For private circulation only

Ambuja foundations
A KNOWLEDGE INITIATIVE

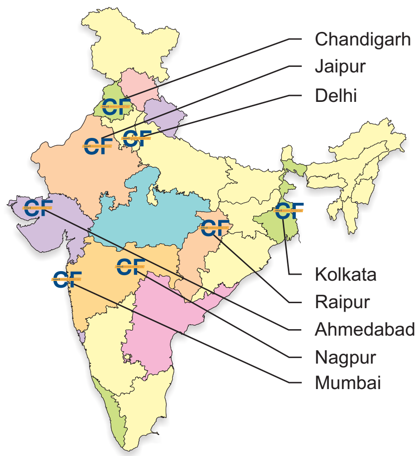
ATJ
Ambuja Technical Journal

Volume 2 | October 2016

ENGINEER · ARCHITECT · STRUCTURAL ENGINEER · CEMENT · SKILL

Come...Partner with us
as we build the Foundations of the Future

We have raised the bar for our labs, they are now NABL accredited



Ambuja Cements, Concrete Futures Laboratory (CFL) have earned National Accreditation Board for Testing and Calibration Laboratories (NABL) accreditation.
And, as such they are designed for almost 0% error to carry out the following testing :

- Concrete Material - coarse and fine aggregates
- Physical properties of concrete

Besides, we also offer concrete mix design services for :

- Concrete up to M55 Grade
- High Strength & High Performance Concrete above M55 Grade
- Self Compacting Concrete
- Fiber Reinforced Concrete
- High Volume Fly Ash Concrete
- Pavement Quality Concrete
- Pervious Concrete
- Light Weight Concrete & High Density Concrete

Our CFL Labs are equipped to provide some very special tests like HolcimCone™ (to assess mechanical & rheological properties of concrete by testing its mortar), HolcimBlu™ (to quantify clay contamination in sand) and HolcimShape™ (to study shape and texture of fine aggregates).

Currently, of the 8 such laboratories, 5 laboratories are NABL accredited and planning more for providing services to make stronger and better structures.

Ambuja Cement
Giant Compressive Strength

राष्ट्रीय परीक्षण और अंशशोधन प्रयोगशाला प्रत्यायन बोर्ड • National Accreditation Board For Testing & Calibration Laboratories • INDIA • भारत

CF Ambuja CONCRETE FUTURES LAB

Keeping The Knowledge Lamp Burning

Having received an overwhelming response for our first volume of Ambuja Technical Journal, we are proudly pleased to present the second volume.

The articles of interest in the first volume has been highly appreciated by you all & continuing on the similar manner, we have yet again tried to bring into focus relevant bits of information & articles, to further enhance knowledge & to keep abreast with constant changing technology / construction solutions worldwide.

We look forward to your relevant contributions if any, which we could publish in this Journal and which could be knowledge & learning for the readers.

We also eagerly await your views, comments & suggestions, which would only help us improve & create better value through this medium.

At Ambuja Cement, we are sure that this small step of knowledge sharing would go a long way in helping to seek gain useful information. This journal would be the medium for the same.

HAPPY READING!!!!!

Team: Technical Services

Index

Message from MD & CEO

"Gaining knowledge is the first step to wisdom. Sharing it, is the first step to humanity"

Dear Friends

It gives me great pleasure to write to you in this second issue of the Ambuja Technical Journal (ATJ). As I was browsing through the first issue, I realised how unique this journal was to the industry; and the value it brought even as it served as an inspiration and learning where Best Practices are shared and then emulated on the ground.

I was pleased to note that several articles were drafted by practicing professionals. Without doubt, this journal endeavours to provide a platform to share field experiences and will only garner further knowledge and know-how on construction techniques. Rightly so, the first issue has received an overwhelming response and appreciated by many.

Over the years, Ambuja has stood apart from the rest with its many initiatives to support our most valued partners – from creating 27 Ambuja Knowledge Centres, eight NABL-accredited Concrete Future Labs, hosting seminars, round tables and workshops all year round – we try our best to ensure we serve and replenish every need of a construction professional.

I urge the fraternity – whether civil engineers, architects, structural engineers, QC engineers, designers etc -- to continue contributing proactively on their field experiences as we together take another step in enhancing construction practices that would go a long way in nation building.

Even as, each of us at Ambuja stand firm in our commitment on knowledge sharing, I also personally urge every practicing professional to participate in this process, to the best of their ability. As influencers and users, the involvement of a professional will only add value.

My appreciation to all contributors' for their insightful articles; and congratulations to the team spearheading ATJ; and my best wishes for all such future endeavours.

Kind regards

Ajay
MD & CEO

Feedback of First ATJ

Dr J D Bapat - Independent Professional: Cement & Concrete, Pune

"The first issue of recently published Ambuja Technical Journal - With interest, I went through the contents. The articles published have direct relevance to current construction practices as well as advances in the area. My best compliments to Ambuja Foundations' knowledge initiative"

Prof. R. J. Shah, Ahmedabad

“The publication of this nature will be very much useful to professionals involved in the discipline of design and construction, academicians involved in teaching and research and senior students going through the courses related to concrete technology, Design of reinforced and pre-stressed concrete structures at Undergraduate and Post-graduate programs”.

Mr Deepak Sogani (CEO NMRD), Jaipur

" It will help us to understand the work done by various professionals across the country ".

Mr. Pramod Jain (Pramod Jain Associated, Jaipur)

" It will give us an opportunity to show case our work.”

Sarang K - Vastupurna Const. & Interior, Solapur

“Pleased to read excellent journal having contents of civil engineering subjects. The varieties & depth of subjects are very nice especially Precast Housing – Sustainable Solution for Rural & Semi-urban, Individual Housing Builders articles are very innovative. The Modular Curing Solutions and Waste water treatment and re-use – such articles are self-initiatives towards water saving is very essential to human future & global environment. I give my best compliments to this beautiful magazine and waiting for your next edition shortly.”

Mr Sanjay Mundra (Group Manager NCCBM), New Delhi

“Felt it to be very useful for further up gradation of our knowledge.”

Mr. I C Chauhan (Chauhan & Associates), Gurgaon

“It's an excellent initiative by Ambuja who has provided another platform other than AKC to share the knowledge”.

Crushed Rock Sand — An Economic and Ecological Alternative to Natural Sand to Optimize Concrete Mix

Sanjay Mundra - Ballabhgarh

Summary

The study investigates the use of crushed rock sand as viable alternative to Natural River sand that is being conventionally used as fine aggregate in cement concrete. Various mix designs were developed for different grades of concrete based on IS, ACI and British codes using Natural River sand and crushed rock sand. In each case, the cube compressive strength test, and beam flexure tests were conducted. The results of the study show that, the strength properties of concrete using crushed rock sand are nearly similar to the conventional concrete. The study has shown that crushed stone sand can be used as economic and readily available alternative to river sand and can therefore help to arrest the detrimental effects on the environment caused due to excessive mining of river sand.

Keywords

Crushed rock sand; Concrete; Workability; Compressive strength; Flexure strength

Introduction

Rapid growth in the infrastructure at the global level has made concrete the most widely and commonly used construction material throughout the world. This has created immense pressure on the concrete industry to produce large quantum of concrete to meet the growing demand of infrastructure development. The cost of concrete production primarily depends on the cost of its constituent raw materials namely, cement, aggregates (coarse and fine) and water. Among the constituent raw materials, the Natural River sand which forms around 35% of the concrete volume plays an important role in deciding the cost of concrete. Depleting sources of Natural River sand and strict environmental guidelines on mining has gradually shifted the attention of the concrete industry towards a suitable fine aggregate alternative that can replace the presently used Natural River sand. Crushed rock sand has surfaced as a viable alternative to Natural River sand and is being now used commonly throughout the world as fine aggregate in concrete. It is manufactured by crushing the quarried stone to a size that will completely pass through 4.75 mm sieve.

Several studies have been conducted in the past to inves-tigate the effect of partial replacement of Natural River sand with crushed rock sand. Celik and Marar (1996) con-cluded that partial replacement upto 30% leads to decrease in slump value. However, a significant improvement in the compressive, flexural strength and impact resistance was observed. A significant reduction in the cost of con-crete without affecting the strength property was reported in the study conducted by Ilangovan (2000). Sahu et al. (2003) observed that concrete made using crushed rock sand attained the comparable compressive strength, tensile strength and modulus of rupture as the control concrete. Sahul Hameed and Sekar (2009) concluded that the compressive strength, split tensile strength and the durability properties of concrete made of quarry rock dust are nearly 14% more than the conventional concrete.

A survey of literature has shown that numerous studies have been conducted in the past to utilize crushed rock sand as fine aggregates in concrete. But, an in-depth study has not been performed to optimize the replacement level of crushed rock sand in concrete. The present study has attempted to study the effect of partial to full replace-ment of Natural River sand with crushed rock sand on the workability, compressive strength and flexural strength of concrete.

Materials

The materials for the study comprised of cement, fly ash, fine aggregates, coarse aggregates, admixture and water. Ordinary Portland cement (OPC) 43-grade was used in most of concrete design mixes. In some design mixes pulverized fly ash (PFA) was used as a supplementary cementing mate-rial. The percentage of fly ash was limited to 35%. The fine aggregates included Natural River sand from River Banas, and crushed stone sand from Gunavata and Chandwaji region in the State of Rajasthan. The coarse aggregates selected for study comprised of 20 mm and 12.5 mm-sized aggregates. High range water reducer admixture were incorporated to reach the desired workability.

The experimental program was divided into two parts. The first part was dedicated to examine the effect of fine aggregates type, grading and blend ratio on the fresh and hardened properties of concrete. The second part of the program focused on the optimization of the selected design mix. The Natural River sand from Banas was mixed with crushed stone sand from Gunavata and Chandwaji and concrete design mixes corresponding to M25 and M30 grade of concrete were prepared. The samples were tested for slump, compressive strength and flexural strength. The effects on each of these properties were examined by changing the percentage replacement of Natural River sand (NS) with crushed rock sand (CRS). An optimization study was performed to study the effect on the properties of concrete when paste content was held constant and the fly ash was considered to be powder instead of aggregates. Other goals of optimization were to examine the effect of partial replacement of cement with fly ash.

Results and Discussion

Workability Study

The workability of concrete was measured in terms of the slump value. The values of initial and final slump (after 2 h) were measured in mm and are exhibited in Table 1. The results indicate that, the initial slump values for OPC and partial replacement of OPC with PFA design mixes are same even at higher percentages of blending. But, the final slump values after 2 h tend to be slightly higher in case when PFA is used as partial replacement for OPC thereby indicating that PFA has a positive influence on concrete slump.

Admixture Demand Study

The admixture dosage was increased from 0 to 1% and the slump values were measured. The slump values for concrete manufactured using NS and 100% replacement with CRS were plotted (Fig. 1). The plots reveal that at low level of admix-ture dosage (upto 0.70%), the concrete manufactured using CRS as 100% fine aggregates has almost zero slump values. However, at higher dosage of admixture, the slump values of concrete manufactured using 100% NS and 100% CRS as fine aggregates become almost comparable.

Compressive Strength Study

The compressive strength was tested for different specimens of concrete manufactured with different percentages of fine aggregate blending. The results are tabulated in Table 2. The results show that the compressive strength is almost the same for concrete using OPC and OPC with partial replace-ment with PFA for all blending percentages. However, it is seen that as the blending percentage is increased beyond 50% the compressive strength tends to reduce. The incorpo-ration of PFA in the mix is also seen to slightly reduce the compressive strength.

Flexure Strength Study

Experimental studies for flexure strength were also carried out. Flexure strength is tabulated at Table 3.

Conclusions

Following broad conclusions can be drawn from the study:

a. Expect that a higher blend ratio of crushed stone to nat-ural sand will decrease workability. Even the best shaped manufactured sands are usually more poorly shaped than silica Silicious river sand. It is viable to use mix with high percentage of micro-fines in all concrete type. The work-ability is decreased, but it can be restored by increasing the paste content and including water reducing admix-ture, especially high range water reducing admixture (HRWRA).

b. Considerable reduction in compressive strength was noticeable at and beyond 50% CRS replacement. There-fore for mix with 70–100% CRS replacement it is desired to mix washed crushed rock sand along with proper screening at crushing stages so that one gets compressive strength higher than the designed strength.

c. The properties of concrete (Compressive and flexural strength) made with partial or full replacement with CRS are comparable to natural sand results.

d. The cost of concrete can be decreased by increasing the amount of crushed stone sand. The price can further be lowered by including the PFA in mix.

e. Besides being a cost effective alternative, use of CRS as fine aggregates in concrete helps in sustaining the ecological balance.

PFA for all blending percentages.However, it is seen that as the blending percentage is increased beyond

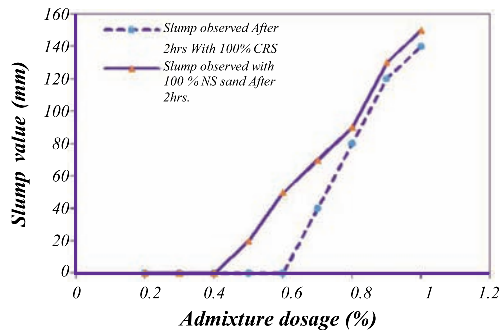


Figure 1: Plot of Slump Value with Varying Admixtures

Table 1: Slump Results For Sand Blend Study.

Fine aggregate blend (%)	M25 slump (mm)				M30 slump (mm)			
	OPC + PFA		OPC		OPC + PFA		OPC	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
NS/CRS (70/30)	200	140	200	135	200	145	200	135
NS/CRS (50/50)	200	135	200	130	200	135	200	130
NS/CRS (30/70)	180	125	180	120	180	125	180	120
NS/CRS (0/100)	180	115	180	110	180	120	180	110

Table 2: Compressive Strength Values For Different Blend Percentages.

Fine aggregate blend (%)	M25 grade concrete		M30 grade concrete	
	OPC	OPC + PFA	OPC	OPC + PFA
NS/CRS(100/0)	35.33 MPa	34.18 MPa	38.83 MPa	40.42 MPa
NS/CRS (70/30)	37.82 MPa	36.70 MPa	42.34 MPa	41.17 MPa
NS/CRS (50/50)	35.27 MPa	34.32 MPa	39.21 MPa	35.27 MPa
NS/CRS (30/70)	29.37 MPa	28.27 MPa	35.00 MPa	33.53 MPa
NS/CRS (0/100)	26.67 MPa	22.67 MPa	31.08 MPa	28.11 MPa

Table 3: Flexure Strength Of Concrete With NS And CRS.

Grade	Flexure strength (CRS)		Flexure strength (NS)	
	7 Days	28 Days	7 Days	28 Days
M25 (OPC + PFA)	2.93 MPa	3.50 MPa	3.09 MPa	3.72 MPa
M30 (OPC + PFA)	3.20 MPa	3.80 MPa	3.34 MPa	3.98 MPa

Author:
Mr. Sanjay Mundra is Group manager in NCCBM Ballabgarh (Haryana) & his interest Lies in Utilizatio of Mineral Waste for sustainable concrete.

Durability Considerations in IS 456:2000

Dr. J.D.Bapat - Pune

The author discusses the "Plain and Reinforced Concrete – Code of Practice", IS 456:2000, in connection with blended cements and durability, with particular reference to attack by deleterious agents, like sulphate attack, alkali aggregate reaction and carbonation.

In the last few years, the emphasis of construction industry has shifted from high-strength to high-performance concrete. The realization has come on account of the fact that nearly 65 percent of the total cement sales in the country presently go towards the repairs of old structures, many of which are built with OPC. The need to build durable structures is felt not only form the point of view of economy, but also for the conservation of resources, energy and environment.

In the fourth revision of the Indian standard Code of Practice for Plain and Reinforced Concrete, IS 456:2000, special consideration has been given to the durability of concrete structures. The provisions of the code on durability are given in clause 8 of section 2, on 'Materials, Workmanship, Inspection and Testing'. Some of the important provisions related to durability are as follows:

(i) The permeability of concrete to the ingress of deleterious agents has been identified as one of the major characteristics affecting the durability.

(ii) The factors influencing the durability have been delineated as environment, cover to embedded steel, type and quality of construction materials, cement content and water-cement ratio, workmanship to obtain full compaction and efficient curing, and shape and size of the member.

(iii) The general environment, to which the concrete will be exposed during its working life, is classified into five levels of severity, namely mild, moderate, severe, very severe and extreme.

(iv) The air-entraining admixtures have been recommended for use in the concrete where freezing and thawing actions under wet conditions exist.

(v) Recommendations have been given for the type of cement, maximum free water-cement ratio and minimum cement content, to develop adequate resistance in the concrete exposed to different sulphate concentrations.

(vi) The minimum values for the nominal cover have been specified, to meet the durability requirements.

(vii) Recommendations have been given on the appropriate values for the minimum cement content and the maximum free-water-cement ratio of the concrete, for different exposure conditions.

(viii) The upper limit of the cement content, not including flyash (FA) and ground granulated blast furnace slag (GGBS), has kept at 450kg/m3, considering the increased risk of cracking due to drying shrinkage in thin sections or early thermal cracking and the increased risk of damage due to alkali aggregate reaction, at the higher cement contents.

(ix) The total amount of chloride content (as Cl) in the concrete, at the time of placing has been specified.

(x) The maximum total water soluble sulphate content of the concrete mix, expressed as SO3, has been specified as 4 percent by mass of the cement in the mix.

(xi) As a precaution against alkali aggregate reaction, recommendations have been given on the constituent materials like use of non-reactive aggregates and low alkali Portland cement (<0.6 percent Na2O equiv.), partial replacement of cement with the mineral admixtures, use of impermeable membranes to reduce the degree of saturation of concrete during service and limiting cement content of concrete.

(xii) The use of proper and adequate curing techniques has been stressed, to reduce the permeability of the concrete and enhance its durability by extending the hydration of cement.

(xiii) Recommendations have been given on the concrete constructions in sea water or directly exposed along the sea coast, with respect to the grade of the concrete, type of cement, mix design and the use of precast members.

The durability of concrete incorporates, besides strength, its capacity to resist the erect of the internal and external deteriorating factors, such as sulphate attack, chloride attack manifested in the corrosion of the reinforcement, carbonation, alkali-aggregate reaction, freezing and thawing, so as to give a satisfactory performance during the economic life, for which it is designed. The present study reviews the provisions of IS 456:2000 towards building durable structures and highlights the importance of blended cements achieving that goal.

Blended Cements

Plant Manufactured Cements

The code mentions the following two varieties of blended cement in Clause 5.1:

- Portland slag cement (PSC) conforming to IS 455
- Portland pozzolana cement (PPC) (flyash (Part I) and calcined clay (Part II) based conforming to IS 1489.

The addition of flyash (FA) and blast furnace slag (BFS), as permitted by the Standards is given in Table1

Table 1: Addition of FA and BFS Permitted in Indian Standards

Designation	Cement Standard	Main constituents percent		
		Clinker*	BFS	FA
Portland pozzolana cement	IS 1489 (Part 1)-1991	90-75		10-35
Portland slag cement	IS 455-1989	75-30	25-70	-

*Note: * Includes calcium sulphate*

Site Additions

The code also permits addition of mineral admixtures at the construction site, such as Grade 1 FA conforming to IS 3812, Silica fume, rice husk ash, metakaolin and ground granulated blast furnace slug (GGBS) conforming to IS 12089.

The addition of FA and GGBS to cement concrete, at the construction site is prevalent. It requires careful quality control and proper blending of the constituents in the concrete mixture. Although there are examples where successful blending has been carried out even in a one-bag mixer, the mechanized batching and mixing facilities, such as that in a RMC unit, fully control the proportion of various constituents, including that of chemical admixtures like super plasticisers (SP) to impart the desired properties of the fresh and hardened concrete. In order to ensure the uniformity in blending (measured by the standard deviation), it is desirable to blend the mineral admixtures in the cement before addition to the concrete mixer, in the RMC unit. In this way, the tests on the uniformity of blending can also be conducted.

Permeability and Durability

Clause 8.1.1 of the code states as follows: "One of the main characteristics influencing the durability of concrete is its permeability to the ingress of water, oxygen, carbon dioxide, chlorides, sulphates and other potentially deleterious substances. Impermeability is governed by the constituents and workmanship used in making the concrete. With normal weight aggregates a suitable low permeability is achieved by having an adequate cement content, sufficiently low free water-cement ratio, by ensuring complete compaction of the concrete and by adequate curing".

The use of blended cements and mineral admixtures significantly affects the permeability of concrete. As an illustration, Table 2 shows how the chloride diffusivity significantly reduces with the use of PSC/GBBS. The Table presents the results obtained by different workers at different times and conditions, on cement pastes, mortars and concretes. The w/c ratio varied between 0.4 to 0.6 and the slag percentage between 50 to 80 percent. As can be seen, the chloride diffusivities are reduced by an order of magnitude of 10 to 120, depending upon the mix proportions and other conditions. There is also evidence to show that the diffusivity with respect to the oxygen and water also reduces substantially, using blended cements in the concrete (2,3).

The reduction in the permeability is a result of refinement of pore structure of the concrete matrix on account of the following reasons:

(i) Filling effect of the ultrafine calcium-silicate-hydrate (C-S-H) produced by the secondary hydration reaction between calcium hydroxide (released by the hydration of OPC component) and the active silica and alumina in FA/BFS, in the blend.

(ii) Packing effect of the unreacted cement/BFS/FA particles as micro-aggregates.

Curing and Durability:

The code lays considerable emphasis on curing. Clause 8.2.1 states, "…Adequate curing in essential to avoid harmful effects of early loss of moisture….."

Clause 8.2.7 on compaction finishing and curing states as follows,

"….. It is essential to use proper and adequate curing techniques to reduce the permeability of the concrete and enhance its durability by extending the hydration of cement, particularly in its surface zone…."

Curing is the process of preventing loss of moisture from the concrete whilst maintaining a satisfactory temperature regime. Clause 13.5 further states as follows,

"…….The prevention of moisture loss from the concrete is particularly important if the w.c ratio is low, if cement has high rate of strength development, if the concrete contains ground granulated blast furnace slag or pulverized fuel ash…."

The code recommends 14 days minimum period of damp or wet curing for concretes containing mineral admixtures or blended cements.

It is well known that the hydration reaction of concrete containing Fly Ash (FA) and Blast Furnace Slag (BFS) continues longer, through the reaction of calcium hydroxide with reactive silica and alumina present in these admixtures, in presence of water. This reaction known as secondary hydration produces additional calcium-silicate-hydrate (C-S-H) gel, which is the principal strength giving compound in the concrete. As a result of this secondary

Table 2: Effect of BFS / GGBS Addition on the Chloride Diffusivity of Concrete.

Sl. No.	Paste/Mortar/Concrete	W-C ratio	BFS, percent	Chloride diffusivity (10^{-12} m^2/s) OPC	PSC	Authors and year
1	Paste	0.5	65	4.5	0.4	Holden et. Al
2	Concrete	0.49	50	7.5	0.5	Jackson et al (1991)
3	Concrete	0.4-0.5	70	0.1-0.8	0.04-0.08	Frey et al (1985)
4	Concrete	0.5	70	2.4	0.02	Bamforth et al (1990)
5	Paste	0.5	65	15.1	0.2	Roberts
6	Paste	0.6	80	6.2	0.06	Brodersen (1982)
7	Mortar	0.5	75	3.0	0.04	Bakker (1980)

hydration, concrete containing FA ad BFS exhibits higher long term strength. Adequate curing shall ensure continuous supply water for secondary hydration.

The effect of inadequate curing is illustrated in Table 34. The table shows water penetration according to DIN 1048 on samples of one-year old concrete with PSC, cured wet for 1,7,28 and 90 days and stored outdoors. As can be seen, the water penetration on 1-day cured samples is very high whereas that on 7-day or longer cured concrete samples is very low.

Table 3: Effect of Curing on Water Penetration on Concrete with PSC

Period of Curing, days	Water Penetration depth, mm
1	85
7	8
28	2

The curing and the carbonation of concrete are related. When the moisture level in the concrete is not properly maintained during the initial stages of hydration, the concrete dries and the hydration reaction slows down or stops and consequently the concrete becomes permeable. The drying is accompanied by carbonation, hence renewed hydration occurs only partly, and when the cement gets wet again this aspect should be particularly taken care of in the regions where the relative humidity of the atmosphere is low.

Resistance of Concrete to the Attack of Deleterious Agents

Clause 8.2.2.1 of the code classifies the general environment to which the concrete will be exposed during its working life, in the following five levels of severity: "mild, moderate, severe, very severe and extreme". The requirement of durability will be direly felt in the last three regimes, as given in Table 4 (partial extract of Table 3 of IS 456, clause 8.2.2.1). The concrete containing blended cements gives excellent performance under these conditions.

Exposure to Sulphate Attack

Table 4 of clause 8.2.2.4 of IS 456 gives recommendation for the type of cement, maximum cement content required at different sulphate concentrations in the soil and in the ground water. Besides OPC, the use of PSC and PPC is recommended UP TO Class 3 sulphate concentration, i.e. 0.5 – 1.0 percent SO3 in soil or 1.2 – 2.5 g/l in ground water. In situations of higher sulphate concentrations, use of supersulphate or sulphate resisting Portland cement (SRPC) with protective coatings has been recommended.

Footnotes 6 and 7 of the table reproduced below, only corroborate the experience on durability performance gained world over, on slang cement.

Table 4: Environmental Exposure Conditions of IS 456:2001

Environment	Exposure Conditions
Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in sea water Concrete exposed to coastal environment
Very Severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet Concrete in contact with or buried under aggressive sub-soil/ground water
Extreme	Surfaces of members in tidal zone Member in direct contact with liquid/soil aggressive chemicals

Source: (Partial extract of the Table 3, Clause 8.2.2.1)

Table 5: Chloride Resistance of Cements

Cement Type	Chloride diffusivity (10^{-13} m^2/s)
SRPC	100.0
OPC	44.7
70 percent OPC + 30 percent FA	14.7
35 percent OPC + 65 percent GGBS	4.1
(Cement pastes of w=c = 0.5 at 25^0 C)	

"Footnote 6: Portland slag cement conforming to IS 455 with slag content more than 50 percent, exhibits better sulphate resisting properties."

"Footnote 7: Where chloride is encountered along with sulphates in soil and ground water, OPC with C3A Content 5 to 8 percent shall be desirable to be used in concrete, instead of sulphate resisting cement. Alternatively PSC conforming to IS 455 having more than 50 percent slag or a blend of OPC and slag may be used, provided sufficient information is available on performance of such blended cement in these conditions"

With regard to sulphate resistance of blended cements the following points may be noted:

(i) Both the Na and Mg Sulphates, obtained in soil and water, are deleterious to concrete but their actions produce different effects. Whereas the action of Na2SO4 is manifested in the expansion, that of MgSo4 is manifested in the reduction of strength, of the concrete. These effects mainly result from the reaction of these sulphates with the free Ca(OH)2 and the C-S-H gel in the concrete, respectively. In comparison to OPC (C3A 5 to 8 percent), blended cements have been found to offer better resistance to sulphate expansion due to (a) Less free Ca(OH)2 in concrete matrix, (b) Lesser C3A and (c) impermeability. Both the OPC and blended cements are prone to MgSO4 attack (blended cements somewhat more). Therefore, it is desirable to apply some kind of protective coating on the concrete surface exposed to MgSO4 environment irrespective of the type of cement.

(ii)The footnote 7 of Table 4 in clause 8.2.2.4 specifically mentions that sulphate resisting cement (SRPC) should not be used where sulphate attack is accompanied by chlorides in the soil or the ground water. The test results and the experience show that the resistance of SRPC to combined sulphate and chloride attack is rather low, as evident from Table 51,6,7

Exposure to Chloride Attack

Clause 8.2.5.2 of the Code titled "Chlorides in Concrete" states the following:

"......To minimize the chances of deterioration of concrete from harmful chemicals salts, the levels of such harmful salts in concrete, coming from concrete materials, that is, cement aggregates, water and admixtures, as well as by diffusion from the environment should be limited."

Table 6: Chloride Binding Capacity of Concrete with FA and BFS Cements Exposed to Sea Water for 7 Years8

Sl. No.	Cement	Concrete w-c	Concrete curing	Friedel Salt up to 10 mm depth (XRD peak, cps)
1	PC	0.55	Water at 20^0 C -7 days	70
2	FA	0.55		60
3	BFS	0.55	60 percent RH-up to 28 days	100

Note: (i) Total cementitious material 300 kg/m3
(ii) Cement replacement: FA = 30 percent, BFS = 50 percent
(iii) Friedel Salt: 3CaO.Al2O3. CaCl2. 10H2O

Table 7 of the clause specifies the maximum chloride content (as Cl) in concrete at the time of placing. The upper limit of chlorides for concrete containing metal and steam-cured at elevated temperature and pre-stressed concrete is 0.4, while that for reinforced or plain concrete containing embedded metal is 0.6.

Concrete with blended cements have been found to effectively resist the corrosion of reinforcement, initiated and propagated by the chloride ion diffusion, for the following reasons3:

(i) Refinement of poor structure and resultant reduction in the chloride, oxygen and water diffusivity.

(ii) Higher electrical resistance of concrete resulting in reduction of the corrosion current and the rate of corrosion current and the rat of corrosion.

(iii) Higher binding capacity towards chloride ions of concrete containing blended cements, especially PSC, effectively reduces the depth of penetration of the chloride ions inside the concrete, as seen in Table 68. The higher concentration of Friedel salt indicates higher chloride binding capacity.

(iii) Higher binding capacity towards chloride ions of concrete containing blended cements, especially PSC, effectively reduces the depth of penetration of the chloride ions inside the concrete, as seen in Table 68. The higher concentration of Friedel salt indicates higher chloride binding capacity.

Alkali-Aggregate Reaction

Clause 8.2.5.4 on alkali-aggregate reaction states as follows:

"Some aggregate containing particular varieties of silica may be susceptible to attack by alkalis (Na_2O and K_2O) originating from cement or other sources, producing an expansive reaction which can cause cracking and disruption of concrete. Damage to concrete from this reaction will normally only occurs when all the following are present together:

(a) A high moisture level, within the concrete

(b) A cement with high alkali content, or another source of alkali

(c) Aggregate containing an alkali reactive constituent".

This clause also gives recommendations on constituent materials, like the use of nonreactive aggregates and low alkali Portland cement (<0.6 percent Na_2O equivalent), use of impermeable membranes to reduce the degree of saturation of concrete during service and limiting the cement content of concrete. Para (b) of the Clause states as follows:

"….further advantage can be obtained by use of fly ash (Grade 1) conforming to IS 3812 or granulated blast furnace slag conforming to IS 12089 as part replacement or ordinary Portland cement (having total alkali content as Na_2O equivalent not more than 0.6 percent), provided fly ash content is at least 20 percent or slag content is at least 50 percent…."

The use of blended cements in concrete has been found to effectively control alkali-aggregate reaction, on account of the following reasons9:

(i) Low C-S ratio in C-S-H (formed by the secondary hydration) fixes alkalis through adsorption or solid solution, thereby decreasing the alkali ion concentration in pre solution. About 95 percent of the total alkali content can be retained by blended cement whereas only 15 percent is blocked in OPC.

(ii) C-S-H formed by the secondary reaction of $Ca(OH)_2$ with FA or BFS fills up the pores in hardened cement paste, thus making the structure denser, suppressing the movement of pore solution.

The addition of FA and BFS turns the zeta potential, on the surface of pores in hardened cement paste, positive thereby suppressing the movement and diffusion of alkali ions in pore liquid.

Table 7: Depth of Carbonation Observed in Dutch Marine Structures

Carbonation depth, mm	Number of structures	Age, years
0-5	48	3-62
5-6	1	8
6-7	1	47
Up to 10	1	47

Carbonation

Clause 8.1.1 of the code mentions carbon dioxide as one of the deleterious agents causing concrete deterioration. The performance of most of the commonly used cements, with regard to carbonation, is more or less similar.

The accelerated laboratory tests on the carbonation of concrete containing PSC/GGBS sometimes give misleading results as they are not conducted under practical conditions. These tests are normally conducted under higher carbon dioxide concentrations, constant drying conditions and shorter duration, all of which are not obtained in the practice. The field experience reported by Bijen1, gives a different picture (Table 7). The large scale investigation conducted in Netherlands, along the North Sea coast, included the performance evaluation of 51 structures (sluices, piers, quays, landing stages). In most cases BFS cement was used and the average cementitious content was 340 kg/m3. The data given in Table 7 reveal that the depth of carbonation in 48 out of 51 structures was less than 5 mm.

The results given in Table 7 refer to marine structures. Higher incidences of carbonation are reported in the old concrete structures built mostly with OPC, in dry areas, where the relative humidity of the atmosphere is low. One of the reasons of this phenomenon could be the inadequacy of curing in the initial stages of concrete setting, as explained in the section 4 of this paper.

Suggestions for Further Improvement:

Like mineral admixtures (FA, BFS, rice husk ash, metakaolin, silica Fume), the use of chemical admixtures in concrete also needs to be viewed from the durability angle. The use of chemical admixture becomes necessary to produce high strength (M60 to M80), pumped, concrete at low water-cement ratios. There are reports to suggest that appropriate choice and use of chemical admixtures lead to improved durability.

Conclusions

IS 456-2000 lays special emphasis on ensuring the durability of concrete

- The recommendations are given on the selection of constituent materials, namely aggregates, cement, water and admixtures to effectively counter the deteriorating effect of sulphate and chloride attack, alkali aggregate reaction, freezing and thawing.
- The code recommends the use of blended cements in concrete to improve its durability performance.

References

1. BIJEN, JAN. Blast furnace slag cement for durable marine structures VNC – Beton, Netherlands, 1998.–

2. Flyash addition to concrete. Report of Intron Institute for Environmental Research, Netherlands, November 1991.

3. GEISELER, J., KOLLO, H. AND LANG, E. Influence of blastfurnace slag on durability of concrete structures, ACI mat. J., Vol 92, No. 3, May – June 1995, pp. 252 – 257.

4. WEGEN, G., BIJEN, J., SELS R. VAN, Intron Report 88205, Netherlands, June 1988.

5. BAPAT J.D. Performance of Concrete with blended cement, Seminar on Eco-friendly Blended Cements for Economical and Durable Concrete in the New Millennium, ACI (Maharashtra, India Chapter) February 18-19, 2000, Mumbai, pp 121 – 140.

6. RAJKUMAR C. Portland slag cement in civil engineering constructions National Council for Cement and Building Materials, New Delhi.

7. HEUMMEN, VAN, BOVEE H. ZANDEN J VAN DER, BIJEN J., Materials and durability, Proc. Symp. Saudi Arabia – Bahrain Causeway, Delft University of Technology, Faculty of Civil Engineering, Delft, Netherlands, 1985.

8. TORIL K. SASATANI T., KAWAMURA M., Chloride penetration into concrete incorporating mineral admixtures in marine environment, Sixth CANMET-ACI Conference ON, Flyash, Silica Fume, Slag and Natural Pozzolans in Concrete, Bangkok, Thialand, May 31-June 5, 1998, Vol II, pp 701-16.

9. Progress in Cement and Concrete – mineral Admixtures in Cement and Concrete Vol. 4, Editor DR. S.N. GHOSH, Academia Books International, New Delhi.

Author:

Dr, Jayant D. Bapat (born April 9, 1952), B.Tech., M.E., Ph.D. (IIT, Delhi). Stationed at Pune (Maharashtra, India), he currently works as an independent professional consultant for cement manufacturing and concrete

He worked at senior positions at the National Council for Cement and Building materials (NCB) (1975-1991), New Delhi and Walchandnagar Industries Ltd. (WIL) (1991-1994)

His long standing expertise lies in the areas of cement manufacturing, durability of concrete and utilization of industrial and agricultural wastes in building materials..

He is a reviewer of technical papers for number of international journals, such as the Journal of Cement and Concrete Research, Journal of Waste Management, ACI Materials and ACI Structural Journal He has 53 publications to his credit in the national/ international journals / seminars. His biography has been included in the Who's Who in the World, Who's Who in Asia and Who's Who in Science and Engineering.

He has been distinguished as among "Top 100 Engineers 2012" and "International Engineer of the Year 2012", by the International Biographical Centre, Cambridge, England

Emails - : consult@drjdbapat.com , consult.bapat@yahoo.com

URL: http://www.drjdbapat.com

Comparison of Strength Between Retempered Concrete of Two Different Grades

A.R. Pethkar and G.K. Deshmukh - Solapur

Summary

As the grade of concrete increases, the quantity of cement also increases which affects the properties of retempered concrete. For M20 concrete we can retemper the concrete up to 120 min. but for M40 concrete retempering time is only 30 min. Adding water to a plastic mix to increase slump is an extremely common practice, even though it is not recommended because it increases the porosity of concrete. Concrete often arrives on site more than half an hour after initial mixing. Placement operations can take anywhere from 10 to 60 minutes, depending on the field conditions and the size of the load. When the slump decreases to an unacceptable level during the operations, water is added to the mix. The objective of this paper is to study the strength characteristics of retempered concrete M20 and M40 concrete. Usually the retempering process is used with normal concrete or with ready mixed concrete; an attempt is made to check the compressive strength of normal retempered concrete with an addition of retarder in three different percentages as 0.2%, 0.4% and 0.6% at strength retempering time of 15 minutes to 90 minutes.

Keywords

Retempering of concrete; Compressive strength of concrete; Slump of concrete.

Introduction

Retempering is defined as 'Addition of water and remixing of concrete or mortar which has lost enough workability to become unplaceable'. Retempering inevitably results in some loss of strength compared with the original concrete [1].

Concrete is a material obtained by mixing cement, fine aggregate, coarse aggregate and water in specific proportions. Water is added for chemical reaction and gives workability to fill in the form of shape and dimension for structure. The chemical interaction between cement and water bonds the aggregate into solid mass [2].

Slump Loss

The most important result of prolonged mixing is slump value of concrete. Fresh concrete mixes stiffen with time, particularly if continuously mixed. This stiffening effect is reflected in a reduced slump and accordingly, this phenomenon is reflected as slump loss. This loss of slump value at prolonged mixed concrete is caused by a number of reasons. The main reasons are simply that some water from the mix is absorbed by the aggregate if mix is not saturated, some water is lost by evaporation and some water is removed by initial chemical reactions. The higher water absorption rate of aggregates as a result of longer mixing time is a reason for slump loss of prolonged mixed concrete. The grinding effect caused by extra mixing of fresh concrete causes greater amount of fine aggregate than the one determined during design process. This situation results in a decrease in slump value, since increase in finer aggregate increases the water demand for same consistency of concrete [3]. As the grade of concrete increases the quantity of cement increases which effects on the properties of retempered concrete. For M20 concrete we can retempered the concrete up to 120 min. but for M40 concrete retempering time is only 30 min.

Research Significance

Ready-mixed (RMC) concrete which is mixed at the plant, using a normal, well-designed concrete mix, should arrive at its destination with sufficient workability to enable it to be properly placed and fully compacted. In such circumstances, where there is a significant period of time between mixing and placing the concrete, there will be a noticeable reduction in the workability of the fresh concrete. If for any reason, the placement of the concrete is unduly delayed, then it may stiffen to an unacceptable degree and site staff would normally insist on the rejection of a batch or otherwise good concrete, on the grounds of insufficient workability. If not rejected, excessive vibration would be needed to attempt to fully compact the concrete, with the risk of incomplete compaction, expensive repair, or, at worst, removal of the hardened concrete [4, 5].

Experimental Programme

The main aim of this experimentation work is to find the effect of addition of retarder admixtures on the properties of retempered concrete. Portland Pozzolona Cement and locally available aggregates and crushed sand were used in the experimentation. The specific gravity of fine and coarse aggregate was 2.76 and 2.87 respectively. The experiments were conducted on a mix proportion of 1: 1.26:2.1 with water cement ratio (w/c) equal to 0.54 which corresponds to M20 grade of concrete. The experiment were conducted on a mix for M40 grade concrete Water: cement: F.A.: C.A. = 0.4: 1: 1.65: 2.92 Admixture = 0.6 % by weight of cement = 2.4 kg.

After thoroughly mixing all the ingredients in dry state, the required quantity of water was added in the mix and thoroughly mixed. At this stage the homogeneous concrete mix was obtained. This concrete mix was covered with gunny bags for 15 minutes. The time was calculated and another set of retempered concrete specimens were cast by adding 0.2% retarder and the required extra amount of water to balance a w/c ratio of 0.54 & 0.40 for M20 & M40 respectively. Slump and compaction factor are shown in Tables 1 and 2 respectively. All the specimens were demoulded and were transferred to curing tank to cure them for 28 days. After 28 days of curing the specimens were tested for their compressive strength as per IS specifications. For compressive strength test, the cubes of dimensions 150 mm x 150 mm x 150 mm were cast and were tested under compression testing machine as per IS 516:1959. Compressive strength of retempered concrete are shown in Table 3.

When we add more than 0.2% retarder the demoulding time of the concrete increases. Due to this, scaffolding cost for construction increases. The optimum percentage of retarder is 0.2%. For M40 grade concrete skilled labors are employed. So there is no need of retempering process as they can handle it properly.

Conclusion

1. The concrete M20 & M40 without any retarder shows target compressive strength, up to retempering time 30 minutes. & 30 minutes respectively.

2. The concrete M20 & M40 with 0.2% retarder shows target compressive strength, up to retempering time 45 minutes & 45 minutes respectively.

3. The concrete M20 & M40 with 0.4% retarder shows target compressive strength, up to retempering time 90 minutes & 45 minutes respectively.

4. The concrete M20 & M40 without any retarder shows target slump, up to retempering time 30 minutes & 0 minutes respectively.

5. The concrete M20 & M40 with 0.2% retarder shows target slump, up to retempering time 45 minutes & 15 minutes respectively.

6. The concrete M20 & M40 with 0.4% retarder shows target slump, up to retempering time 75 minutes & 15 minutes respectively.

7. The concrete M20 & M40 without any retarder shows target compaction factor, up to retempering time 45 minutes & 15 minutes respectively.

8. The concrete M20 & M40 with 0.2% retarder shows target compaction factor, up to retempering time 60 minutes & 15 minutes respectively.

9. The concrete M20 & M40 with 0.4% retarder shows target compaction factor, up to retempering time 90 minutes & 30 minutes

respectively.

10. With the addition of 0.2% retarder the demoulding period increase is up to 24 hours.

11. With the addition of 0.4 % retarder the demoulding period increase is up to 36 hours.

Table 1: Slump of Retempered Concrete

Retempering time	Target Slump = 50 mm					
	O% retarder		O.2 % retarder		O.4 % retarder	
	M 20	M 40	M 20	M 40	M 20	M 40
0 minutes	76	50	80	70	100	100
15 minutes	73	30	77	50	80	65
30 minutes	62	10	73	20	77	30
45 minutes	30	0	68	10	70	15
60 minutes	20	0	33	0	65	0
75 minutes	10	0	25	0	50	0
90 minutes	0	0	20	0	33	0

Table 2: Compaction Factor of Retempered Concrete

Retempering time	Compaction Factor					
	O% retarder		O.2 % retarder		O.4 % retarder	
	M 20	M 40	M 20	M 40	M 20	M 40
0 minutes	0.93	0.87	0.87	0.92	0.94	0.94
15 minutes	0.91	0.85	0.92	0.87	0.93	0.88
30 minutes	0.87	0.78	0.87	0.80	0.93	0.85
45 minutes	0.85	0.70	0.86	0.78	0.92	0.80
60 minutes	0.80	0	0.85	0.78	0.91	0.79
75 minutes	0.79	0	0.84	0	0.89	0
90 minutes	0.78	0	0.81	0	0.87	0

Table 3: Compressive Strength of Retempered Concrete

Retempering time	Compressive Strength at 28 days in N/mm2					
	O% retarder		O.2 % retarder		O.4 % retarder	
	M 20	M 40	M 20	M 40	M 20	M 40
0 minutes	35.48	53.45	38.32	56.20	36.71	56.41
15 minutes	34.64	51.00	36.25	54.12	35.52	55.17
30 minutes	33.32	42.51	35.12	52.43	35.51	53.18
45 minutes	30.22	31.62	31.86	41.11	33.63	44.09
60 minutes	26.67	-	30.01	32.94	33.51	34.54
75 minutes	23.29	-	26.73	-	33.36	--
90 minutes	21.29	-	22.84	-	32.02	--

References

1. Dr D.K. Kulkarni and Dr. K. B. Prakash studied "The effect of addition of more than two chemicals admixtures on the properties of retempering of concrete", NBA Media, (8-11 Feb. 2010)

2. M.S. Shetty, "Concrete Technology Books", S. Chand and company Ltd. 1st edition 1982

3. Onder Krica, lutfullah Turanlt, Turhan Y. Erdoogan "Effect of retempering on consistency and compressive strength of concrete subjected to prolonged mixing", Cement and concrete Research 32(2002), (page 441-445)

4. M. Alhozaimy "Effect of retempering of R.M.C. IN Hot - dry environments", Cement & concrete composites 29(2007), 124-127

5. M. Alhozaimy "Retempering of ready mixed concrete in Riyadh, Saudi Arabia" 6th Saudi Engineering Conference, KFUPM, Dec. 2002 vol.3 (Pages 137-146).

Professor A.R. Pethkar, M.E. (Structures), is Head of Department, Civil Engineering, Vidya Vikas Pratishthan Polytechnic, Solapur, Maharashtra. His area of interest is retempered concrete.

Professor G.K. Deshmukh, holds an M.Tech. (Env.) and is pursuing his PhD. He is President of Vidya Vikas Pratishthan Institute of Engineering & Technology, Solapur. His area of interest is concrete.

Architectural Concrete

Pradeep Ghumare - Pune

Almost every Architect and Developer wants their buildings and structures to be somewhat unique and unmistakable… and nowadays Green!

One special subset of concrete is called architectural & decorative concrete, which refers to a concrete that provides an aesthetic finish and structural capabilities in one. Because of its versatility, concrete offers endless design possibilities. Moreover, concrete permanently captures the chosen look. Concrete is a visually rich material that allows the architect to be innovative and obtain design objectives that cannot be achieved with other materials. Whether that involves special moulds, special finishing techniques, or special ingredients, the variety of effects is almost unlimited. Fair-faced or exposed quality concrete is in vogue and the demands on its performance are continuously rising. In the last couple of years, concrete has slowly made a comeback with innovative decorative methods which are not only gorgeous but much more affordable.

Concrete can easily replicate the high-end look of masonry, marble, cut stone and even exotic and sculpted motifs in both physical beauty and durability.

Achieving an architectural or decorative appearance usually requires that something different be done to the concrete. However, many factors must be optimised with one another in order to create high-quality concrete surfaces.

Figure 1: Architectural Precast for Cologne Fire Brigade Station

Important Aspects in ARCHITECTURAL CONCRETE

Colours, Stains

Concrete can be tinted or coloured to provide several tones by using various surface treatments allow designers to specify any color they want. A wide range of finish combinations can be achieved easily.

Integral Colour

This colouring system encompasses subtly muted earth tones. It is based on synthetic oxides for UV-stability and conforms to DIN/EN standards. Integral color is typically added to precast concrete-mix. It cannot be applied to the surface of fresh concrete because it will not permanently bond to the concrete as shake-on color hardeners do.

Shake-on Colour Hardener

Shake-on color hardener comes in light colors, rich hues, and select greens and blues that may be cost-prohibitive as an integral color. Topically applied and finished over fresh precast, this system is a prepackaged blend of synthetic oxides, graded silica quartz aggregate, and

portland cement. It also lends wear-resistance to the surface. It cannot be added to ready-mixed concrete as the pigment load in a bag of the product is too low to color the full depth of a precast slab, unlike packaged integral color.

Chemically Non-Reactive / Reactive Stains:

Including a limited range of translucent, variegated, and mottled earth tones, chemically reactive stains consist of metallic salts in an acidic solution that reacts with the calcium hydroxide formed as cement hydrates. These stains are applied to hardened precast concrete and cementitious overlays, with surface preparation being important. Stains cannot be applied to uncured precast concrete because the calcium hydroxide needed for the colouring reaction is more readily and consistently available once the concrete hardens.

When selecting from a colour chart, it is imperative to ensure the product in question is aesthetically and functionally appropriate for the installation in question. Though colouring systems are not interchangeable, they can be combined for more colourful and creative effects.

Figure 2: Staining on Concrete

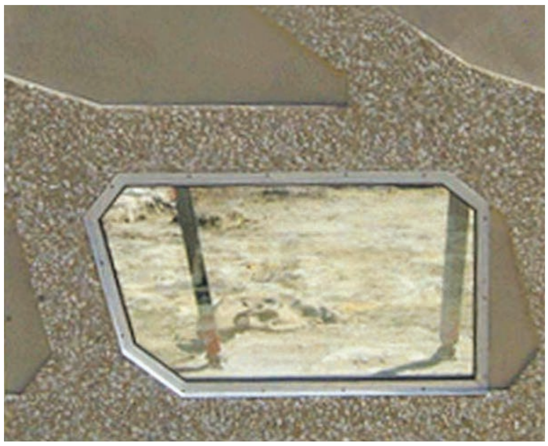


Figure 3: Colour (Pigment) + Design (Formliner)+Exposed Aggregate (Texture) on Precast Panel

The inherent natural beauty of sand and stone are most often expressed in architectural concrete. A wide variety of textures can be created in the concrete to add interest. The most common of these are:

Smooth or off-the-form finishes show the natural look of the concrete without trying to simulate any other building product.

Figure 4: Design, Texture & Colour on concrete precast panels with glass using NOEplast formliners,Hebau deactivators

Exposed-aggregate finishes, via chemical deactivators, are achieved with a non-abrasive process that effectively brings out the full color, texture and beauty of the coarse aggregate.

Micro/Acid etching via acid-gel dissolves the surface cement paste to reveal the sand, with only a small percentage of coarse aggregate being visible, providing a light exposure.

Sand or abrasive blasting however has limitations.

Honing or polished finishes are achieved by grinding the surface to produce smooth, exposed-aggregate appearances so as to reach a certain level of gloss. The use of a densifier is also possible to achieve a better luster.

Combination Finishes two or more finishes can be readily achieved using the same concrete mix.

Designs on concrete

A variety of attractive patterns shapes and surface textures can be achieved by using pre-shaped formliners as the casting surface. The formliners are normally made of PU elastomer plastic or rubber for heavy duty or light duty applications considering the repetitions, or wood, plaster for limited usage.

Some of the designs used are:

Stone Replication

Special mixes and finish techniques are used to mimic limestone, sandstone, granite and any other type of stone desired. The finishes are produced far more economically than real stone can be laid, and they can be erected much quicker. Formliners can replicate unusual pieces such as cut stone or slate, limiting options only to the designer's imagination.

Figure 5: Photo on Precast Concrete using NOEplast

Figure 6: Colour + Acid etchining on precast staircase

Contemporary Designs

Concrete offer a plasticity in shapes, curves and geometries that can create any desired look. They interface smoothly with glass and other modern materials.

Timber Designs

Wood, bamboo, grass related designs can be casted on concrete using these formliners.

Figure 7: Timber Designs

Replicating Existing Styles

With its ability to replicate such a wide range of materials, precast concrete panels ensure new buildings blend with existing ones.

Embellishments

Corporate or school names, emblems and other custom touches can be embedded into concrete, creating unique accents at an attractive cost. Special formliners can create sculptural forms for custom designs that create a standout facility.

Figure 8: Embellishments

Architectural Aggregates

Use of natural crushed rock aggregates… Dolomite, Quartz, Aluminium silica slag, Sandstone, Limestone, Granite, Porphyry, Syenite, Andesite, Marble, Diabase, Calcite, Altered Granite, Quartzite, Basalt, Anorthosite in a wide range of gradings (1-3, 2-5, 2-8, 5-8, 8-12, 8-16, 12-16 mm) and in various colours.

The large choice of raw materials opens the way for the fulfillment of the desire of designers, architects and developers for customised architectural precast.

Figure 9: Architectural Aggregates

Figure 10: Architectural Aggregates

Formwork releasing Agents

Conventional de-shuttering oils are not suitable as they lead to cloud formation and the excess oil, which accumulates in the often deep structures of the moulds, causes increased formation of pores. In addition surfaces produced with this type of release agent result in dusty concrete surfaces, which leads to faster weathering.

The releasing agents make it easier to strip the formwork/mould without damaging the casted design, and protect the formliner thereby increasing its durability.

Figure 11: Formwork Releasing Agents

Efflorescence causes white filmy deposits on concrete surfaces, and spoils the look of architectural precast. Alkalies and calcium hydroxide in solution in the pores migrate to the surface. At the surface, CO2 reacts with these alkalies & hydroxides to form Ca, Na, K salts. Use of integral water-repellent/efflorescence-control admixtures for precast minimises the efflorescence.

Architectural concrete are often used as outside wall or façade or flooring and are therefore exposed to dirt and weathering. The sensitive concrete surfaces however make the cleaning very difficult, if not impossible, as the cleaning with standard cleaners very often leaves stains and remain visible. It is therefore recommendable to protect the sensitive and priced concrete product with a suitable protective agent. Conventional protective coatings are not suitable, as they either contain solvents or are not compatible with the residual moisture in the concrete, or they do not offer sufficient breathability and show a tendency to discolouration. Hence use of specific concrete-protective coating will protect against efflorescence, frost, weathering effects, soiling, moss formation.

Concrete offers a virtually unlimited palette of options for creating unique aesthetic treatments ranging from a historic appearance to blend with nearby landmarks or a contemporary style that makes a strong statement of its own.

Concrete can provide any appearance desired in a cost-effective way with added benefits no other cladding material can match.

Figure 12: Architectural Concrete Outside Wall Faced

Er. Pradeep Ghumare, Director
NOE Formwork India Pvt. Ltd., Ind-Tech Consultants
11 Lane, Prabhat Road, Sanjeevani Apartments,
E-6, Pune 411 004. India

Pervious Concrete A Rain Water Harvesting Concrete

Yogesh D Barot - Delhi

Preamble

At many projects water logging at parking & walkways is the major issue especially during monsoon as pavements & floors are normally impermeable. This results into considerable amount of investment in repairs & providing storm water drain system which may get clog during peak over flow situation. Besides this there are many other problems that arise due to above. In such situation it is very important to think about an economical & sustainable solution which helps in getting rid of all above problems.

Figure 1: Water Logging

The best solution to above issue is "Pervious Concrete"

What is Pervious Concrete?

Pervious concrete is a unique, sustainable & economical means to provide complete solution to important environmental issues and support green construction. By capturing storm water and allowing it to seep into the ground due to its design properties, pervious concrete is instrumental in recharging groundwater & reducing storm water runoff. In other words we term it as "Rain water Harvesting Concrete".

This concrete technology is helpful in creating more efficient land use by eliminating the need for water retention bodies, costly storm water drainage & repairing cost which other wise would have incurred due to water accumulation. In doing so, pervious concrete has the potential to lower overall project costs thus making it more economical.

Figure 2: Pervious Concrete

Advantages of Pervious Concrete

(1) Environmental Benefits

- Helps in saving precious water which other wise goes to drains.
- Helps in keeping earth below wetter, greener & cooler.
- Recharging groundwater level.
- Replace costly water drainage systems.
- Eliminates use of asphalt which normally causes environmental pollution.
- Use of fly ash thus reducing pollution.

Figure 3: Pervious Concrete

2) Other Benefits

- Eliminates the need of costly water drainage systems.
- Rough texture thus avoiding skidding of vehicles.
- Low maintenance cost.
- Stronger & durable for light traffic loads.
- Use of local building material as shown above.
- Economical, lower cost compared to other pavement solutions.
- Conventional construction practices.
- Use of local semi-skilled mason / machineries etc.

How it is made?

The basic advantage with this type of concrete is the use of locally available building material like coarse aggregate, fine aggregate, cement, chemical admixtures, machineries, labor etc. This concrete is also known as no fines concrete but here we have considered about 10% of sand also looking to strength requirements. Details of building material used are as tabulated below:-

1)20 mm aggregates properties: Crushing value 20.50 %, Specific Gravity: 2.70 (other parameters conforming to IS 383-1970)

Table 1: 20mm Sieve Analysis

IS Sieve Size	Cumulative %	Cumulative % Passing
20 mm	28.15	71.85
16 mm	60.95	39.05
12.5 mm	96.70	3.30
10.0 mm	100.00	0.00
6.3 mm	100.00	0.00

2) 10 mm aggregates properties: Crushing value 20.50 %, Specific Gravity 2.7. (Other parameters confirming to IS 383 :197

Table 2: 10mm Sieve Analysis

IS Sieve Size	Cumulative %	Cumulative % Passing
12.5 mm	0.50	99.50
10.0 mm	16.60	83.40
6.3 mm	55.70	44.30
4.75 mm	85.50	14.50
2.36 mm	100.00	0.00

3) Sand Properties: (Specific gravity 2.74 & other parameters confirming to IS 383 :1970). In many countries it is also termed as no fines concrete but looking to possibilities of aggregate failure & strength requirements in Indian context we have used sand also though less in quantity of about 9 %.

Table 3: Sand Properties

IS Sieve Size	Cumulative % retained	Cumulative % Passing
4.75 mm	3. 35	96. 65
2.36 mm	6. 55	93. 45
1.18 mm	12. 05	87.95
600 mcr	43. 55	56. 45
300 mcr	87. 00	13. 00
150 mcr	99.30	0. 70
Pan	100. 00	

Concrete Mix Design

Table 4: Mix Design Properties

Material	Quantity per (CuM)	Remarks
Cement (Kg)	422 Kg	Ambuja PPC
20 mm (kg)	715 Kg	
10 mm (Kg)	715 Kg	
Sand (Kg)	141 Kg	
Water (Ltr.)	148 Ltrs	
Admixture (Ltr)	3.38 Ltrs.	Best quality available

Test Results

Following strength results were obtained. Total 15 trials were conducted at Ambuja concrete laboratory at Jaipur. Cubes were cured in gunny bags & not in curing tanks so as to create exact site conditions.

Table 5: Test Results

Age (Days)	Wt. of Cubes (kg.)	Strength (Mpa)
3	7.250	27
7	7.700	31
28	7.600	34

Figure 4: Testing of Cubes

Demo project at Rabriawas (Distt Pali, Rajasthan)

A demonstration project was executed at Rabriawas (Distt Pali ,Rajasthan) where a 200 sft of pervious pavement was laid for parking of vehicles near the main gate. The details & few photographs are as below:

Details:

Size of parking pavement: 200 Sq.ft

Total excavation : 10 inches.

Subgrade:4inch BBCC (Burnt bricks concrete 1:5:10. Using brick bats laying aproject sites aswastage.

Main pervious concrete: 6 inches finished with normal float & wooden plank.

Photographs: Subgrade preparation Pavement finish Curing by gunny bags Porosity test

Figure 5: Construction Practice

Architectural Pervious Concrete Pavements

Many architectural designs can also be easily created using said concrete as shown below:

Figure 6: Architecture Design

Caution

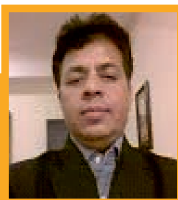
In India we observed that there are chances that porosity of this pavement may get blocked by the passage of time. Avoid the this near sandy areas & if it gets blocked same may be cleaned by pressure water jet. It is not recommended for heavy traffic roads.

Conclusion

Pervious Concrete is one of the finest solutions towards water logging problems especially at parking & walk ways. It also helps in saving precious water. Though the use of such concrete is at very preliminary stage in India but is expected to increase in future looking to enormous advantages. Let's make our earth greener for generations to come."

Author:

Yogesh D Barot is (VP) - Technical Services North Ambuja Cements Ltd & is based at Gurgaon. He has an experience of about 26 years in the field of construction & his area of interest is innovative concretes, Earthquake Resistant Structures etc.



Construction of Concrete Roads (Rigid Pavement)

Jignesh D. Gandhi - Ahmedabad

Abstract

The paper describe Concrete roads offer many advantages over conventional flexible pavement. The two major types of materials used in road construction in the country are bitumen based roads and those made of concrete. Only a very small share of all roads in the country is made of concrete. Concrete Roads having many advantages like Operation and Financial are well known by all of us. The most salient of these advantages are durability and relative very less maintenance which go to offer substantial long term economies in our country. Various Materials, Equipment's and agencies are ready to meet all the challenges of helping build world class roads.

Concrete is the preferred choice of material to build roads in most of the developed world. Concrete roads were first built in US a century ago, beginning with a six mile stretch. That multiplied to 11000 miles in 20 years. It is interesting to note that in US, the growth of automobiles is correlated strongly with the growth of concrete roads.

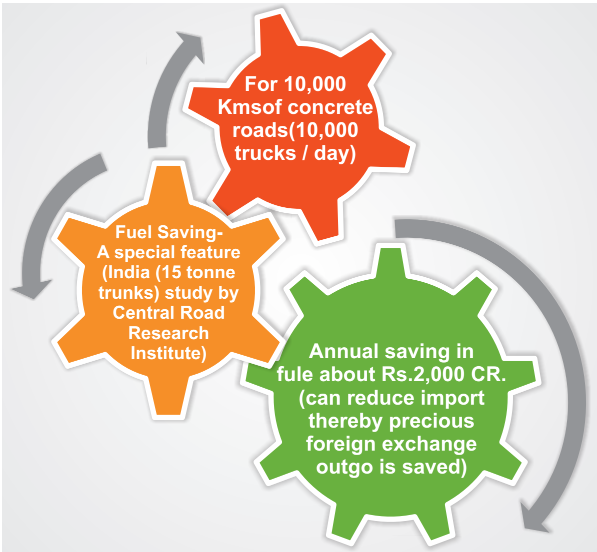
This paper broadly covers the need, advantages, materials, approach, towards concrete roads based on learning at various projects across Gujarat and how it provide sustainable solution to our future.

Introduction & Objective

An explosion in the population of automobiles in our cities and towns now swelling with sprawling residential townships, commercial estates, malls and multiplexes point to one of the most pressing problems of the time – coping with ever burgeoning public and private transport that challenges road traffic like never before. Urban planners have realized that a key ingredient in traffic management is the creation of an efficient city road network based on the ideal road surface. The adoption of concrete provides a sensible way to grapple with this problem.

- 1st Concrete road made in India was marine Drive, Mumbai in 1940.
- In 1980, Agra- Mathura concrete road made.

At present, 8 % road network in India is rigid pavement



Advantages of Concrete Roads:

- Long service Life
- Superior Performance
- Maintenance Free
- Smooth riding quality
- Fuel Savings
- Ability to withstand heavy loads
- Water resistant
- Beneficial in life cycle cost compare to bituminous road.
- Negligible annual maintenance compare to bituminous road.
- Less wear and tear on tire and on engine of vehicles
- 14 % Lower fuel consumption compare to bituminous road.
- In bituminous roads, bitumen is imported. In

India, we produce cement in our country only. Foreign exchange can be saved.

- More effective in heavy rainfall area as well black cotton soil compare to bituminous road

Correct Steps for Concrete Road

- ***Strong Sub Base :*** Properly Rolled and Compaction of PCC

- ***Proper Shuttering :***

Figure 1: Correct steps

- ***Thickness of Road :*** Thickness of the slab designed after considering various factors such as intensity of Traffic, Load Impact, Subgrade, California Bearing Ratio (CBR) value of subgrade, Modulus of subgrade reaction (K- Value)

- ***Strong Concrete:***
- ✓ Concrete should be Dense and Cohesive
- ✓ Use of 2 size coarse aggregates.
- ✓ W/C < 0.4
- ✓ Implementation of concrete mix design very important.

Expansion and Contraction Joints

Dummy groove construction joints and dowel expansion joints specified as given in following figure 2.

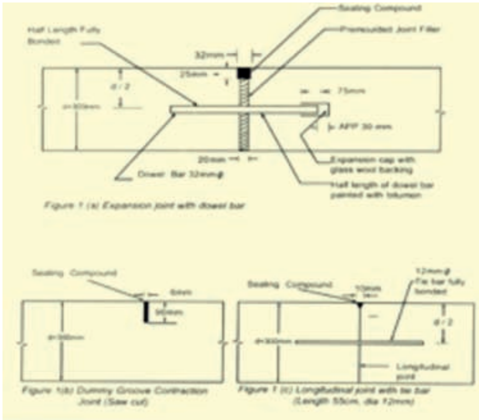


Figure 2: Expansion & Contraction Joint

- ***Concrete Placement***

✓ Deposit concrete as close to paver as possible
✓ Avoid stop & go operation
✓ Maintain uniform speed & head
✓ No front end loaders or backhoes to distribute concrete

- ***Brooming***

Figure 3: Brooming : Groove cutting

- ***Groove Cutting and Sealant :*** Groove cutting and sealant will be done within 48 hours of concreting to minimize cracking. It should be done in both direction (Longitudinal and Horizontal). Improper/No provision for groove cutting leads to cracks in concrete surface.

✓ Provided slop from center 1:50 (camber)
✓ In length 1:200

Curing

Need to maintain adequate moisture & temperature after concreting.
Curing must be carried out for the laid down period. This is generally 14days
Inadequate curing leads to –

1) Excessive moisture loss at surface (plastic shrinkage cracking)
2) Weak surface (Affect the durability
3) Excessive slab warping

Following types of curing methods used after concreting

1) Pond / Continuous Sprinkling

2) Jute Bags

3) Plastic Sheet

4) Curing Compound

Figure 4: Curing Methodology

Test Conducted for Concrete

Concrete cubes cast for each day's work (Nine cubes) are tested at the end of three , seven and twenty eight days respectively for the quality assurance. Also recommend to find strength of the concrete in Flexural.

Figure 5: Testing of Concrete

Case Study

Concrete Road in Municipal Corporation

- ✓ Width of road 10.75 Mt on either side of center of road
- ✓ Quantity of concrete: 1,00,000 Cu mt.
- ✓ RMC used for whole project.
- ✓ Dumpers used for transporting concrete from batching plant to site as slump is 0 mm, transit mixer could not unload concrete at very low slump.

Only night concreting permitted for PQC to control temperature of concrete at the time of placement max up to 30 C

Figure 6: Batching Plant Of 120 Cu Mt/ Hr Capacity, 8 Mt Width Slipform Paver

Details of Road Section

- ✓ Existing road excavated up to 550 mm
- ✓ 150 mm Granular Sub Base(GSB)
- ✓ 150 mm Dry Lean Concrete (DLC)
- ✓ 250 mm Pavement Quality Concrete (PQC)

Figure 7: DLC Layer 150mm Thickness, Dowel Bar Caging, Dummy Groove Cutting

Detail about Joint

- ✓ At every 4.5 Mt, transverse construction joint provided with dowel MS plain bar 32 mm diameter 500 mm length at 300 mm C/C.
- ✓ At every 3.5 Mt, longitudinal joint provided with tie bar 12 mm diameter tor 600 mm length at 400 mm C/C.
- ✓ At every 250 Mt, 300 mm diameter RCC pipe 4 no. Provided for future.
- ✓ 2.5 % slope provide from centre of road.

Concrete Mix Design for M40 Grade of Concrete

Cement PPC	: 380 Kg
20mm	: 878 kg
10mm	: 388 kg
Natural Sand	: 347 kg
Crushed Sand	: 429 kg
Admixture	: 3.2kg/Lit
w/c ration	: 0.38
Slump	: 30 mm at site

Figure 8: Curing with Jute Bags, Brooming and Curing Compound Sprinkling

Concrete Cube and Flexural Beam Test Result For M 40 Grade

1 Day	: 22.8 Mpa
3 Days	: 35.7 Mpa
7 Days	: 43.6 Mpa
28 Days	: 49.5 Mpa
7Days Flexure	: 5.5 Mpa
28Days Flexure	:6.1 Mpa (Minimum required is 4.8Mpa)

Challenges for Cement Concrete Road

- Inefficient contraction joint spacing resulting in drying shrinkage cracks.
- Cracks on concrete roads generally occurred due to plastic or drying shrinkage. Cracks due to heat of hydration of cement are most unlikely to occur on concrete roads.
- After concrete surface finished fresh surface should be properly covered with using plastic sheet. In warm/Hot weather this is strongly recommended as it protect unhardened concrete from strong wind and high ambient temperature more effectively then the hessian cloth
- Excessive presence of fine materials (including cement) should be another factor responsible for cracking of concrete. Concrete mix with high cement content (450 kg/Cu.mt) are more prone to drying shrinkage cracking then mix which have lower cement content.
- Over compaction may lead to surfacing of cement slurry on the top of the concrete pavement. This causes cracks on the concrete surface as coarse aggregates are not available on the top to give the surface adequate strength against the tensile stresses developing due to drying of the concrete surface both in plastic as well as hardened state.

Conclusion

- Concrete pavements must meet the requirements of transportation systems. Concrete pavements required much less maintenance. However defects like corner, random longitudinal cracks unacceptable rough areas with poor texture should be avoided by resolving the deficiencies in workmanship and techniques.
- Ready mix concrete helps in speeding the works beside giving better quality control then site mix concrete.
- The most important factor is review of concrete specification for greater economy and better performance of concrete roads.

Author:

Er. Jignesh Gandhi is currently working with Ambuja Cements Ltd, Ahmedabad as General Manger (Technical Services)- Gujarat and South. He is having total 26 years of experience in field of cement, concrete and construction. He is actively involved in concrete road construction in Ambuja cement Ltd plant internal roads as well as closely associated with customers for helping them in making strong and durable concrete roads. He has shared his experience of concrete roads with professionals in various forums.

Building Damage due to Natural Causes & Designing Procedure

G.K ROY - Kolkata

Abstract

Building failure occurs when a building fails to do its designated functions. Such failures can be either Structural failures and serviceability failures. Failure of a building can take place in various ways. The factors affecting may be one or more of the following viz.

- Geometrical shape and size of the building
- the structural design considering the geotechnical aspects of the site
- the material used in construction
- the construction practice and
- the construction techniques adopted
- poor/ improper workmanship
- Corrosion, improper periodic maintenance and supervision, etc.

The failure often occurs in the form of slowly developed cracks and then progress over the period of time.

Introduction

Building Damage due to Natural Causes

- Some of the major natural causes that result into the failure of a building are Rainfall, Temperature, Wind Pressure, etc. Due to these natural factors coming into force one or all at a time, structural failures may take place slowly or suddenly if they are not properly architecturally and/ or structurally designed to take care of these factors.

- An earthquake is the result of a sudden release of energy in the Earth's crust that creates seismic waves. At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground. Due to the seismic effect, structural failures may take place suddenly if seismic provisions are not kept during design and construction. Earthquakes are measured using observations from seismometers. Magnitude 3 or lower earthquakes are mostly almost imperceptible and magnitude 7 and over potentially causes serious damage over large areas, depending on their depth. The largest earthquakes in historic times have been of magnitude slightly over 9, although there is no limit to the possible magnitude.

Evaluation of many multi-storied building in urban areas of India have exposed the vulnerability of many RCC framed structures in high seismic zones. The experience with regard to earthquake damages to buildings has mostly been on non-engineered buildings. These buildings of low heights are the first targets of the earthquakes.

A number of defects were observed in the non-engineered buildings, such as:

- Unsymmetrical plans and elevations resulted in the development of torsional sheer stresses in the walls during earthquakes.
- Large spanned walls with openings for doors and windows at improper positions became unstable during earthquakes.
- The use of poor quality building material was also one of the major causes for damage of buildings.
- Improperly designed floor slabs and lintels do not provide adequate diaphragm action for providing lateral supports to the walls.

The construction of reinforced concrete buildings with brick masonry infill walls is a very common practice in urban India. In most of the multi-storied RCC framed buildings, parking is provided at the ground floor, where only columns are there and no infill panels are provided. This resulting into soft storey of the building which means the lateral resistance offered by the storey is much less as compared to the storey above or below it resulting in the crushing of concrete or columns, failure of steel, shear failure due to excessive torsion. In RCC framed building at many places the failure of beam-column joints is observed after earthquake of moderate intensity.

The degree of damage depends on the earthquake intensity and the quality of building. Stiff structures such as low rise masonry structures survive when founded on soft clay. Stone and brick masonry buildings of low height have short fundamental time period. The seismic response for such period is very high if the buildings are constructed on hard soil or rock.

The most common damage in buildings observed is development of vertical cracks resulting separation of perpendicular walls at corners and T- junctions during earthquake condition. In some cases inclined cracks have developed in the walls starting from corner of door/ window openings, horizontal cracks at lintel, sill and plinth level.

Large number of houses are collapsed and/ or severely damaged due to out of plane failure and in plane failures resulting caving in of roofs. Buildings having wooden floors experience more damage than those having reinforced concrete floors due to diaphragm action.

Techniques of Retrofitting

The traditional techniques such as plaster with wire mesh, cement grouting, pre-stressing, RCC and steel ties and beams, continuous lintels, connection between walls and floors, etc. are recommended by most of the codes and research institutions. Some modern techniques which are presently emerging such as use of masonry arch, base isolation and composite material are adopted also to strengthen the damaged structure as well as to existing structures against the earth quakes and wind forces.

The in-plane and out of plane collapse can be prevented by providing properly designed reinforcements. It is experimentally observed that the in-plane lateral load capacity of wall with 10% opening reduce to 50% of the solid wall for same vertical to lateral load ratio and it reduces to 5% with 20% percent opening. The strength can be increased by introducing arch over door and window opening. The purpose of Base isolation system is to isolate the structure from the ground motions which actually impose the forces on the structure.

Summary & Conclusion

In high degree earthquake prone area, the following points must be kept in mind while designing the building:

- Multi-storied buildings should not bedesigned with smaller lower floor areas than the upper floor areas, because, in earthquake conditions, these buildings are affected most.
- Designing of asymmetric building should be avoided because; these buildings have got lesser stiffness to withstand seismic forces. In case of extreme need, proper expansion joint must be provided between the asymmetric portions.
- Large cantilever projections must be avoided beyond the column line.
- In multi-storied R.C.C. framed buildings, parking space design must be done with infill brick panels suitably located at the ground floor in conjunction with the columns to avert soft storey development.
- Long brick masonry walls should be avoided, if there is no intervention of perpendicular walls in between.
- Band Lintel should be provided above doors and windows between two floors to lessen the slenderness ratio, which would be seismic efficient.
- Doors and windows and large openings

must be kept as far as possible from the corner of the building.

- The plot with possibilities of having liquefaction during earthquake must be avoided.
- Beam Column junction must be properly taken care of during designing and construction/ execution. designed with smaller lower floor areas than the upper floor areas, because, in earthquake conditions, these buildings are affected most.
- Designing of asymmetric building should be avoided because; these buildings have got lesser stiffness to withstand seismic forces. In case of extreme need, proper expansion joint must be provided between the asymmetric portions.
- Large cantilever projections must be avoided beyond the column line.
- In multi-storied R.C.C. framed buildings, parking space design must be done with infill brick panels suitably located at the ground floor in conjunction with the columns to avert soft storey development.
- Long brick masonry walls should be avoided, if there is no intervention of perpendicular walls in between.
- Band Lintel should be provided above doors and windows between two floors to lessen the slenderness ratio, which would be seismic efficient.
- Doors and windows and large openings must be kept as far as possible from the corner of the building.
- The plot with possibilities of having liquefaction during earthquake must be avoided.
- Beam Column junction must be properly taken care of during designing and construction/ execution.

Most of the earthquake related damages can be avoided utilizing the current knowledge of earthquake Resistant design and detailing practice, good quality control of material and good engineering construction practice.

Figure 1: Failure of Structure Due to Earthquake

***Author :* Er. G.K ROY**

G K Roy is a graduate civil engineer. He has completed his M.E in Structural engineering. He is having more than 20 years of experience in field of construction. Currently he is having his own structural consultancy firm.

Low Cost Gravity Wall

Dhiman Paul - Barrackpore

Abstract

On a RCC foundation, constructed folded plate masonry work having 52.6 m length and width at joints was 0.65 m. The average height of the gravity wall is 2.1m. At 1/3 height of the structure, provided a brick projection for increasing the self-weight of the structure after backfilling and prevent it from over turning. The construction of the gravity wall was done by semi-skilled locally available masons. Thirty numbers of workers completed the whole work in 45 days. The low cost gravity wall saved 70% fund required for the same work done with concrete. Total cost of work from excavation to earth filling was INR 227417(Two lakh twenty seven thousand four hundred seventeen only)

Introduction

General

Patulia Gram Panchayat, Barrackpore in West Bengal had the first project in the year 2016 was to build a gravity wall around two sides of a pond at territory named Patulia. During the first visit, I found that on two sides there were village roads on which light vehicles were plying on them and it could affect the safety of road users and therefore strong wall was needed in between the pond and road on two sides of the pond.

While returning from the site, I discussed the matter with Sarpanch of Gram Panchayat but he informed that there was a shortage of fund and need to construct the wall within the available fund. Therefore, I started to design a strong gravity wall with a view to control the cost so as to fit in the budget available. With experience of brick work in past projects, I started to think how brick masonry can be used in construction of gravity wall as it will drastically reduce the cost and make it economical.

Main Challenges of this Project were

- The weight of the wall should be adequate to sustain the lateral pressure
- It should withstand global stability to resist sliding failure
- It should resist overturning moment
- Resistance to sink due to low bearing capacity of soil
- Low fund availability and non-availability of skilled mason

Project Details

- The construction of straight brick wall having wider base and narrowing at the top requires skilled masons, which were not available in that area more over in this type of brick work wastage is more so did not consider such design. Then I thought about designing a straight wall with a zig-zag shape having thickness of 0.40 meter at interval of 1.60 meter to have adequate moment of inertia (MI) which could resist overturning moment.

- Another consideration in design was that in extreme load condition if failure occurs then due to the zig-zag shape only a portion of the wall may fall instead of the whole wall. To increase the self-weight of the gravity wall I provided a brick projection at one-third height of the wall. Self-weight of the surcharge soil above this projection would work as weight of the wall itself and also create a moment against the overturning force which will increase the stability of the gravity wall. This idea was obtained from old masonry structures constructed in British era.

Figure 1: Zig-zag Shapre Wall

- Thus the part of stability was due to self-weight and moment of resistance was ensured against overturning moment. To transfer the weight to the underlying soil which had low bearing capacity a RCC foundation of 0.8 meter width and 0.125 meter thickness was constructed over compacted soil.

- Considering mixed type of soil (Silty sand) which had medium frictional angle and 2.1 meter average height of the wall it would provide global stability against sliding failure. To resist the wall from sliding over concrete foundation a locking projection was provided at the concrete foundation.

Figure 2: Gravity Wall Construction Process

- The pond remained filled with water in most of the time during the year and at lowest level in summer it had not lowered more than a meter from the road level. So there is always remains good amount of passive force to counter active force of retained soil.

- Thus 0.23 meter thick wall with a joint thickness of 0.40 meter at an interval of 1.6 meter will resist the pressure of soil at the sides of the pond. The angle of backfill was kept almost level to support stability of soil. Weep holes were kept in the wall to provide ways to soil water to flow freely.

- Failure of finite slopes occurs along a curved surface. In stability analysis of finite slopes, the real surface of rupture is replaced by an arc of a circle. The rupture is deep seated and passes through the embankment supporting soil below the toe of the slope is known as base failure.

- By global stability he wanted to mean stability against base failure or stability of finite slope.

- Total cost of work from excavation to earth filling was INR 227417(Two lakh twenty seven thousand four hundred seventeen only).

Detailed Drawing and Cross Section

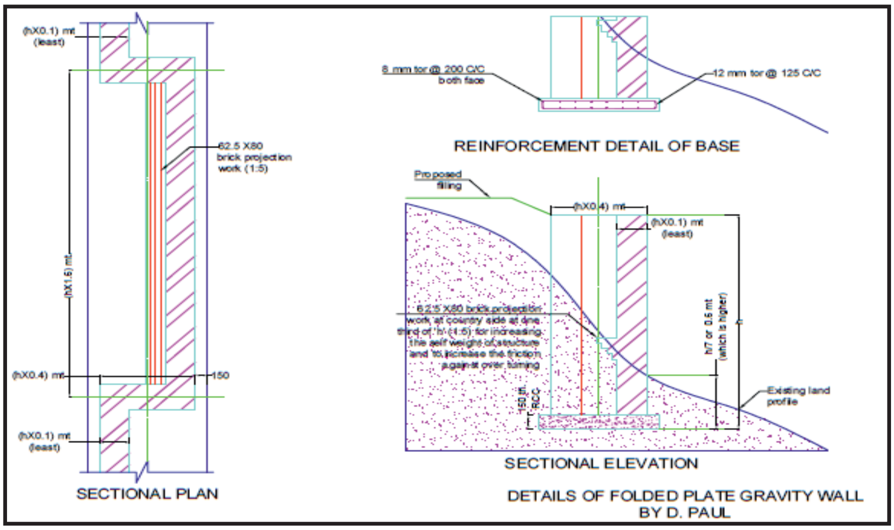


Figure 3: Structural Details of Folded Plate Gravity Wall

Summary & Conclusion

The execution part was very challenging includes activities like removing water, excavation, casting of foundation was done by close supervision of the engineer in-charge. Level was checked at each layer of work with accuracy. Most of the masons worked was semi-skilled and arranged from nearby areas by the contractor. There was a pressure to complete the work within two months and therefore designing, deliberation and getting permission was completed on priority and the work was completed within 45 days with 30 numbers of workers.

Finally, the low cost gravity wall saved 70% fund required for the same work done with RCC.

Figure 4: Complete View of Gravity Wall

Author

Dhiman Paul is a M. Tech in Structural Engineering working with Patulia Gram Panchayat, Barrackpore, West Bengal. He is well-known person for his creative work and Innovative thinking.

Industrial Flooring & Pavement Construction with Scrap Steel Fibre Reinforced Concrete (SSFRC) with fly-ash mixed

Atanu Das - Kolkata

Abstract

Due to price hike in cement & steel bar for construction, the construction of cement concreting becomes a critical situation. To reduce that cost & to make it cost effective, it may be a good thinking of use of alternatives like SSFRC (Scrap steel fibre reinforced concrete) with fly-ash mixed.

Introduction

The concept of SSFRC is using of scrap steel which are obtained from industrial wastage product. Some other properties are as follows:-

- SSFRC is also a reinforced concrete containing fibrous materials which increases structural integrity.
- It contains short discrete fibres that are uniformly distributed and randomly oriented.
- These fibers are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage.

Need For Alternatives (SSFRC)

Plain cement concrete is a brittle material, with a lower tensile strength and with low strain capacity. The role of randomly distributed discontinuous fibres is to bridge across the crack. "If the fibres are sufficiently strong, sufficiently bonded to material and permit the SSFRC to carry sufficient stress over a relatively large strain capacity in the post cracking stage".

Process

- The characteristics of scrap steel fibre reinforced concrete are changed by the alternation of quantities of concrete, scrap steel fibre substances, geometric configuration especially length, diameter or thickness and type of anchorage, dispersion, direction and concentration.
- When plain cement concrete is exposed to tensile stresses, it is likely to fracture and fail.
- The failure mode is moreover very brittle. After the reinforcement of concrete by steel, it becomes a composite group in which the steel endures the tensile stress.
- When concrete is reinforced by using scrap steel fibre in the mixture, it further increases the tensile strength of the composite system.
- The concrete cracks due to tensile stress induced by shrinkage or stresses occurring during setting or use. There are various means to overcome this crack.
- Scrap Steel Fibre Reinforced Concrete uses fine fibres distributed throughout the mix or larger metal or other reinforcement elements to limit the size and extent of cracks.
- In many large structures, joints or concealed saw-cuts are placed in the concrete as it sets to make the inevitable cracks which can be managed. The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develop.
- Concrete has a very low co-efficient of thermal expansion, and as it matures concrete shrinks. All concrete structures will crack to some extent, due to shrinkage and tension.

Importance of Fly-ash with SSFRC

Fly-ash is a versatile material. It is the by-products of thermal power plant. It may be utilized successfully, economically and of course "Environmentally" in many ways for floor & road construction. The stabilizing properties of fly-ash make it an excellent additive (instead of costlier cement) for locally available soft soil.

It can reduce the amount of Portland cement by 30% - 40% with use of fly-ash.

Conclusion

SSFRC with fly-ash mixed is very much superior to crack resistance and crack propagation. As a result it has ability to arrest cracks. Fibre composite process increases extensibility and tensile strength (substitute of steel bar), both at first crack and at ultimate, particularly under flexural loading, and the steel scrap fibres are able to hold the matrix together even after extensive cracking.

Case Study

In 2012, a pavement was made through SSFRC procedure with a width of 3.75 metre & 750 metre length with in Factory inside road at Howrah under a CPSU. The cost comes nearly 24 Lacks. Presently 50 ton Trailer with load, moving on that pavement. Till date no cracks or settlement has been seen.

Figure 1: Pavement with SSFRC

Author

Er. Atanu Das is currently working as Assistant Engineer, West Bengal Highway Development Corporation. He did his graduation in B. Tech (Civil). He has completed his M. Tech in Construction Technology & Management. He also has degree in Masters in Business Administration.

Impact Of Treated Waste Water On Flexural And Split-Tensile Strength Of Concrete Of Variable Grades By Replacing Part Opc By Raw Iron Slag

Himanshu Mishra, Dr. Hemant Sood - Chandigarh

Abstract

In this research paper, a study was made to obtain environment friendly building materials using industrial wastes (raw iron slag) and treated waste water. The objective of the study was to use these materials in concrete and obtain adequate flexural and split-tensile strength. Different cement replacements have been studied by substituting 5%, 10%, 15%, 20% and 25% raw iron slag. Concrete cube specimens were cast using treated waste water and potable water with various proportions of raw iron slag. Iron slag was substituted for replacement of cement and for the preparation of concrete beams and cylinders. Mix designs for M25, M30 and M35 concrete were carried out as per Indian standard code. Experimental studies were carried out only on plain cement concrete. Results from the tests indicate that addition of 5% raw iron slag to M25 and M35 grade of concrete give highest flexural strength values whereas addition of 25% raw iron slag to M30 concrete gives highest flexural strength values. Addition of 5% slag to M25 and M30 grade concrete gives highest split tensile strength values whereas addition of 10% slag to M35 grade concrete gives highest split tensile strength values.

Keywords

Ordinary Portland Cement (OPC), Raw Iron Slag, Potable Water (PW), Treated Waste water (TWW), and Compressive Strength.

Introduction

The need to reduce the consumption of Ordinary Portland Cement in order to obtain environment friendly concrete construction has intensified research into the use of some locally available industrial waste materials that could be used as partial replacement of Ordinary Portland Cement (OPC) in civil engineering and building works. Raw iron slag (an industrial waste by-product of steel industries) is one such material which can be used as a partial replacement of cement in concrete. Supplementary cementitious materials have proved to be effective in meeting most of the requirements of durable concrete and blended cements are used in many parts of the world. In construction industry concrete being most widely used construction material, uses most of the water. About 5 billion cubic yards of concrete is used each year. On an average 150 litres of water is required for 1m3 of concrete. About 97 percent of water is held in the oceans, while only 3 percent is fresh water. Of the freshwater, only 1 percent is easily accessible as ground or surface water, remaining part is stored in glaciers and icecaps. Moreover, freshwater is not evenly distributed across land surfaces, and there are number of heavily populated countries located in arid lands where fresh water is scarce. If the potable water is replaced by treated waste water in concrete industry, pressure on freshwater sources can be reduced tremendously.

Sr No.	Parameters	Laboratory Potable Water (mg/l or ml)	Treated Waste Water (mg/l or ml)	Permissible Limits (mg/l or ml)
1	pH	7.49	7.24	>6
2	DO	7.38	6.83	-
3	COD	10	196	3000
4	BOD	6	140	200
5	TDS	225	532	2000
6	Sulphate Content	24.72	36.3	400
7	Chloride Content	18.5	140	2000
8	Acidity	-	3.5	5
9	Alkalinity	11.5	-	25

Materials & Methods

Cement: The cement used for this project was ultra-tech OPC 43 grade conforming to BIS: 8112.

Water: The treated waste water used for the investigation was obtained from sewage treatment plant located in 3BRD Chandigarh. Waste water discharged after aeration process was used. Laboratory tests for various properties of waste water were carried out as per BIS: 3025.

Coarse Aggregate: Aggregates are the major ingredients of concrete. They provide a rigid skeleton structure for concrete and act as economical space filters. Size of the aggregates used were 20mm and 10mm crushed (angular) aggregate conforming to BIS code 383: 1970. The specific gravity of coarse aggregate was 2.74.

Fine Aggregates: Locally available clean river sand conforming to zone III was used. The specific gravity of sand was 2.65.

Raw Iron Slag: Raw iron slag used in this project was obtained from Jain Steel Industries Located in Mandi, Gobindgarh. The specific gravity of the slag passing BIS: 300 micron sieve was 6.3.

Mix Design: Mix designs for M25, M30 and M35 concrete was carried out conforming to BIS: 10260-2009. Different percentages of raw iron slag was used as partial replacement of cement.

Casting: For flexural strength test beams of standard size 150x150x750mm were cast. For split-tensile strength test cylinders of standard size 150x300mm were cast. Samples were cast at room temperature for grades M25, M30, M35 with varying percentage of raw iron slag. Beams and cylinders were tested at 7, 14, and 28 days of curing. Mixing of concrete was carried out with varying percentage of slag as follows:

- 5% slag with treated waste water and potable water
- 10% slag with treated waste water and potable water
- 5% slag with treated waste water and potable water
- 20% slag with treated waste water and potable water
- 25% slag with treated waste water and potable water

Curing: Concrete specimens were placed in curing tank containing potable water for 7, 14 and 28 days for curing.

Number of cubes cast

Number of beams and cylinders cast for M25, M30, and M35 for different percentages of raw iron slag was 3 per sample for both treated waste water and potable water.

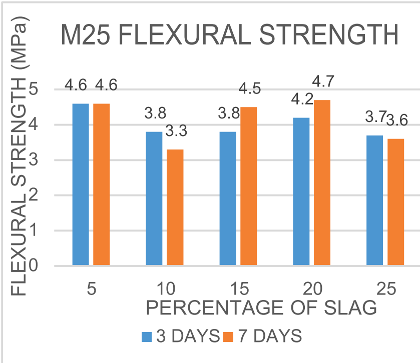


Figure 1: Flexural Strength of M25 Grade Concrete using Treated Waste Water

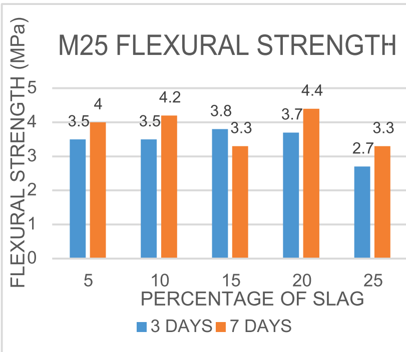


Figure 2: Flexural Strength of M25 Grade Concrete using Potable Water

M30 Grade Concrete

Average flexural strength of concrete specimens for various percentage of slag using treated waste water and potable water are depicted in figure 3 and 4 respectively.

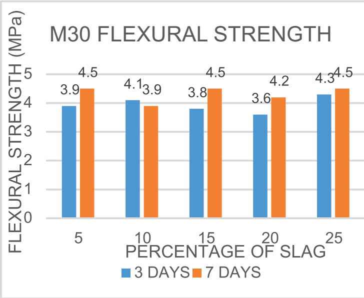


Figure 3: Flexural Strength of M30 Grade Concrete using Treated Waste Water

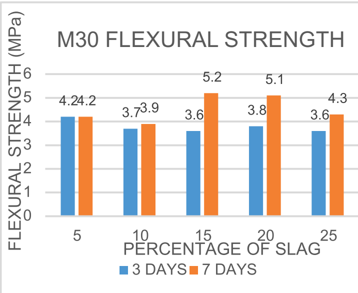


Figure 4: Flexural Strength of M30 Grade Concrete using Potable Water

M35 Grade Concrete

Average flexural strength of concrete specimens for various percentage of slag using treated waste water and potable water are depicted in figure 5 and 6 respectively.

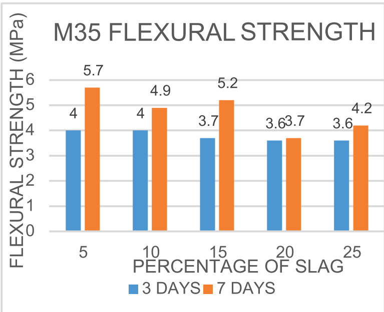


Figure 5: Flexural Strength of M35 Grade Concrete using Treated Waste Water

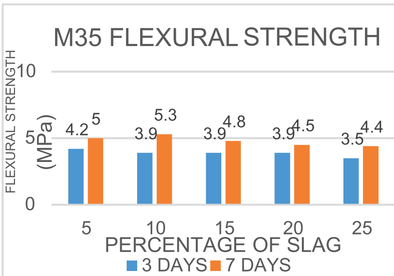


Figure 6: Flexural Strength of M35 Grade Concrete using Potable Water

Split-Tensile Strength Results

M25 Grade Concrete

Average split-tensile strength of concrete specimens for various percentage of slag using treated waste water and potable water are depicted in figure 7, 8, 9, 10 and 11 respectively.

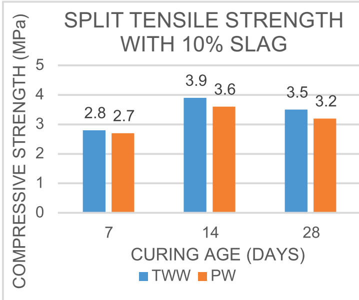


Figure 7: Split Tensile Strength of M25 Grade Concrete using 5% Slag

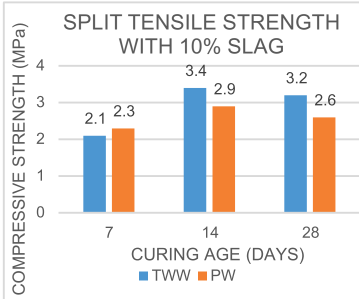


Figure 8: Split Tensile Strength of M25 Grade Concrete using 10% Slag

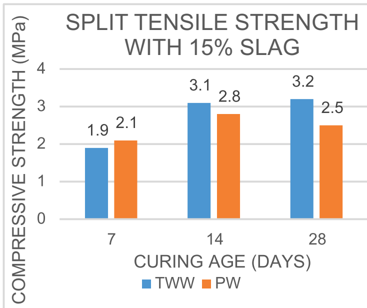


Figure 9: Split Tensile Strength of M25 Grade Concrete using 15% Slag

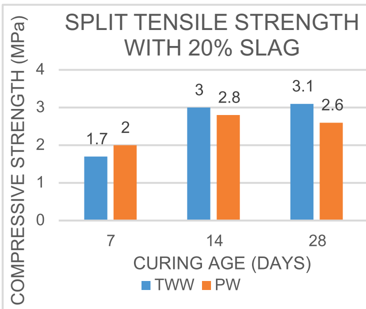


Figure 10: Split Tensile Strength of M25 Grade Concrete using 20% Slag

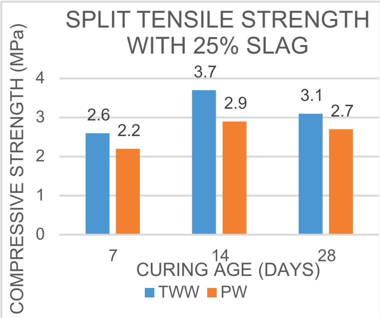


Figure 11: Split Tensile Strength of M25 Grade Concrete using 25% Slag

M30 Grade Concrete

Average split-tensile strength of concrete specimens for various percentage of slag using treated waste water and potable water are depicted in figure 12, 13, 14, 15 and 16 respectively.

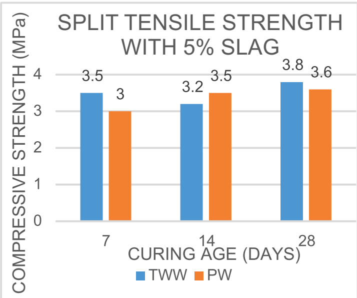


Figure 12: Split tensile Strength of M30 Grade Concrete using 5% Slag

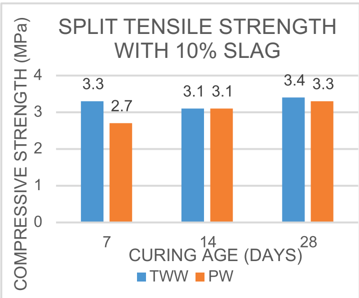


Figure 13: Split Tensile Strength of M30 Grade Concrete using 10% Slag

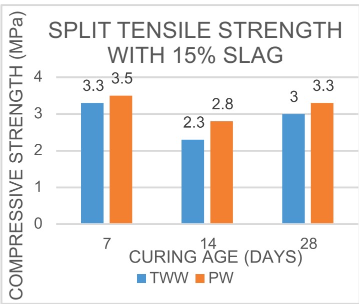


Figure 14: Split Tensile Strength of M30 Grade Concrete using 15% Slag

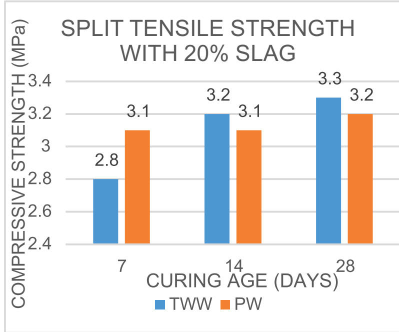


Figure 15: Split Tensile Strength of M30 Grade Concrete using 20% Slag

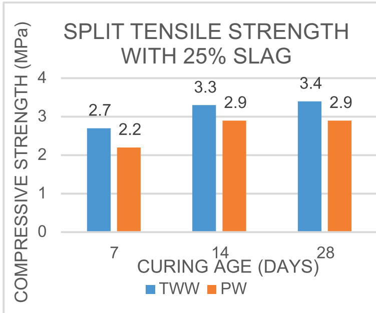


Figure 16: Split Tensile Strength of M30 Grade Concrete using 25% Slag

M35Grade Concrete

Average split-tensile strength of concrete specimens for various percentage of slag using treated waste water and potable water are depicted in figure 17, 18, 19, 20 and 21 respectively.

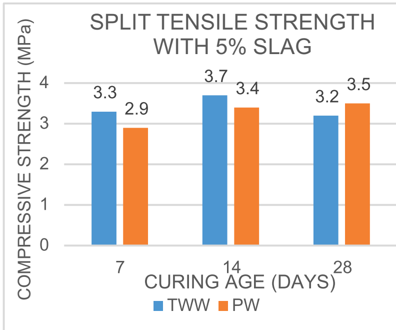


Figure 17: Split Tensile Strength of M35 Grade Concrete using 5% Slag

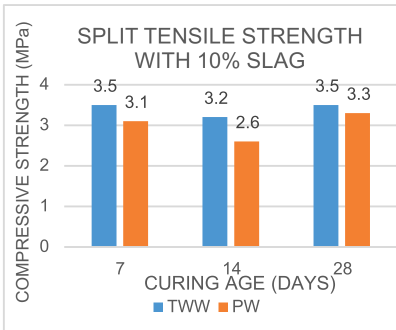


Figure 18: Split Tensile Strength of M35 Grade Concrete using 10% Slag

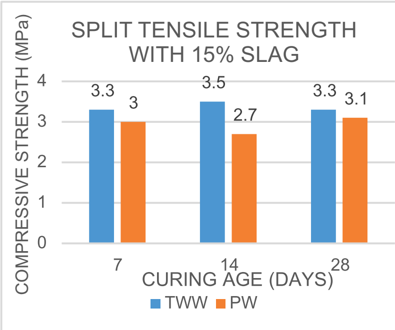


Figure 19: Split Tensile Strength of M35 Grade Concrete using 15% Slag

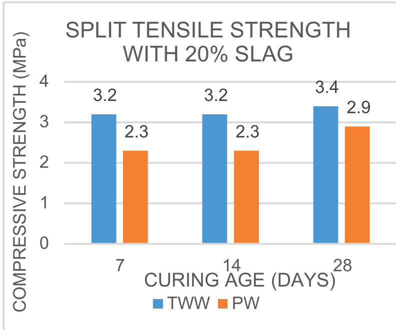


Figure 20: Split Tensile Strength of M35 Grade Concrete using 20% Slag

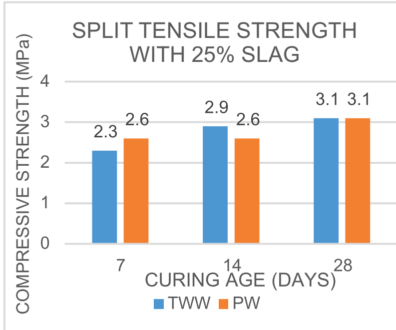


Figure 21: Split Tensile Strength of M35 Grade Concrete using 25% Slag

Flextural Strength Test Results

Results of flexural strength test on concrete with varying proportions of raw iron slag replacement at the age of 3 and 7 days are given in Table 2 and 3 respectively.

Table 2: - Flexural Strength (in MPa) of M25, M30 and M35 grade concrete with varying proportions of slag using treated waste water

Curing Age (Days)	5% Slag			10% Slag			15% Slag			20% Slag			25% Slag		
	M25	M30	M35	M25	M30	M35	M25	M30	M35	M25	M30	M35	M25	M30	M35
3	4.6	3.9	4.0	3.8	4.1	4.0	3.8	3.8	3.7	4.2	3.6	3.7	3.7	4.3	3.6
7	4.6	4.5	5.7	3.3	3.9	4.9	4.5	4.5	5.2	4.7	4.2	3.7	3.6	4.5	4.2

Table 3: - Flexural Strength (in MPa) of M25, M30 and M35 grade concrete with varying proportions of slag using Potable water

Curing Age (Days)	5% Slag			10% Slag			15% Slag			20% Slag			25% Slag		
	M25	M30	M35	M25	M30	M35	M25	M30	M35	M25	M30	M35	M25	M30	M35
3	3.5	4.2	4.2	3.5	3.7	3.9	3.8	3.6	3.9	3.7	3.8	3.9	2.7	3.6	3.5
7	4.0	4.2	5.0	4.2	3.9	5.3	3.3	5.2	4.8	4.4	5.1	4.5	3.3	4.3	4.4

Split Tensile Strength Test Results

Results of split tensile strength test on concrete with varying proportions of raw iron slag replacement at the age of 7, 14 and 28 days are given in Table 4 and 5 respectively.

Table 4: - Split tensile Strength (in MPa) of M25, M30 and M35 grade concrete with varying proportions of slag using treated waste water

Curing Age (Days)	5% Slag			10% Slag			15% Slag			20% Slag			25% Slag		
	M25	M30	M35	M25	M30	M35	M25	M30	M35	M25	M30	M35	M25	M30	M35
7	2.3	2.7	3.3	2.1	3.3	2.7	1.9	3.3	3.3	1.7	2.8	3.2	2.6	2.7	2.3
14	3.9	3.2	3.7	3.4	3.1	3.2	3.1	2.3	3.5	3.0	3.2	3.2	3.7	3.3	2.9
28	3.3	3.8	3.2	3.2	3.4	3.5	3.2	3.0	3.3	3.1	3.3	3.4	3.1	3.4	3.1

Table 5: - Split tensile Strength (in MPa) of M25, M30 and M35 grade concrete with varying proportions of slag using Potable water

Curing Age (Days)	5% Slag			10% Slag			15% Slag			20% Slag			25% Slag		
	M25	M30	M35	M25	M30	M35	M25	M30	M35	M25	M30	M35	M25	M30	M35
7	2.8	2.2	2.9	2.3	2.7	3.1	2.1	3.5	3.0	2.0	3.1	2.3	2.2	2.2	2.6
14	3.6	3.5	3.4	2.9	3.1	2.6	2.8	2.8	2.7	2.8	3.1	2.3	2.9	2.9	2.6
28	3.2	3.6	3.5	2.6	3.3	3.3	2.5	3.3	3.1	2.6	3.2	3.9	2.7	2.9	3.1

Discussion & Conclusion

- When 5% slag is added to M25 grade of concrete flexural strength achieved at 3 and 7 days is highest using treated waste water.
- Addition of 20% slag to M25 grade concrete exhibits highest 3 and 7 day flexural strength using potable water.
- Addition of 25% slag to M30 grade concrete exhibits highest 3 and 7 day flexural strength using treated waste water.
- When 20% slag is added to M30 grade of concrete flexural strength achieved at 3 and 7 days is highest using potable water.
- For M35 grade concrete addition of 25% slag gives highest 3 and 7 day flexural strength values using both treated waste water and potable water.
- Addition of 5% slag to M25 and M30 grade concrete gives highest split tensile strength values using both treated waste water and potable water.
- For M35 grade concrete addition of 10% slag gives highest 7 and 28 day split tensile strength values using treated waste water.
- Results from the tests indicate that addition of 5% slag to M25 grade of concrete can be recommended to be use to achieve good flexural and split tensile strength.
- Observing the 3 and 7 day flexural strength results addition of 25% raw iron slag can be recommended to be use in M30 and M35 grade of concrete.
- Addition of 5% slag to M30 grade of concrete can be recommended to be use to achieve split tensile strength.
- Addition of 10% slag to M35 grade of concrete can be recommended to be use to achieve split tensile strength.

References

- Saxena Pranshu; Simalti Ashish; "Scope of replacing fine aggregates with copper slag in concrete", International journal of technical research and applications, Vol 3, Issue 4, pp. 44-88, July-August 2015.
- Patniak; Binaya; T.SekharSeshadri; Rao Shrinivasa; "Strength and durability characteristics of copper slag admixed concrete", International journal of research in engineering and technology, Vol 4, Issue 1, pp. 158-196, February 2015.
- Raza Khalid; Singh Apoorv; Patel R. D; "Strength analysis of concrete by using iron slag as partial replacement of normal aggregates (coarse) in concrete", International journal of science and research, Vol 3, Issue 10, pp. 190-193, October 2014.
- Gadpalliwar K. Sonali; Deotale R. S; Narde R. Abhijit; "To study the partial replacement of GGBS & RHA and Natural sand by Quarry sand in concrete", IOSR journal of science and engineering (IOSR-JMCE), Vol 11, Issue 2, pp. 69-77, April 2014.
- Al- Anzi Bader; Abusam Abdallah; Shahalam Abulbasher; "Assesmant of waste water reuse in Kuwait and its impact on amounts of pollutants discharged into the sea", Journal of environmental protection, Vol 3, pp. 935-939, 2012.
- Bureau of Indian Standards Plain and Reinforced concrete Code of Practice 456-2000.
- Bureau of Indian Standards Recommended Guidelines for concrete mix designs 10262-2009

Authors -

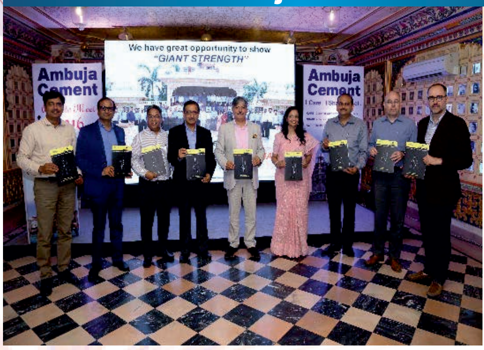
Himanshu Mishra, Dr. Hemant Sood

M.E Scholar, Civil Engineering, NITTTR, Chandigarh, 160019, India, E-mail-himanshu.civil.er@gmail.com

[2]Professor and H.O.D Civil Engineering, NITTTR, Chandigarh, 160019, India, E-mail-sood_hemant@yahoo.co.in

EVENTS

Launch of Ambuja Technical Journal



1st issue of Ambuja Technical Journal was launched at Udaipur by Executive Committee of Ambuja Cement during an off-site meeting.

The objective of Technical Journal is to share practical on-site experience on various construction aspects including practices, usage of newly developed / developing construction materials, etc. for durable and sustainable construction.

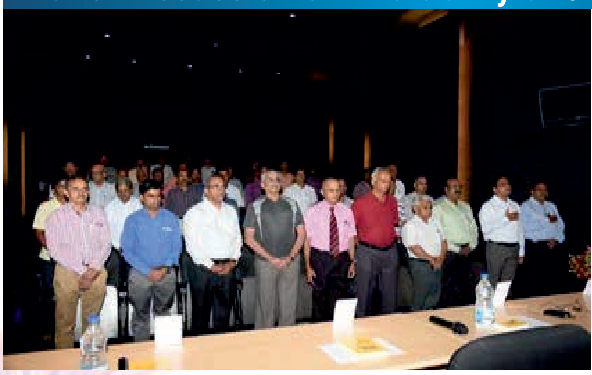
The journal will be published every quarter. Uniqueness of this journal is its contents, which is fully backed by simple data / experience shared by practical engineers / architects.

125th Technical Lecture at Surat AKC celebrated with ICEA-Surat

Team Surat celebrated 125th event at AKC on 30th July'16, Surat with lecture of Dr. Anuj Maheshwari, Reliance, Mumbai on "challenges in high rise pumping".

This event was organised with ICEA (local Engineers Association). 136 Participants attended this which is also ever highest at AKC, Surat.

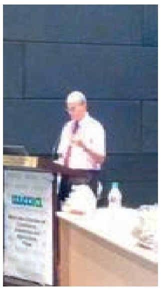
Panel Discussion on "Durability of Concrete Structures"

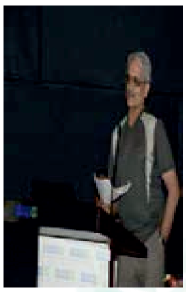


Venue : Ambuja Knowledge Centre Pune, In association with Indian Concrete Institute.

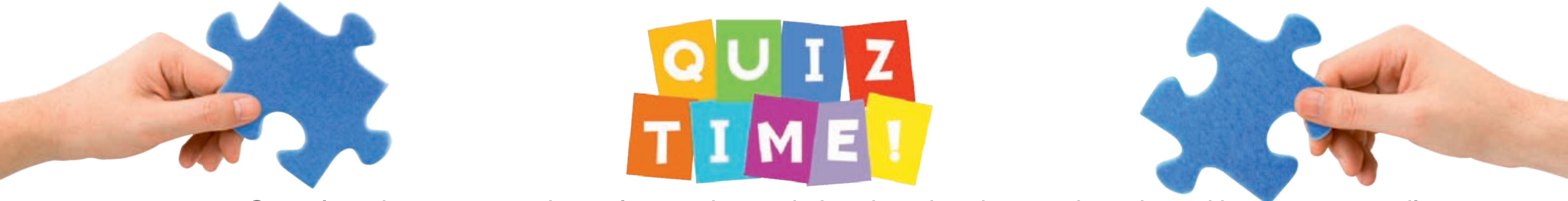
Expert Panellists:

Dr. J. D . Bapat, Er. Ravi Ranade, Er. Yusuf Inamadar Er. Satish Marathe.



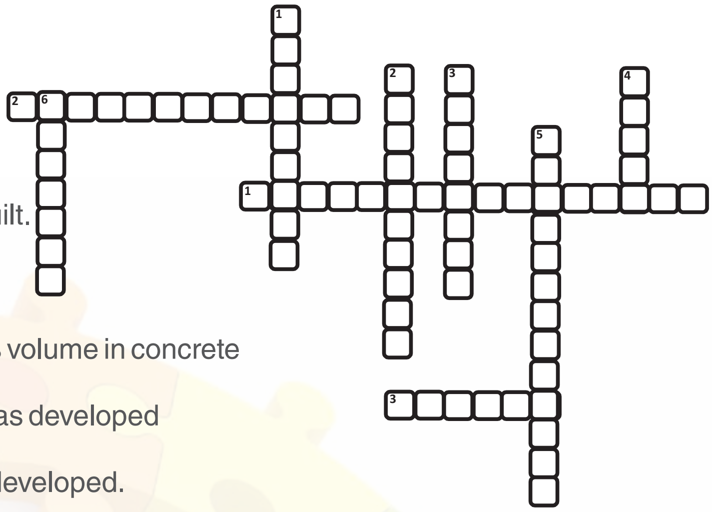


Organised Panel Discussion on Durability of Concrete Structure in association with ICI at Pune.



Complete the cross word puzzle, word search & quiz, take photograh and send it across on mail ID: ambuja.technicaljournal@ambujacement.com to be eligible for lucky winner of exiting prizes.

1) PUZZLE



Across

1. Inventor of prestressed concrete
2. Inventor of Reinforced concrete
3. The Indian city in which 1st concrete road was built.

Down

1. An important ingredient for concrete making
2. The ingredient which makes up more than 70 % volume in concrete
3. The most consumed construction material
4. The country where self compacting concrete was developed
5. Patented Portland cement
6. On his work the self compacting concrete was developed.

- There are 9 words related to construction to put into.
- Complete those and take photo.
- The photo is to be sent to us on e mail id ambuja.technicaljournal@ambujacement.com to be eligible for exciting prizes.

2) WORD SEARCH

- There are 13 words related to construction to search.
- Mark all the 13 words and take photo.
- The photo is to be sent to us on e mail id ambuja.technicaljournal@ambujacement.com to be eligible for exciting prizes.

D	U	R	A	B	L	E	G	N	N
C	S	E	H	G	A	R	N	O	N
E	G	T	O	N	G	U	I	I	L
M	G	E	C	I	G	T	H	T	A
E	N	R	F	M	R	X	C	A	C
N	I	C	C	O	E	I	T	R	I
T	D	N	P	O	G	M	A	D	M
M	A	O	H	R	A	D	B	Y	E
B	R	C	Q	B	T	A	Z	H	H
P	G	M	I	N	E	R	A	L	C

3) QUIZ

1. Portland cement was patented in year ________?
   A. 1924
   B. 1908
   C. 1824
2. The reaction of cement with water is ___________
   A. Exothermic
   B. Endothermic
   C. None of the above
3. _________ is the volume occupied by aggregates in Concrete.
   A. 20 – 30 per cent
   B. 70 – 75 per cent
   C. 40 – 45 per cent
4. Segregation in concrete is i) separation of coarse aggregates from mortar, ii) separation of cement paste from aggregates
   A. Only i)
   B. Only ii)
   C. Either i) or ii)
5. Larger the size of aggregate cement paste requirement will be _____________
   A. Higher
   B. Lower
   C. Neither of the two.

Guidelines & Information for Paper Submission

This guide describes sharing of technical paper to our Email id.
ambuja.technicaljournal@ambujacement.com.

Only original contributions to the construction field are accepted for publication; work should incorporate substantial information not previously published.

Elements of a Paper

The basic elements of a paper or brief are listed below in the order in which they should appear:

1. Title
2. Author names and affiliations
3. Abstract
4. Body of paper
5. Acknowledgments
6. References
7. Figures and tables
8. Style Guide

Title

The title of the paper should be concise and definitive.
Author Names and Affiliations
Author name should consist of first name (or initial), middle initial, and last name. The author affiliation should consist of the following, as applicable, in the order noted:

- University or company (with department name or company division)
- Mailing address
- City, state, zip code
- Country name
- E-mail (university or company email addresses should be used whenever possible)

Abstract

An abstract (500 words maximum) should open the paper or brief. The purpose of the abstract is to give a clear indication of the objective, scope, and results so that readers may determine whether the full text will be of particular interest to them.

Body

The text should be organized into logical parts or sections. The purpose of the paper should be stated at the beginning, followed by a description of the work, the means of solution, and any other information necessary to properly qualify the results presented and the conclusions. The results should be presented in an orderly form, followed by the author's conclusions.

Headings

Headings and subheadings should appear throughout the work to divide the subject matter into logical parts and to emphasize the major elements and considerations. Parts or sections may be numbered, if desired, but paragraphs should not be numbered.

References cited

All references cited in the text, figures, or tables must be included in a list of references.

Tables & Figures

All tables & figures should be numbered consecutively and have a caption consisting of the table & figure number and a brief title. Table & figure references should be included within the text in numerical order according to their order of appearance and should be inserted as part of the text.

Style Guide

Manuscripts should be double-spaced and left-justified throughout; text lines should be numbered consecutively. Submit the file in its native word-processing format (.doc or docx is best).length of the paper is restricted to maximum 8 pages (A4 size) with the use of a 'standard' font, preferably 12-point Times New Roman.

Address of Region Offices in India - TECHNICAL SERVICES

West & South Region	North Region	East Region
Elegant Business Park, MIDC Cross Road "B", JB Nagar, Andheri Kurla Road, Andheri(E) Mumbai - 400059 Tel: 022-40667000	228, Udyog Vihar, Phase - 1, Gurgaon - 122016, Haryana Tel.: 0124-4531100	Indicon Viva, 6th Floor, 53 A, Leela Roy Sarani, Kolkata – 700019 Tel.: 033-44033900

Ambuja foundations

A KNOWLEDGE INITIATIVE