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Web-based quality control of ready mixed concrete

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Abstract

The ready mixed concrete industry is an important part of today's construction business environment. This industry provides the required quality of concrete used in construction works. The production of this concrete has many different operation parts and it is highly essential to obtain the required quality in these operations. The new trend; web-based management, has the characteristics of developing the business methods in any business environment as well as in ready mixed concrete industry. This paper presents a web-based system for the quality control of ready mixed concrete. The system is illustrated step by step and its benefits for this industry are examined.

Keywords: Ready mixed concrete; Quality control; Web-based technology

1. Introduction

Ready mixed concrete (RMC) is prepared generally in a computerized concrete batching plant and it is in plastic state when delivered to the construction site [1]. RMC is one of the most popular building materials owing to its ability to customize its properties for different applications [2]. RMC has several benefits when compared to concrete prepared by conventional methods in construction sites. First, it is subjected to a better quality control. Then, the materials used in the production of RMC are selected and stored properly in the batching plant, and ingredient materials for concrete production are weighed and mixed by automated devices. Moreover, the manufacture and transportation of this concrete are performed by skilled personnel. All of these factors results into better quality product of concrete in standard conditions [3].

Concrete as a new material came first to building construction and later to other types of constructions [4]. The production of RMC started at the beginning of 20th century in European countries and middle 1970s in Turkey. According to the European Ready Mixed Concrete Organization (ERMCO) records in 2001, 350 million m^3 of RMC was produced in 12 000 operating plants and the European RMC industry consumed 33–65% of the total cement sales [5]. In Turkey, the number of batching plants increased during this period and the production reached to 25 million m^3 in 2003 [6]. The quality control of RMC is getting more important due to the increase in the number of batching plants and amount of production of this concrete. Reducing the variations in production of RMC and producing uniform material for construction works are the aims of the quality control. This makes the quality control procedure such a system that considers all characteristics of materials, equipment and workmanship [7]. Concrete quality is continuously improving by using today's modern technology [8]. The quality of RMC can be controlled easily and more accurately by means of these new technologies. This paper presents a method using web-based technology that improves the quality control of RMC, reduces paper works in documentation and saves time and money for companies in RMC industry.

2. Ready mixed concrete

The Turkish standard (TS EN 206-1 "Concrete-Section 1: Properties, Performance, Production and Conformity of Concrete") specifies the quality control criteria of RMC.

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The standard is also used for the reference of the quality certificate of the batching plants. Concrete is a composite material, which is produced by using cement, aggregate, water and sometimes admixture. In the quality control of concrete, first, these materials should satisfy the requirements mentioned in the standards. The production and the delivery of the concrete involve the following important stages. In the concrete order form, the customer should inform the manufacturer about the properties of concrete, the delivery time and the type of vehicle. On the other side, the manufacturer should give the type of the cement, aggregate, chemical admixture and water/cement ratio in the order form. According to the standard, the concrete should be placed within 2 h after mixing water with cement and aggregate. The temperature of the concrete should not be less than 5 °C at the time of delivery. The maximum concrete temperature is not mentioned in the TS EN 206-1 Standard but it is generally specified as 32 °C in most of the concrete practice [7]. Although TS EN 206-1 Standard defines several methods of measuring the workability of concrete such as Vebe time, degree of compactibility and flow diameter, the slump test is commonly conducted on freshly ready mixed concrete. The slump value is measured by taking a sample at the delivery time in construction site. The measured slump value should satisfy the requirements of the specifications and the customer needs. Quality control continues with the tests carried out on hardened concrete samples generally at the age of 28 days unless it is specified. The strength of concrete should reach the minimum requirements given in the standard specifications for concrete class [9].

The important points by ordering RMC are the amount of concrete, compressive strength class, slump value, maximum aggregate size, type of construction, and exposure classes related to environmental actions, etc. The customer should order concrete 2 or 3 days before casting and the time of casting and placing of concrete can be arranged at site. Environmental conditions that affect the properties of concrete must be specified clearly to the manufacturer before ordering the concrete. Before pouring the concrete the waybill of the RMC should be checked and the customer should be sure if it is the same that he ordered. The slump value first must be measured and controlled by the manufacturer at the batching plant. If the slump value becomes higher than the specified, the concrete must not be casted. The temperature of the fresh concrete should be measured clearly especially in extreme weather conditions. Cubes or cylinders should be taken from different truck-mixers for standard compressive strength tests on concrete [9]. It should be noted that concrete can be ordered either as designed concrete or as prescribed concrete in accordance with TS EN 206-1. In the former type, the general requirements given in the standard should be satisfied. In the prescribed concrete the customer should give the composition of concrete and he or she is responsible for the performance of concrete. After all, the quality of the concrete production depends upon several factors. These are the quality of the ingredient materials, machine quality and personnel quality of batching plant. Because of these factors, the batching plant and their machine or laboratory can be inspected by the customer. It is better that the customer gets the whole information about the ready mixed batching plant before ordering the concrete [9].

3. Quality control of RMC

Concrete is generally produced in batches at the site with the locally available materials which result a variability of the product from one batch to another. Factors of this variation are the differences in the quality of constituent materials; variation in mix proportions; variation in the quality of operating and mixing equipment; workmanship and supervision quality at the site. In addition, during transportation, placing, compacting, and curing, variations may occur partly because of the quality of the batching plant and partly because of the differences in the efficiency of techniques used. As a result, personnel, materials and workmanship are the critical factors affecting the quality of RMC in any concreting work. These different factors causing variations in the quality and the way of control mechanism should be extensively analyzed. [7].

One of the definitions of quality control is producing, improving, planning and servicing any product of quality with the most economical and practical way [10]. Quality control of RMC can be divided into three areas as forward control, immediate control and retrospective control. Forward control covers mainly material storage, monitoring of qualities of materials, modification of concrete mix design, batching plant maintenance, transfer and weighing equipment, plant mixers and truck mixers [11].

Immediate control covers subjects such as weighing, visual observation of concrete during production, workability of the fresh concrete, making corresponding adjustments at the plant automatically or manually to batched quantities, inspection at delivery by driver and customer for uniformity and adjustments to workability within company policy. Finally, retrospective control covers sampling of concrete, testing, monitoring of test results, stock control of materials, diagnosis and correction of faults identified from complaints [11].

Currently, the organization known as Quality Assurance System (QAS), directed by an independent board, is organizing the inspections and working as certification body in Turkey. The inspectors, usually experts from the universities and also from the QAS, carry out the inspections. QAS is being applied since 1995 and it consists of two main stages such as system control and product control. System control is generally performed by corresponding universities and it covers the inspection of batching plant, ingredient materials, laboratory equipment, technical personnel, quality and calibration records. The system control is carried out once a year and at the end of the inspections, a certificate is given for the particular