DOWNLOAD PDF HIGH-PERFORMANCE CONCRETE DEFINED FOR HIGHWAY STRUCTURES

Chapter 1 : High-Performance Concrete Defined For Highway Structures

The American Concrete Institute. Founded in and headquartered in Farmington Hills, Michigan, USA, the American Concrete Institute is a leading authority and resource worldwide for the development, dissemination, and adoption of its consensus-based standards, technical resources, educational programs, and proven expertise for individuals and organizations involved in concrete design.

India is witnessing construction of very interesting projects in all sectors of Infrastructure. Majority of the structures are in structural concrete. The functional demands of such high rise structures include the use of durable materials. High Strength Concrete, Selfâ€"compacting Concrete are gaining widespread acceptance. Apart from the basic structural materials, modern projects require a variety of secondary materials for a variety of purposes such as construction chemicals, waterproofing materials, durability aids etc. The paper highlights some of the recent developments. Concrete grades up to M80 are now being used for highrise buildings in India. However, due to escalation in the repair and replacement costs, more attention is now being paid to durability issues. There are compelling reasons why the concrete construction practice during the next decades should be driven by durability in addition to strength. A large number of flyovers and some elevated roads extending up to 20km in length are being realized in different parts of the country and involve huge outlay of public money. However, the concrete durability is suspect. Many of the structures built during the period from have suffered premature deterioration. Concrete bridge decks built during the period now require extensive repairs and renovations, costing more than the original cost of the project. Multi-storied buildings in urban areas require major repairs every 20 years, involving guniting, shotcreting etc. A holistic view needs to be taken about concrete durability. In this context, there are a large number of materials in the market which facilitate durable construction. Apart from the materials, the construction processes have also undergone changes with a view to improving the durability of the finished structure. Four types of HPC were developed1: Very High Early Strength Concrete â€" Subsequently, a number of bridges and flyovers have introduced HPC up to M75 grade in different parts of India. Many components of the structures were very heavily reinforced and the field engineers found it difficult to place and compact normal concrete without honeycombs and weaker concrete. SCC was successfully used. SCC leaving the batching plant is in a semi-fluid state and is placed into the formwork without the use of vibrators. Due to its fluidity, SCC is able to find its way into the formwork and in between the reinforcement and gets self-compacted in the process. SCC is particularly useful for components of structures which are heavily reinforced. The fluidity is realized by modifying the normal mix components. In addition to cement, coarse and fine aggregates, water, special new generation polymer based admixtures are used to increase the fluidity of the concrete without increasing the water content. Due to its high fluidity, the traditional method of measuring workability by slump does not work. The fluidity is such that any concrete fed to the slump cone falls flat on raising the slump cone; the diameter of the spread of concrete is measured as an indication of workability of SCC. This is called Slump Flow and is in the range of â€" mm. Apart from the use of superior grade chemical admixtures, the physical composition of the concrete for SCC has undergone changes. The concrete is required to have more of fine aggregates and compulsorily any of the mineral admixtures â€" fly ash, ground granulated blast furnace slag GGBFS , silica fume, metakaolin, rice husk ash etc. Fly ash is abundantly available as a waste product at all the thermal power stations and the Government has encouraged use of fly ash by offering them practically free at the thermal power stations. GGBFS is again a by-product of the steel mills. During the production of steel, a molten steel is poured from blast furnaces and travels in special channels, leaving the impurities on top of the stream. The waste material, being lighter moves on top and easily diverted away from the usable steel. The diverted slag is quenched and forms small nodules. These nodules are crushed and granulated into very fine product, with particle size smaller than that of cement. The product is marketed in 50 kg bags and available economically in the regions around steel mills with blast furnaces. In other regions, additional transport cost of this bulk material is involved but its use is justified because of contribution to durability of concrete. For the concrete components of the structure for Bandra and Worli sewage outfalls in Mumbai, the German prime contractor insisted on compulsory use of GGBFS for the M40 concrete in order to improve the durability of concrete. The Use of Mineral Admixtures Figure 2: Palais Royaleâ€"The Tallest Building in India under construction with M Concrete Columns in Selfâ€"compacting Concrete After realization of the need for durable concrete structures, the composition of concrete has undergone changes. From being a product made of three or four materials cement, aggregates, water , today a typical durable concrete consists of six or more materials. The use of low water cement ratio enables a reduction in the volume and size of capillary voids in concrete; this alone is not sufficient to reduce the cement based content of concrete which is the source of micro-cracking from thermal shrinkage and drying shrinkage. To reduce the cement based content, both the water content and cement content must be reduced as much as possible. Concrete mixes with fewer micro cracks can be produced by blending the cement with mineral admixtures either in the batching plant or in the cement plant. This enhances the service life of concrete structures in a cost-effective manner. Fly Ash Thermal power stations are left with an undesirable by-product, fly ash, in large quantities which is not able to effectively utilize or dispose of. Currently, more than million tonne of fly ash are generated annually and the storage and disposal has been costing the power stations substantial unproductive expenditure. Unfortunately, all the fly ash available at the power stations is not fit for use as mineral admixture directly. Fly ash as a mineral admixture should conform to IS: Such a material is available in the finer streams of Electro Static Precipitators fitted to the power generation system. The coarser materials are required to be processed generally with the help of Cyclones before being considered for use as mineral admixture for concrete. As per the Euro Code for Concrete, only processed fly ash can be permitted as mineral admixture in concrete. The code limits the use of fly ash. To obtain adequate strength at early age, further reductions in the mixing water content can be achieved with better aggregate grading and use of super-plasticizers. HVFA concrete has now been successfully used in a few sporadic projects in India. Thus the use of GGBFS as a mineral admixture should be preferred, despite long leads for end users in certain parts of India far from the steel plants. For many landmark structures such as the Burj Dubai the tallest building in the world in GGBFS has been extensively used as a mineral admixture, even though the material is imported from other countries, resulting in the landed cost being more than that of cement. This was a conscious decision with a view to obtaining a more durable concrete structure. Portland Slag Cement PSC is also available and useful for ensuring durability of concrete structures. Due to the proximity to steel mills, PSC is generally produced in locations close to steel plants. Here again due to the bulky nature of the product, the transportation cost predominate. Another issue concerning quality of the PSC is the actual percentage replacement while making PSC; this information is not normally displayed on the bags, leaving the user at a disadvantage. In developed countries, information regarding the percentage of slag utilized in making PSC is generally printed on each bag of cement. The particle size is very small, about times smaller than that of cement. It can occupy the voids in between cement particles in a concrete mix, reduce the water demand and thus contribute to a very dense concrete of high durability. The product is expensive and is used in developed countries only for very high strength concrete above 75 mPa. Indiscriminate use of CSF for lower grades, barring exceptions, only increases the project cost without corresponding technical benefits. Ternary Blends Ternary blends of mineral admixtures are now recommended for improving the durability of important concrete structures. The new bridge has been opened to traffic in September , less than 14 months after the collapse. HPC has been used for reconstruction with a target year life span. High Performance Concrete containing silica fume and fly ash was used for low permeability. Two gleaming white concrete sculptures tower 9 m high at each end of the bridge. The sculptures were pre-cast using an SCC mix that included photo-catalytic cement with self cleaning and pollution reducing characteristics. The photo-catalytic cement is one of the new developments in the construction materials industry. The SCC concrete resulted in a marble-like, smooth white finish to the concrete surface. To control temperature during curing, fly ash and slag were incorporated as the majority of the cementitious material. The concrete mixes for the footings and piers were proportioned for mass concrete and durability through the use of fly ash and slag. As the components were massive in size, concrete mixes were modified by cementitious materials, chilled water and cooled aggregates, use of form insulation and internal cooling pipes. Cement Silos The use of batching plants for producing concrete is gaining increasing acceptance. As large volumes of cement are used in a batching plant, the cement is generally stored in vertical steel silos. When cement is received in bulkers from the factory, the same is directly pneumatically pumped into the silos which have capacities ranging from 50 to tonne depending upon the project requirements. If only bagged cement is available, they are emptied into the silos, usually with the help of screw conveyors. For modern applications, more than one silo will be required depending on the types of cement and mineral admixture used in the concrete mix. In a recently commissioned batching plant complex in the Middle East, each of the two plants feature nine cement silos for Portland cement, slag cement, micro silica, fly ash and SRC cement. Durability Enhancing Products A full line of products are available to prevent or repair corrosion damage. A typical corrosion inhibiting admixture prevents deleterious expansion and cracking caused by the formation of rust during over-induced corrosion. There are also penetrating sealants to protect new and repaired concrete from the corrosive effects of chloride. The silane and siloxane based reacting sealers soak into the surface, creating a barrier against water or chlorides. A number of concrete waterproofing admixtures eliminate the need for conventional external waterproofing membranes and saves time, money and hassle at the construction site. It transforms concrete into a water-resistant barrier by becoming an integral part of the concrete matrix. Hydrophobic Concrete Waterproofing System A typical patented product uses three materials to achieve a water-tight concrete structure, a super-plasticizer which reduces batching water requirements, thus limiting the volume of the capillary pour network in the concrete; a reactive hydrophobic pour blocking concrete admixture and product specific water stop protection at construction dams. Other accessory products include an operation retardant, curing compound, water stops and polypropylene fiber reinforcement. The patented product is typically added while concrete mix is being prepared to assist waterproofing. One product is applied at the rate of 5 liter per of concrete. Typically the manufacturer provides a warranty period of 10 years. The performance warranty provides for repairing water leakage through industry accepted and approved means for a period of 10 years.

Chapter 2 : Measurement of the Rheological Properties of High Performance Concrete: State of the Art Re

A definition for high-performance concrete (HPC) is presented which identifies a set of concrete performance characteristics sufficient to estimate long-term concrete durability and strength for.

Long life in severe environments Depending on its implementation, environmental [3] Ultra-high-performance concrete[edit] Ultra-high-performance concrete is a new type of concrete that is being developed by agencies concerned with infrastructure protection. UHPC is characterized by being a steel fibre-reinforced cement composite material with compressive strengths in excess of MPa, up to and possibly exceeding MPa. Note that there is no large aggregate. The current types in production Ductal, Taktl, etc. Ongoing research into UHPC failure via tensile and shear failure is being conducted by multiple government agencies and universities around the world. Micro-reinforced ultra-high-performance concrete[edit] Micro-reinforced ultra-high-performance concrete is the next generation of UHPC. In addition to high compressive strength, durability and abrasion resistance of UHPC, micro-reinforced UHPC is characterized by extreme ductility, energy absorption and resistance to chemicals, water and temperature. The performance of the discontinuous and scattered fibers in UHPC is relatively unpredictable. Micro-reinforced UHPC is used in blast, ballistic and earthquake resistant construction, structural and architectural overlays, and complex facades. Poor compaction occurred mostly because of the need for speedy construction in the s and s. Hajime Okamura envisioned the need for concrete which is highly workable and does not rely on the mechanical force for compaction. During the s, Okamura and his Ph. SCC is known as self-consolidating concrete in the United States. SCC is characterized by the following: In the precast concrete industry in the U. This emerging technology is made possible by the use of polycarboxylates plasticizer instead of older naphthalene-based polymers, and viscosity modifiers to address aggregate segregation. Vacuum concrete[edit] Vacuum concrete, made by using steam to produce a vacuum inside a concrete mixing truck to release air bubbles inside the concrete, is being researched. The idea is that the steam displaces the air normally over the concrete. When the steam condenses into water it will create a low pressure over the concrete that will pull air from the concrete. This will make the concrete stronger due to there being less air in the mixture. A drawback is that the mixing has to be done in an airtight container. Vacuum concrete stiffens very rapidly so that the formworks can be removed within 30 minutes of casting even on columns of 20 ft. This is of considerable economic value, particularly in a precast factory as the forms can be reused at frequent intervals. These characteristics are of special importance in the construction of concrete structures which are to be in contact with flowing water at a high velocity. It bonds well to old concrete and can, therefore, be used for resurfacing road slabs and other repair work. Shotcrete Shotcrete also known by the trade name Gunite uses compressed air to shoot concrete onto or into a frame or structure. The greatest advantage of the process is that shotcrete can be applied overhead or on vertical surfaces without formwork. It is often used for concrete repairs or placement on bridges, dams, pools, and on other applications where forming is costly or material handling and installation is difficult. Shotcrete is frequently used against vertical soil or rock surfaces, as it eliminates the need for formwork. It is sometimes used for rock support, especially in tunneling. Shotcrete is also used for applications where seepage is an issue to limit the amount of water entering a construction site due to a high water table or other subterranean sources. This type of concrete is often used as a quick fix for weathering for loose soil types in construction zones. There are two application methods for shotcrete. The water needed for the hydration is added at the nozzle. The mixes are pumped through the hoses. At the nozzle compressed air is added for spraying. For both methods additives such as accelerators and fiber reinforcement may be used. This meant that lime could be used in a much wider variety of applications than previously such as floors, vaults or domes. Over the last decade, there has been a renewed interest in using lime for these applications again. This is because of environmental benefits and potential health benefits, when used with other lime products. It is also considered to be more environmentally friendly because of its ability, through carbonation, to re-absorb its own weight in

Carbon Dioxide compensating for that given off during burning. Lime enables other natural and sustainable products such as wood including woodfibre, wood wool boards , hemp, straw etc. Lime plasters and limewash are non-toxic, therefore they do not contribute to indoor air pollution unlike some modern paints. Pervious concrete Pervious concrete, used in permeable paving , contains a network of holes or voids, to allow air or water to move through the concrete This allows water to drain naturally through it, and can both remove the normal surface-water drainage infrastructure, and allow replenishment of groundwater when conventional concrete does not. It is formed by leaving out some or all of the fine aggregate fines. The remaining large aggregate then is bound by a relatively small amount of Portland cement. Installation[edit] Pervious concrete is installed by being poured into forms, then screeded off, to level not smooth the surface, then packed or tamped into place. Due to the low water content and air permeability , within 5â€"15 minutes of tamping, the concrete must be covered with a 6-mil poly plastic, or it will dry out prematurely and not properly hydrate and cure. Characteristics[edit] Pervious concrete can significantly reduce noise, by allowing air to be squeezed between vehicle tyres and the roadway to escape. This product cannot be used on major U. Pervious concrete has been tested up to psi so far. Cellular concrete[edit] Aerated concrete produced by the addition of an air-entraining agent to the concrete or a lightweight aggregate such as expanded clay aggregate or cork granules and vermiculite is sometimes called cellular concrete, lightweight aerated concrete, variable density concrete, Foam Concrete and lightweight or ultra-lightweight concrete, [16] [17] not to be confused with aerated autoclaved concrete , which is manufactured off-site using an entirely different method. In the work on A Pattern Language: Regular concrete is too dense. It is heavy and hard to work. After it sets one cannot cut into it, or nail into it. And yet concrete, in some form, is a fascinating material. It is fluid, strong, and relatively cheap. It is available in almost every part of the world. A University of California professor of engineering sciences, P. Kumar Mehta, has even just recently found a way of converting abandoned rice husks into Portland cement. Is there any way of combining all these good qualities of concrete and also having a material which is light in weight, easy to work, with a pleasant finish? It is possible to use a whole range of ultra-lightweight concretes which have a density and compressive strength very similar to that of wood. They are easy to work with, can be nailed with ordinary nails, cut with a saw, drilled with wood-working tools, easily repaired. We believe that ultra-lightweight concrete is one of the most fundamental bulk materials of the future. The variable density reduces strength [16] to increase thermal [16] and acoustical insulation by replacing the dense heavy concrete with air or a light material such as clay, cork granules and vermiculite. There are many competing products that use a foaming agent that resembles shaving cream to mix air bubbles in with the concrete. All accomplish the same outcome:

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Chapter 3 : Civil Engineering: HIGH PERFORMANCE CONCRETE

Evaluation Of "High-Performance Concrete Defined For Highway Structures" SUMMARY A review of the FHWA definition of HPC was made to identify whether the performance characteristics, test methods, and range of grades were appropriate and to propose any modifications based on experience with the definition since it was published in

The papers are in the public domain and are not subject to copyright in the United States. Articles from J Res may contain photographs or illustrations copyrighted by other commercial organizations or individuals that may not be used without obtaining prior approval from the holder of the copyright. Abstract The rheological or flow properties of concrete in general and of high performance concrete HPC in particular, are important because many factors such as ease of placement, consolidation, durability, and strength depend on the flow properties. Concrete that is not properly consolidated may have defects, such as honeycombs, air voids, and aggregate segregation. Such an important performance attribute has triggered the design of numerous test methods. Generally, the flow behavior of concrete approximates that of a Bingham fluid. Therefore, at least two parameters, yield stress and viscosity, are necessary to characterize the flow. Nevertheless, most methods measure only one parameter. Predictions of the flow properties of concrete from its composition or from the properties of its components are not easy. No general model exists, although some attempts have been made. This paper gives an overview of the flow properties of a fluid or a suspension, followed by a critical review of the most commonly used concrete rheology tests. Particular attention is given to tests that could be used for HPC. Tentative definitions of terms such as workability, consistency, and rheological parameters are provided. An overview of the most promising tests and models for cement paste is given. Introduction The rheological flow properties of concrete are important for the construction industry because concrete is usually put into place in its plastic form. This importance can be attested to by the large body of literature existing on concrete rheology [1 , 2 , 3 , 4]. Unfortunately, due to the complex composition of the material, no definite method for predicting the flow of concrete from its components exists. Even measurements of the rheological parameters are not easily performed due to the large range of particle sizes found in concrete from 1 mm cement grains to 10 mm coarse aggregates or even larger mm as found in a dam. Therefore, the flow of a given concrete is usually measured using one of the many standard tests 1 available that only partially measure the intrinsic flow properties of the material. Flow tests are of limited value unless they measure the intrinsic rheological properties of concrete. A better understanding of the flow properties of concrete is needed to be able to predict the flow of concrete from the properties of the components. The purpose of this paper is to assess the state of the art in measurements of flow properties of concrete. A critical review of the tests available is given with special emphasis given to tests for high performance concrete HPC. Definitions of terms commonly used in the field and their link to material properties are provided. Concrete is really a concentrated suspension of solid particles aggregates in a viscous liquid cement paste. Cement paste is not a homogeneous fluid and is itself composed of particles cement grains in a liquid water. Because concrete, on a macroscopic scale, flows as a liquid, equation 1 is applicable. If a shear force is applied to a liquid as shown in Fig. The proportionality factor between the force and the gradient is called the viscosity. A liquid that obeys this equation is called Newtonian [1].

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Chapter 4 : High Performance Concrete Materials For Pavement Structures

HIGH-PERFORMANCE CONCRETE DEFINED FOR HIGHWAY STRUCTURES. To establish a clear understanding of high performance concrete (HPC), the FHWA is proposing to define HPC by using long-term performance criteria.

The production of High Performance Concrete involves the following three important interrelated steps: The main ingredients of High Performance Concrete are Cement Physical and chemical characteristics of cement play a vital role in developing strength and controlling rheology of fresh concrete. Fineness affects water requirements for consistency. When looking for cement to be used in High Performance Concrete one should choose cement containing as little C3A as possible because the lower amount of C3A, the easier to control the rheology and lesser the problems of cement-super plasticizer compatibility. Fine aggregate Both river sand and crushed stones may be used. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in High Performance Concrete as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, etc. The sand particles should also pack to give minimum void ratio as the test results show that higher void content leads to requirement of more mixing water. Coarse aggregate The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement matrix and aggregate surface in cement concrete. This results in lower strength of cement concrete by restricting the maximum size of aggregate and also by making the transition zone stronger. By usage of mineral admixtures, the cement concrete becomes more homogeneous and there is marked enhancement in the strength properties as well as durability characteristics of concrete. The strength of High Performance Concrete may be controlled by the strength of the coarse aggregate, which is not normally the case with the conventional cement concrete. Hence, the selection of coarse aggregate would be an important step in High Performance Concrete design mix. Water Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement. The strength of cement concrete comes mainly from the binding action of the hydrated cement gel. The requirement of water should be reduced to that required for chemical reaction of unhydrated cement as the excess water would end up in only formation of undesirable voids in the hardened cement paste in concrete. Chemical Admixtures Chemical admixtures are the essential ingredients in the concrete mix, as they increase the efficiency of cement paste by improving workability of the mix and there by resulting in considerable decrease of water requirement. Retarders help in reduction of initial rate of hydration of cement, so that fresh concrete retains its workability for a longer time. Air entraining agents artificially introduce air bubbles that increase workability of the mix and enhance the resistance to deterioration due to freezing and thawing actions. Mineral admixtures The major difference between conventional cement concrete and High Performance Concrete is essentially the use of mineral admixtures in the latter. The use of silica fume fills the space between cement particles and between aggregate and cement particles. It is worth while noting that addition of silica fume to the concrete mix does not impart any strength to it, but acts as a rapid catalyst to gain the early age strength. The behavior of fresh High Performance Concrete is not substantially different from conventional concretes. Workability is normally better than conventional concretes produced from the same set of raw materials. Curing is not fundamentally different for High Performance Concrete than for conventional concretes although many High Performance Concretes with good early strength characteristics may be less sensitive to curing. Workability The workability of High Performance Concrete is normally good, even at low slumps, and High Performance Concrete typically pumps very well, due to the ample volume cementitious materials and the presence if chemical admixtures. High Performance Concrete has been successfully pumped even up to 80 storeys. While pumping of concrete, one should have a contingency plan for pump breakdown. These mixtures are intended to be self-leveling and the rate of flow is an important factor in determining the rate of production and placement schedule. It is also a useful tool in assessing the quality of the mixture. Flowing concrete is, of course, not required in all High Performance Concrete and adequate workability is normally not difficult to attain. Setting time Setting time can vary dramatically depending on the application and the presence of set modifying admixtures and percentage of the paste composed of Portland cement. Concretes for applications with early strength requirements can lead to mixtures with rapid slump loss and reduced working time. This is particularly true in warmer construction periods and when the concrete temperature has been kept high to promote rapid strength gain. The use of large quantities of water reducing admixtures can significantly extend setting time and therefore reduce very early strengths even though strengths at more than 24 hours may be relatively high. Dosage has to be monitored closely with mixtures containing substantial quantities of mineral admixtures so as to not overdose the Portland cement if adding the chemical admixture on the basis of total cementitious material. Short-term properties include strength in compression, tension and bond. The long-term properties include creep, shrinkage, behaviour under fatigue and durability characteristics such as porosity, permeability, freeze-thaw resistance and abrasion resistance. Strength The strength of concrete depends on a number of factors including the properties and proportions of the constituent materials, degree of hydration, rate of loading, method of testing and specimen geometry. Hence, in order to increase the strength steps must be taken to strengthen these three sources. Testing conditions including age, rate of loading, method of testing and specimen geometry significantly influence the measured strength. The strength of saturated specimens can be 15 to 20 percent lower than that of dry specimens. Under impact loading, strength may be as much as 25 to 35 percent higher than under a normal rate of loading. Cube specimens generally exhibit 20 to 25 percent higher strengths than cylindrical specimens. Larger specimens exhibit lower average strengths. Strength development The strength development with time is a function of the constituent materials and curing techniques. An adequate amount of moisture is necessary to ensure that hydration is sufficient to reduce the porosity to a level necessary to attain the desired strength. Although cement paste in practice will never completely hydrate, the aim of curing is to ensure sufficient hydration. In general, a higher rate of strength gain is observed for higher strength concrete at early ages. At later ages the difference is not significant. Compressive strength Maximum practically achievable, compressive strengths have increased steadily over the years. Presently,28 days strength of up to 80Mpa are obtainable. However, it has been reported that concrete with day cylinder strength of Mpa has been used in buildings in US. The trend for the future as identified by the ACI committee is to develop concrete with compressive strength in excess of Mpa and identify its appropriate applications. Tensile strength The tensile strength governs the cracking behavior and affects other properties such as stiffness; damping action, bond to embedded steel and durability of concrete. It is also of importance with regard to the behavior of concrete under shear loads. The tensile strength is determined either by direct tensile tests or by indirect tensile tests such as split cylinder tests. This is due to the refinement of pore structure of microstructure of the cement concrete to achieve a very compact material with very low permeability to ingress of water, air, oxygen, chlorides, sulphates and other deleterious agents. Thus the steel reinforcement embedded in High Performance Concrete is very effectively protected. As far as the resistance to freezing and thawing is concerned, several aspects of High Performance Concrete should be considered. First, the structure of hydrated cement paste is such that very little freezable water is present. Second, entrained air reduces the strength of high performance concrete because the improvement in workability due to the air bubbles cannot be fully compensated by a reduction in the water content in the presence of a superplasticizer. The abrasion resistance of High Performance Concrete is very good, not only because of high strength of the concrete but also because of the good bond between the coarse aggregate and the matrix which prevents differential wear of the surface. On the other hand, High Performance Concrete has a poor resistance to fire because the very low permeability of High Performance Concrete does not allow the egress of steam formed from water in the hydrated cement paste. The absence of open pores in the structure zone of High Performance Concrete prevents growth of bacteria. Because of all the above- reasons, High Performance Concrete is said to have better durability characteristics when compared to conventional cement concrete. This results in carbonation of concrete which destroys the reinforcement and leads to corrosion.

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Aggressive salts are sometimes present in the soil, which may cause abrasion. High Performance Concrete can be used to prevent deterioration of concrete. Since High Performance Concrete has got low permeability it ensures long life of a structure exposed to such conditions. High strength and superior durability characteristics of High Performance Concrete have already been utilized in many structural applications in various countries. Some of the applications of High Performance Concrete are: After extensive research and development in French laboratories, the French ministry of public works and the national project on New concretes team agreed to build an experimental bridge using High Performance Concrete. The organizations wanted to demonstrate the feasibility of building a typical prestressed bridge with High Performance Concrete, using means and materials that could be found throughout France. The bridge was built crossing the river Yonne near the town of Joigny, approximately km southeast of Paris. Aesthetical and economical considerations led to the classical design of a balanced continuous three span bridge, which span lengths of Limit State Design Of Reinforced concrete. These codes have been upgraded to incorporate 60Mpa concretes since they previously dealt only with concrete strength up to 40Mpa. It should be emphasized that comparison carried out during the preliminary design of the bridge showed that the concrete quantities could be reduced from m3 when using ordinary 35Mpa concrete to m3 with 60Mpa high strength concrete. This 30 percent reduction in concrete volume led to a 24 percent load reduction on the pier, abutments and foundations. The water cement ratio remained between 0. The entrained air contents were within 0. The slumps, measured at the site were mm for more than 2 hours. The concrete strength was measured according to French standards using mmxmm test cylinders cast in metallic mould. At 28 days the minimum and maximum strength values were The tensile strength was measured on cylinders where the average tensile strength was 5. The first French prestressed concrete bridge designed and built with a 60Mpa characteristic strength and following the French building codes was successfully completed in early

Chapter 5 : High Performance Concrete | Seminar Report, PPT, PDF for Civil Engineering

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Oct, By Steven J. In Articles , Structural Design Comments 0 Recent advances in concrete reinforcement technology have led to the availability of high strength as high as ksi and large diameter as large as 3. These bars are available with thread-like deformation patterns that permit the use of complimentary connection and anchoring hardware, and facilitate prefabrication of large reinforcing cages. These advances in material and manufacturing technologies can be combined to create High Performance Concrete Reinforcing HPCR systems that can be used to significantly reduce the quantity of reinforcing and associated material and labor costs, and create potential schedule savings for concrete building structures. However, the implementation of these new reinforcing materials into the design of concrete structures can pose some significant challenges, as current design practices and prescriptive code procedures do not always address some of the unique performance characteristics of these materials. As the availability of these materials becomes more prevalent, it is important that engineers understand the primary challenges and limitations associated with utilizing HPCR systems. Comparison of two commercially available high strength reinforcing materials and conventional ASTM A Such materials have been in existence for quite some time and are used regularly in Japan and Europe. Figure 1 shows the stress strain curves for two such high strength reinforcing materials that are commercially available in the U. One of the common characteristics of most high strength reinforcing materials is their lack of a well-defined yield point, exhibiting more of a roundhouse transition above the proportional limit. However, it is also readily apparent that although the two higher strength materials utilize a similar design yield stress of approximately ksi, the stress strain curves are quite different. The Grade 97 material, while more similar in performance to conventional A and perhaps even closer to A, within the low to moderate strain range, does not exhibit nearly the same degree of strain hardening in the higher strain ranges. Alternatively, the Grade material exhibits a rapid and significant strength gain even at very small strains, but then little to no strain hardening beyond approximately 0. The ACI prescriptive design provisions are based on an idealized bi-linear elastic-perfectly plastic stress strain relationship. This is a reasonable assumption for conventional A and A materials because they do not deviate significantly from the bi-linear idealization until the higher strains that would be associated more with high seismic applications. For these reasons, it is often more prudent to consider the full non-linear stress strain relationship of high strength reinforcing materials for design, rather than a simplified bi-linear relationship. In some cases, the ACI prescriptive procedures are simply not applicable to high-strength reinforcing material and require performance-based design methods. Threaded Bar Reinforcement Systems Threaded bar reinforcement has been used for many years in foundation and post-tensioning applications, and occasionally as reinforcement for building structures. A number of large-scale building projects in New York and New Jersey recently utilized the HPCR systems as the primary longitudinal reinforcement in columns and shear walls. Threaded reinforcing bars are characterized by their continuous thread-like deformations, which provide equal or better bond than conventional rebar deformations. The thread-like deformation also provides a threading mechanism to facilitate the use of complimentary threaded accessories, such as couplings and anchors, at any location along their length Figure 2. Threaded reinforcing bars can be cut anywhere along their length with no additional machining required. These features allow for full tension couplers to be used economically and efficiently because a full tension threaded bar coupler is often less expensive than the material cost of the required lap splice length. Additionally, using couplers on the full range of available threaded bar sizes eliminates the need to try to limit bar sizes to 11, which is the current limit beyond which conventional couplers are required. Similarly, anchorage hardware is easily installed onto the ends of threaded bars, eliminating the need for hooks, or machine threaded, or welded, headed anchors. Typical features of threaded reinforcing bars. Continuous thread-like deformations are either a hot rolled or b cold rolled or cut into bar. The first source of quantity reduction is due to the higher strength of the HPCR materials. The second source is the elimination of required lap splice lengths. Even after accounting for the cost of the full tension coupler for one 24 â€" ksi threaded reinforcing bar, the material cost savings is significant. Other constructability and logistical benefits include less congestion, less pieces to fabricate transport and install, less labor and less tie reinforcing, when present. The drawback of a 24 bar being too heavy for hand-installation is readily offset by the advantage of threaded features of the bars, grouping multiple bars into cages, or modules for off-site pre-fabrication. The cages can then be delivered when needed and erected relatively easily with the use of a crane Figure 4. Figure 3 illustrates a realistic example of how the features of HPCR systems replace, and oftentimes increase, the capacity of shear walls in tall building structures. HPCR systems can consolidate the capacity of large quantities of conventional reinforcing into a few optimally placed clusters of HPCR. The reinforcement between these clusters can be significantly minimized to ideally be only the required minimum reinforcement. Additionally, the clusters can be fabricated into two-story high cages, saving erection costs on alternate floors. Alternately, staggering the two-story cages would require only half of the cages to be installed on any one floor. Comparison of alternate design of high rise core walls reinforced with a conventional 11 Grade 75 bars and b 24 Grade threaded bars. Example of a prefabricated shear wall cage of HPCR. Code Considerations ACI does not explicitly address the use of high strength reinforcing materials. This limitation is partly to ensure that the assumption of an elasto-plastic stress strain relationship for materials that lack a well-defined yield point will not lead to unconservative calculations of member strength. The limitation is also intended to provide some measure of control for service level cracking. The maximum compressive strain of 0. The use of a higher compression yield stress can be justified by considering the long term redistribution of creep and shrinkage strains from the concrete to the reinforcement. Although ACI does not address this phenomenon, Section 9. ACI enforces minimum ductility requirements for flexural members in Sections However, the tension and compression control limits specified in these sections were developed for conventional A reinforcing material, and thus must be modified for high strength reinforcing materials to achieve similar ductility levels. Strength Design Considerations Regardless of the level of sophistication used for the design of concrete members with HPCR, any design must still respect the basic tenants of the ACI design philosophy. Foremost among them is the assurance of ductile failure modes for flexural and tension members. Equally important is the assurance that such ductile failure modes are not prevented or otherwise limited by a less ductile supporting mechanism. This is of critical importance in reinforced concrete design because the limit states design philosophy of ACI is strain-based, not stress based. Engineers must exercise greater care in determining the appropriateness of any such design procedures and formulae due to some of the unique challenges and limitations of HPCR systems, as previously described; however, the engineer has the option of using non-prescriptive performance-based design procedures. Figure 6 illustrates a standard P-M interaction diagram for the shear walls shown in Figure 3. The diagrams use nominal strength because the transition zone for the applicable phi-factors between tension-controlled and compression-controlled limits is different in conventional reinforcing materials and high strength materials. Redistributing the HPCR to their most effective locations achieves an equal or greater wall stiffness with an overall lesser reinforcement quantity, while also increasing the moment capacity for the same axial capacity Figure 6. The use of HPCR in the superstructure may also result in special design considerations for the foundation elements. The effective use of HPCR in shear walls can result in large localized concentrations of high strength reinforcement at wall ends Figure 3. This may impose higher than usual foundation anchorage and pull-out, or shear, demands on foundation mats and footings. The use of shear reinforcement or distribution elements subgrade walls, grade beams, etc. Representative floor plan and coupled shear wall arrangement for a high rise building. Comparison of the P-M nominal interaction diagrams for the lower shear wall in Figure 5 with the reinforcement distributions shown in Figure 3. Stiffness Design Considerations High strength reinforcing materials generally exhibit larger tensile strains at service level loading than conventional reinforcing materials, which will result in larger deflections and wider crack widths. Because one of the primary benefits of utilizing HPCR is to decrease the total reinforcement quantity, the effects of any such reductions in reinforcement quantity on the stiffness of the structural elements may become an important consideration. The relevancy depends on to what degree, if any, the engineer considers the reinforcement in his or her stiffness calculations. Many engineers still utilize effective stiffness modifiers i. However, in cases where the structural elements are stiffness-controlled, or where HPCR is being proposed as a value engineering alternate, it may become necessary to verify that stiffness of the elements reinforced with HPCR is not less than that of conventional reinforcement. Non-linear moment-curvature analysis is an effective way to compare the stiffness of sections reinforced with conventional versus high strength reinforcing and incorporates the actual stress-strain behavior of the materials, as well as the spatial distribution of the reinforcement. If there is significant axial force due to gravity or lateral loading, such as the case with coupled or linked shear walls in figure 5, then the moment curvature analysis can incorporate those axial forces in the analysis. Comparison of the moment-curvature diagrams for the walls in Figure 3 with a no net tension load and b high net tension load. Summary Features of HPCR systems help significantly reduce the total reinforcement quantities for concrete structures because of their high strength, large size and the ability to couple and anchor the bars efficiently and economically. Additionally, their use permits higher concentrations of HPCR to be placed at optimal locations to further increase their effectiveness. As is often the case, proposing HPCR systems as a value-engineering alternate only provides a simplified direct substitution which often fails to exploit the full advantages of HPCR systems. A direct substitution almost invariably results in a decrease in section stiffness because the area of reinforcing is being decreased, without any compensation that may be achieved by concentrating the reinforcing at a more efficient location. However, when integrating HPCR into the original design, the engineer can incorporate the HPCR features and maximize the advantages using appropriate design procedures and recommendations for strength and stiffness. He can be reached at Stevenbongiorno stevenbongiorno.

Chapter 6 : Types of concrete - Wikipedia

Revising High-Performance Concrete Classifications: An Evaluation of "High-Performance Concrete Defined for Highway Structures." The Federal Highway Administration (FHWA) initiated a national program in to implement the use of high-performance concrete (HPC) in bridges.

A Robust Solution for Highway Infrastructure Advances in the science of concrete materials have led to the development of a new class of cementitious composites called ultra-high performance concrete UHPC. The mechanical and durability properties of UHPC make it an ideal candidate for use in developing new solutions to pressing concerns about highway infrastructure deterioration, repair, and replacement. Since , when UHPC became commercially available in the United States, a series of research projects has demonstrated the capabilities of the material. UHPC is a cementitious composite material composed of an optimized gradation of granular constituents, a water-to-cementitious materials ratio less than 0. The mechanical properties of UHPC include compressive strength greater than Ultra-high performance concrete has a discontinuous pore structure that reduces liquid ingress, significantly enhancing durability compared to conventional and high-performance concretes. UHPC is being considered for use in a wide variety of highway infrastructure applications. The high compressive and tensile strengths allow for the redesign and optimization of structural elements. Concurrently, the enhanced durability properties facilitate a lengthening of design life and allow for potential use as thin overlays, claddings, or shells. In the United States, UHPC has been used in prestressed concrete girder simple-span bridges, precast concrete deck panels, and field-cast connections between prefabricated bridge components. Ultra-high performance concretes have demonstrated exceptional performance when used as a field-cast closure pour or grout material in applications requiring the onsite connection of multiple prefabricated elements. This use of UHPC has gained significant momentum recently, with States around the country considering the application. Field-cast UHPC can simplify connection details and ease constructability. This photo shows the casting of fluid ultra-high performance concrete UHPC from a wheelbarrow into the void space between the top flanges of two deck-bulb-tee prestressed concrete girders. The rebar can be seen extending from the girders into the void. The UHPC is self-consolidating. New York State Department of Transportation. UHPC is also being investigated for use in a variety of other applications. These applications include precast concrete piles, seismic retrofit of substandard bridge substructures, thin-bonded overlays on deteriorated bridge decks, and security and blast mitigation applications. In a general sense, UHPC has proven to be particularly relevant in applications where conventional solutions are lacking. For example, conventional connection solutions have hindered the use of prefabricated elements; field-cast UHPC allows for a redesign and simplification of the system while simultaneously promoting long-term durability. The report compiles more than 30 years of worldwide research, more than English-language references, and 12 years of Federal Highway Administration FHWA research and development into a first-of-its-kind reference document for UHPC. This report is expected to spur further innovation in the field as innovators will now have an easier time building on the work of their predecessors. It will also provide support to technical experts around the United States as they begin facilitating deployment of UHPC technology. Wednesday, August 29, Related Links.

Chapter 7 : New Construction Materials for Modern Projects

Ultra-high performance concrete has a discontinuous pore structure that reduces liquid ingress, significantly enhancing durability compared to conventional and high-performance concretes. UHPC is being considered for use in a wide variety of highway infrastructure applications.

Chapter 8 : STRUCTURE magazine | Designing with High Performance Concrete Reinforcing

DOWNLOAD PDF HIGH-PERFORMANCE CONCRETE DEFINED FOR HIGHWAY STRUCTURES

High performance concrete is a concrete mixture, which possess high durability and high strength when compared to conventional concrete. This concrete contains one or more of cementious materials such as fly ash, Silica fume or ground granulated blast furnace slag and usually a super plasticizer.

Chapter 9 : Ultra-High Performance Concrete | FHWA

Therefore HPC is often of high strength, but high strength concrete may not necessarily be of High-Performance. For the purpose of the SHRP C project [Zia et al.], HPC was defined in terms of certain target strength and durability criteria as shown in Table