circuits normally found in a precast plant or other industrial facility. Unless specifically noted, the information in this document applies to all VMCM equipment.

1.2—Scope

This guide contains background information to be considered when using the VMCM method. A discussion of other types of continuous-measurement equipment (conveyor belt scales or weigh-in-motion scales) is outside the scope of this report.

1.3—History

Volumetric measurement and continuous mixing have a long history in the production of concrete. For many years, the concept of "one shovel of cement, two shovels of sand, and three shovels of stone" was used to produce concrete. Patents on continuous mixers date back at least to 1913. It was not until volumetric measurement and continuous mixing were successfully combined in the early 1960s that general field use of this type of equipment began. The first commercial unit was delivered in 1964. Because of the detail of original patents, there was only one manufacturer of VMCM units until the early 1980s, when other manufacturers began to offer this type of equipment for concrete production.

By the mid-1970s, there were over 4000 VMCM machines in operation in the United States that were generally used to produce small volumes of concrete. During the late 1970s and early 1980s, specialty concretes needed for bridge-deck renovation and highway repair, which were difficult to produce in conventional transit mixers, were produced successfully with VMCM equipment. This application gave the equipment credence by proving that it could consistently produce close-tolerance, high-quality concrete. VMCM equipment was previously thought to be limited to producing special mixtures or small volumes; however, VMCM may be suitable for almost any concrete requirement.

Standards activities related to concrete produced by VMCM equipment have been increasing as the field units increase. In 1971, ASTM developed C685, and now maintains ASTM C685/C685M. The American Association of State Highway and Transportation Officials covers VMCM equipment in M 241. In 1993, ACI published ACI 548.4, "Standard Specification for Latex Modified Concrete (LMC) Overlays," which lists mobile mixers as the equipment used to produce this product, and designates ASTM C685/C685M as the standard by which these units are defined. In 1999, a group of VMCM equipment manufacturers approached the National Ready Mixed Concrete Association (NRMCA) for assistance in forming the Volumetric Mixer Manufacturer Bureau (VMMB). The VMMB was formed, and in 2001 published VMMB 100-01, which defines the volume of ingredients needed to produce a cubic yard of concrete, and references ASTM C685/C685M uniformity requirements as the measure of accuracy in this type of equipment.

CHAPTER 2—DEFINITIONS

measuring, volumetric—dispensing an ingredient based on volume, either in discrete quantities or by continuous flow.

mixing, continuous—producing concrete by continuously blending ingredients in fixed proportions. The discharge of the concrete mixture may be started or stopped as required.

CHAPTER 3—EQUIPMENT

3.1—Materials storage and measurement

Measurement of material by volume can be accomplished by a variety of means. Rotary vane feeders (both horizontal and vertical axis), screw conveyors (both adjustable and fixed speed), drag chains, calibrated gate openings, variable-volume sliding compartments, and vibrating plate feeders have been used to measure quantities of dry ingredients. Liquids can be introduced by air pressure, pumps, or cylinders, with the flow controlled by valves or timers and measured by flow meters. Whichever methods of material metering are used, they should be consistent to ensure the production of a proper mixture. Documents produced by the equipment manufacturers should be referenced for operating details of the various types of equipment. Cement, water, and admixtures are stored in separate containers and are measured separately. Fine and coarse aggregates are stored either separately or combined. If aggregates are stored and used in a combined state, they should be accurately preblended, and particular care should be taken to avoid segregation.

A meter or other indicator on the equipment records the amount and the rate of introduction of cement into the mixture, and this rate serves, directly or indirectly, to control the rate at which other ingredients are added. All systems are interconnected so that once they are calibrated and set to produce a specific concrete mixture, all ingredients are simultaneously and continuously measured into the mixer. This interconnecting allows either continuous or intermittent operation of the system to accommodate the quantities of the concrete needed. These interconnections should not be confused with the interlocks typically found in weigh-type batch plants. VMCM equipment is designed to allow the relative proportions of ingredients to be changed rapidly to vary the concrete mixture as required. Because the mixing chamber only holds approximately 4 ft^3 (0.10 m^3), such changes can be made with little or no waste. Typical VMCM units carry enough materials to produce 6 to 10 yd^3 (4.5 to 8 m^3) of concrete (Fig. 3.1). This limitation is based on axle loading limitations. Production of larger volumes of concrete or high rates of production will require provisions for recharging the material storage compartments.

3.2—Mixers

Most continuous mixers use an auger rotated in a sloped trough or tube. Materials are introduced at or near the lower end, and the mixed concrete is discharged at the other. This basic principle is the same for all VMCM equipment, although there are many individual variations. Augers are available in different lengths and diameters, can operate at different speeds, and can have continuous or interrupted flights. Troughs may have flexible or rigid bottoms and covered or open tops. The slope of the mixer may be fixed or adjustable. Lowering the trough (which is normally set at about a 15-degree inclination) may reduce the mixing time, while raising the trough may extend it. Mixing time can be adjusted by modifying the mixer angle of inclination, mixer rpm, mixer flighting configuration, throughput rate, or a combination of these. Actual mixing time from input to output is usually less than 20 seconds. Mixing times as long as 45 seconds have been achieved, but this comes at a considerable reduction in production throughput.

With this type of mixer, output is always equal to input, with a relatively small amount of material being mixed at any one time. Thorough mixing is accomplished in a very short time by applying high-shear, high-energy mixing to the

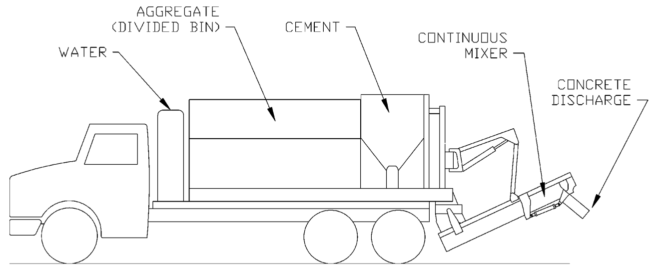

Fig. 3.1—Typical VMCM system.

material. A pivot at the base of most mixers allows them to swing from side to side.

3.3—Equipment condition

All proportioning and mixing equipment should be well maintained in accordance with the manufacturer's instructions. This point cannot be overemphasized. Equipment condition directly impacts the quality of the finished product.

Attention should be paid to the following areas:

- The cement dispenser should be clean and free of any buildup;
- Valves should operate smoothly and not leak;
- Any accumulation of materials on any controlling surface or opening in the system will alter the calibrated flow of materials;
- Mixer augers should not be allowed to wear beyond the manufacturer's recommended limits;
- There should be no buildup of concrete on the mixer auger surfaces;
- Delivery mechanisms should be properly adjusted and kept in good repair;
- There should be no leaks in the hydraulic or air systems;
- There should be no cut or damaged insulation on electrical wires; and
- All covers and guards should be securely in place.

ASTM C685/C685M provides guidance for evaluating mixer uniformity.

CHAPTER 4—OPERATIONS

4.1—General

Volumetric measurement and continuous mixing are suitable for producing almost any concrete with appropriately sized aggregate, provided the equipment is operated with the same attention to detail as would be required to produce concrete by any other means. Most of the present equipment is truck- or trailer-mounted, or at least portable, and typically serves as its own material transport. The portability of the equipment makes it practical to bring the VMCM unit to the placement site, which can be an advantage in many applications. Having the unit on site also allows close control of concrete quality. Several manufacturers offer VMCM equipment designed to be placed in a fixed position in a precast plant or at a job site.

4.2—Production rates

Maximum production rates are dependent on the physical and mechanical characteristics of the VMCM unit. Discharge rates for 100 lb (45 kg) of cement range from