THE USE OF SUPERPLASTICIZERS IN HOT WEATHER COUNTRIES - MIDDLE EAST EXPERIENCES

BY

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ABSTRACT

Concreting problems in the Middle East arising from poor concrete raw materials, adverse climatic conditions and the necessity to conform to stringent specifications are cited. The manner in which superplasticizers such as sulphonates of melamine formaldehyde and naphthalene formaldehyde are used to alleviate some of the problems is discussed.

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I INTRODUCTION

The recent expanding construction programme in countries of the Middle East, Central and South America, and the Carribean has resulted in the implementation of a number of large construction projects. Such projects include the construction of dams, jetties, dry docks, airports, government complexes, and university campuses. However, the growing number of serious defects encountered in all classes of concrete during this period of intense construction activity has prompted grave concern for the quality of the concrete being used. These countries lying predominently in the equatorial belt are unfortunately areas where drastic climatic and geological conditions, poor quality of available raw materials, inexperienced workmanship and inadequate supervision, act in concert to produce a low grade concrete. This paper cites concreting problems encountered in these countries; specifically the Middle East. It presents the limiting environmental conditions and the constraints that arise from the necessity to adhere to rather rigid specifications in order to provide a durable concrete. The manner in which superplasticizers can be used to minimize such problems is discussed.

II Hot Weather Factors Contributing to Adverse Effects on Concrete

II:(a) The Climate: most hot weather countries have weather conditions where (for the most part of the year) an arid climate prevails - one where evaporation exceeds precipitation. The annual average rainfalls are very low and frequently the temperature is in excess of $35^{o}C$. The contrast between night

and the maximum day temperatures and humidities is great. In these conditions, together with strong drying winds concrete is adversely affected unless it is designed and placed with special hot weather precautions.

II:(b) Concrete Raw Materials

II:(b):1 Cements: The cements manufactured locally or supplied by neighbouring countries are often found to have inadequate performance in comparison with North American and European cements. eg. During the initial stages of the construction of the Ahmed Hamdi Tunnel in Egypt a preliminary materials study of available raw materials revealed that both local cements (Tourah & Hewlan) had general strength levels which were half to two thirds the values expected from average U.K. Cements. It is customary, therefore, to find Middle East concrete specifications stipulating only the use of imported cements or higher cement contents for local cements when their use is permitted. Table I shows the chemical composition of a cement currently used in the Middle East

II:(b):2 Aggregates: Natural sands are usually abundant but their gradings and sometimes their shapes are generally poor and frequently contaminated by deleterious salts (predominantly sulphates and chlorides). The coarse aggregates are often found to be of a friable and porous nature and also contaminated with injurious salts. The aggregate, therefore, requires washing to remove sulphate and chloride contamination and frequent testing to determine potential reactivity. When trial mixes are done it is not uncommon to find low strengths

with a ceiling of about 25.0 N/mm^2. Fig. I shows the gradation of some coarse and fine aggregates used in the East coast of Saudi Arabia. Table II gives the chloride and sulphate contents present in these aggregates.

II:(b):3 Construction Practices: In addition to the environmental and climatic conditions stated above, the concrete is also affected by factors introduced by construction practices. High cement contents are used to ensure that specified strengths and desired strength margins are achieved for high strength concretes. Finely ground cement is used to achieve early stripping strengths for advantageous production cycles in precast operations. Batch sizes of concrete delivered to distant locations are larger than normal. The use of pumping equipment to place mixes made from available raw materials and the need for compliance with specifications, often result in delays arising from equipment failure or incorrect mix design.

III Concreting Problems

The common problems encountered at construction sites in the Middle East include the following:

1. decreased strengths due to increased water demand, resulting from high mix temperatures and the use of local concrete raw materials;
2. the rapid decay of workability due to high slump loss, posing retempering problems;
3. difficulties in the handling and finishing of concrete as a result of accelerated setting due to increased rate of hydration;

4. the increased tendency for plastic shrinkage caused by rapid evaporation which occurs at high mix temperature and low relative humidity;
5. increased tendency for drying shrinkage and differential thermal cracking;
6. decreased durability due to the presence of deleterious salts in aggregates;
7. difficulty in maintaining desired air contents as a result of high mix temperatures;
8. The increased tendency for bleeding and settlement resulting from poor aggregate gradation.

III Concrete Specifications and the Contractor

Specifications usually stipulate the quality of concrete raw materials to be used and the fresh and hardened properties relevant to a particular class of concrete. They also specify the extent of control and supervision to ensure the serviceability of the concrete. Typical concrete parameters specified include: minimum cement contents, 7 and 28 day compressive strengths; maximum aggregate size; water:cement ratio and maximum slump.

The contractor, in attempting to provide a concrete meeting desired strength requirements, and stipulated durability criteria, is often compelled to accept the following impositions:

(a) Endure the costly and time-consuming placing due to the poor workability of mixes of low water:cement ratio.
(b) Use an uneconomical mix design due to the necessity of

achieving high strength margins.
(c) Tolerate a high percentage of rejected units having severe blemishes and surface voids, due to the poor compaction of dry mixes;
(d) Perform such tests as necessary to demonstrate that his concrete meets the required absorption, drying shrinkage and moisture movement values.

For the contractor, therefore, strict adherence to specifications with conventional concreting practices brings a soaring cost to the project.

IV The Use of Admixtures

Recent studies have shown that traditional methods of increasing cement contents, to ensure strength and durability factors, account for some of the defects observed in both precast and in-situ concrete in the Middle East. The prudent use of admixtures often provides cost savings both in raw materials and labour, enabling the production of quality concrete with the limited equipment available.

Some of the commonly sought mix modifications (improvements) under such limited environmental and drastic geological conditions can be listed as follows:

(1) High water reduction and plasticizing effects for concretes where low water cement ratios and minimum cement contents are specified.
(2) Increased cohesiveness in harsh mixes and mixes prone to bleeding.