Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2020, 7(1):10-14

Review Article ISSN: 2394 - 658X

Development of Concrete as a Construction Material: A Review

Aamer Najim Abbas

Mustansiriyah University, College of Engineering, Water Resources Engineering Department

ABSTRACT

Concrete is considered one of the most construction materials used in buildings construction, it was used in different constructions such as multi-story frame structures, dams, reservoirs .... etc. concrete is characterized by good resistance to fire compared to other materials used, such as steel wood, as well as the possibility to form according to architectural design because of its fluid nature, taking the form of the mold. All these benefits led scientists and researchers to improve concrete specifications especially the weak properties in concrete such as tensile strength and ductility. The previous year have appeared new types of concrete characterized by high strength to compression and tension. In this study, the development of concrete was considered during the previous two centuries, and reviewing the several types of concrete and its use.

Key words: Concrete Development, Construction Material

INTRODUCTION

Concrete Development

Cement, gravel, sand and a little water; with this mixture obtained the most common building materials used in construction in the world, despite the primacy of the components of this mixture is produced from it a strong solid material such as rock ideal for the construction of types of human installations such as buildings, bridges, dams, tunnels and skyscrapers, called Concrete [1].

Concrete, in English is from the Latin term i.e. stacked and bonded, and much has been written about the concrete structures of the Roman Empire, and that the Romans used concrete as the main building material for what they built, and many researchers see that the first actual use of cement material. It happened in Italy in the second century BC, where a special type of volcanic sand called (Pozzolana) was found near the Gulf of Naples in Italy [2], and this sand was used in making cement at the time, and it was used to combine rocks together to make concrete from The path of reacting chemically Pozzolana sand with lime and water to harden and produce a rock-like mass, then the Romans used this mixture of materials to build bridges, ponds, drains, and buildings as well [2], and Roman concrete resembled modern Portland cement concrete, as it was never a flowed that glowed into molds of the building, in fact, cannot be separated from what can be called (the first concrete mixture in the world) and what is adjacent rubble; that is, the Roman concrete at the time [2], and the Pantheon Temple and its dome represent a model of Roman concrete, and embodies Roman architecture in its best form, and its construction ended in 217 AD, AD Still holding out today.

The first modern use of concrete was in the nineteenth century A.D. In 1820, the English stone builder Joseph Aspen obtained an improved patent for what he called (Portland cement); relative to natural stone on Portland Island, and this is still the most common and used Portland cement in the manufacture of concrete Modern to the present day [2].

Reinforcement steel was not known until the eighteenth century, because Roman concrete was not reinforced and if the Romans used iron in the construction of some of their facilities, they did not have any knowledge of the science of designing reinforced concrete and its principles, and ordinary unreinforced concrete remained prevalent until 1850 when making the French farms Jean-Louis had several rowing boats, supported them with iron wires and bars, and then planned to use iron as a building material with concrete, and in 1856 he applied for a patent [2], and in 1854 the British architect William and Lincoln built a two-storey servant tent and reinforced the floor and ceiling Basically with steel bars, and put iron so that it resists tensile stresses, which demonstrated his understanding of the basic principles of reinforced concrete, and got a patent because he was the first to build by this way [2], It is worth noting that there are several people who had a great role in the use of reinforcing steel in the Nineteenth century; them: Joseph Mounier in 1867, William Ward 1871 [2].

Despite some exceptions, concrete was used in the nineteenth century AD only in the construction of commercial buildings, and at that time it did not have the acceptance of society; for aesthetic reasons, then it entered into the construction of houses between the years 1850-1880, and as mentioned it was the house of servants built by the British William and Dickinson in 1854 first A house made of reinforced concrete in the world, and in 1875 the mechanical engineer William Ward built the first reinforced concrete house in America, and to make it socially acceptable he built it so that it resembles stone construction [3], and the funny thing is that he used reinforced concrete because his wife was afraid of fire, and it is known that the resistance of concrete fire is much better than it in wood, this was the beginning of concrete in America, while the value of the concrete sector today in America is 35 billion dollars, and more than two million people work in this sector alone in America alone [3]. In the late nineteenth century, the development of rebar began, but we cannot say that credit belongs to one individual, as many contributed to it, including: German Gustav Weiss, French Francois Hanbeek, and American Ernest Ransom [3], Gustave Weiss bought a patent from the Frenchman Joseph Munnier, who was a garden worker who discovered rebars in 1867 when he decided to manufacture implant bans of concrete instead of clay and wood, and notice a difference in strength [3]. As for François Hanbeek, he began building concrete houses in France in the late 1870s, and he patented in France and Belgium for the success of his system, and then presented his method of construction in several conferences [3].

Ernst Ransom achieved patent in 1877 after bending the square iron bars to improve its bonding with concrete [3]. In 1902, the French architect, Auguste Perret, built a residential building of reinforced concrete in which the reinforcing steel was placed in columns and ceilings, and he was keen that the facade of the building should be beautiful so that it would be accepted by people. For people at the time, that concrete is not suitable for residential buildings, because it is not architecturally beautiful [3]. Thus the concrete invaded the world of construction, and recorded its remarkable presence in the late nineteenth century. A major development following the discovery of reinforced concrete.

The following is a simple explaning of what the concrete did in the construction field:

1. In 1891, the first concrete road in the world was established in the United States in Ohio, and it was poured with concrete with a rupture strength of 550 kg/cm^2 [4].
2. In 1903, the world's first skyscraper made of reinforced concrete was constructed, and it was also in the United States in Ohio [5].
3. In 1911, the first suspended concrete bridge in the world was built to carry all types of loads, which is the Risorgimento Bridge in Rome, and the suspended distance from it reached 100 meters [6].
4. In 1913, the first load of ready-mixed concrete was delivered to Maryland in America [7].
5. In 1921, the French engineer Eugene Fresne built a massive aircraft depot in the form of an arch for the French airport [8].
6. In 1935, the first concrete dam in the world was built, which is the Hoover Dam in the United States, and the amount of concrete used in its construction was approximately 2.5 million cubic meters [9].

It is no secret to the centrality of reinforced concrete in the construction field today, as it produces more than two billion tons of cement annually, and by 2050 it is expected that the rate of cement production will be four times what it was in 1990 [10]. We cannot talk about concrete Without mentioning its negative impact on the environment, the cement industry produces CO_2 emissions at 800 kg of CO_2 per 1,000 kg of cement, and the percentage of CO_2 emitted after cement production is 5% of the total CO_2 globally, and China alone contributes to 3% of Total CO_2 globally [10]. Some think that concrete is a highly influencing material on the environment, while in reality it has little effect, but its mass production has a huge impact on the environment, and if it were replaced by other material such as steel, the effect would be worse in the environment [10]. When engineers choose a building material, this material should fulfill several conditions and criteria, including:

1. Economic factors: Several effects affect the price of the building material other than the net cost of the material itself. These include: the availability and price of the raw material, the cost of manufacturing, the cost of transportation, the difficulty of placing the material on the site, and its maintenance demand [11]; that is, choosing a ideal material for the construction of a particular building in a specific place depends on many things that all contribute to the pricing of this material. In the American state of Hawston, for example, the nearest source of aggregate (the main component of concrete) is located 150 kilometers from the city, which increases the price of concrete in this city to double. Hence, steel is a better option for construction [11], as for our home country There is no raw material for the manufacture of steel, as it is imported from abroad and then locally installed and welded, so its cost is very high compared to the concrete whose components are all available locally at low prices [11]; that is, it is an ideal option for construction in our country, as it may be up to a quarter of the price of steel or less, and this is the opposite of what is in the United States [11], but despite all this, it is not possible to generalize a rule regarding the optimal material for construction, each facility has its own characteristics and requirements.
2. Mechanical properties: that is, the behavior of the material when applying external loads to it. This behavior has scientific terms and vocabulary that are more important to specialists than others [11], the most prominent of which is known as (elasticity factor), and means in practice that the greater the elasticity factor of a substance, the greater its susceptibility to deformation. Before it fails, i.e. it will be like rubber; it is deformed a lot when the loads are applied to it, but it will not fail, and we will not represent this with a bridge made of steel, so when any weight is placed on it the bridge will start to curve down after applying the loads to it, and it will curve greatly before it collapses, it will only curve a very suddenly collapse; steel is so elastic material, concrete is

plastic material, and it is impossible to concrete alone independent building material, must be reinforced with steel.

3. Non-mechanical properties: that is, which are not related to the effect of the loads on them, such as density, thermal expansion coefficient, and surface properties of the material [11]. In order to know the effect of density in the selection of the construction material, it is necessary to compare the weight of concrete and steel, as the weight of a cubic meter of reinforced concrete is 2500 kg, while the weight of a cubic meter of steel is approximately 7850 kg, the difference is large, as the weight of a cubic meter of steel is about three times the weight of concrete; therefore, steel sections are always designed as voided, not rigid, and also because steel is of high strength, so the bearing strength of its sections is not voided, while 90% of concrete sections are designed, and it is necessary to alert to the strength difference between steel and concrete. The concrete is much weaker than a thousand, and therefore, its designed to withstand the stresses on it.
4. Considerations for its manufacture and construction: The material chosen for the implementation of a particular building may suit all requirements of the structural engineer, but it may preclude his choice of this material for several operational factors; including: the availability of the material locally, the ease of its formation, the requirements of the building, and the presence of skilled workforce working with it, knowing It is easier to work with steel structures than to work with concrete, as the latter requires erection of wooden molds for casting, and then reinforcing them with steel, then casting them, while the steel reaches ready from its factory, and the worker only has to connect the structural elements to each other, either by screws or by welding [11]. However, concrete option remains the cheapest option of steel in most Arab countries; because of the primitive components and provided in abundance, unlike steel.
5. Aesthetic characteristics: That is, the view of the construction material, and this is responsible for the general architect, but the structural engineer should work with the architect to ensure that the building's structural system and its specifications are in line with the architect’s views [11], this is because a good percentage of the general budget for creating a lot of the general projects; it is devoted to the technical side of the facility, and then the structural and architectural engineers are encouraged to cooperate with them to increase the value of the facility and to reduce the cost as much as possible; therefore, the structural engineers must realize the fact that there is a lot to take into account when choosing the appropriate building material other than its specifications.

Types of Concrete

1. Plain Concrete: Concrete without any reinforcing steel and used in the work of concrete under the foundations, as well as in the production of blocks that are not subject to tensile stresses, as well as floors and dams, and their resistance ranges from 150 kg/cm^2 to 200 kg/cm^2 [12].
2. Reinforced Concrete: Reinforced Concrete is a common concrete with reinforced steel to resist tensile stresses, in which compatibility must be taken into account, as well as Equilibrium between stresses and strains in both steel and concrete, and its resistance ranges from 250-400 kg/cm^2 [13].
3. Prestressed Concrete: It is a type of ordinary concrete that is prestressed before it is loaded and these loads are sufficient to ignore the tensile stresses resulting from the effect of the loads and therefore do not need reinforcing steel as the final result of the stresses along the sector after loading (working) is often Pressure stresses [14].
4. Precast Concrete: It is concrete that is poured and processed until it is completely hardened in the factory and then transferred to the site, and this concrete can be normal - reinforced – prestressed [15].
5. High Strength Concrete: It is a concrete with a strength greater than 600 kg/cm^2 and sometimes up to 1400 kg/cm^2 and it can be obtained by using an additional material such as Super-Plasticizers in order to reduce the mixing water to the maximum degree with keeping the same workability and thus obtaining high resistance [16].
6. High Performance Concrete: It is concrete that has certain characteristics, and characteristics that allow it to match in specific environments and conditions. These characteristics may include the characteristics of fresh concrete (workability - flowability ...) or include the characteristics of hardened concrete (resistance to corrosion - scratching – frost-Shrinkage). These characteristics may be combined or separated to give a different performance than the usual conventional concrete performance. High-performance concrete does not require it to be highly resistant [17].
7. Fiber reinforced concrete: It is a concrete that contains fibers, and this fiber is distributed regularly and in all directions throughout the concrete mix. Fibers also have the ability to improve the resistance of concrete in tensile and flexural, shear, impact, shrinkage, and reduce cracking capacity. The most important characteristics of the fibers are that they increase the value of the durability parameters in a significant way, thus the fracture mechanism in the concrete changes from a non-creeping and gradual fracture (Ductile Failure) to a sudden and brittle fracture (Brittle) Sudden Failure [18].
8. Concrete spray Shotcrete: a mixture of cement and sand in a ratio of approximately 4: 1 and add water to obtain the appropriate operational degree. This concrete is pumped with compressed air to the surface to be lined and used in the work of restoration and lining of tunnels and canals. The defects of these types of concrete are

subject to shrinkage due to a large quantity of water or the possibility of non-adhesion and the consistency of components to the surfaces that are sprayed on top of them [19].

9. Polymer-concrete: It is a special concrete that can be obtained by treating ordinary concrete with polymer materials, that act as a bond or filler material for the spaces between the aggregates, which represent (6-8)% of the concrete's weight. Polymer - an organic material consisting of many similar molecules with a high partial weight such as the Polyster and epoxy polyester. One of its defects is the high cost, as it represents (2-3) times of ordinary concrete, and its advantages are high compressive strength about 1000 kg/cm^2 - tensile strength 100 kg/cm^2 and high resistance to shrinkage and external factors [20].
10. Light weight concrete: It is concrete that weighs less than 2000 kg/m^3. The purpose of their use is to reduce the weight of the structure and thus reduce the cost of the foundations. There are three types of light concrete:
    - Fine less Concrete
    - Lightweight Aggregate
    - Aerated concrete (Cellular Concrete) [21].
11. Heavy Weight Concrete: It is concrete whose volumetric weight ranges from 2400 kg/cm^2 - 6000 kg/cm^2. The purpose of its use is to prevent nuclear and atomic radiation as the ability of concrete to absorb this radiation is inversely proportional to its weight [1].
12. Mass Concrete: It is a concrete with large masses and used as a 15 cm aggregate. It is used in concrete dams and ground tanks [22].
13. Air Entrained Concrete: It is concrete with a percentage of Entrained air that does not exceed 6% of the volume of concrete (as a result of using some additives - foams or materials that produce hydrogen from its interaction with cement, ammonium powder or zinc. It is a concrete that has the advantage of being easier to work and has a high resistance to weathering, especially frost [23].
14. Fresh Concrete: It is concrete that starts from the moment of adding water to the components to the mixture until the moment of initial suspicion. The stage is characterized by the ability to mix, transport and pour and, it represents 1-2 hours [24].
15. Green Concrete: Green concrete is the concrete formed in the period from the beginning of the setting of the cement paste to the beginning of hardening (the period from the initial doubt - the final doubt). At this stage, mixing, transportation or casting is not permitted, and it represents 24 hours from the beginning of casting (which is concrete do not carry any stress [25].
16. Hardened Concrete: It is concrete in the stage after the final setting. The stage is characterized by an increase in compressive strength and the ability to carry loads over the time, which represents the period from the end of 24 hours to the end of life the life span [26].

CONCLUSIONS

The following conclusions can be drawn from this study:

1. It is preferable to use the concrete because has high resistance to fire and water.
2. The reinforced concrete structures are rigid.
3. Concrete is a low-maintenance material.
4. The service life of concrete is long and economical material compared to other construction materials.
5. It can be cast in different shapes.
6. Less construction workers skills required compared to other construction materials.
7. Concrete can be used as a construction material in most structures, regardless of structure complexity.
8. Each type of concrete can be used for a specific purposes, depending on the nature of the loads and stresses on the structural member.
9. Due to importance of using the concrete, it has been developed to advanced large stages compared to the concrete that was discovered previously.

REFERENCES

[1]. Neville A.M., Properties of concrete, fifth edition, Pearson Education 2011.
[2]. https://www.memphis.edu/ce/index.php.
[3]. https://www.kuhlman-corp.com/history-of-concrete.
[4]. Steven H. Kosmatka and Michelle L. Wilson,” Design and Controlof Concrete Mixtures”, Fifteenth Edition, Portland Cement Association, Skokie, Illinois, USA, 2011, 460 pages.
[5]. Elzner, A. O., "The First Concrete Skyscraper," The Architectural Record, June, p. 515, 1904.
[6]. Nick Gromicko and Kenton Shepard, “The History of Concrete”, International association of certified home inspectors, Technical Report, 2016.
[7]. Auburn University. 2007. Historical Timeline of Concrete (accessed 8/10/10 at https://fp.auburn.edu/heinmic/ConcreteHistory/index.htm).
[8]. Guedes P. (1979) Building materials. In: The Macmillan Encyclopedia of Architecture and Technological Change. Palgrave Macmillan, London.

[9]. Hiltzik, M. (2010). "Colossus: Hoover Dam and the making of the American Century." Simon & Schuster.
[10]. Bapata, J. D., Sabnisb, S. S., Joshic, S. V., and Hazaree, C. V.: History of Cement and Concrete in India – A Paradigm Shift, American Concrete Institute (ACI) Technical Session on History of Concrete, Atlanta, USA, April 2007, 2007.
[11]. https://drive.google.com/file/d/0B5YLpbJnZ6JtREpTU1ZCYzIyVm8/view.
[12]. Cordon, W. A. and Gillespie, H. A. (1963) "Variables in Concrete Aggregates and Portland Cement Paste Which Influence the Strength of Concrete," ACI Journal, Proceedings V. 60, No.8, August, pp. 1029-1052.
[13]. Halrorsen, T., Concrete Reinforced with Plain and Deformed Steel Fibres, Report No. DOTTST 76T-20. Federal Railroad Administration, Washington, D.C., 71 p. (Aug., 1976).
[14]. Nawy, E. G., 2006, Prestressed Concrete: A Fundamental Approach, 5th ed., (Upper Saddle River, NJ: Prentice-Hall), pp. 38.
[15]. everestprecastmaster (18 November 2019). "Precast concrete". Everest Precast. Retrieved 18 November 2019.
[16]. ACI Committee 363. (1992) "State-of-the-Art Report on High-Strength Concrete (ACI 363R-92)," ACI Manual of Concrete Practice, 1997 Edition, Part I, Farmington Hills, MI.
[17]. ASCE, High-Performance Construction Materials and Systems, Technical Report 93-5011, American Society of Civil Engineers, New York, April 1993.
[18]. ACI Committee 440. 1996. "State-of-the-Art Report on Fiber Reinforced Plastic (FRP) for Concrete Structures (ACI 440R)", "ACI Manual of Concrete Practice, Part 5, American Concrete Institute", Detroit, MI, 68 pp.
[19]. Rispin, M, Kleven, OB, Dimmock, R & Myrdal, R 2017, 'Shotcrete: early strength and re-entry revisited – practices and technology', in M Hudyma & Y Potvin (eds), Proceedings of the First International Conference on Underground Mining Technology, Australian Centre for Geomechanics, Perth, pp. 55-70.
[20]. American Concrete Institute, Polymer Concrete, SP-137, Farmington Hills, Mich., 1993, 130pp.
[21]. Maage, M., Smeplass, S., and Thienel, K. 2000. "Structural LWAC Specifications and Guideline for Materials and Production." Second International Symposium on Structural Lightweight Aggregate Concrete. Accessed June 22, 2000. http:// www.sintef.no..
[22]. American Concrete Institute Committee 207, Mass Concrete, ACI 207.2R-95, 2005.
[23]. ASTM C260 / C260M Standard Specification for Air-Entraining Admixtures for Concrete.
[24]. S. H. Kosmatka and M. L. Wilson, Design and control of concrete mixtures: the guide to applications, methods, and materials. Skokie, Ill.: Portland Cement Association, 2011.
[25]. Green Concrete in Denmark' Our Concrete Environment, Sydney Australia.
[26]. J. B. Newman and B. S. Choo, Advanced Concrete Technology: Processes, vol. 3, Butterworth-Heinemann, 2003.