A Review on Advancement of Concrete Technology

SARUK MALLICK,Raajdhani Engineering College, Bhubaneswar[1],AMLAN PATTNAYAK,Aryan Institute of Engineering and Technology, Bhubaneswar[2],SUCHAMPA BAGCHI,NM Institute of Engineering and Technology, Bhubaneswar[3],Mr. SATYAPRAKASH MISHRA,Capital Engineering College, Bhubaneswar[4]

Abstract - *Concrete is considered as the backbone of construction industry which is a composite material composed of coarse aggregate bonded together with fluid cement that hardens overtime. 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, and power plants. Concrete industries are one of the major consumers of natural resources as they spends annually 1.5 billion tons of cement, 900 million liters of water and 9 million tons of sand and water, so there is need to find an alternative eco friendly material which will save our natural resources from being depleted. In this paper the author explains about the materials used in preparation of concrete along with its types and tests. The main aim of the sustainable development is to meet Advances in Concrete Technology we should have to maintain Concrete Materials, Workability of Concrete, Concrete Mixture Proportioning, Concrete Mechanical Properties, Concrete Durability Properties, Concrete tests, Concrete Construction Control and 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. Alternative resources, which would decrease negative effect of concrete industry on environment and contribute to preservation of natural resources. The objective of this paper is to explain about process of preparing concrete and also about harmful effect of the materials used in it.*

Keywords *- Mixes and Tests of Concrete*

I. INTRODUCTION

India has done a major leap on developing the infrastructure such as industrial structures, power projects and express highways etc., to meet the requirements of globalization. Concrete leads main role and a large quantum of concrete is being utilized for the construction of civil engineering works. The construction industry uses billion tons of raw material each year, is the largest user of natural resources in the world. Concrete is the most useful material in construction liable for the depletion of natural resources and increases the shortage of the ingredients such as steel, cement, and aggregates consequently there is a large demand for these materials in the commercial sector [8]. Concrete is a synthetic construction material made by mixing of cement, fine aggregates, coarse aggregate and water in the proper proportions and it is also a well known heterogeneous mix of cement, water and aggregates [1].Conventionally concrete is mixture of cement, sand and aggregate. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand. Fine and coarse aggregate constitute about 75% of total volume. It is therefore, important to obtain right type and good quality aggregate at site, because the aggregate form the main matrix of concrete or mortar [3, 4]. Concrete industry spends annually 1.5 billion tons of cement, 900 million liters of water and 9 billion tons of sand and stone. Since concrete industry is one of the major consumers of natural resources, until today many efforts were made in order to replace non-renewable resources with renewable one [2].The global consumption of natural sand is very high, due to the extensive use of concrete. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth, in this situation developing country like India facing shortage in good quality natural sand [5, 6]. Generally in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. Increasing extraction of natural sand from river beds causing many problems, loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table etc. [7].

II. HISTORY

The word concrete comes from the Latin word "*concretus*" (meaning compact or condensed) [9]. the perfect passive participle of "*concrescere*", from "*con-*" (together) and "*crescere*" (to grow). Perhaps the earliest known occurrence of cement was twelve million years ago. A deposit of cement was formed after an occurrence of oil shale located adjacent to a bed of limestone burned due to natural causes. These ancient deposits were investigated in the 1960s and 1970s [10]. On a human timescale, small usages of concrete go back for thousands of years. Concrete like materials were used since 6500 BC by the Nabataea traders or Bedouins who occupied and controlled a series of oases and developed a small empire in the regions of southern Syria and northern Jordan. They discovered the advantages of hydraulic lime, with some self-cementing properties, by 700 BC. They built kilns to supply mortar for the construction of rubble-wall houses, concrete floors, and underground waterproof cisterns. The cisterns were kept secret and were one of the reasons the Nabataea were able to thrive in the desert [11]. Some of these structures survive to this day [11]. In both Roman and Egyptian times, it was re-discovered that adding volcanic ash to the mix allowed it to set underwater. Similarly, the Romans knew that adding horse hair made concrete less liable to crack while it hardened, and adding blood made it more frost-resistant [12]. Crystallization of stratlingite and the introduction of pyroclastic clays creates further fracture resistance[13] German archaeologist Heinrich.

Schliemann found concrete floors, which were made of lime and pebbles, in the royal palace of Tiryns, Greece, which dates roughly to 1400–1200 BC.[14,15] Lime mortars were used in Greece, Crete, and Cyprus in 800 BC. The Assyrian Jerwan Aqueduct (688 BC) made use of waterproof concrete [16]. Concrete was used for construction in many ancient structures [17]. The Romans used concrete extensively from 300 BC to 476 AD, a span of more than seven hundred years [10]. During the Roman Empire, Roman concrete (or *opus caementicium*) was made from quicklime, pozzolana and an aggregate of pumice. Its widespread use in many Roman structures, a key event in the history of architecture termed the Roman Architectural Revolution, freed Roman construction from the restrictions of stone and brick material and allowed for revolutionary new designs in terms of both structural complexity and dimension [18]. Concrete, as the Romans knew it, was a new and revolutionary material. Laid in the shape of arches, vaults and domes, it quickly hardened into a rigid mass, free from many of the internal thrusts and strains that troubled the builders of similar structures in stone or brick [19]. Modern tests show that *opus caementicium* had as much compressive strength as modern Portland-cement concrete (ca. 200 kg/cm^2 [20 MPa; 2,800 psi]) [20]. However, due to the absence of reinforcement, its tensile strength was far lower than modern reinforced concrete, and its mode of application was also different [21]. Modern structural concrete differs from Roman concrete in two important details. First, its mix consistency is fluid and homogeneous, allowing it to be poured into forms rather than requiring hand-layering together with the placement of aggregate, which, in Roman practice, often consisted of rubble. Second, integral reinforcing steel gives modern concrete assemblies great strength in tension, whereas Roman concrete could depend only upon the strength of the concrete bonding to resist tension [22].

III. TYPES OF MIXES USED IN CONCRETE

Researchers classified mixes into three types mainly name are [23]

(i) Nominal Mixes
(ii) Standard/Prescribed Mixes
(iii) Designed Mixes

Nominal Mixes

The specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement aggregate ratio which ensures adequate strength are termed nominal mixes. These offer simplicity and under normal circumstances, have a margin of strength above that specified. The proportion of cement and aggregate is fixed, only the water cement ratio is varied. However, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength.

Standard/Prescribed mixes

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes. Here the structural Engineer prescribes a standard concrete mix ratio that he thinks will produce the required concrete. He may also indicate the type and size of aggregate to be used. The Builder/site engineer prepares the mixes based on the ratio that has been prescribed.

Designed Mixes

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. However, the designed mix does not serve as a guide since this does not guarantee the correct mix proportions for the prescribed performance. Proportioning concrete based on the specified design mixes involves; more steps, and the use of tabulated data and charts. The approach results in the production of concrete with the appropriate properties most economically. This is because the characteristics of the materials to be used and the characteristics of the concrete required are incorporated in the design procedure**.**

IV. GRADE DESIGNATION FOR CONCRETE

According to Yunusa (2011) every concrete has its strength in N/mm^2 when subject to test after 28 days of curing in any medium. The choice of concrete grade depends on the purpose and usage as shown in Table 1 [23].

Table 1: Grades of Concrete

Grade of concrete in N/mm^2	Ratio of cement, sand & aggregate	Usage
M-10	1:4:8	Blinding concrete
M-15	1:3:6	Mass concrete
M-20	1:2.5:5	Light reinforced concrete
M-25	1:2:4	Reinforced concrete/precast
M-30	1:1.5:3	Heavy reinforced concrete/pre-cast
M-35	1:1.5:2	Pre-stressed/precast concrete
M-40	1:1:1	Very heavy reinforced concrete/pre-cast/pre-stressed

V. MATERIALS USED IN CONCRETE

The materials used in the concrete and the method to prepare it are as follows [23]

Cement

Concrete without admixtures and of high cement content, over about 460 kg/m^3 are liable to prove difficult to pump, because of high friction between the concrete and the pipeline. Cement contents below 270 to 320 kg/m^3 depend upon the proportion of the aggregates may also prove difficult to pump because of segregation within the pipe line.

Aggregate

The maximum size of crushed aggregate is limited to one-third of the smallest inside diameter of the hose or pipe based on simple geometry of cubical shape aggregates. For uncrushed (rounded) aggregates, the maximum size should be limited to 40 percent of the pipe or hose diameter. The shape of the coarse aggregate, whether crushed or uncrushed has an influence on the mix proportions, although both shapes can be pumped satisfactorily. The crushed pieces have a larger surface area per unit volume as compared to uncrushed pieces and thus require relatively more mortar to coat the surface. Coarse aggregate of a very bad particles shape should be avoided. Difficulties with pump mixed have often been experienced when too large a proportion of coarse aggregate is used in an attempt to achieve economy by reducing the amount of cement such mixes are also more difficult and costly to finish. The grading of coarse aggregate should be as per IS: 383-1970. If they are nominal single sized then 10 mm and 20 mm shall be combine in the ratio of 1:2 to get a graded coarse aggregate. In the same way 10 mm, 20 mm and 40 mm aggregates shall be combine in the ratio of 1:1.5:3 to get a graded coarse aggregate. Fine aggregate of Zone II as per IS: 383-1970 is generally suitable for pumped concrete provided 15 to 30 percent sand should pass the 300 micron sieve and 5 to 10 percent should pass the 150 micron sieve.

Water

Water is very actively participated in the chemical action with cement. Potable fresh water with pH value of 7 available from local sources free from deleterious materials should be used.

VI. PROCESS OF PRODUCTION OF CONCRETE

The various stages of manufacture of concrete are

a) Batching
b) Mixing

Batching

6.1.1 Volume Batching

Volume batching is not a good method for proportioning the material because of the difficulty it offers to measure granular material in terms of volume. Volume of moist sand in a loose condition weighs much less than the same volume of dry compacted sand. The effect of bulking should be considered for moist fine aggregate. For unimportant concrete or for any small job, concrete may be batched by volume.

6.1.2. Weigh Batching

Weigh batching is the correct method of measuring the materials. Use of weight system in batching, facilitates accuracy, flexibility and simplicity. Large weigh batching plants have automatic weighing equipment. On large work sites, the weigh bucket type of weighing equipment is used.

Mixing

Thorough mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in color and consistency. There are two methods adopted for mixing concrete

(i) Hand mixing
(ii) Machine mixing

Hand mixing

Hand mixing is practiced for small scale unimportant concrete works. As the mixing cannot be thorough and efficient, it is desirable to add 10 per cent more cement to cater for the inferior concrete produced by this method. Hand mixing should be done over an impervious concrete or brick floor of sufficiently large size to take one bag of cement. Spread out the measured quantity of coarse aggregate and fine aggregate in alternate layers. Pour the cement on the top of it, and mix them dry by shovel, turning the mixture over and over again until uniformity of color is achieved. Water is taken in a water-can fitted with a rose-head and sprinkled over the mixture and simultaneously turned over. This operation is continued till such time a good uniform, homogeneous concrete is obtained.

Machine Mixing

Mixing of concrete is almost invariably carried out by machine, for reinforced concrete work and for medium or large scale mass concrete work. Machine mixing is not only efficient, but also economical, when the quantity of concrete to be produced is large. They can be classified as batch-mixers and continuous mixers. Batch mixers produce concrete, batch by batch with time interval, whereas continuous mixers produce concrete continuously without stoppage till such time the plant is working. In normal concrete work, it is the batch mixers that are used. Batch mixer may be of pan type or drum type. The drum type may be further classified as tilting, non-tilting, reversing or forced action type. As per I.S. 1791–1985, concrete mixers are designated by a number representing its nominal mixed batch capacity in liters. The following are the standardized sizes of three types:

a. Tilting: 85 T, 100 T, 140 T, 200 T
b. Non-Tilting: 200 NT, 280 NT, 375 NT, 500 NT, 1000 NT
c. Reversing: 200 R, 280 R, 375 R, 500 R and 1000 R

VII. TESTS OF CONCRETE

Generally to test the concrete it is necessary to pass it from the different tests is available. For which the standard cubes size of dimension 150mm x 150mm x 150mm were produced for the compression strength test while beams of 100mm x 100mm x 500mm were produced for the flexural test [23]

Workability Tests

Slump test was carried out to determine the workability of each mix. The tests were carried out in all cases in accordance with the requirements of BS 1881: Part 102(1983) for slump test and BS 1881: Part103 (1983) for compacting factor tests.

Compressive Strength Test

The compressive testing machine was used to test the entire concrete cubes for crushing strength at 7, 14 and 28 days respectively. The various weights were taken in order to determine the various densities of the sample produced. The average failure loads were used to obtain the compressive strength.

Flexural Strength Test on Sample Beams

The tensile strength testing machine was used to test the flexural strength of the concrete beams at 7, 14 and 28 days respectively after taking their weights in order to ascertain their densities. Results should be recorded based on the average tensile strength.

The concrete should follow the criteria discussed below

a) Characteristic compressive strength required in the field at 28 days = 35 N/mm2
b) Type and size of coarse aggregate = 20-10 mm and 10-5 mm crushed aggregates as per grading.
c) Fine aggregate = River sand of Zone II as per IS: 383-1970.
d) Degree of workability = 50 – 100 mm slump at pour after 90 Minutes.
e) Minimum cement content = 340 kg/m3.
f) Maximum free water/cement ratio = 0.45.
g) Standard deviation for good site control = 5.0 N/mm^2.
h) Accepted proportion of low results= 5%.

VIII. ENVIRONMENTAL AND HEALTH EFFECTS DUE TO CONCRETE

The manufacture and use of concrete produce a wide range of environmental and social consequences. Some are harmful, some welcome, and some both, depending on circumstances. A major component of concrete is cement, which similarly exerts environmental and social effects [24]. The cement industry is one of the three primary producers of carbon dioxide, a major greenhouse gas (the other two being the energy production and transportation industries). As of 2001, the production of Portland cement contributed 7% to global anthropogenic CO_2 emissions, largely due to the sintering of limestone and clay at 1,500 °C (2,730 °F) [25]. Concrete is used to create hard surfaces that contribute to surface runoff, which can cause heavy soil erosion, water pollution, and flooding, but conversely can be used to divert, dam, and control flooding. Concrete is a contributor to the urban heat island effect, though less so than asphalt [26]. Workers who cut, grind or polish concrete are at risk of inhaling airborne silica, which can lead to silicosis [27]. Concrete dust released by building demolition and natural disasters can be a major source of dangerous air pollution. The presence of some substances in concrete, including useful and unwanted additives, can cause health concerns due to toxicity and radioactivity. Fresh concrete (before curing is complete) is highly alkaline and must be handled with proper protective equipment.

REFERENCE

1. Akinwonmi, Ademola Samuel, Seckley, Emmanuel, „Mechanical Strength of Concrete With Crumb And Shredded Tyre As Aggregate Replacement‟ International Journal of Engineering Research and Applications , March -April 2013.
2. Dubravka Bjegovic ,Ana Baricevic, Marijana Serdar , 'Durability Properties of Concrete with Recycled Waste Tyres 'international conference on durability of building material and components April 12-15 2011
3. Hudson, B. P., "Manufactured Sand for concrete," The Indian concrete Journal, May 1997, pp. 237-240.
4. Sahu, A. K.; Sunil, K., and Sachan, A. K., "Crushed stone waste as fine aggregate for concrete," The Indian Concrete Journal, January 2003, pp. 845-847.
5. Amnon, K., and Hadassa, B., "Effect of high levels of fines content on concrete properties," ACI Material Journal, V.103, November-December 2006, pp. 474-481
6. Safiuddin, M.; Raman, S. N., and Zain, M. F. N., "Utilization of Quarry Waste Fine Aggregate in Concrete Mixtures," Journal of Applied Sciences Research, 2007
7. Priyanka A. Jadhava and Dilip K. Kulkarnib, „AN experimental investigation on the properties of concrete containing manufactured sand‟International Journal of Advanced Engineering Technology‟. April-June, 2012.
8. Vishal Porwal, Ravi Dwivedi „Studies on Tyre Aggregate Concrete with Fly Ash‟, International Journal of Science and Research (IJSR) August 2016.
9. "Concretus". Latin Lookup. Retrieved 1 October 2012.
10. "The History of Concrete". Dept. of Materials Science and Engineering, University of Illinois, Urbana-Champaign. Retrieved 8 January 2013.
11. From The History of Concrete – InterNACHI http://www.nachi.org/history-of-concrete.
12. Brief history of concrete. Djc.com. Retrieved on 2013-02-19.
13. Jackson, Marie D, Landis, Eric N. Brune, Philip F., Vitti, Massimo; Chen, Heng; Li, Qinfei; Kunz, Martin; Wenk, Hans-Rudolf; Monteiro, Paulo J. M.; Ingraffea, Anthony R. (30 December 2014). "Mechanical resilience and cementitious processes in Imperial Roman architectural mortar". Retrieved 14 December 2016
14. Heinrich Schliemann with Wilhelm Dörpfeld and Felix Adler, tiryns: the prehistoric palace of the kings of tiryns, the results of the latest excavations, (New York, New York: Charles Scribner's Sons, 1885),
15. Amelia Carolina Sparavigna, "Ancient concrete works"
16. Jacobsen T and Lloyd S, Oriental Institute Publications 24, Chicago University Press, (1935) Sennacherib's Aqueduct at Jerwan
17. Stella L. Marusin "Ancient Concrete Structures". Concrete International.(1 January 1996).
18. Lancaster, Lynne Concrete Vaulted Construction in Imperial Rome. Innovations in Context. Cambridge University Press..(2005).
19. D.S. Robertson: Greek and Roman Architecture, Cambridge, 1969.

20. Henry Cowan: The Masterbuilders, New York 1977.
21. History of Concrete. Ce.memphis.edu. Retrieved on 2013..
22. Robert Mark, Paul Hutchinson: "On the Structure of the Roman Pantheon", Art Bulletin, (1986).Anum, I, Williams, F.N, Adole, A.M and Haruna, „Properties of Different Grades of Concrete Using Mix Design Method" A.C International Journal of Geology, Agriculture and Environmental Sciences, 6 December 2014
23. Fridman, Vladen, "Method for producing Construction Mixture for concrete", issued August 22, 1995
24. Worrell, E.; Price, L.; Martin, N.; Hendriks, C.; Ozawa Meida, L. "Carbon dioxide emissions from the global cement industry". Annu. Rev. Energy Environ. (2001).
25. Reducing Urban Heat Islands",United States Environmental Protection Agency
26. Shepherd & Woskie. "Controlling Dust from Concrete Saw Cutting" (PDF). Journal of Occupational and Environmental Hygiene. 2013.

