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ADVANCEMENTS IN CONCRETE TECHNOLOGY

Shri Purvansh B. Shah[1] , Shri Prakash D. Gohil[2] ,Shri Hiren J. Chavda[3], Shri Tejas D. Khediya[4]

[1,2,3,4]*Lecturer, Civil engineering Department, Sir Bhavsinhji Polytechnic Institute-Bhavnagar*

Abstract - Developing and maintaining world's infrastructure to meet the future needs of industrialized and developing countries is necessary to economically grow and improve the quality of life. The quality and performance of concrete plays a key role for most of infrastructure including commercial, industrial, residential and military structures, dams, power plants. Concrete is the single largest manufactured material in the world and accounts for more than 6 billion metric tons of materials annually. Initial and life-cycle costs play a major role in today's infrastructure development. There have been number of notable advancements made in concrete technology in the last fifty years.So to meet Advances in Concrete Technologywe should have to maintain Concrete Materials, Workability of Concrete, Concrete Mixture Proportioning, Concrete Mechanical Properties, Concrete Durability Properties, Concrete tests, Concrete Construction Controland to meet advancements made in concrete technology we should have to use latest technologies and various applications of concrete technologies like Use of recycled materials in concrete , High Performance Concrete, Air Void Analyzer, Concrete Composition Technologies, Self compacting Concrete.

Key Words: *Concrete Technology, Advancements in Construction Technologies, Development of Construction Technologies*

I. INTRODUCTION

The use of cementing material dates back to several hundred years. The ancient Egyptians used claimed impure gypsum to grout the space between huge rocks of stone in pyramid.

The Greeks and Romans used claimed limestone and later learned to add to lime and water, sand and crushed stone or brick and broken tiles. This was first concrete in History.

Lime mortar does not harden under water, and for construction under water the Romans ground together lime and a volcanic ash or finely ground burnt clay tiles. Roman builders used volcanic tuff found near Pozzuoli village near mount Vesuvius in Italy. This Volcanic tuff or ash mostly siliceous in nature thus acquired the name pozzolana, having nearly the same composition as that of volcanic tuff or ash found at Pozzuoli.

Some of the structures in which masonry was bonded by mortar, such as the Coliseum in Rome and the Pont du Gard near Nimes, have survived to this day, with the cementations material still hard and firm. In the ruins at Pompeii, the mortar is often less weathered than the rather soft stone. The superiority of Roman mortar has been attributed to thoroughness of mixing and long continued ramming.

It is learnt that the Romans added milk, blood and lard to their mortar and concrete to achieve better workability. Hemoglobin is a powerful air-entraining agent and plasticizer, which perhaps is yet another reason for the durability of roman structures Probably they didn't knew about the durability aspect but used them as workability agents.

In India, the South India Industrial ltd, first manufactured Portlands cement near madras in 1904.

In 1912, the Indian Cement Co. Ltd. Was established at Porbandar (Gujarat) and by 1914 this company was able to deliver about 1000 tonnes of Portland Cement.

Prior to the manufacture of Portland Cement in India, it was imported from U.K. A three storeyed structure build at Byculla, Bombay is one of the oldest RCC structures built using Portland cement.

The Cement Corporation of India, a government owned company is set up with the aim of surveying prospecting and providing limestone deposits in the country and establishing cement manufacturing capacity.

II. LITURATURE OF CONCRETE TECHNOLOGY

Concrete :-Concrete is comprised of Portland cement, fine aggregate, coarse aggregate, water, pozzolans, and air. Portland cement got its name when it was first used in the early nineteenth century in England, because its product resembled building stone from the isle of Portland off the British coast. Portland cement is made by grinding a calcareous material, such as limestone or shell, with an argillaceous (clayish) material such as clay, shale or blast furnace slag. These two finely ground materials are heated in a giant rotary furnace to the point where they begin to fuse. The resulting product is called a clinker. The clinker is cooled and reground to a fine powder to form Portland cement.

While the clinker is being ground, small amounts of additional ingredients are added to produce the various types of cement :

-Standard setting
-Slow setting (low tri-calcium aluminates)
moderate sulfate resistance
-Fast setting - High early strength
-Slow setting - Low heat of hydration
-High sulfate resistance

When cement is mixed with water the resultant product is referred to as PASTE. This is if Substance that binds all other ingredients together. Aggregates are divided into two categories and are comprised of a large number of naturally occurring and manufactured products. The basic distinction is as follows:

- **Fine aggregate**– 4# sieve to pan (1/4" to powder)
- **Coarse aggregate** - 3/8" to 1-1/2"

The addition of fine aggregate to the PASTE transforms the product to a MORTAR. The Subsequent addition of coarse aggregate results in CONCRETE.

III. ADVANCES IN CONCRETE TECHNOLOGIES

A. Concrete materials :

The development of chemical admixtures has revolutionized concrete technology in the last fifty years. The use of air entraining admixtures, accelerators, retarders, water reducers and corrosion inbitititors are commonly used for bridges. The use of Self-compacting concrete is beginning (mostly used for precast elements). Shrinkage reducing admixtures are rarely used for bridges. Supplementary cementitious materials e.g. fly ash, ground granulated blast furnace slag and silica fume are routinely used.

B. Workability of Concrete :

Workability of fresh concrete depends on its rheological properties. This rheological behavior is defined by two characteristics of the concrete, i.e. yield stress and plastic viscosity. Yield stress is the effort needed to initiate movement of the fresh concrete, and correlates well with slump. Plastic viscosity is the flow characteristics of the concrete while moving and for low stiffness concretes can be determined by various rheometers currently available.

C. Concrete mixture proportioning :

Continuous gradation and consideration of workability during laboratory testing are slowly gaining acceptance in practice.

D. Concrete mechanical properties :

Higher strength concrete for bridges is commonly used for columns and beams. Higher strength concrete usually provides higher abrasion resistance and where appropriate this is considered in the bridge deck and pavement designs.

E. Concrete tests :

The utilization of advanced test procedures e.g. various shrinkage tests, air-void analyzer and non-destructive tests have become widespread. Workability test for stiff concrete mixes is being evaluated by several organizations.

F. Concrete construction control :

In-situ concrete testing, effective curing practices and utilization of computer software to monitor concrete strength development as well as minimizing cracking potential are used on major transportation projects.

IV. LATEST TECHNOLOGY AND APPLICATIONSOF CONCRETE TECHNOLOGIES

A. LATEST TECHNOLOGY :

- Use of recycled materials in concrete

The use of recycled materials generated from transportation, industrial, municipal and mining processes in transportation facilities is a issue of great importance. Recycled concrete aggregates and slag aggregates are being used where appropriate. As the useable sources for natural aggregates for concrete are depleted utilization of these products will increase. Utilization of fly ash and ground granulated blast furnace slag in concrete addresses this issue in addition to improving concrete properties. The replacement of Portland cement by fly ash or GGBFS reduces the volumes of cement utilized which is a major benefit since the cement manufacture is a significant source of carbon dioxide emissions worldwide. Silica fume is a comparatively expensive product and it is added in smaller quantities in concrete mixture rather than as a cement replacement.

B. APPLICATIONS :

1.HIGH-PERFORMANCE CONCRETE(HPC)

The term “HPC” was first introduced by NIST,FHWA, COE and ACI in early 1990s. Concrete meeting special performance requirements that cannot always beachieved routinely using conventional constituents and normal mixing, placing, and curing practices. Many conferences and publications since 1990s were conducted for HPC.

Performance Requirements for HPC :

- Placement & Compaction w/o Segregation
- Early-Age Strength
- Enhanced Mechanical Properties
- Volume Stability
- Enhanced Durability & Service Life:
    - Low Permeability
    - Abrasion Resistance
    - Fire Resistance

General Characteristics of HPC :

- High Strength
- Good Workability
- Good Durability

Benefits of HPC :

The direct advantage of HPC construction schedule is the early stripping of formwork. In addition, the greater stiffness and higher axial strength allows for the use of smaller columns in the construction. This will improve the construction schedule by reducing the amount of concrete that must be placed. These factors combined lead to construction elements of high economic efficiency, high utility, and long-term engineering economy

- Reduction of structural steel allows for greater flexibility in designing the shape and form of structural members
- Superior ductility and energy absorption provides structural reliability under earthquakes
- Reduction of structural steel allows numerous structural member shape and form freedom
- Superior corrosion resistance

Applications of HPC:

- Off-shore structures
- Long-span bridges
- HPLC (Floating offshore platforms)
- Repair materials (early strength)
- HP Shotcrete

Fig.1 HPC bridge

- HPC bridge – 8 spans
- Normal strength – 9 spans
- HPC strength –75-101 MPa in 56 days
- Unit cost of the HPC bridge was 16% higher than that of the normal strength concrete

Fig.2 HPC bridge in Texas

- HPC bridge in Texas Span length = 41 m
- Girder Spacing = 4.8 m
- Strength =110 Mpa
- Unit cost was similar to that for normal strength concrete

2.Air Void Analyzer (AVA)

AVA device can characterize the air void structure (volume, size and spacing) of fresh concrete. The clear advantage of the AVA is its ability to characterize the air void structure on fresh concrete in less than 30 minutes. With this information, adjustments can be made in the production process during concrete placement.

Fig.3 Air Void Analyzer

3.Concrete Composition Technologies

Addition to increasing the comprehensive strength of the concrete, available admixtures can improve other characteristics, such as low permeability, limited shrinkage, and increased corrosion resistance. These changes can also reduce the curing time required by reducing the required thickness of concrete members as well as the reducing the number of special construction steps involved in curing. Admixtures are used to improve a specific characteristic of the concrete for a specific application. The advantages are a more place able concrete for improved construction productivity without performance tradeoffs. Additionally, this product can be used in combination with a super plasticizer without modifying its properties.

4.Self-Compacting Concrete(SCC)

SCC provides improvements in strength, density, durability, volume stability, bond, and abrasion resistance. SCC is especially useful in confined zones where vibrating compaction is difficult. The reduction in schedule is limited since a large portion of the schedule is still controlled by the time required to erect and remove formwork. Although the schedule reduction is limited, it is still sufficient that the reduction in labor costs overcomes the higher material costs.Self-compacting concrete may be especially beneficial when used in combination with steelplate reinforced concrete structures, which requires a flow-able concrete due to the complicated geometries.

V. CONCLUSION

Significant advances have been made in concrete technology during the last fifty years. This paper has highlighted some of the significant advancements in technologies and their effect on the design and preservation of infrastructure. While it is not the definitive state-of-practice for design and preservation, it does bring to the forefront some of the technologies that are being considered by professionals. As with all new technologies, long term performance monitoring identifying both successes and failures, will prove to be invaluable for advancing the concept of long-life pavements. Some of the successful examples are discussed in this paper. Many of the innovations have been incorporated in the routine practice.

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