Analysis of High Performance Concrete

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***Abstract**:* The focus on High Performance concrete (HPC) has immensely increased due to utilization of large quantity of concrete, thereby leading to the development of infrastructure Viz., Buildings, Industrial Structures, Hydraulic Structures, Bridges and Highways etc. This paper includes the detailed study on the recent developments in High Performance Concrete, stressing more on the earthquake prone areas. It highlights the advantages and importance of High Performance concrete over conventional concrete and also includes effect of Mineral and Chemical Admixtures used to improve performance of concrete. The behaviour of SIFCON is also discussed briefly. The alternative for the HPC is also recommended.

1. INTRODUCTION

Concrete is the most widely used construction material in India with annual consumption exceeding 100 million cubic metres. Also, the recent earthquakes in differentparts of the world have once again revealed the importance ofdesign of structures with high ductility. The strength and ductility of structures mainly depends on proper detailing of reinforcement in beam-column joints. Under seismic excitations, the beam-column joint region is subjected to highhorizontal & vertical forces whose magnitudes are much higher than those within the adjacent beams & columns. Conventional Ordinary Portland Cement Concrete which is designed on the basis of compressive strength does not meet many functional requirements as it is found deficit in aggressive environments, time of construction, energy absorption capacity, repair and retrofitting jobs etc. and loses its tensile resistance after the formation of multiple cracks. So, there is a need to design High Performance Concrete which is far superior to Conventional Concrete, as the Ingredients of High Performance Concrete contribute most efficiently to the various requirements [1].

The attribute “High Performance” implies an optimized combination of structural properties such as strength, toughness, energy absorption capacity, stiffness, durability, multiple cracking and corrosion resistance, taking into account the final cost of the material and above all, of the produce manufactured. Generally speaking, high performance is meant to distinguish structural materials from the conventional once, as well as to optimize a combination of properties in term of final application in civil engineering.

HPC concretes are usually designed using materials other than cement alone to achieve these requirements, such as Fly Ash (from the coal burning process), Ground Blast Furnace Slag (from the steel making process), or Silica fume (fromthe reduction of high quality quartz in an electric arc furnace). Different amounts of these materials are combined with Portland cement in varying percentages depending on the specific HPC requirements.

Though there are many definitions for High Performance Concrete (HPC), the most widely-accepted one is that given by the American Concrete Institute (ACI), which states; “High Performance Concrete is concrete that meets special performance and uniformity requirements that cannot always be achieved routinely by using only conventional materials and normal mixing, placing and curing practices.” It is not possible to give a unique definition of HPC without determining the performance requirements of the intended use of the concrete.

The requirements may involve enhancement of characteristics such as placement and compaction withoutsegregation, long-term mechanical properties, and early age strength or service life in severe environments. Concretes possessing many of these characteristics often achieve High Strength, but High Strength concrete may not necessarily be of High Performance. A classification of High Performance Concrete related to strength is shown below.

Compressive Strength (MPa)	50	75	100	125	150
High Performance Class	I	II	III	IV	V

2. APPLICATION OF ADMIXTURES

Admixtures plays key role in the production of High Performance Concrete. Both Chemical and Mineral Admixtures form a part of the High Performance Concrete mix. The major difference between Conventional Cement Concrete and High Performance Concrete is essentially the use of Mineral Admixtures in the latter. They are used for various purposes depending upon their properties. Table 1 shows different types of Mineral Admixtures with their particle characteristics.

Table 1. Different Mineral Admixtures used in HPC.

Mineral Admixtures	Classification	Particle characteristics
Ground granulated blast furnace slag	Cementitious and pozzolanic	Unprocessed materials are grain like sand, ground to size <45 µm particles and have a rough texture
Fly ash	Cementitious and pozzolanic	Powder consists of particles size <45 µm, 10% to 15% are more than 45 µm, solid spheres and generally smooth
Silica fume	Highly active pozzolana	Fine powder consistingof solid spheres of 0.1 µm average diameter
Rice husk ash	Highly active pozzolana	Particles are <45 µm in size and have cellularand porous structure

Chemical composition determines the role of Mineral Admixtures in enhancing properties of concrete. Different materials with Pozzolanic properties such as Fly Ash (FA), Ground Granulated Blast Furnace Slag (GGBS), Silica fume (SF), High Reactivity Metakaolin (HRM), Rice Husk Ash (RHA), Copper Slag, Fine Ground Ceramics have been widely used as supplementary cementitious materials in the production of High Performance Concrete. Fly Ash (FA) and Silica fume (SF) act as Pozzolanic materials as well as fine fillers; thereby the microstructure of the hardened cement matrix becomes denser and stronger. The use of Silica fume fills the space between cement particles and between aggregate and cement particles. It does not impart any strength to it, but acts as a rapid catalyst to gain the early age strength. Such applications not only help to improve the strength and durability characteristics of High Performance Concrete but will also help to dispose more of the industrial by-products which are major environmental threats [2].

Different Chemical admixtures (Super plasticizers) are extensively used in development of High Performance Concrete, as they increase the efficiency of cement paste by improving workability of the mix and thereby resulting in considerable decrease of water requirement. Plasticizers and Super Plasticizers help to disperse the cement particles in the mix and promote mobility of the concrete mix. Retarders helpin 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. Some of the Chemical Admixtures are represented in Table 2 with their functions.

Table 2. Different Chemical Admixtures used in HPC.

Chemical Admixtures	Function
Super Plasticizer	To reduce the water requirement by 15% to 20% without affecting the workability leading to a high strength and dense concrete
Accelerator	To reduce the setting time of concrete thushelping early removal of forms and therefore used in cold weather concreting
Retarder	To increase the setting time by slowing down the hydration of cement and therefore are preferred in places of high temperatureconcreting
Water reducing admixture	To achieve certain workability (slump) at low water cement ratio for a specified strength thus saving on the cement
Air entraining admixture	To entrain small air bubbles in concrete which act as rollers thus improving the workability and therefore very effective in freeze-thaw cycles as they provide a cushioning effect on the expanding water in the concreting in cold climate

3. BRIEF LITERATURE REVIEW

Beam - column joints have been recognized as critical elements in the seismic design of reinforced concrete frames (ACI 1999, AIJ 1990, Euro Code 1994, SNZ 1995).

Numerous studies were conducted in the past to study the behaviour of beam-column joints with normal concrete (Shamim and Kumar 1999, Gefken and Ramey 1989, Filiatrault et al 1994). ACI- ASCE committee 352 (2002) makes recommendation on the design aspects of different types of beam-column joints, calculation of shear strength, and on reinforcement details to be provided (ACI 2002).These recommendations are however not intended for fiber reinforced concrete.

Bakir (2003) conducted extensive research on parameters that influence the behaviour of cyclically loaded joints and has derived equations for calculating shear strength of the joints. A study conducted on fiber reinforced normal strength concrete by Filiatrault et al (1994) indicated that this material can be an alternative to the confining reinforcement in the joint region. The study conducted by Gefkon & Ramey (1989) illustrated that the joint hoop spacing specified by ACI-ASCE committee can be increased by a factor of 1.7 by the addition of fibers in the concrete mix.

Jiuru et al (1992) studied effect of fibers on the beam- column joints and developed equation for predicting shear strength of joints for normal strength concrete. Bayasi and Gevman (2002) also experimentally proved the confinement effects of fibers in the joints reason and reduction in the lateral reinforcement by the use of fiber concrete. Besides these, there are several investigations on the effect of additionof fibers on the strength and durability of flexural members.

Oh (1992) also indicated that the ductility and ultimate resistance of flexural members are increased remarkably due to the addition of steel fibers. ACI committee 544(1998) also reported considerable improvement in strength, ductility and energy absorption capacity with an addition of steel fibres. All these studies are, however, confined to normal strength concrete and the research in the area of High Performance Lightweight Fibrous Concrete joints is limited.

Yung Chih Wang (2007) studied reinforced concrete beamcolumn junctions strengthened with Ultra high steel Fiber reinforced Concrete (UFC). It was concluded that UFC displayed excellent performance in terms of mechanical and durability behaviour. The test results showed that UFC replaced joint frame behaves very well in seismic resistance. The performance was found to be much better than the frame strengthened with RC jacketing as normally seen in the traditional retrofit schemes.

Kiyoung-Kyuchoi (2007) conducted analytical studies to investigate punching shear strength of interior slab-column connections made of steel fiber reinforced concrete. A new strength model for the punching shear strength of SFRC slab- column connections was developed.

Singh & Kaushik (2001) studied behaviour of fiber reinforced concrete corners under opening bending moments. It was indicated that there is a noticeable gain in efficiency with increase in fiber volume fraction up to a certain limit beyond which there is a drop in mix workability and joint efficiencies.

Kilar et al (2003) explored the possibilities to use high performance concrete for the design of seismic resistant cost effective and durable buildings. Building frames made up High Strength Light Weight Aggregate Fiber Reinforced Concrete (HPLWAFRC) were tested and analyzed under dynamic loads and the response of building in terms of force displacement relationship and rotation ductility factors were investigated.

Kumar et al (2010) studied the use of Slurry Infiltrated Fibrous CONcrete (SIFCON) as a substantial material in RC beams. It was reported that SIFCON can be used in places where structures need to be designed to resist impact loads. It was also concluded that with proper design the cross-section can be optimized by replacing certain portion by SIFCON.

The literature review of previous works conducted by various researchers on high performance fibrous concrete structural systems illustrates that most of the researchers have used Steel Fiber Reinforced Concrete (SFRC) at the beam – column junctions. The fiber contents were restricted to 2% by volume. It was observed that the enhancement in terms of strength, ductility, energy absorption capacity, toughness and other structural properties was not significant, primarily because of low fiber volume contents. The effect of fiber types, fiber volume content and aspect ratio was also notstudied. Further, most of the research work was restricted to the study of behaviour of structural members independently using normal weight concrete only. Very few researchers have studied behaviour of beam-columns and beam-column- slab junctions collectively. Since beam-column & beam-column-slab junctions are the vulnerable locations which are subjected to high horizontal & vertical forces whose magnitudes are much higher than those within the adjacent beams & columns, the use of SFRC was found to be inadequate.

4. BEHAVIOUR OF SIFCON

Slurry infiltrated fibrous concrete (SIFCON) introduced by David Lankard [20], is a composite material utilizing short steel fibres in a cement based matrix. SIFCON composites differs from conventional FRC in which the steel fibres are directly added to concrete mix in the ratio of 1-3% by volume, whereas, SIFCON uses matrix consisting of very fine particles leading to a bed of well compacted steel fibresin the range of 5-20% by volume [21]. The fibers in SIFCON are subjected to frictional and mechanical interlock in addition to the bond with the matrix. The matrix plays the role not only of transferring of forces between fibers by shear but also acts as bearing to keep the fibers interlocked. In general, when fibers are added to concrete, tensile strain in the neighbour-hood of fibers improves significantly. In the case of high performance fiber-reinforced concrete, since the concrete is dense even at the micro-structure level, tensile strain would be much higher than that of conventional SFRC. This in turn, will improve cracking behaviour, ductility & energy absorption capacity of the composites. In order to tap the potential of Slurry Infiltrated Fibrous High Performance Concrete (SIFHPC), the existing body of knowledge has beenexpanded to investigate the performance characteristics of SIFHPC beam-column and beam-column-slab joints under positive cyclic loading.

5. OBJECTIVES

In a rapidly changing global world, the adverse consequences of natural disaster on the society, economy and environment cannot be over-emphasized. Recent experiences of Jammu & Kashmir and Bhuj earthquakes, and also the North India Flood that struck Uttrakhand, once again exposedpoor quality construction methods, lack of preparedness in rescue and rehabilitation, etc. In recent years, the development in the concrete technology is direct result of the increased demand for the construction industry to strengthen and upgrade the existing concrete structure. This may be due to various reasons such as environmental degradation, design inadequacies, poor construction practices, increase in load, revision of codal provisions, and unexpected seismic loading conditions. The main objective of present research is to studyHigh Performance Concrete.

6. METHODOLOGY

The cost of civil infrastructure constitutes the major portion of the national wealth. Its rapid deterioration has created an urgent need for the development of novel, long lasting & cost effective methods for new construction, repair and retrofit. Promising way of resolving this problem is to selectively develop advanced composites such as

HPRC. Novel construction approaches can be developed with such materials that will lead to substantially higher strength, seismic resistance, durability and ductility while construction also being faster and more cost effective than conventional methods.

Beam-column joints using HPRC will be constructed and tested under flexural cyclic loading. High Performance Concrete (HPC) mix proportions for M60 & above will be designed as per ACI 211 guide lines (ACI1998) and modified by Aitcin (1998). Part of the cement will be replaced by micro-fillers such as silica fumes and fly-ash. Same mix proportion will be maintained for all the mixes. The typical data obtained from experimental investigations will be utilized to investigate performance characteristics of beam- column joints, to fulfill strength, durability & serviceability requirement. Similar investigations will also be conducted on beam-column - slab joints to investigate their structural performance in the light of above mentioned parameters.

Analytical investigations will also be conducted to study behaviour of beam-column and beam-column - slab joints by utilizing HPRC. Simple variable angle truss model may be used to illustrate the joint shear transfer mechanism.

Likewise, shear strength of joints will also be evaluated by using various analytical models available in the literature (for normal strength concrete) after suitable modifications for HPRC. The results of analytical study will be compared with experimental results and an appropriate design procedure and guidelines will be proposed pertaining to the structural application of HPRC in various structural systems.

7. ALTERNATIVE

Many efforts have been applied towards developing high performance concrete for building structures with enhanced performance and safety. Many concrete products like Autoclaved Aerated Lightweight Concrete (AALC), Fiber Reinforced Concrete (FRC), and Lightweight Concrete, have been developed and experimentally verified. AALC is well known and widely accepted, but its small size and weak strength limit its use in structural elements [22]. Lightweight aggregate concretes offer strength, dead load reduction, and thermal conductivity, but their limited ability to absorb earthquake energy raises concerns. In contrast, FRC has greater energy-absorbing ability, which is called "ductility or inelastic deformation capacity," than normal concrete, but itsweight poses problems.

But HPLWAFRC has better thermal properties, fire rating and reduced autogenous shrinkage. It also possesses excellent freezing & thawing durability, less micro cracking as a result of better elastic compatibility and has more fire resistance and better shock & sound absorption. In addition to its improved structural characteristics, HPLWAFRC has less cracking and improved skid resistance and is readily placed by the concrete pumping method. The use of structural high performance light weight concrete reduces the dead load by about 25 to 35 percentage as compared to normal weight concrete thereby offering substantial cost saving by providingless dead load Improved seismic response, longer span, thinner sections, less reinforcing steel and lower foundation cost, reduced trucking and placement cost, further make this material more versatile for its applications.

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Recurrent Neural Network with Attention-based Model for Predicting Urban Vehicle Trajectories

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Abstract

Massive amounts of spatial and temporal information data are gathered and amassed as the variety of positioning sensors and location-based devices grows. By joining the data points in a chronological order, these data—which include movement information for any moving object—are expressed as trajectory data. In particular, this study uses vehicle trajectory data from the urban traffic network to explore the prediction of urban vehicle trajectories. Recurrent neural network model for urban vehicle trajectory prediction is proposed in the earlier work. In this work, we present the Attention-based Recurrent Neural Network model for urban vehicle trajectory prediction as a means of further improving the model. The attention mechanism in this suggested model is used to incorporate network traffic state data into the trajectory prediction of urban vehicles. The Bluetooth data that was gathered in Brisbane, Australia, which incorporates private vehicle movement information, is used to assess the model. Five metrics are used to assess the model's performance: BLEU-1, BLEU-2, BLEU-3, BLEU-4, and METEOR. The outcome demonstrates that the ARNN model performs better than the RNN model**.**

Keywords: Vehicle Trajectory; Trajectory Prediction; Recurrent Neural Network; Attention Mechanism; Network Traffic State

1. Introduction

Trajectory data, which is a large amount of location data acquired with different location sensors and location-aware gadgets, is researched. An object's trajectory is a record of its movement across space. A location sequence arranged chronologically serves as a representation of this. We concentrate on one kind of trajectory data in our study: data on urban vehicles. One kind of trajectory data that depicts the motions of vehicles in urban networks is the urban

vehicle trajectory data. This data provides options for comprehending urban traffic network movement patterns by providing a wealth of information regarding aggregate flows and disaggregate travel behaviors, including user-centric traffic experiences and system-wide mobility patterns.

This work focuses on the trajectory-based location prediction problem, one of the many uses of trajectory data mining This problem involves predicting future locations destinations and the occurrence of traffic-related events like incidents and traffic jams by analyzing a large amount of vehicle and pedestrian trajectories moving through a city. In this work, we tackle the task of forecasting the order in which the vehicle under study will visit the next locations, given the prior locations from the current trip's starting point and a historical database that depicts patterns of urban mobility.

A method for predicting a vehicle's next location using a Recurrent Neural Network (RNN) model was presented in the previous study. Neural network models, such as RNN, are frequently employed in natural language processing. In the prior study, we elucidated the similarities between trajectory-based location prediction and text generation, and we implemented the RNN model for trajectory-based location prediction. The only input for the RNN model was the location data from previous visits. Despite having a straightforward structure, the RNN-based location prediction model yielded positive outcomes. For instance, for over 50% of all tested trajectory samples, the probability of correctly predicting the vehicle's next location was greater than 0.7, whereas the base case model only