The history of ancient concrete construction construction essay

CONTENT

Chapter 1: Overview of the Concrete

1. 0 Introduction

Concrete is everywhere. This is the second most consumed material after water. It shapes our built environment. Housing, schools, hospitals, bridges, roads, and footpaths all make use of concrete. Concrete is a good material to build long-and energy-efficient buildings. However, even with Produces good design humane changes in demand and potential waste. In the results generated by the demand Construction and demolition waste, it is estimated 900 million Tons a year in Europe, and the United States. (CSI)To begin with we will provide a brief background on the concrete. Concrete is a composite structure material consisting of a primary aggregate, cement, and water. Concretes have a lot of recipes with different performance. The polymerization is generally coarse gravel or crushed rock, such as limestone, granite, fine aggregate, such as sand. And the Cement, such as ordinary Portland cement, fly ash and slag cement, and other cementitious materials, such as a binder for the aggregate. When water are mixed, and then the dry compound, which makes it is solidified-shaped, and then by a chemical process which is called hydration and harden. It will turn the concrete into a rock hard strength. Water and cement, together with other components of the reaction of the bond, and ultimately create a material as stone. Concrete is with high compressive strength, but the tensile strength is much lower. For this reason, it is usually the reinforcing material is a strong tension, usually using steel. Many processes, such as the water trapped in the freezing may

damage the concrete. (Fig 1. 1)Worker prepearing concrete steel reinforcement □□□□□ - 14958302Fig 1. 1: The reinforce material in concrete.

Historical Background

1. 1. 1 History of Concrete

Nowadays, the concrete is common made by Portland cement, aggregates which are from rock and sand, and the water. Some admixtures chemicals material are added into the concrete to control its setting properties, and some of them are used primarily when placing concrete during bad environmental, such as in high temperatures, freezing condition, corrosive condition, windy conditions, and so on.

1. 1. 2 Early Use of Concrete

There were many ancient countries had ever use concrete to build some great engineering marvel in the world. Such as Pyramid of Khufu, Great Wall and the Pantheon. These ancient buildings were built without today's theories, but still stand in the history for thousands years. The first concrete like structures was built in around 6500 BC. The merchant from Nabataea or Bedouins controlled this area, and developed a small country at the southern of Syria and northern of Jordan. The structures of built by the technology of hydraulic lime, It can hardened the cement with water. In the processing of making concrete structure, the Nabataea had already known it need to keep the mixing as low-slump as possible in dry condition, as the retaining water would cause voids in the concrete. They also invented a special tool to tamping fresh concrete which could create more gel. It happened when the mixing, the chemical reaction happened

1. 2 Ancient Concrete construction

There are lot of countries with long history have experience of using similar concrete material. Such as China, Egypt, Rome. It reveals the developing history of concrete in human history.

1. 2. 1 China

In About 200 BC, the Chinese of north used a form of cement in boat building and in building the Great Wall. This is a very huge project. It was made up by 6, 259 km part of actual wall, 359 km of trenches and 2, 232 km part of environmental defensive barriers as the mountains and waters. The other archaeological survey shows that the all branches of Great Wall were measured out to be 21, 196 km. Some experiment such as Spectrometer testing has proven that the most important ingredient in the mortar of the Great Wall and some other ancient Chinese structures is glutinous and sticky rice. Some of these structures have stood the test of environment and time, now they are treated as cultural constructions for tourism. (Fig1. 2)http://1. bp. blogspot. com/-VmEJqGsRKl8/Ta2n1S9gLeI/AAAAAAAAMns/sW0ipRGrBVg/s1600/great-wall-of-china. jpgFig 1. 2: The Great Wall

1. 2. 2 Egypt

In about 3000 BC, the Egyptians had already known use mud mixed with straw to create huge bricks. These kinds of bricks structures are very similar to concrete structures. However, the pyramid was built by gypsum and lime mortar. In generally, the mortar and concrete were different materials, but in that age it still can be consider as a great creation in civil engineering. By

the statistics, it required about 500, 000 tons of mortar to create the construction materials to create the Great pyramid at Giza. It means millions of slaves were worked for the pyramid.(Fig 1. 3)http://www. 99sj. com/Upload/Media/2AD01B0895DD2. jpgFig 1. 3: The Pyramid of Khufu

1. 2. 3 Rome

At the about 600 BC, the Greeks had found a natural pozzuolana material. It has hydraulic properties when mixed with lime, but their neighbor romans that have more buildings with concrete in the same time. At the about 200 BC, the Romans had already known how successful to build structures with concrete, but there is difference between how we used concrete today. The way Roman used mostly like cemented rubble. They using different kinds of size stone with mortar, the walls were clad all sides of the structure with bricks, but the bricks had few structure value. In this time, most of buildings of Rome were used limestone cement; it hardened slowly in with reaction of air, after thousands of year, the strength of the concrete have a high value. The concrete buildings in roman already have great cultural in architecture, it stand the symbol of roman, such as the Colosseum and Pantheon. (nachi) (Fig 1. 4 and 1. 5)Rome Colosseum About the instituteFig 1. 4: The Colosseum in Rome Fig 1. 5: The Pantheon.

1. 3 Material of Modern Concrete

1. 3. 1 Cement

Cement is the most important and costliest ingredient of concrete. The mix design of concrete indirectly means optimizing the use of cement for obtaining the desired properties of concrete in green as well as hardened

state. It affects the overall economy of the structure too. Different types of cement are available for different type of structures and different types of location. In general, cement is described as a material as a material used to bind mineral fragments called aggregate. The cement paste acts as glue which makes a cohesive mass with all the aggregates. This bonding is very important as the concrete fails not because of less strength of aggregates but mainly due to failure of bonding. (Fig 1. 6)cementFig 1. 6: General cementDifferent types of cementNormal type of cement will not be suitable for different locations and climate conditions. Therefore, various types of cement have been developed as different requirements. The changes have been achieved by different ways such as: Changing oxide compositionChanging finenessUsing additives or mineral mixtures like slag, fly-ash or silica fumes. The various types of cement generally used in different locations are as given belowOrdinary Portland Cement (OPC)OPC is the most commonly produced and used cement. The name Portland war derived from lime stone called as Portland Stone quarried in Dorset-UK, due to its resemblance with the set cement. Rapid Hardening Cement (RHC)It is also called Early Strength Cement because its 3 days strength is almost equal to 7days strength of OPC. It is different from quick setting cement which only sets quickly whereas in RHC, strength development is very fast. Sulphate Resistant Cement (SRC)The normal OPC is susceptible to sulphate attack particularly magnesium sulphate. Blast furnace slag cementThis cement is also known as ground granulated blast furnace slag (GGBFS). It is produced by blending OPC clinkers with blast furnace slag in suitable proportion and grinding together. Portland Pozzolana Cement (PPC)Pozzolana essentially means a siliceous material have none content of cementing

properties in it. But in some situation it has react with Ca(OH)2 in presence of water at normal temperature, and its forms compounds with the possess of cementing properties. Air Entraining CementAir is entrained in the concrete in the form of bubbles which modify the properties of fresh concrete such as workability, segregation, bleeding and finishing characteristic. Quick Setting CementThe setting time of ordinary cement is very less if gypsum is not added at the clinkering stage. Therefore when quick setting cement is required, the gypsum is deliberately added in less quantity or not added at all. Expansive CementThis cement is used for repair works where the change in volume is not desirableHigh alumina cementThis cement has a very high rate of strength development.(INDIAN RAILWAY INSITITUTE, 2007)

1. 3. 2 Aggregates

Aggregates give body to the concrete. They also reduce shrinkage and effect overall economy. Since aggregate is cheaper than cement, it is economical to put as much aggregates as possible. Not only the use of more volume of aggregate in concrete is economical, it also provides higher volume stability to the concrete. Generally they occupy 60-70% of the total volume of concrete. At the same time the aggregates should be strong because the weak aggregates cannot make strong concrete and they may limit the strength of concrete. Therefore the selection of aggregate becomes very vital. Earlier aggregates were viewed as an inert ingredient of concrete but now their importance has been understood and these are no more considered inert. Their physical, chemical as well as thermal properties greatly influence the properties of concrete. (Fig 1. 7)http://www.

campbellredimix. com/images/aggregate_2. jpgFig 1. 7: General aggregateThe definition of different types of aggregate are given below, Coarse aggregateThe aggregate mostly retained on the NO. 4 (4. 75-mm) sieve; or that content of an aggregate retained on the No. 4 (4. 75-mm) sieve. Fine aggregateThe aggregate mostly passing the 3/8-in (9. 5-mm) sieve and mostly passing the NO. 4 (4. 75-mm) sieve and mostly retained on the NO. 200 (75-µm) sieve; or the part of an aggregate passing NO. 4 (4. 75-mm) sieve and mostly retained on the NO. 200 (75-µm) sieve. GravelGranular material mostly retained on the NO. 4 (4. 75-mm) sieve and resulting from natural environment erosion and abrasion of stone or it will processing the weakness bound of conglomerate, or that part of an aggregate mostly retained on the NO. 4 (4. 75-mm) sieve and resulting from natural environment erosion and abrasion of stone or it will processing the weakness bound of conglomerate. SandGranular material passing the 3/8-in (9. 5-mm) sieve and mostly entirely passing the NO. 4 (4. 75-mm) and mostly retained on the NO. 200(75-µm) sieve, and resulting from natural environmental erosion and abrasion of stone or it will processing the completely friable sandstone; or that part of an aggregate passing the NO. 4 (4. 75-mm) and mostly retained on the NO. 200(75-µm) sieve, and resulting from natural environmental erosion and abrasion of stone or it will processing the completely friable sandstone. Crushed StoneThe product of resulting from the manmade crushing of stone, large cobblestones or boulders all has the definition of crush stone and they have resulted from crush processing. Air-Cooled Blast Furnace SlagThe nonmetallic product, consisting essentially or silicates and aluminosilicates of calcium and other bases, it is developed in molten condition simultaneously with iron in a blast

furnace. Crushed gravelThe product resulted from the manmade crushing of gravel which specified minimum percentage of fragments; it has one or more side resulting from fracture.(Neville, A. M, and Brooks, 1987)

1. 3. 3 Water

The quality of water needed for making good concrete is very important. The quality of water has great influence on the strength as well as durability of concrete. There is a popular yardstick that water fit for drinking purpose can be used for concrete. But technically speaking various chemical in water should be with in prescribed limits as given below: PH value if water should be between 6 and 8. The value less than 6 means acidic in nature which may lead to corrosion of reinforcement. It should be free from organic material and other impurities.

1. 3. 3. 1 Effect of impurities if water

Carbonate and bicarbonates will affect setting time of cement. Sodium carbonate is the reason caused quick setting. If the content of bicarbonate is more than 1000 ppm, the test of setting time and strength should be processing. The content of Turbidity should not more than 2000 ppm. This is caused by silt or other suspended material, it is not only interfere setting, but also interfere hardening time and bond characteristics. The algae, if occurred in water, it will entrap a large content of water in it which causes the strength reduction of concrete. Brackish water contains Cl- and SO4-, the content of Chloride should not be more than 10, 000 ppm, and the content of sulphate should not be more than 3000 ppm, or It will affect the strength of concrete. (Neville, A. M, and Brooks, 1987)In generally, the source of water should be reliable and safety. In case of any bad situation, such as coastal

area, marshy land and other places where brackish water is occurred, it should compare the cube strength of the concrete in 7 days and 28 days between the available water and pure water. This will give and overall effect of the source water. If the strength of the concrete achieved with available water is greater than 90% of strength achieved with pure water, and there is no other problems is occurred in the concrete made, then the source of water can be accepted. But it is still need the tests on a regular basis. (Concrete 2003)

1. 3. 3. 2 Effect of Sea Water

The salinity of sea water is about 3. 5%. If sea water is used in the processing of concrete, the most problem will occur should be the corrosion or erosion of steel. This is very dangerous situation; it may reduce the strength of the concrete, and even break it. The strength reduction is around 15%. The other bad effect, such as accelerates the setting time of cement, causes efflorescence, persistent dampness. Therefore, the seawater is not a good material in concrete works, if must use the seawater it need the test on a regular basis. (Neville, A. M, and Brooks, 1987) (Fig 1. 8)http://g-ecx. images-amazon. com/images/G/01/wikipedia/images/4841516ba43eeba4d41ba90f20a3720c6bc23399. jpgFig 1. 8: Effect of sea water on concrete

1. 4 Properties of Concrete

1. 4. 1 Workability

All concrete mixture must be properly proportioned to have satisfactory economy, workability, required strength, and durability properties. These

different objectives require differences in proportioning, and consequently most concrete mixtures are compromises rather than mixtures having the best workability, or the highest compressive strength at a given age or the greatest economy. Excellent workability, for example, normally requires high cement and fine- aggregate contents with a low coarse-aggregate contents and relatively high water content. Such a mixture would certainly not be economical, and its properties would not be optimum. Consequently as the proportions of a given mixture are changed to provide greater workability, the effects on the other properties must be considered, and the desired improvement in workability should be obtained by means of such changes as have the least harmful effects on the other properties. In the other word, the concrete mixture must have sufficient workability to enable satisfactory placement under job conditions, sufficient strength to carry design loads, sufficient durability to allow satisfactory service under expected exposure conditions, and necessary economy not only in first cost but in ultimate service. (Shetty 2000)

1. 4. 2 Strength of Concrete

The compressive strength of concrete is the most important and useful properties of concrete. In most structural applications the concrete is employed by the primarily to resist compressive stresses of the structure. In these cases, the strength in tension or in shear is very important; the compressive strength is mostly used to measure these properties. Therefore, the concrete making properties of various ingredients in mixing are usually measured in terms of the compressive strength. The compressive strength is also used to measure for other properties of concrete. No exact quantitative

relationship between compressive strength and flexural strength, tensile strength, modulus of elasticity, wear resistance, fire resistance, or permeability have been established nor are they likely to be. However, approximate or statistical relationships, in some cases, have been established and these give much useful information to engineers. (Shetty 2000)

1. 4. 2. 1 The effect factor of strength of Concrete

In order to given acceptable cement and aggregates, the strength should be developed by workability. The mixture of cement, aggregate and water under the same mixing condition in a proper placed. The testing conditions are influenced by the follow situation: 1) The ratio of cement to mixing water; 2) The ratio of cement to aggregate; 3) The maximum size of aggregate; 4) The properties such as grading, surface texture, shape, strength and stiffness of aggregate particlesIn the above it can be further inferred that water/cement ratio primarily affects theStrength factor, whereas other factors indirectly affect the strength of concrete by affecting the W/C ratio. Fig 1. 9: The effect of Compressive stress to W/C

1. 4. 2. 2 Gain of Strength with Age

The concrete develops strength with continued hydration. The rate of gain of strength is faster to start with and the rate gets reduced with age. It is always to assume the 28 days strength achieved the full strength of concrete. Actually concrete develops strength beyond 28 days also. Earlier codes have not been permitting to consider this increase of strength beyond 28 days for design purposes. The increasing strength beyond 28 days used to get immersed with the factor of safety. With better understanding of the

material, progressive designers have been trying to reduce the factor of safety and make the structure more economical. In this direction, the increase in strength beyond 28 days is taken into consideration in design of structures. Some of the more progressive codes have been permitting this practice.(L. Taerwe and H. Lambotte, 1991)Table 1. 1: Age Factors for Permissible Compressive Stress in Concrete as per British Code

1. 4. 2. 3 Effect of Maximum size of Aggregate on Strength

At one time it was thought that the use of larger size aggregate leads to higher strength. This was due to the fact that the larger the aggregate the lower is the total surface area and, therefore, the lower is the requirement of water for the given workability. For this reason, a lower water/cement ratio can be used which will result in higher strength. However, later it was found that the use of larger size aggregate did not contribute to higher strength as expected from the theoretical considerations due to the following reasons. The larger maximum size aggregate gives lower surface area for developments of gel bonds which is responsible for the lower strength of the concrete. Secondly bigger aggregate size causes a more heterogeneity in the concrete which will prevent the uniform distribution of load when stressed. (Shetty 2000)When large size aggregate is used, due to internal bleeding, the transition zone will become much weaker due to the development of microcracks which result in lower compressive strength.

1. 4. 3 The durability of concrete

For a long time, concrete was considered to be very durable material requiring a little or no maintenance. The assumption is absolutely true, except when it is faced to high value aggressive environment. We build

concrete structures in highly polluted urban and industrial areas, aggressive marine environments, harmful sub-soil water in coastal area and many other hostile conditions where other materials of construction are found to be non-durable. Since the use of concrete in recent years, have spread to highly harsh and hostile conditions, the earlier impression that concrete is a very durable material is being threatened, particularly on account of premature failures of number of structures in the recent past.(Durable 1992)The durability of cement concrete is its ability to resist environmental erosion, chemical reaction, abrasion, or other processing of deterioration. The high durability concrete will retain its form, quality, and functional.

1. 4. 3. 1 Significance of Durability

When designing a concrete mix or designing a concrete structure, the exposure condition at which the concrete is supposed to withstand is to be assessed in the beginning with good judgment. In case of foundations, the soil characteristics are also required to be investigated. The environmental pollution is increasing day by day particularly in urban areas and industrial atmospheres. It is reported that in industrially developed countries over 40 per cent of total resources of the building industries are spent on repairs and maintenance. Every government department and municipal bodies have their own " Repair Boards" to deal with repairs of buildings. It is a sad state of affairs that we do not give enough attention to durability aspects even when we carry out repairs.

1. 4. 3. 2 Impact of W/C Ratio on Durability

For the volume change results in cracks and cracks are responsible for disintegration of concrete. We may add now that permeability is the

contributory factor for volume change and higher W/C ratio is the key of higher permeability. Therefore, use of higher W/C ratio →permeability → volume change → cracks → disintegration → failure of concrete is a cyclic process in concrete. Therefore, for a durable concrete, use of lowest possible W/C ratio is the key to produce dense and impermeable concrete.

1. 4. 4 Permeability of concrete

The W/C ratio is the fundamental point for concrete durability. Another important point for consideration is the permeability of concrete. Generally we start discussion from the permeability of concrete as it has much wider and direct repercussion on durability than that of W/C ratio. For example, microcracks at transition zone are a consideration for permeability whereas W/C ratio may not get involved directly. It may be mentioned that microcracks in the initial stage are so small that they may not increase the permeability. But propagation of microcracks with time due to drying shrinkage, thermal shrinkage and externally applied load will increase the permeability of the system. (Shetty 2000)

1. 4. 4. 1 The effect of aggregate in Permeability

The introduction of aggregate of low permeability into cement paste, it is expected to reduce the permeability of the system because the aggregate particles intercept the channels of flows and it take a circuitous route. Compared to neat cement paste, concrete with the same W/C ratio and degree of maturity, should give a lower coefficient of permeability. But in practice, it is seen from test data it is not the case. The larger size of aggregates will increase the permeability of concrete. Table 1. 2: Typical values of Permeability of concrete used in Dams

Chapter 2: Investigation the durability of concrete

2. 0 Introduction

This chapter is an investigation to the durability of the concrete. As there are widely use of concrete, the concrete can be attacked by many ways both in physical and chemical.

2. 1 Chemical processes in concrete

The durability of concrete structure will often be determined by result of concrete reaction with chemical. From these reactions, the aggressive substance of concrete, such as the ions and molecules are transport to outside, mostly from the environment. In generally, the reaction between the aggressive substance and the reactive substance take place as soon as the substance meets. But, as the low rate of the transport of the aggressive substance, these reactions may take many years to show their effect. (Durable 1992)The chemical reaction will decrease the quality of the concrete, the important parts include: The reaction of acidsThe reaction of sulphatesThe reaction of alkalis

2. 1. 1 Acid attack

Hydrated cement paste is a kind of alkaline material, for this reason attack by other alkaline material will not encountered by normal. High concentration of alkaline materials that may come in contact with concrete in industrial processes cause deterioration by processes other than direct chemical reaction with hydroxide ions.(Fig 2. 1)https://encrypted-tbn0. gstatic. com/images? q= tbn: ANd9GcTmAPeqnp0w0wHNILKwc8No6K95Ly8jDfKUqVqKeYZ8VmZzF0LtFig 2.

1: Acid attack to concrete. The hydrogen ion accelerate the leaching if the calcium hydroxide, Ca(OH)2+2H+→Ca2++2H2OIf the ion is highly concentrated, CSH may also be attacked, 3CaO. 2SiO2. 3H2O+6H+→3Ca2++2(SiO2. nH2O)+6H2OCarbonic acid can also be very corrosive because of formation of soluble calcium bicarbonateCa(OH)2+H2CO3→Ca(HCO3)2+H2O (Concrete 2003)It should be realized, there is a fundamental difference between acid attack, sulphate attack and alkali attack. In the former case, there is a complete processing of the hardened cement, and destroying the pore system. With the acid attack, the effect on permeability of the concrete is very low, but with the other attack, the effect on permeability of the concrete is very high.

2. 1. 2 Sulphate attack

In contrast to acid attack, where the pore system as a whole is destroyed because the acid react with all the component in cement, sulphate attacks only certain components in the cement. Sulphate attack is characterized by the chemical reaction of sulphate ion with the aluminate component and ions of sulphate, calcium and hydroxyl of hardened Portland cement or the cement containing Portland clinker, it forming a lesser extent gypsum. (Durable 1992)(Fig 2. 2)http://www. ceratechinc. com/Content/img/KEMROK-MIC. pngFig 2. 2: Cracking due to sulphate attack. The cement has a high rate of C3A, It is attack by reaction between sulphate ions and calcium hydroxideCH+SO42-(aq)←→CSH2+2OH- (aq) (Concrete 2003)It is important to realize that classification or cements for sulphate resistance only takes sulphate resistance as such into consideration. In case of combined attack, the other factors may influence the choice of the cement.

2. 1. 3 Alkali attack

The mechanism of alkali attack resembles that of sulphate attack more than acid attack, as the reason of the alkali attack is only on certain substances in the concrete. The difference between sulphate attack and alkali attack is that the reactive substance in the former case in the cement, and later in the aggregate. (Fig2. 3)http://ars. els-cdn. com/content/image/1-s2. 0-S0008884601006597-gr4. jpgFig 2. 3: Alkali attack on concrete. Carbonate materials may also be easily attack by alkaline materials. In dolomite or limestone, the reaction may produce magnesium hydroxide. It may result ultimately in the completely destruction of concrete. (Durable 1992)

2. 2 Physical processes in concrete

2. 2. 1 Cracking

Crack may be caused by many different situations and may range from very small internal micro cracks that occur on the application of modest amount of stress to quite large cracks caused by undesirable interaction with the environment, poor construction practices, and errors in structure design and detailing. (Concrete 2003)Cracking will occur whenever the tensile strain to which concrete is subjected exceeds the tensile stain capacity of the concrete. The tensile strains capacity of concrete varies with age and with rate of the application strain.(Fig 2. 4)[types+and+causes+of+cracks. JPG]Fig 2. 4: Types of crack. There are lots of kinds of basic mechanisms by which strains may be generated. Movement generated by the concrete. Example: drying shrinkage, expansion or contraction due to temperature change, and plastic settlement or shrinkage. Expansion of material embedded by the concrete. Example: corrosion of reinforcement. Externally

imposed conditions. Example: Loading or deformations imposed by differential settlement or foundation. Cracking developed during the execution process and during the initial period of hardening time may be the main reason for the acceleration or deleterious action, it depends on the water or the aggressive substances enter into to concrete from outside. (Durable 1992)

2. 2. 2 Erosion

2. 2. 2. 1Erosion by abrasion

Abrasive wear of the concrete surface can be caused, for example, by the grinding action of pedestrian traffic on floors, by the scraping, percussive impact of studded tires on pavements or by impact or sliding of loose bulk material. (Durable 1992)Abrasive wear also can be caused by the action of heavy particles suspended in water, especially at high water velocities. Especially the places which water occurred. Such as the dams, the hydraulic plants, the constructions for steam regulation, the structure protecting embankment, and the bridge piers. (Fig 2. 5)concrete erosionFig 2. 5: Erosion on concrete

2. 2. 2. 2 Erosion by the cavitation

If the water without solid is flowing rapidly parallel to a limiting surface, any change in the geometry of the surface causes a flow detachment and zones of low pressure at the limiting surface. If the static pressure of streaming water becomes lower than the vapor pressure of water, the vapor bubbles will fill in this zone. If the bubbles stream to zones where the static pressure exceeds the vapor pressure of water, vapor condenses in the bubbles and

bubbles collapse suddenly. This implosion causes impact and pressure waves to develop, it is similar those caused by explosions. This process is called cavitation, and results in damage similar to pitting and excavations. (Durable 1992)The cavitation or similar impact and pressure waves occur when water hits limiting surfaces with high velocity. The 90 degree angle surfaces constitute an extreme case of this.

2. 2. 3 Frost attack

In the case of water freezing in porous building material, for example the cement paste, the physical processes are the major reason to determine the freezing resistance by their mutual interaction. Transition of the volume from water to ice is increased 9%. In case of completely water filled pore, this will cause spitting of the concrete. (Fig 2. 6)http://ars. els-cdn. com/content/image/1-s2. 0-S0008884606001049-gr1. jpgFig 2. 6: The crack due to frost attackThe over energy at the pore surface results in a reduction of the potential energy of the pore water, and in a depression of the freezing point, due to the wide range of pore radii of cement paste, only about 33% of the pore water will be frozen at the temperature -30oc and 66% of the pore water will be frozen at the temperature of -60oc. A thin film of water coating the pore surfaces will remain even after the pore water has formed as the ice. As a result of increasing strength of the concrete and the changing pore structure, the frost resistance will growing stronger as the age of the concrete increasingIn further, it should be noted that even in ambient humilities not likely to cause damage by frost, concrete at very early age shows high moisture content, and it has confined expansion space. This is

due to the fact that the retained water from the processing has not been disposed. (Durable 1992)

Chapter 3: Repairing of Concrete

3. 1 Introduction

This part of the report outlines repair processes for concrete and selection of the most suitable method for damage repair. Concrete is a versatile building material that is cast inexpensively and is durable, strong and takes the shape of the form in which it is cast. Most concrete members are cast on site and in their final location. Marginal work and construction procedures cause imperfections that require repair. Natural forces and use in service cause deterioration or damage which must be replaced during maintenance of the structure. (Joseph A. 1998)Most small repairing is made to make the structure appearance acceptable and when completed, it should be blend with adjacent untouched surfaces by matching its color and texture. In addition the repair must be: Thoroughly and permanently bond to adjacent concrete; Sufficiently impermeable to protect original structure; Free of shrinkage cracks and checking; Resistant to freezing and thawing where required. Repairs to old concrete require analysis and planning as deteriorated concrete must be isolated and removed. Some dams have complete resurfacing with shotcrete and prepackage aggregate method. In earthquake countries, retrofitting old buildings and repair of seismic damage become normal practice. This chapter discusses recommended materials and methods for making most types of concrete repairs. (Joseph A. 1998)

3. 2 Material of Concrete repair

3. 2. 1 Cement

A range of concrete repair materials are available. Portland cement concrete can be used as a kind of reliable repairing material for concrete pavement repair. It is most useful for full depth patches or full slab replacement. A low slump concrete of high density or mortar patching mix, properly placed, it is going too compacted by vibration and cured, it has already proven for partial depth patches. Mixed results have, however, been reported. By using portland cement and its accelerators, concrete mixing can be produced and that will enable the pavement to be trafficked after 6 to 24 hours.(Joseph A. 1998)Lots of special products for patching concrete are have special names. It included organic and inorganic materials, such as epoxies, gypsum-based cements, magnesium phosphate cements and methacrylate. It should be taken to prevent the use of impervious materials in areas large enough to block water vapor coming up from below and trapping water which can cause further damage. Table 3. 1 Typical characteristics of selected repair materials from Cement Concrete & Aggregates Australia June 2009The characteristics of portland cement and other rapid set with high early strength cements are reviewed. They are widely used in the main constituent as pavement repair materials. Their typical characteristics are summarized in the table. (Table 3. 1)

3. 2. 2 Aggregates

Requirement for aggregates are similar to those for concrete and mortar. Special aggregates required by the specifications may have to be used in the

repair of an exposed aggregate finish to match the adjacent color and texture.

3. 2. 3 Admixture

Admixture used in concrete can also use in repairs. These include water reducer, air entraining agent, chemical accelerators, steel, alkali resistant glass of polypropylene fibers, silica fume, flying ash, natural pozzlans and integrally used polymers.

3. 3 Preparation of Concrete repair

Most concrete repairs involve the removal of concrete which may either have deteriorated or have a construction defect or be damaged. Choice of the various methods of removal is determined by the extent and location of repair , economy, safety , effect on the concrete remain, effect on use of the structure due to delay for repairing and curing . Specification should outline the expected result of the repair and in some cases outline the allowable methods of concrete removal. Large repairs requiring replacement of structural concrete should be done as soon as possible after removal of the forms. (Joseph A. 1998)

3. 3. 1 Removal method

Damaged deteriorated of substandard concrete can be removed by abrasion, cutting, impacting, splitting and blasting. (Fig 3. 1 and 3. 2)1) Abrasive methodsAbrasive methods include the sand blasting, shot blasting and high pressure water blasting. They are used to remove layers of concrete which may be discolored deteriorated or uneven and roughen the surface in preparation for the repair. 2) BlastingSand blasting should be done on

horizontal or vertical surfaces. Shot blasting is limited to horizontal surfaces as floors. High pressure water blasting can be done similar to sand blasting. 3) Impacting methodsImpacting methods consist of using a hand held chipping gun, or bush hammer, scarifier, needle gun or boom mounted breaker. The chipping gun is a chisel type bit operated pneumatically. 4) The splitting methodThe splitting method consists of mechanical wedging, water pressure and expansive chemicals. A type of mechanical wedging uses a hydraulic splitter placed in predrilled holes for removal of large volumes of concrete in massive structure. 5) Cutting methodsCutting methods include high pressure jet, diamond or carborundum blade saws, diamond wire, and thermal. The high pressure water jet uses a small jet of water driven by pressures of 70 to 310 MPa. (Fig3. 1 and 3. 2)Waterblasting 10000 psiFig 3. 1: Cleaning the concrete surface by the water blasting prior. http://static. concretenetwork. com/photo-gallery/images/420x320Exact_0x100/floor-logos-and-more_122/rockmolds-com_22848. jpgFig 3. 2: The worker removing the excess material by chipping gun.

3. 3. 2 Cleaning and Grouting

Once the deteriorated or damaged concrete is removed, and dust, dirt of loose material must be removed by water blasting followed by air blowing to remove excess moisture. If repair material is cementations, the base concrete to be repaired should be kept moist at 48hrs prior to application of the repair material. Presence of oil or other contaminants will require washing with detergents. (Joseph A. 1998)

3. 4 Repair methods of Concrete

A thorough study of the underlying reasons for the deterioration or damage to be repaired is necessary as it will determine the type of repair method. Epoxy injection of cracks still subjected to large thermal changes or load deflections will not be permanent. Once the causes have been determined, a permanent repair solution can be found. Maintenance schedules and planning may also dictate the expected life of repair. Use of the structure may require a method of repair that will have a minimal effect on operations during the repair application. Weather conditions will also influence the choice of repair. Modifications may be required to environmental conditions to prevent future deterioration or damage. (Joseph A. 1998)Methods of repair include concrete replacement which can be same as the base concrete or modified with silica fume, acrylic, styrene butadiene latex or epoxy; dry pack replacement; shorcrete application ; preplaced aggregate with pumped or formed concrete; injection of cement grout or chemical formulation; and manually applied mortar.

3. 4. 1 Concrete replacement

Conventional concrete similar to original concrete may be used for the repair if forming, placement and consolidation are feasible. This method is used where large void extend through section. The conventional concrete repair consists of forming on both sides of the concrete section so that the form is completely sealed around the repair. A chimney or hopper is constructed on the top integrally with form so that a hydraulic head will assist in maintaining pressure on the concrete. The top of the concrete void should have a slight upward incline to the outside of 10□, Minimum to allow air to escape during

consolidation. In addition, the form hopper should be as wide as the void to be repair and have sufficient opening for concrete placement and insertion of internal vibrators. (Joseph A. 1998)

3. 4. 2 Topping repair of unformed concrete

The repair of damaged or deteriorated concrete slabs and decks involves the placement of toppings or replacement. The complete replacement is the same as normal concrete placement and finishing. Bonding of thin toppings is accomplished by broom into the existing surface a thick creamy mortar of 1 part cement and 1part sand, similar to that of the topping, just before application or topping mix.

3. 4. 3 Shotcrete

Shotcrete is an excellent method of repairing vertical and overhead surfaces. Either the dry or wet mix shotcrete can be used for repair. The water for the dry mix of blended damp sand is added at the nozzle while water for the wet mix is added to the sand and cement at the batch plant and mixed in a transit mix truck. The mix is chuted from the truck into a pump hopper which pumps the concrete or mortar to the nozzle. Air under the pressure, is used to impel the wet mix against the form of base concrete. The applied shotcrete is finished to match the adjacent concrete. Finishing should be done carefully to avoid disturbing the bond of the finished product. A hard troweled surface is not recommended as it has tendency to affect the bond of a shotcrete layer due to excessive working. (Fig 3. 3)c: usersstaxappdata oaming360se6User DataTempshotcrete. gifFig 3. 3: Worker use shotcrete technology.

3. 4. 4 Injection Methods

Various injection materials are used to repair cracked slabs that are on the ground or suspended, fill voids under slabs structures to restore support and grades, repair cracked structural members and fill voids in structural members. These include cement grout, epoxies, acrylamide, polyurethanes which are injected by pressure or gravity. (Fig 3. 4)http://www. lotus-inc. com/Lotos_Gallery/Epoxy%20Injection%20Ports%20over%20concrete %20cracks. JPGFig 3. 4: The epoxy injection on concrete. Cement grouts can be jobsite formulated or purchased as proprietary packaged material. They are economical and easy to obtain and install. Admixtures are available to minimize shrinkage and mineral fillers to make them more economical when large quantities are required. Epoxies have ranges of viscosity and setting time. They have excellent bond to clean and dry substrates and some will bond to plastic concrete. The structural integrity or cracked structural member can be restored to monolithic and load supporting capacity. The short pot life and working time is further shortened during high ambient temperature. It may be more economical to remove and replace and extensively cracked slab on ground, than to repair by epoxy injection. Gel type formulation such as the acrylamide and polyurethanes are excellent for repair of water containing structures as some have a viscosity allowing injection into any crack or opening that water can flow through. They cannot be used to repair a structural member. (Joseph A. 1998)Pressure injection requires the sealing of cracks at the surfaces which epoxy or a heavy wax and leaving injection ports at 250 to 305mm intervals. The injection nozzle has two lines converging which blend the epoxy and its catalyst just before ejection. The nozzle has a slit type opening or round tip for injection into the

ports. The epoxy or gel is injected at one end of crack until it is seen at the next adjacent port. (Joseph A. 1998)If only light traffic is anticipated to continue and the slab cracks have minor spall edges, continued deterioration can be prevented by grooving out the cracks and gravity filling the grooved cracks with a low modulus epoxy.

3. 4. 5 Manually Applied mortar

Mortar applied manually can be mixed at the jobsite from regular Portland cement and sand, prepackaged cementations material or poly modified mortars. Poly modified mortars should not be used to repair areas where reinforcing steel is exposed and undercut as it is difficult to compact the material behind a reinforcing bar. The surface must be roughened and cleaned to achieve bond . Curing is critical for the repair and should be initiated as soon as portion is available when the repair is a large area and as application has been completed for a small area. Application of a curing membrane does not drift over the uncompleted work. (Fig3. 5)http://www. promain. co. uk/images/categories/FloorsEpoxy_Repair_Mortar_Concrete_Steps_Floors_Ramps_Promain. jpgFig 3. 5: Surface repaired by the mortar

3. 5 Recommendation on repair methods of concrete

From this Chapter, we have investigated the repair of concrete, as there are lots of way to repair, we can choose a proper way to repair concrete. In general, for small part of concrete repair, we usually use the mortar method, as it is simple and easy for a single man to work. But it only fixes the problem of the surface of the concrete. In the other complex situation, such as the crack on the slab in the ground or the crack on the wall, it is very hard

to repair by mortar. The topping repair of unformed concrete method is usually for the slab, it gives a quick way to fix thin concrete. The injection method is recommended for that situation, as it can fix the problem of inside concrete, and provide a high value of bend in the concrete. For the huge building repair, the shotcrete method is good way to repair, as it can provide a huge amount fresh concrete in short time. In the situation of void extend through section on the concrete, the replacement method is recommend. As if the damaged part of concrete is in a height, it is hardly to repair in other method.

Chapter 4: The Study of Concrete Recycles

4. 0 Introduction

There was insufficient time to carry out practical trials on recycling; therefore this section of the project is an evaluation of work carried out in both China and the USA. Concrete is everywhere in today. This is the second most consumed material after water. It shapes our built environment. Housing, schools, hospitals, bridges, roads, and footpaths all make use of concrete. Concrete is a good material to build long-and energy-efficient buildings. However, even with Produces good design humane changes in demand and potential waste. In the results generated by the demand Construction and demolition waste, it is estimated 900 million Tons a year in Europe, and the United States.(William A. Yrjanson)Cement Concrete Pavement reaches its useful life, or need to re-built after the destruction of the other reasons, the old concrete waste Often bring the environmental problems of the Giants, and if the old concrete can be applied in new construction. It will bring great economic and social Benefits. This paper discusses the feasibility of closing

with the use of the old Concrete; focuses on old cement concrete reconfigure into a cement concrete road: raw materials properties, compressive, flexural, wear. It occurs because of the experimental results.

4. 1 Problems caused by concrete damage

Cement concrete pavement reaches its useful life, or other causes damage such as pavement structure design is unreasonable, improper construction measures, Overloading use, or conservation is not timely, etc. It need to be rebuilt, the general practice is to excavation and discard the old concrete surface layer, Patch grassroots, re-paving. Get rid of the old concrete is often discarded as construction waste, and this raises many problems. As shown in the figures bellowing.(Fig 4. 1 and 4. 2)http://pavingatlanta. com/Portals/164977/images/concrete-pavement4. jpgFigure 4. 1: Pavement damage by carhttp://wildomarmagazine. files. wordpress. com/2009/11/pavement-damage. jpg? w= 450&h= 337Figure 4. 2: Pavement damage by earthquake

4. 1. 2 The waste of concrete

The waste discarded bring environmental issues: the old concrete discarded as waste, produce large amounts of construction waste. As concrete materials are inorganic materials, better durability, this garbage is not naturally break down like organic matter. Therefore this kind of pollution will be permanent. http://www. tribuneindia. com/2006/20060724/jal1. jpgFigure 4. 3.: Concrete waste

4. 1. 3 The Environmental problems

Environmental problems brought about by the exploitation of the material required for new roads: the new road required material exploitation, generally excavation of the surface layer of the mountain weathered rock, the undisturbed rock fragmentation by blasting and mechanical action and as coarse aggregate. Required due to the paving of the road is very coarse aggregate, it will result in people mountain area excavation, a large area of vegetation has been destroyed, resulting in unexpected losses on the environment.

4. 1. 4 The waste on recourses

Other problems: coarse aggregate mining and transport to bring a huge waste of human and material resources, leading to overall economic decline. In short, the traditional road reconstruction, repair lead to social and economic decline and social waste of resources, the need to use the new technology overall improvement.(Fig 4. 4)http://www. oremininggmachine. net/wp-content/plugins/get-search-result/random/cheap-second-hand-jaw-crusher-and-cone-crusher-for-india. jpgFigure 4. 4: coarse aggregate mining

4. 1. 5 The feasibility of recycling old concrete

Based on these basic facts, if the excavation of old concrete is broken at the construction site, as the coarse aggregate used again to generate significant social and economic benefits, it is to avoid the waste of social resources. From this practice of engineering technology is entirely feasible: Stores venue set at the construction site of the stone crushing machinery, Demolish the old cement concrete in the field, and appropriate adjustments to the

performance of the broken machinery. It can completely be produced to meet the road requirements level with coarse aggregate. Road concrete numerals are generally not high, its hardness is less than the hardness of rock, relatively speaking, and fragmentation on the mechanical requirements is lower. There is no problem with Concrete crushing technology. In addition, with the requirements of the practice, it is also possible to manufacture the mountains suitable for special machinery concrete crushing. On the other hand, in the large and medium-sized cities, there has many commercial concrete mixing station now, they are generally larger venues, and has a variety of concrete market demand. Around the city, the use of the old concrete from the road to promote housing construction, will achieve more significant benefits

4. 1. 6 The study aiming

Old concrete recycling has been a lot of achievements. However, these data are too concentrated on the old concrete aggregate of pavement and pavement base, very few old concrete aggregate for cement concrete is considered, in generally the old concrete aggregate is preparation of cement concrete as coarse aggregate, and just added the old concrete aggregate, the added rate is around 30%, the rest of the coarse aggregate is still with gravel aggregate. Much coarse aggregate all use the old concrete aggregates for cement concrete, in order to improve the recoveries of the old concrete, the study focused on the all old concrete aggregates use. Due to the urban scale expansion and strengthening of urban transformation, in fact, many other types of construction waste, such as brick slag. Some discarded material crushing strength may be low, but as the social

production, low-performance materials just in the requirements low places, as much as possible to reach the best has become possible. Therefore, it has configured to the old concrete aggregate cement concrete hope to attract the attention of the parties concerned, to expand research in this area and to expand the scope of the study.

4. 2

te.

Chapter 5: Conclusions

5. 1 In conclusions

in concrete. Thirdly, same as senior expert of concrete said." good practice of the day is based on up to date knowledge. But new materials are being developed and new uses for concrete are being found . often, at first, these changes may be viewed simply as After mentioned these, we must admit the concrete is an excellent structural material for construction. It is economic, environmental, and even sustainable. For that reason, our Civil engineering must have mastery knowledge of concrete to make more good use of concrete in the future.