IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

Experimental investigation on abrasion, chlorine penetration and compressive strength of controlled and steel slag mixed concrete

Yuvraj Rajesh Patil

Government Engineering College, Karad

Abstract

The most common cause of concrete deterioration is surface abrasion. Abrasion, which causes structural cracks and reinforcement corrosion, can act as a catalyst for structural failures. The compressive strength and quality grading of the concrete are reflected in the abrasion of the concrete surface. The goal of this study is to look into the relationship between abrasion, compressive strength, and concrete quality grading. The concrete's mechanical characteristics, quality grading, and abrasion were assessed using the sand blasting abrasion testing (IS 516), ultrasonic pulse velocity (IS 13311), and compressive strength (IS 516).9284) and 9284), respectively. Compressive strength and ultrasonic pulse velocity both increased abrasion resistance. Also the chlorine affected the properties of the concrete mix. It was found that concrete with greater quality grading, sound microstructure, and abrasion resistance had higher quality grading, sound microstructure, and abrasion resistance. Abrasion resistance is improved by combining compressive strength with the application of a super-plasticizer.

Keywords: Cracks, Chlorine, compressive, abrasion, sand

INTRODUCTION

Concrete is a proportional mixture of cement, aggregates, water, and admixtures used in building. Concrete delivery of the right quality is an important aspect of the building industry. Despite significant advancements in concrete manufacturing, the compressive strength of concrete is still the most prevalent indicator of its quality. Additionally, the concrete's mechanical qualities and longevity are employed as indicators of its quality [1]. As indicated, the concrete cross-section is separated into two parts: heartcrete and covercrete. The concretemass collected in the reinforcement is what gives the concrete its mechanical qualities like compressive strength, tensile strength, and flexural strength. Covercrete is the top layer of concrete that extends from the reinforcement to the surface and is responsible for the concrete's endurance features such as abrasion resistance, ion penetration, electric resistivity, and acid attack resistance. [2]. Deterioration of concrete's covercrete qualities causes the concrete surface to weaken, which affects the concrete's mechanical properties [2]. Despite the fact that the writers looked into the concrete's durability (electrical resistivity) and compressive strength, there was no exact association between the compressive strength and the cement type. Nonetheless, it was discovered that surface resistivity, as measured by resistance to chlorine penetration through the surface, has an impact on the concrete's strength. Surface resistivity, in particular, was observed to rise as compressive strength increased [3]. According to IS 13311 part 1 [4], ultrasonic pulse velocity (UPV) can be used to determine the quality of concrete. The ultrasonic pulse velocity grows sharply in the early age of concrete (i.e. 16 h to 72 h), then slowly increases up to 120 h, according to experimental findings. According to another study, UPV does not significantly grow until 672 hours since pour filling and gap reduction begin early in the concrete process. To link UPV with compressive strength, a linear regression equation was applied. Given the UPV readings, the linear regression equation was then utilised to calculate the concrete's compressive strength[5]. Coarse particles alter the ultrasonic pulse velocity and, as a result, the concrete's compressive strength. Al-Numan et al. used UPV measurements to investigate the effect of coarse aggregate density on the compressive strength of concrete. They discovered minor differences in compressive strength as the coarse aggregate density was adjusted between 1100 kg/m3 and 1400 kg/m3. [6]. The material selection, mix proportion, and compressive strength of concrete all affect abrasion resistance [7–9]. Abrasion resistance increases with increasing compressive strength for all types of aggregates, according to researchers; notably, abrasion resistance rose when hematite was employed as coarse aggregate [10]. Because the abrasion resistance of concrete depends on the concrete manufacturing process, establishing a link between abrasion resistance and compressive strength is difficult [7]. According to reports, concrete with nanoparticles has a more abrasion-resistant surface than cement mortar without them. Wang et al discovered that nano Silica (SiO2) blended with 1 percent to 3 percent weight of cement and cured at room temperature had an abrasion loss of about 0.38 kg/m2 to 0.50 kg/m2, with an absolute decrease in abrasion loss from about 0.25 kg/ m2 to 0.13 kg/m2. Similarly, adding 1% to 3% Nano-TiO2 and Nano-ZrO2 to concrete reduced abrasion from 0.44 kg/m2 to 0.43 kg/m2 and from 0.42 kg/m2 to 0.14 kg/m2, respectively. These findings suggest that a small amount of nanomaterials added to the cement mortar can significantly improve its abrasion resistance. The compressive strength of the cement mortar that had been cured for 28 days, on the other hand, was found to be roughly 48 percent higher than that of the control cement mortar[11, 12]. As a result, it can be inferred that adding nanomaterials like Graphene, SiO2, TiO2, and ZrO2 to concrete improves both abrasion resistance and compressive strength [12].

Hence, the main aim of the research work is to evaluate performance of concrete against chlorine and abrasive forces for serviceability and durability.

LITERATURE REVIEW

Followings are the literature review those are studied for the investigation:

Table: 1 Literature Review Process

Author's details	Title's	Details of work
Tarun R. Naik, Shiv S. Singh, Mohmmad M. Hussain. 6th June 2013.	Abrasion resistance of concrete as influenced by inclusion of fly ash	This research was conducted to evaluate abrasion resistance of high volume fly ash concrete mixture have two levels of cement replacement (50% & 70%) with an ASTM class C fly ash, Rotary cutter device is used.
Gcp Applied Technologies. 10th July 2014	Understanding AASHTO T277 & ASTM C1202 Rapid Chloride Permeability Test (RCPT).	At the present time this is the only test method that is widely accepted by the concrete industry. As more and more experience is gained with this test, as well as with other test methods, new procedures may be developed that measure concrete permeability more accurately.
Sonebi, M & Khayat, K. H. Cement Concrete And Aggragates, Ccagdp, Vol. 23, No. 1 (June 2001)	Testing abrasion resistance of high-strength concrete	An experimental program was undertaken to examine the effect of the nature of the test surface & testing duration on mechanical & underwater abrasion resistance of HSC. Both ASTM C779 & ASTM C1138 Tests are suitable for evaluating the abrasion resistance of HSC mixtures.
A. Kilic, C. D. Atis, A. Teymen, O. Karahan, F. Ozcan (2006)	The Influence Of Aggregate Type On The Strength And Abrasion Resistance Of High Strength Concrete.	Influence of aggregate type on the abrasion resistance of concrete were investigated using constant mixture proportion. High abrasion resistant aggregate produced a concrete with high abrasion resistance.
Rafat Siddique (24 June 2003)	Effect of Fine Aggregate Replacement With Class F-Fly Ash On The Abrasion Resistance Of Concrete	This paper present the abrasion resistance of concrete proportional to four levels of fine aggregate replacement. (10%, 20%, 30%, 40%) with class F fly ash. This results indicates the abrasion resistance & compressive strength of concrete mixture increased with the increase in percentage of fine aggregate replacement with fly ash.

C.C.Yang, S.W.Cho (1991)	A modified rapid chloride permeability test method to assess the permeability of fly ash concrete	The rapid chloride permeability test (RCPT) designated as ASTM C1202. Portland cement (OPC) concrete and fly ash concrete were subjected to the ASTM C1202. The only additional step taken during the modified RCPT procedure entails measuring the surface chloride content after the completion of the RCPT. Conductivity of the free pore fluid increases with increased temperature, and that the applied electrical potential of the RCPT heats the concrete specimen.
Fhwa Contract Dtfh61-97-R-00022 “Prediction Of Chloride Penetration In Concrete By Doug Hooton”	Testing of chloride penetration of chloride in concrete	Reinforced concrete structure are exposed to harsh environment yet often expected to last with little or no repair or maintenance for longer period of time(100 year or more).for reinforced concrete bridge, one of the major environmental attack is chloride ingress which lead to be the corrosion of reinforcement bar which reduce the strength, serviceability of concrete hence method of preventing such deterioration is to prevent chloride from penetrating the structure to the level of reinforcement bar by using relative impermeable concrete.
L.Evangelista, J.De Brito	Durability performance of concrete made with fine recycled concrete aggregates.	The durability of concrete made with FRA was analysed by means of three tests, namely water absorption by immersion, water absorption through capillarity, and chloride penetration in a non-steady state condition.

Odd E. Gjorv	Durability Design Of Concrete Structures In Severe Environments.	During operation of the structure, updated estimates of the probability of corrosion are developed using data on the real chloride penetration taking place. Before the probability of corrosion becomes too high, appropriate protective measures should be implemented.
Tarun Gehlot, Dr. S. S Gupta, Sankhla, Akash. American Journal Of Engineering Research (Ajer), 2016.	Study of Concrete Quality Assessment of Structural Elements Using Rebound Hammer Test.	Presently the system is limited to penetration depths of 1 ft. Research is on going to develop a system that can penetrate to a depth of 10 ft or more. The Schmidt hammer provides an inexpensive, simple and quick method of obtaining an indication of concrete strength, but accuracy of around up to ±15 per cent is possible only for specimens cast cured and tested under conditions for which calibration curves have been established.

Results and Discussion

- **Results on compression and Density**

Table: 2 Compressions and Density

Sample	Density (Average of 3 Sample After 28 days Curing) Kg/m^3	Compressive Strength (Average Strength of 3 samples after 28 Days of curing) N/mm^2
S1	**27.34**	**38.04**
S2	**27.79**	**42.54**
S3	**26.15**	**38.71**
S4	**26.04**	**38.15**
S5	**25.67**	**42.66**
S6	**25.95**	**37.48**
S7	**25.95**	**41.33**
S8	**25.95**	**45.33**
S9	**25.51**	**44.01**

- **Abrasion depth vs Compressive Strength**

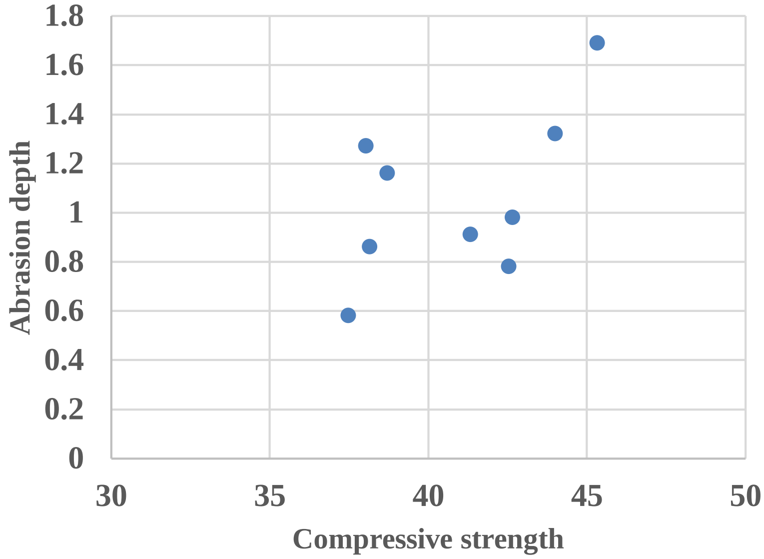


Fig. 1 Compressive strength vs abrasion depth

- **Result on abrasion by IS:1237 at different curing days**

Sample	Abrasion By Average Percentage Weight Loss			Abrasion by Loss in Average Thickness (mm)		
	28 Days	56 Days	90 Days	28 Days	56 Days	90 Days
S1	3.17	5.34	3.17	1.27	0.92	1.08
S2	2.32	1.77	2.64	0.78	1.16	0.96
S3	2.39	2.10	1.88	1.16	0.77	1.18
S4	3.12	1.90	1.83	0.86	0.83	0.52
S5	1.62	1.28	1.82	0.98	0.91	1.17
S6	1.61	2.10	0.00	0.58	0.69	0.59
S7	1.83	1.86	0.00	0.91	0.68	0.56
S8	3.33	2.24	0.00	1.69	0.67	O.61
S9	2.27	2.51	0.00	1.32	0.54	0.48

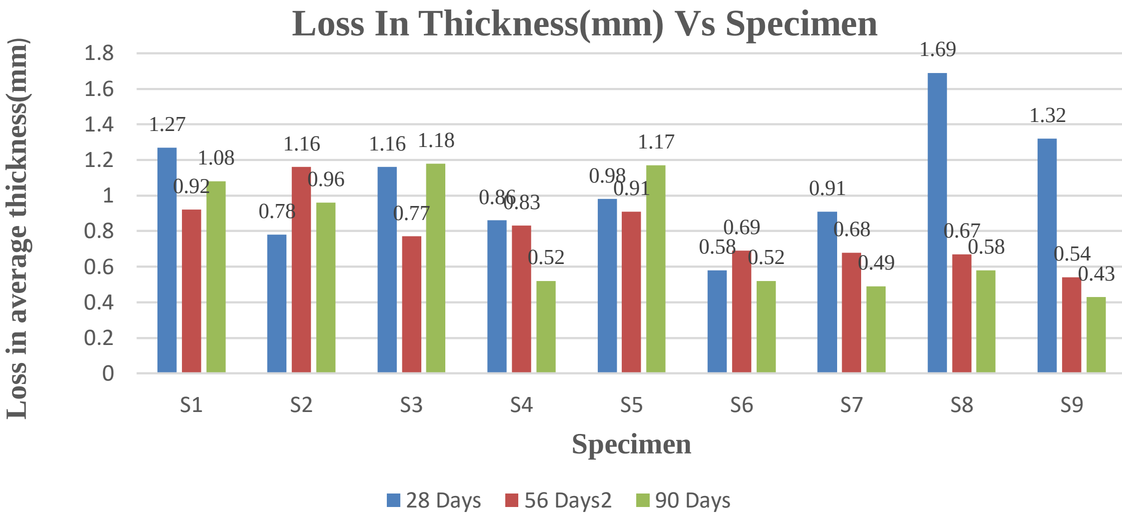


Fig. 2 Loss in thickness vs specimen at different curing days

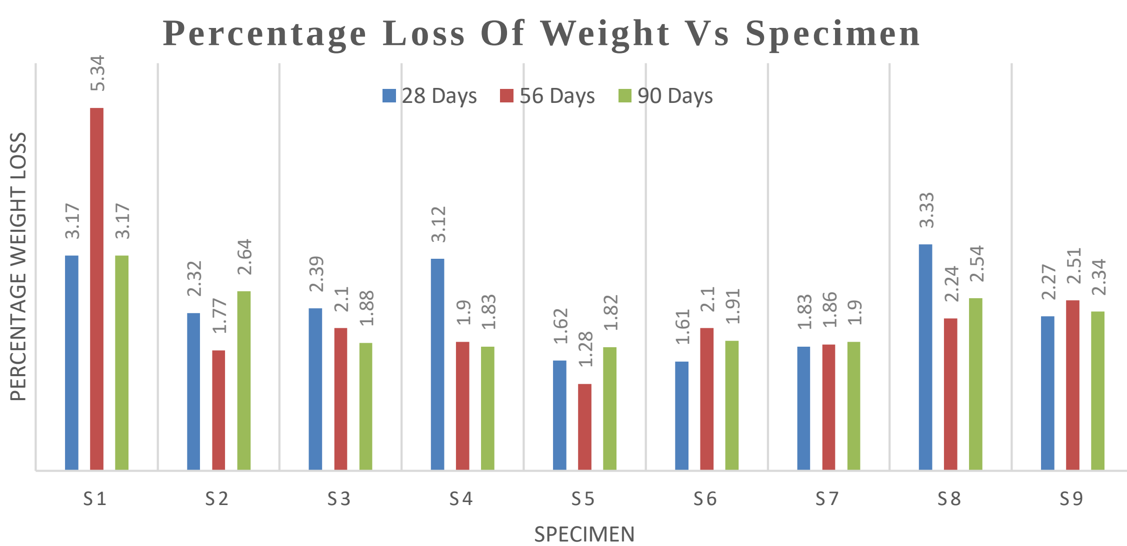
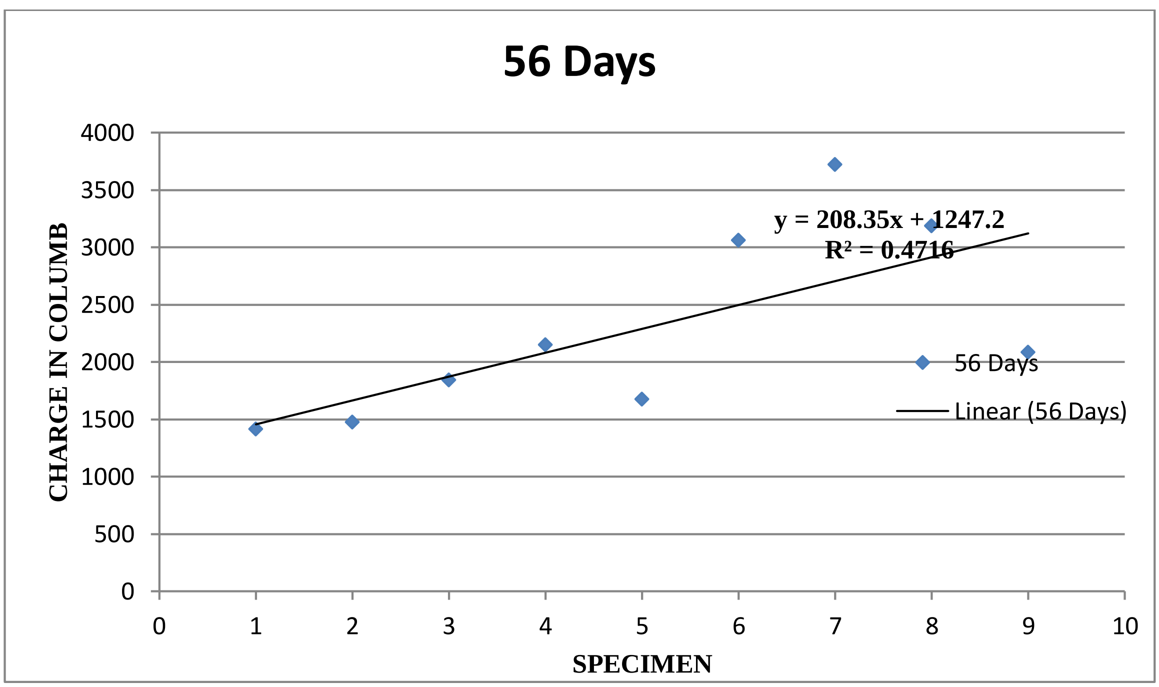


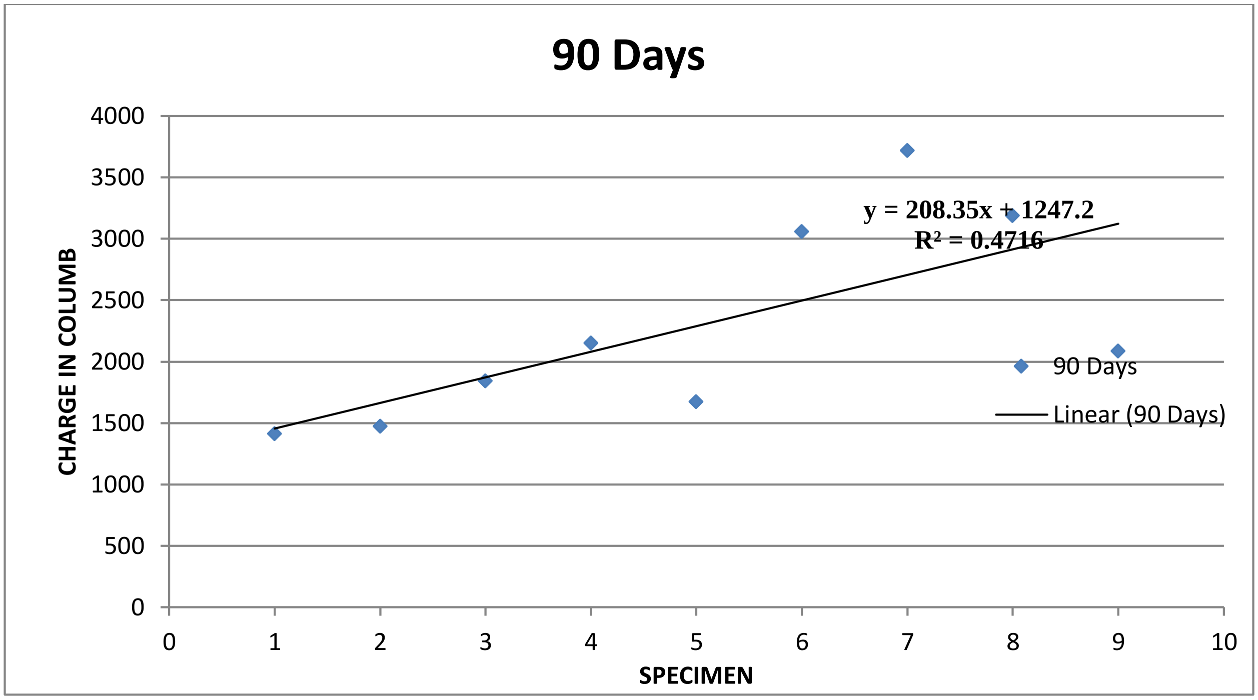
Fig. 3 **Percentage Loss of Weight Vs Specimen**

- RCPT Results

Sample	Time	Reading
1	9:00 am	37.7
2	9:30 am	41.6
3	10:00 am	42.6
4	10:30 am	43.7
5	11:00 am	44.3
6	11:30 am	45.2
7	12:00 pm	45.9
8	12:30 pm	46.5
9	1:00 pm	47.4
10	1:30 pm	48.1
11	2:00 pm	48.8
12	2:30 pm	50.1

- **RCPT Test and Mathematical Model**





Conclusion and Discussion

Following are the conclusion drawn out from the current investigation:

- The compressive strength of controlled concrete mixed concrete is goes on increasing for the higher grades of concrete mix and abrasion depth is seems to be decreasing. Hence we conclude that compressive strength and abrasion of concrete surface are inversely proportional to each other.
- Abrasion weight loss of controlled mixed concrete is much higher than steel slag mixed concrete hence we conclude that the weight loss of lower grade controlled mixed concrete is higher than steel slag mixed concrete irrespective of its grade.
- Dense concrete is having property to avoid penetration of chloride ions through it but in case of concrete having replacement for coarse aggregate as 25%, 50%, 75% and 100% is having higher chloride penetration through it hence we conclude that steel slag leads towards to more permeability and causes less durable and week concrete specimen.
- Rebound hammer test conducted on non-abraded surface shows higher compressive strength as compared to abraded surface hence we conclude that abrasion of concrete surface causes loss in compressive strength of concrete surface.

REFERENCES

- D. Ravikumar, N. Neithalath, Electrically induced chloride ion transport in alkali activated slag concretes and the influence of microstructure, Cem. Concr. Res. 47 (2013) 31–42.
- C.C. Yang, L.C. Wang, T.L. Weng, Using charge passed and total chloride content to assess the effect of penetrating silane sealer on the transport properties of concrete, Mater. Chem. Phys. 85 (2004) 238–244.
- C.C. Yang, J.K. Su, Approximate migration coefficient of interfacial transition zone and the effect of aggregate content on the migration coefficient of mortar, Cem. Concr. Res. 32 (2002) 1559–1565.
- C.M. Aldea, F. Young, K. Wang, S.P. Shah, Effects of curing conditions on properties of concrete using slag replacement, Cem. Concr. Res. 30 (2000) 465–472.
- S.S. Park, S.J. Kwon, S.H. Jung, Analysis technique for chloride penetration in cracked concrete using equivalent diffusion and permeation, Constr. Build. Mater. 29 (2012) 183– 192.
- Standards B of I. Plain and Reinforced Concrete New Delhi Bureau of Indian Standards IS 4562005 (https://www.iitk.ac.in/ce/test/ IS-codes/is.456.2000.pdf1-100)
- Shetty M S 2008 Concrete Technology: Theory and Practice(New Delhi: S. Chand & Company Ltd) 9788121900034
- Ramezanianpour A A, Pilvar A, Mahdikhani M and Moodi F 2011 Practical evaluation of relationship between concrete resistivity, water penetration, rapid chloride penetration and compressive strength Constr. Build. Mater. 25 2472–9
- Bureau of Indian Standard 1992 Method of non-destructive testing of concret: I. Ultrasonic pulse velocity Bur Indian SatandardsI 1–7 (https://www.iitk.ac.in/ce/test/IS-codes/is.13311.1.1992.pdf)IS 13311 (Part 1)
- Hong S, Yoon S, Kim J, Lee C, Kim S and Lee Y 2020 Evaluation of condition of concrete structures using ultrasonic pulse velocity method Appl. Sci. 10
- Al-Nu’man PDB S, Aziz B R, Abdulla S A and Khaleel S E 2015 Compressive strength formula for concrete using ultrasonic pulse velocity Int. J. Eng. Trends Technol. 26 9–13
- Warudkar A and Elavenil S 2020 A comprehensive review on abrasion resistance of concrete Int. J. Appl. Sci. Eng. 17 29–43
- Scott B D and Safiuddin M 2015 Abrasion resistance of concrete—design, construction and case study ISSR Journals 6 136–48
- Warudkar A, Elavenil S and Arunkumar A 2018 Assessment of abrasion resistance of concrete pavement for durability Int. J. Civ. Eng. Technol. 9 1176–1181 (https://iaeme.com/MasterAdmin/Journal_uploads/IJCIET/VOLUME_9_ISSUE_6/IJCIET_09_06_ 133.pdf)
- Gencel O, Ozel C and Filiz M 2011 Investigation on abrasive wear of concrete containing hematite Indian J. Eng. Mater. Sci. 18 40–8
- Wang D, Zhang W, Ruan Y, Yu X and Han B 2018 Enhancements and mechanisms of nanoparticles on wear resistance and chloride penetration resistance of reactive powder concrete Constr. Build. Mater. 189 487–97

- Han B, Ding S, Wang J and Ou J 2019 Nano-BN-engineered cementitious composites Nano-Engineered Cementitious Composites 639–664 12269:2013 I 1992 Ordinary portland cement, 53 grade—specification Bur Indian Stand. 6 141–2
- Bureau of Indian Standard(BIS) IS 383 Specification for Coarse and Fine Aggregate From Natural Sources for Concrete. IS 383 2nd rev (New Delhi, India)
- IS 4031- Part I 1996 Method of Physical Tests for Hydraulic Cement: Determination of Fineness by Dry Sieving (New Delhi: Bureau of Indian Standards) Reaffirmed in 2005
- Bureau of Indian Standards 1963 IS 2386 (Part III) methods of test for aggregates for concrete specific gravity, density, voids, absorption and bulking Indian Stand. 2386 1–19
- Kisan M, Sangathan S, Nehru J and Pitroda S G 1963 IS: 2386 (Part II)-1963. Method of Test for Aggregate for Concrete, Part II Estimation of Deleterious Materials and Organic Impurities (New Delhi, India: Bureau of Indian Standards.)
- Bureau of Indian Standards(BIS) IS 2386 (Part I) Methods of Test for Aggregates for Concrete Part I Particle Size and Shape 2386 (New Delhi: Bureau of Indian Standards)
- Bureau of Indian Standard 1963 1–28 Methods of Test for Aggregates for Concrete. IS 2386 (Part IV) (https://www.iitk.ac.in/ce/test/ IS-codes/is.2386.4.1963.pdf)
- BIS: 10262 2009 Concrete mix proportioning—guidelinesIndian Concrete Mix Design Guide Lines (New Delhi: Bureau of Indian Standards)
- IS-516 Methods of Tests for Strengtii of Concrerte. Method of Tests for Strength of Concrete(New Delhi: Bureau of Indian Standards) 1–30
- Bureau of Indian Standards(BIS) 2004 IS 5816: 1999 (Reaffirmed 2004) Splitting Tensile Strength of Concrete - Method of Test 1–8
- Bureau of Indian Standards 1979 IS: 9284 Method of Test for Abrasion Resistance of ConcreteI 1–11 (https://law.resource.org/pub/in/ bis/S03/is.9284.1979.pdf)