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AN EXPERIMENTAL STUDY ON COMPRESSIVE STRENGTH OF DIFFERENT TYPES OF PAVEMENTS BY USING NON-DESTRUCTIVE TECHNIQE(NDT) & DESTRUCTIVE TECHNIQUE METHODS

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Abstract: *The objective of this study is to estimate the compressive strength of pavement made by using chemical admixture polycarboxile ether (PCE SP) on Portland Slag Cement(PSC) of three differentwatercementratio's.ie,0.55,0.45&0.35,byusingthemostpopularNonDestructive Test(NDT) method RH(Rebound Hammer). In assessing compressive strength of pavement, in this study prepared, cured and subjected to RH (Rebound Hammer) at the end of 14 & 28 days. The destructive tests are also be done for same specimens after completion of non-destructive tests to compare the results. The obtained results shows that slight difference between OPC,PPC and PSC. But the maximum strength obtained for OPC for all w/c ratios. The final mix designs for w/c ratios of 0.55, 0.45 and 0.35 are M25, M30&M35 by taking average compressive strength from the graphs*

INTRODUCTION

Concrete technology has developed at a fast pace indeed during the last two decades and material can be determined and controlled by means performance has been significantly improved. It is difficult to maintain strength of concrete and increase its durability, Concrete is a brittle material and if un cracked any reinforcingplacedwithintheconcretematrixisredundantbut90%ofthetimeconcretewill fatigueandshowsignsofcrackingbuttowhereishardtopredictbuthowmuchitwillcrack of reinforcement. What type of reinforcing and the material properties of the reinforcing play a major role in the redistribution of these stresses and how significant the crack widths will be. This project undergoes to find compressive strength of different types of concretes.

Based on the principle that the rebound of an elastic mass depends on the hardness of practical and engineering value. Thesubject has received agrowing attention during recent years, especially the quality characterisation of damaged structure made of concrete using NDT testing.

The advantages of Non-Destructive tests as reduction in the labour consumption of testing (Malhotra 1976), a decrease in labour consumption of preparatory work, a smaller amount of structural damage, a possibility of testing concrete strength in structures where cores cannot be drilled and application of less expensive testing equipment, as compared to core testing.Theseadvantagesareofnovalueiftheresultsarenotreliable,representative,andas close as possible to the actual strength of the tested part of the structure. Rebound hammer isusefultodetectchangesinconcretecharacteristicsovertime,suchashydrationofcement, forthepurposeofremovingformsorshoring.Thistestisthesurfaceagainstwhichthemass impinges.

The test procedure is described in IS:13311 Part 2: 1992 and BS1881 202 (1986). It is portable,easy-to-use,low-cost,andcanquicklycoverlargeareasbutitisvaluableonlyasa qualitative tool since it measures the relative surface hardness of the concrete. Other tests, such as a compression test, must be used to determine the actual strength of the concrete. Therebound measurement is governed by several factors including thesize, age, and finish of the concrete, as well as the aggregate type and the moisture content. A rebound hammer will give a false reading if used over exposed aggregate.

Longitudinal ultrasonic waves are an attractive tool for investigating concrete. Such waves have the highest velocity so it is simple to separate them from the other wave modes. The equipmentisportable,usableinthefieldforinsituatesting,istrulynon-destructiveandhas beensuccessfulfortestingmaterialsotherthanconcrete.Theultrasonicpulsevelocitytester isthemostcommonlyusedonesinpractice.Testisdescribedin(IS:13311Part1;1992and BS1881-203;1986).Nevertheless,thereareintrinsicandpracticalfactorsthatmayinterfere with the determination of concrete strength by ultrasonic means. Concrete is a mixture of fourmaterials:Portlandcement,coarseaggregate,fine aggregateandwater.Thiscomplexity makes the behaviour of ultrasonic waves in concrete highly irregular, which in turn hinders non-destructivetesting.Intheviewof thecomplexitiesof theproblemitwouldappeartobe overly optimistic to attempt to formulate an ultrasonic test method for the determination of concrete strength. However, considering the seriousness of the infrastructure problem and the magnitude of the cost of rehabilitation, major advancement is desperately needed to improve the current situation. For instance, it has been demonstrated repeatedly that the standard ultrasonic method using longitudinal waves for testing concrete can estimate the concrete strength only with ± 20 percent accuracy under laboratory conditions (Popovics 1998). The use of UPV and rebound hammer has been experimentally investigated by inducingvoidsinthesamplebyLorenzi(2009)andresultshowedtheNDTdatacanbeused to make trustworthy guess about concrete condition with damaging structural elements, if the defects are sizeable enough. The effect of admixture, different water cement ratio, its compositionandagesofconcretecancreateuncertaintiesinthestrengthofconcretebyNon- destructive Testing.

The use of Non-Destructive test has been discussed individually, but it is possible to use it more than one method at a time. This is advantageous when a variation in properties of concrete affects the test results in opposite direction. The increase in the moisture content increasestheultrasonicpulsevelocitybutdecreasethereboundnumberrecordedbyrebound hammer (Bellander 1991).

Recommendations on the use of the combined use of non- destructive testing have been prepared by RILEM(1993). When variation in properties of concrete affect thetest results, the use of one method alone would not be sufficient to evaluate the required property. Therefore, the use of more than one method yields more reliable results. Of a number of purely non-destructive tests, the rebound hammer and the ultrasonic pulse velocity combinationsarethemostcommonlyused.Attemptshavebeendonetorelaterebound

number and ultrasonic pulse velocity to concrete strength as demonstrated (Qasrawi 2000, De Almeida 1991, and Khaeder 1998).

The influence of concrete materials, mix, workmanship related variables such as intentionally induced flaws, improper compaction and different lengths of moist curing on Rebound No. and UPV is studied. The aim is to develop correlation curves between compressive strength and NDT testing and to develop multiple regression curves from the results of UPV and Rebound Hammer in determining the compressive strength of concrete for better assessment.

1.2 REBOUNDHAMMER:-(BSEN 12504-2)

Attheendofeachcuringdays, the pavements were removed from curing tank and allowed todrainandtheyweresubjectedtoReboundHammer.Thereadingisverysensitivetolocal variation of the concrete, mainly to the aggregate particles to the surface. There is no. of readings are taken and average recorded. **BS EN 12504-2** states that not less than nine readingsaretakenoveranareanotexceeding**300mm2**, withtheimpactpointsnotlessthan 25mm from each or from an edge. The test was carried out at the **'Concrete TechnologyLab Civil Engineering at AITAM, Tekkali'.**

1.3 OBJECTIVESOFTHESTUDY:

- Tostudythestrength properties of concrete along with chemical admixture ofdifferent water-cement ratio.
- Calulatethepercentageofchemicaladmixturefordifferentwater-cementratiosi.e,0.55 ,0.44 and 0.35.
- TocomparethestrengthpropertiesofNDT andDT.

LITERATUREREVIEW

Jameshalelet.alpaperreviewsthatthemostfrequentnon-destructivetesting(NDT) proceduresofconcretestructuresusedbythestructural engineeringindustryarereviewedin James Halel's study. The principles of non-destructive testing (NDT) methodologies are investigated in terms of their potential, limitations, inspection procedures, and interpretations.TheelementsthatinfluencethesuccessofNDTapproachesarereviewed,as well as strategies for mitigating their impact. Standard guidelines for the application and interpretation of the discussed NDT methods are referred to. Concrete non-destructive testing (NDT) is gaining popularity as a method of assessing the strength, homogeneity, durability, and other qualities of existing concrete buildings. Lack of understanding of construction materials and NDT technologies contributed to NDT perceptions of inadequacy. The purpose of this work is to address these concerns by identifying and explaining the most often used successful NDT methods for concrete buildings.

Tarsem lal et.al research looked into the accuracy of non-destructive tests for hardened concrete strength. Two groups of test specimens in the shape of 150mmX150mmX150mm cubes were employed in this study. The initial set of specimens were used to create calibrationcurvesforthereboundhammerandultrasonicpulsevelocityequipmentthatwere utilised in the test. The results obtained from the calibration curves of the rebound hammer and ultrasonic pulse velocity tester were compared to those acquired from the compressive testing equipment with the second group of test specimens. At the age of 28 days, all of the test samples were examined. . A statistical study was performed to determine if there was a linkbetweentheCTMtestandnon-destructivetests.Accordingtothetesting,thedifference in results between a fully calibrated hammer and a CTM is between 2 and 7%, while the difference between a properly calibrated USPV and a CTM is between 7 and 17%. By sampling samples from the same batch and curing them in the same conditions, this conclusion was reached. The results strongly suggest that non-destructive testing be used after correctly calibrating the device.

N. R. Chandank et.al The authors attempted to describe methodology, benefits and drawbacks, as well as current work in the field of non-destructive techniques (NDT), such asultrasonicpulsevelocity(UPV)and reboundhammer(RH).Thesemethodsallowforthe low-cost evaluation of wider areas of concrete members while also providing more informationthaneyeinspection.Theeffectofthew/cratio,castingprocess,castingdirection, andcementdoseonNDTreadingshasbeendocumented. Thepurposeofthisstudyis topresent UPV,RH,andtheelementsthatinfluencetheresults.The precautionsthatmustbetakenwhen doing NDT tests are also discussed

D. Dahiru This is an evaluation of the two most popular Non-Destructive Testing (NDT) methods – Ultrasonic Pulse Velocity (UPV) and Rebound Hammer (RH) in assessing compressive strength of concrete. 150mmx150mmx150mm concrete cube samples were prepared, cured and subjectedto UPV and RHtests at theend of:1, 3, 7,14, 21, 28, 56 and 90 days. The same samples were, then subjected to destructive (compressive strength) test. Correlation test, multiple regression analysis, graphs and visual inspection were used to analyze the data obtained. Results indicated increase in rebound hammer from 24 rebounds on the day to 43 rebounds on the 90 days; while the result of UPV decreases from 43.10 th Micro-Sec.ontheday,to 35.90Micro-Sec.onthe90daysofcuring.RegressionModel22 whichcombinesUPVwithRHgavethefollowingresults :10.93N/mm,13.99N/mm,25.23 222222N/mm29.72N/mm,33.45N/mm,33.32N/mm, 35.45N/mmand36.75N/mmfor 1, 3, 14, 21, 28, 56 and 90 curing days, respectively. The conclusion drawn from the analysis,isthatcombinationofreboundhammerandUPVmethodsiseffectiveinassessing compressive strength of concrete. Hence it is recommended that for more accurate result, rebound hammer should be combined with UPV testing concrete, and that the following formula should be used = 45.80 + 0.88 X -1.31 X.

Y. B. I. Shaheen, B. Eltaly and M. Kameel The primary goal of this research is to look intotheuseofferrocementconcreteintheconstruction ofwatersupplypipes.Asafirststep toward studying the performance of this type of pipe under impact load, the current work comparestheperformanceofferrocementpipeandreinforcementconcretepipeunderstatic load. The current study presents experimental models of ferrocement and concrete water pipes, as well as numerical models based on the finite element method. Using the ANSYS Package, finite element models werecreated to simulate thebehaviour of the pipesthrough

nonlinear response and up to failure. In addition, the results of the theoretical and experimental models are presented and discussed.

Ali Poorarbabi, Mohammadreza Ghasemi, Mehdi Azhdary Moghaddam Existing structure assessment, particularly compressive strength evaluation of concrete structures, is an important topic for engineers working in construction in the majority of industrial countries. Non-destructive tests (NDT), particularly ultrasonic pulse velocity and rebound number tests, are widely used to predict the compressive strength of existing concrete structures. This study conducted an experimental programme on concrete specimens using non-destructive tests such as ultrasonic pulse velocity and rebound number, and then an efficient approach known as Response Surface Methodology (RSM) was used to estimate the compressive strength of concrete with greater accuracy than other models available in theliterature.TheuseofasingleNDTaswellasacombinationofthemisbeinginvestigated. Theresultsdemonstrated thatultrasonicpulsevelocityisthebestNDTtestattheearlyages when used in the RSM process.

O.D.Atoyebi,O.P.Ayanrinde,J.Oluwafemi,Thecompressivestrengthisoneofthemost important concrete properties for structural concrete design or redesign because it provides information on the characteristics of concrete. This strength measure is obtained through standardised crushing tests on cast cubes; the cubes are manufactured on-site alongsidethe construction of concrete elements; however, they are not available for strengthtesting of existingbuildings,necessitatingtheuseofnon-destructivetestmethods.Schmidt'sRebound Hammer is a nondestructive test that uses the rebound index to determine the compressive strength of concrete. Surface hardness tests were performed on various concretemixes and compared tocubecompressivestrengthtests.Changesinonevariableexplainedby changes in another, as measured by R-squared, are 93.79 percent, 99.42 percent, 86.8 percent, 1 percent,and98.5percentforMix1,2,3,4,and5.Itshouldbenotedthatmorethanonenon- destructive test should be used for proper results.

DunaSamson,Omoniyi,TopeMoses Thispaperexaminestherelationshipandcomparison of a Destructive and a NonDestructive Method (Rebound Hammer) of testing the compressivestrengthofconcrete.Concretecubesmeasuring100mmx100mmx100mmwere made with concrete mixes containing 20N/mm2, 30N/mm2, and 35N/mm2 and curedfor7,14,and28days.A totalof90cubeswerecreatedandusedintheresearch.**MINITAB**

15 was used to perform regression analysis on the data in order to establish linear mathematical relationships between compressive strength and rebound number. The dependent and independent variables were the compressive strength and rebound number, respectively. The results revealed that the coefficient of correlation of all proposed models ranged from 91.6 to 97.9 percent, indicating a perfect relationship between compressive strength and rebound number. For proposed concrete cured at 7, the average percentage of residual error was determined to be 1.78 percent, 1.29 percent, and 1.32 percent.

Krzysztof Schabowicz This issue was proposed and organised to present recent advances inthefieldofnon-destructivetestingofmaterialsincivilengineering.As aresult,thearticles highlighted in this editorial deal with various aspects of non-destructive testing of various materials in civil engineering, ranging from building materials to building structures. The current development trend in non-destructive testing of materials in civil engineering is primarily concerned with the detection of flaws and defects in concrete elements and structures, and acoustic methods predominate in this field. As in medicine, the trend is toward developing test equipment that allows one to see inside the tested element and materials. Interesting findings with implications for building practises were obtained.

3. METHODOLOGY

3.1 GENERAL

Experimentalinvestigationwasplannedtoprovidesufficientinformationaboutthestrength characteristics

3.2 MATERIALSUSED

3.2.1 CEMENT

Cementisabinder,asubstancethatsetsandhardnessandcanbindothermaterialstogether. The word “cement” can be traced back to roman term opus caementicium, used to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder.Thevolcanicashandpulverizedbricksupplementsthatwereaddedtotheburntlime to,obtainahydraulicbinder,werereferredto ascementum,cimentum,camentandcement. Cementusedinconstructioncanbecharacterizedasbeingeitherhydraulicornon-hydraulic, depending upon the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster.

Non-hydraulic cement will notset in wet conditions or underwater: rather, it sets as it dries and reacts with carbons dioxide in the air. It can be attacked by some aggressive chemicals after setting.

Hydraulic cements (e.g., Portland cement) set and become adhesive due to a chemicals reactionbetweenthedryingredientsandwater.Thechemicalsreactioninmineralshydrates that are not very water-soluble and so are quite durable in water and safe from chemicals attack. This follow settling in wet conditions or ground water and further protects the hardenedmaterialsfromchemicalsattack.Thechemicalprocessforhydrauliccementfound by ancient roman used volcanic ash.

The most important uses of cement are as a component in the production of mortar in masonry,andofcement,acombinationofcementandanaggregatetoformastrongbuilding material.

3.2.2 PORTLANDCEMENT

Portlandcementisfarbythemostcommontypeofcementingeneralusearoundtheworld. Thiscementismadebyheatinglimestone(calciumcarbonates)withothermaterial(suchas clay) to 1450c in a kiln, in a process known as calcinations, whereby a molecule of carbondioxideis liberatedfrom thecalcium carbonateto form calcium oxide,orquicklime, which is then blended with the othermaterials that have been included in the mix to form calcium silicatesandtheothercementationcompounds.Theresultinghardsubstance,called'clinker' is then ground with a small amount of gypsum into a powder to make 'ordinary Portland cement', the most commonly used type of cement (often referred to as OPC). Portland cementisabasicingredientofaconcrete,mortarandnon-specialtygrout.Themostcommon use for Portland cement is in the production of concrete is a composite material consisting of aggregate (gravel and sand), cement, and water. As a construction material, concretecanbecastinalmostanyshapedesired,andonce hardened,canbecomeastructural(load bearing) element. Portland cement may be grey or white.

3.2.3 POZZALANASLAGCEMENT

Slag cement, or ground granulated blast-furnace slag has been used in concrete projects in the United States for over a century. Earlier usage of slag cement in Europe and elsewhere demonstrates that long-term performance is enhanced in many ways. Based on these early experiences, modern designers have found that these improved durability characteristics help further reduce life-cycle costs and lower maintenance costs.

Usingslagcementtoreplaceaportionofportlandcementinaconcretemixtureisausefulmethod to make concrete better and more consistent. Among the measurable improvements are:

- Betterconcrete workability
- Easierfinishability
- Highercompressiveand flexural strengths
- Lower permeability
- Improvedresistancetoaggressivechemicals
- Moreconsistent

plasticandhardenedproperties
- Lightercolor

When iron is manufactured using a blast furnace, the furnace is continuously charged from the top with oxides,fluxing material, and fuel. Two products—slagand iron—collect in the bottom of the hearth. Molten slag floats on top of the molten iron; both are tapped separately.

The molten iron is sent to the steel producing facility, while the molten slag is diverted to a granulator. This process, known as granulation, is the rapid quenching with water of the molten slag into a raw material called granules. Rapid cooling prohibits the formation of crystals and forms glassy, non-metallic, silicates and aluminosilicates of calcium.

Thesegranulesaredriedandthengroundtoasuitablefineness,theresultofwhichisslagcement. The granules can also be incorporated as an ingredient in the manufacture of blended portlandcement.

3.2.4 TYPESOFPORTLANDCEMENT:-

ThefollowingformsofPortlandcementcanbefurthercategorizedinto

1. OrdinaryPortland cement
2. Portlandpozzolaniccement
3. Portlandslagcement
4. RapidhardeningPortlandcement
5. LowheatPortlandcement
6. WhiteareculturedPortlandcement
7. SulphateresistingPortlandcement
8. Water-repellentPortland cement
9. Portlandblastfurnacecement

TABLE1:CHEMICALCOMPOSIONSOFOPC,PPCandPSC

Compound	OPC	PSC
Cao	62-63.0	35-38.0
Sio2	18.5-19.2	29-32
Al2o3	4.5-6.5	4.5-5.5
Fe2o3	3.5-5.3	3.3-5.5
MgO	0.6-3.1	3.5-4
So3	1.3-1.6	2.4-2.8
Lossofignition	3.5	5

TABLE2:PHYSICALPROPERTIESOFCEMENT

PhysicalProperties	OPC	PSC
Fineness	7.2	6.8
Normal Consistency(%)	32	32
SpecificGravity	3.15	2.85
InitialSetting Time	135 Min	124 Min
FinalSettingTime	230 Min	224 Min

3.3 TestsonCement

Tests conductedonCementareasfollows:-

1) Fineness
2) Normal Consistency
3) Settingtime
4) Soundness
5) CompressiveStrength
6) SpecificGravity

3.3.1 Fineness

Cement fineness is a cement property that implies cement particle volume and a certain surfacearea.Thehydrationratedeterminesthefinenessofcement.Fineconcretereactsmore rapidly with water and increases the rate of strength growth and hydration heat. The improved fineness increases the precise surface area and the water responds better. The improvement in strength is therefore also faster, but the ultimate strength remains unchanged. IS Codes that prescribe only the limited precision values that are needed for various cement forms. Fineness can be measured with the

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aid of the air permeability test, eitherbytheparticularsurfaceor throughtheactualsieving.100gofcementishand-sieved by 90µ IS 7 for 15minutes to ensure the correct fineness. A cylindrical frame of 150 mm - 200mmnominaldiameter,40mm-100mmdepthwitha90µgridsieveofwovenstainless steel is used in the evaluation. It has a solid, durable, non-corrodible cylinders. In order to preventlossofmaterialduringsieving,atrayfittingunderthestrapandalidfittingaboveit shall be given. A trained and skilled technician conducts the screening process manually. The residue limits for OPC should be less than 10%.

Fig 1:IS 90µ Sieve

3.3.2 Normalconsistency

This measure does not have a consistency criterion for cement itself, but rather it specifies thequantityofwaterthat is added forother measurements, such as initial setting time,final settingtimeandsolidity.Thestandardconsistencyofacementpasteisdefinedasthatwhich enables the Vicat plunger to penetrate the bottom of the Vicatmould to a point of 5 mm to 7 mm while measuring the cement paste. This protocol for the experiment is given below: Prepareapastewithaweightedvolumeofpotableorpurifiedwaterinweighedvolumes,be careful to calculate neither less than 3 minutes but more than 5 minutes, and the measuring mustbedonebeforeanyevidenceofsettingtakesplace. Theexperimentisconductedinthe following manner: The period to estimate must be measured from the moment water is applied to thedrycementbeforethemould is filled. Cover this paste with theVicatmould,themouldonanon-poroustray.Oncethemouldhasbeenfilledcompletely, thepastesurface is glued and the top of the mould levelled. The air may be removed from the mould somewhat. For gauging, clean instruments must be used. The hand of the operator and the bladeofthegagetrowelareusedforfillingthemouldalone.Placethetestblockinthemould withthenon-porouspad,undertheplungerrod;lowerthedipsoftlyto thetestblocksurface andreleaserapidly,allowingthediptofallintothepaste. Thisprocedureisdoneright after the mould has been filled. Prepare test pastes with different water percentages and test as stated above until the amount of water required to make the usual consistency is defined.

Fig2:NormalConsistencyTest

3.3.3 Setting Time

The time taken to reinforce the cement paste to a given consistency indicates the time required. Two important time limits are important for the cement environment:

1. Initialsetting time
2. Finalsettingtime

Initialsetting time

By example, it is timeto apply water at a time when the paste begins to lose plasticity. The test is done with the Vicat unit. For the estimation of the penetration, a needle of volume 1 mm2isused.Torenderthepaste,theexaminationisco mpletedat27+2°Candwaterequal to 0,85P is applied. The needle is lowered and tightened until it reaches the top surface of themould. This releases theneedleeasily and tracks penetration. It should go downand hit thegroundfirst.Thepenetrationoftheneedlewilldecli neastimepassesandthepaste

stiffenes.Themeasurementisrepeateduntiltheneedlei s5mm(+0.5mm)abovethemould. Originalsettingtimeisnamedthistime.Onceagain,the moulddoesnotpenetratetheneedle at the same position such that it is pushed a bit.

Fig3:InitialSettingTimeTest

3.3.4 Finalsettingtime

Itistimetousewatersopastecompletelylacksitsplastic ity.Theprevioustestisreplicated, but the needle is altered. The penetration is wider than 0.5mm. The first impression is the main needle, and the second impression is the circular tip. This needle is fitted in a special way. However, when penetration is less than 0,5 mm, only one major needle sensation occurs. Therefore, the last set-up is where the penetration is less than 0,5 mm or where the ring of the cement paste is not spectacular.

Fig4: Final SettingTime Test

3.3.5 Soundness

Thistestisconductedtofindoutthepresenceofexcessu nburntlimeinthecement.Dueto this lime, cracks may develop in the set cement because of increase in volume. This free or hard burnt lime hydrates very slowly and some of it will hydrate only when the cement has alreadyset.Duetothisdelayedhydrationoflime,expan sionwilltakeplaceinthesetcement. Since no space is available for expansion after setting of cement, this expansion causes cracks in the set cement which is called unsoundness of cement. The test to find out the expansion due to free lime will indicate the presence of free lime andlimitof expansion will be a guiding factor for the soundness of cement. The cement will be considered sound if the expansion is within the permissible limits otherwise it will indicate unsoundness. The expansion is measured using Le Chatelier Apparatus and it should be limited to **10mm**. Cementpasteispreparedinthemouldandfilledwithwa ter0.78xP(standardconstancy)by weight of cement. It has a width of 30 mm, a diameter of 30 mm. Glass plates are placed at the top and at the bottom after filling of the mould. The assemblyis then mounted in a temperatureinwater.From27to32oC.Thedifferenceb etweenthepointersisregisteredon the extreme end after 24 hours (x). The mounting is again immersed

inwaterandinanother30minutes,waterisheatedtothe boilingpoint. Itisheldfor3hours in boiling water. Again, at the extreme end the distance between points is noted (y). This is clearly greater than x because free chalk extension has already arisen because of boiling water. Free lime net expansion = y – x.

Fig5:SoundnessTest

3.3.6 CompressiveStrength

Compressive cement strength is measured by a compressive strength test on the compacted cylindricalpiecesusingaregulartampimgprocedure. Forcementmortarpreparation,regular sandisused.Vibrationunit,tampingrod,pavementmould,balancingtheequipmentusedto measure.TheRectangularmouldvolumeis70.6to70.6to70.6to70.6cm.Take200grams of cement and 600 grams of normal sand and dry fully. Then apply [(P/4)+3] % of water to the dry mix ofcement and sand (with normal consistency P) and mix vigorously for at least 3 minutes to produceaconsistentcolourmixture.Ifaconsistentcolourofthemixevenin4 minutesdoesnotproducethemixrejectsandmixesfreshamountsofcement,sandandwater in order to obtain a uniform colour. Compose and vibrate the mould at a required speed of 12000±400 per minute at a complete compaction with whole amounts of mortar using a fitting hopper mounted to the top ofthemould. Remove the mould from the press and hold for24hoursatatemperatureof27±20Candarelativemoisturecontentof90%.Removethe Rectangularfromthemouldandimmerseitinfresh,cleanwaterattheendof24hours.And duringcheckingwouldtheRectangularberemovedfromthebath.PlacethetestRectangular without packaging between the Rectangular and the test plates on the compressive test.

Fig6:CementCylinderforCompressiveStrengthTest

Applytheloadcontinuouslyandevenlyatarateof140Kg/cm2/minstartingfromzero.The compressive power of the specimen in the Contact Region (A) is measured as the ultimate load (P).

$$\textit{Compressivestrength} = \mathbf{P/A}$$

3.3.7 SpecificGravity

Normally, specific gravity is known as a ratio of the weight of a certain material volume to the weight of equivalent water volume. Kerosene that does not react with cement is used to assess the basic gravity of cement. Basic gravity bottles with capacity of 50 mL, kerosene, weighting balance and weighing container and sample that need to be checked are used for the specific gravity study. The empty weight is first registered and classified as w1. Then, up to a third of its volume, the particular gravity bottle is filled with kerosene and then weighedandreportedasw4inweightThentheparticularGravityBottleisfilledwithcement and weighed and reported as w2. Then you fill the remaining two thirds with kerosene and thenweightthebottleandweightw3.Thefollowingtheoremthenindicatesthebasicgravity of cement.

Fig7:SpecificGravityTestonCement

3.4 AGGREGATES

Aggregates are inter granular materials such as sand, gravel, or crushed stone that, along withwaterandPortlandcement,areanessentialingredientinconcrete.Foragoodconcrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that cloud cause the deterioration of concrete. Aggregates, which account for60 to 75 percent of thetotalvolumeofconcrete,aredivided into two distinct categories- fine and coarse. Fine aggregates generally consist of natural sandorcrushedstonewithmostparticlespassingthrougha3/8-inchsieve.Coarseaggregate are any particles greater than 0.19inch, but generally range between 3/8 and 1.5 inches in diameter.

Naturalgravelandsandareusuallydugfromapit,river,lake,orseabed.Crushedaggregate is produced by crushing quarry rock, boulders, cobbles, or large size gravel. Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular sub- bases, soil-cement, and in new concrete.

Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregate is a important process. Although some variation in aggregate properties is expected, characteristics that are considered include

- Grading
- Durability
- Particleshapeandsurface texture
- Abrasionandskidresistance
- Unitweightandvoids
- Absorptionandsurfacemoisture

3.4.1 (A)COARSE AGGREGATES

Coarseaggregateareparticlesgreaterthan4.74mm,butgenerallyrangebetween9.5mmto

37.5mm in diameter. They can either be form primary, secondary or recycled sources. Primary, or virgin, aggregate is either land-marine-won. Gravel is a coarse marine-won aggregate; land-won coarse aggregate includes gravel and crushed rock. Gravels constitute themajorityofcoarseaggregateusedinconcretewithcrushedstonemakingupmostoftheremainder.Secondaryaggregatearematerialswhicharetheby-productofextractiveoperationsandare derived from a very wide range of materials.Recycled concrete is a variable source of aggregate and has been satisfactorily used in granularsub-basessoilcementandinnewconcrete.Recycledaggregateisclassifiedintwo way, as

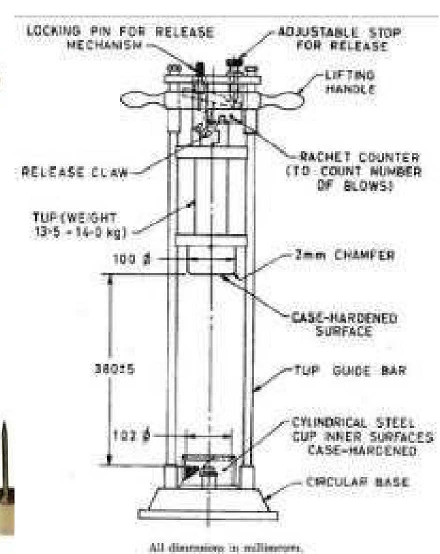
3.4.2 TestsonCorseAggregate

Testsconductedonthenaturalcoarseaggregateareasfollows:-

1) AggregateImpactValuetest
2) AggregateCrushingValuetest
3) SpecificGravityandWaterabsorptiontest
4) LosAnglesAbrasionTest

3.4.3 AggregateImpactValueTest

This test is carried out



in order to create the resistance to the impact by the gross aggregate (suddenorshockloads).Thecrusheddevicewillmovethroughthe ISSieve2.36mm.Effect values as the amount of aggregates going through the sieve is determined by the original weight of the aggregates. The testing machine consists of a metal base with lower surface supportedonthefirmstructure.Ametalhammerweighing13.5kgto14kgwithadiameter of10cmisfastenedwith adepthof5cmwithalowerendoftherollingcylindricalformin orderthatthecylindrical hammerismountedonverticalguidesandthefallingheightofthehammer is 380 mm. A rod with a diameter of 10mm and a length of 230mm is used and roundedononeend.The0.1gmprecisionandISdisplaysaremeasured12.5mm,10mmand 2,36mm and an internal 10.2cm and 5cm depth cup with a separable cylindrical cup is mounted centrally in the base plate. The research sample contains 12.5mm of aggregates, which are held on the 10mm sieve and oven dried at 1000C to 1100C and cooled at room temperature.Theaggregatesarethenfilledinthree-layermeasurementcylinderseachat1/3 ofthecylinderdepth andcompactedwiththetampingrodby25shocksforeachlayer,with thetampingrodeventuallycompletingthesurface.The weightisassessedas(W1)ingrams andtheaggregatesfilledinthemeasurementcylinderaremeasured.Theaggregatesarethen filled in detachable cylinder which is placed on base plate. Then the compaction is done by releasing the hammer from its hook by releasing the hammer for 15 times from a height of 380mm.Afterthatthematerialisremovedandsievedthrough2.36mmsieve.Theweightofaggregates which are passing through 2.36mm sieve is taken and noted as (W2) in grams. Then the impact value is calculated by using the formula

$$Impact\ Value = W2/W1*100$$

Impact value is expresses as in %
Where,W1=Aggregatesampleweight
W2=Aggregatepassingthrough2.36mmsieveweight

Figure8:Impactvaluetestapparatus

3.4.4 AggregateCrushingValue

The crushing value check is carried out to establish the aggreement resistance to crushing loads, which provides the relative resistance to crusting with a compression load progressively being applied. A square base plate on the base of the cylinder with a steel cylindricalendwithaninnerdiameterof152mmandas cubaplungerwitha150mmpiston and an opening for raising and positioning the plunger in the cylindrical. A balancing of necessary capability and a precision of up to 1gm. A 16mm diameter tamping rod, 600mm long and with a rounded end. Diameter 115mm and height 180mm cylindrical measure. IS screens with the following aggregates: 12.5mm, 10mm and 2.36mm. A compression test systemabletoapplya400KNloadatarateof4tonsperminute.Thetestsampleismadeof 12,5mm checked aggregates that are held on a 10mm sieve and dried on 1000C to 1100C and cooled at room temperature. This sample is then put in a three-layer steel measuring cylinderwithonethirdofacylinderdepthandarodoftampingwith25blowsperlayer.The weight of the full unit is weighted and specified as W1 gm in the measuring cylinder. The sample is then put on top by raising the plunger onto the rod in a cylindrical stel with open endsandasquarebaseplate.Thedeviceisthenmounted onthecompressiontestingmachine loadingboardandtheloadisprogressivelyappliedat4t

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onsperminute.Thesolutionisthen taken and the damaged sample is tamed through a sieve of 2.36mm. Weighed and noted as W2gm is the weight of the sample that passes through 2.36mm sieve. The value of the crushing is computed using the formulation

$Crushing\ Value = W2/W1*100$

Aggregatecrushingvalueisexpressedin%

W1=aggregatesampleweightingms

W2=samplepassingthrough2.36mmsieveweightin gms

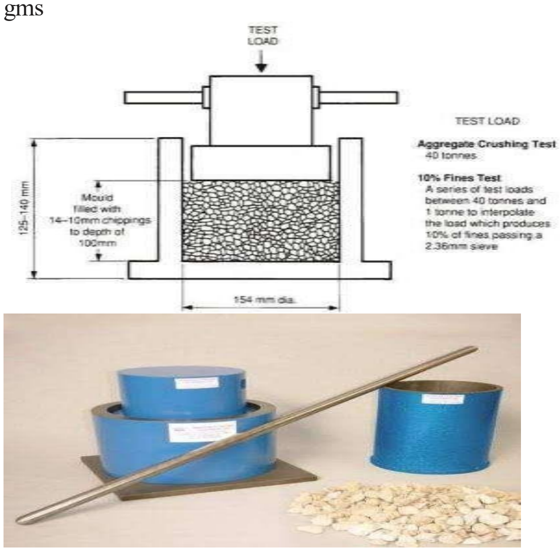

Figure9:CrushingValuetestapparatus

3.4.5 Specificgravityandwaterabsorptiontest

Theratioofthevolumeoftheaggregatestothevolumeo fthewaterisspecifiedinaspecial seriousness. The weighting balance of a coarse aggregate up to 0.5 kg precision, for measuringthesampletonomorethan3kg,shallbethefo llowingtoassesstheexactintensity and water absorption. A thermostat-controlled oven to maintain a water filling and

basket temperature of 1000C to 1100C and a bucket. A wire basket of steel with a mesh of not more than 6.3mm for suspension. Soft tray and clothes to dry the aggregate paper. A dust-free sample of 2kg of aggregates is taken and placed in a wire basket. The pan is then submerged in a water bucket, ensuring that 5cm of water is preserved over the aggregates. Thetrappedairisseparatedfromthesampleshortlyafte rimmersionandthecanisterislifted and immersed at a rate of one drop per second. During immersion into water with a temperatureof220Cto320C,aweightofbasketwiththe aggregatesismeasuredandnoted as W1gms. Then the aggregates and the basket are separated. By using absorbent clothes, thesamplesurfaceiscleaned.Theemptied basket isthenreturned25times andweightedto the water source. W2 gms are observed. After drying with absorbent fabrics, the aggregate is weighed and specified in W3 gms. The sample is then dried into the oven with a temperatureof110^{0}Cfor24hours,thesampleweightis weighedafterremovalandreported as W4 gms. Then a formula measure the specified gravity and water absorption.

Specificgravity={w3/[w3 -(w1-w2)]} Water absorption= [(w3-w4)/w4] *100

W1 =standardaggregate suspended in water weight

W2 = basket suspended in water weight

W3 =saturated surfacedry aggregates in air weight

W4= oven dried aggregates weight

Figure10:SpecificgravityandWaterabsorptiontestapparatus

Figure11:Losangelsabrasiontestapparatus

3.4.6 LosAngelesabrasiontest

The abrasion test in Los Angeles is used to assess the tolerance of the aggregates to decompositionordeterioration.Thatis,thehardnessto wearundercrushingorimpactloads against surfaces can be determined. The abrasion test losangles is based on the idea that regularsteelballscombinedwithadditionalmaterialsa ndrotatedindrumareusedtocreate abrasive activity for certain revolutions creating aggregate wear and wear. The wear percentageismeasuredasaLosAngelesabrasionvalue duetotherubbingactionofballsof steel.Anabrasionmeasuringunit,NormISsheetswiths caleof1.7mm(2.36mm),1.7mm (4.75 mm), 12.5 mm (10.23 mm), 25 mm (25 mm), 40 mm (12.3 mm) and a weighting balance of volume 5 to 10 kg (3.5 to 10 mm), drying oven (6 to 10 times) of cast-iron and steelballsandaweightof390to445gram(12to10years);.Thetestspecimeniscomposed ofacleansampledriedintheoven from1050Cto1100Candasamplewhichgoesthrough a sieve of 12.5mm and is held on a strap of 10mm. The sample is selected according to degree. ForgradesA, B,CandD,takesamplesof5kgandforgradesE, FandG.Basedon the grading of aggregates, the abrasive charge of steel balls is chosen. The aggregates and stainless steel balls are mounted in the drum and the shield is fixed. The engine is starting with 30 to 33 turns per minute, that is, 500 for grades A, B, C and D and 1000 turns for gradesE, FandG.Thesampleistakenoutofthedrumandsieved witha1.7mm sieveafterthecompletionoftherevolutions and theweight of thesampleis weighed 1.7mm by theIS sieve and registered in W2gms.

$$AbrasionValue = W2/W1*100$$

W1isWeightofthesampletakenandW2isWeightofth esamplepassing1.7mm sieve

Table3:TestResultsofCoarseAggregate

S.no	Test	Result
1	ImpactValue	27.51%
2	CrushingValue	25.28%
3	SpecificGravity	2.6
4	Bulk Density	1600 kg/m^3
5	Finenessmodulus	6.81

TABLE4:GRADATION OFCOARSE AGGREGATE

SieveSize (mm)	ntageweight retained	Cumulative percentageweight retained	Cumulative percentagepassing
40	0	0	100
20	0.5	8	92
10	3.2	63.5	36.4
4.75	1.5	98	2
2.36	0.12	100	0

3.5 FINEAGGREGATES

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregate generally consists of natural sand or crushed stone with most particles passing through a 4.75mm sieve, as with coarse aggregate these can be from

SieveSize (mm)	Percentageweightretained	Cumulative percentageweight retained	Cumulative percentagepassing
10	0	0	100
4.75	2	2	98
2.36	4.5	6	94
1.18	24	29	71
0.6	35	64	36
0.3	25	88	12
0.15	11.0	99.5	0.5

primary, secondary or recycled sources.

TABLE5:GRADATIONOFFINEAGGREGATE

RESULTSANDDISCUSSIONS

3.3.1 CompressiveStrength

Compressive cement strength is measured by a compressive strength test on the compacted cylindricalpiecesusingaregulartampimgprocedure. Forcementmortarpreparation,regular sandisused.Vibrationunit,tampingrod,pavementmould,balancingtheequipmentusedto measure.TheRectangularmouldvolumeis70.6to70.6to70.6to70.6cm.Take200grams of cement and 600 grams of normal sand and dry fully. Then apply [(P/4)+3] % of water to the dry mix ofcement and sand (with normal consistency P) and mix vigorously for at least 3 minutes to produceaconsistentcolourmixture.Ifaconsistentcolourofthemixevenin4 minutesdoesnotproducethemixrejectsandmixesfreshamountsofcement,sandandwater in order to obtain a uniform colour. Compose and vibrate the mould at a required speed of 12000±400 per minute at a complete compaction with whole amounts of mortar using a fitting hopper mounted to the top ofthemould. Remove the mould from the press and hold for24hoursatatemperatureof27±20Candarelativemoisturecontentof90%.Removethe Rectangularfromthemouldandimmerseitinfresh,cleanwaterattheendof24hours.And duringcheckingwouldtheRectangularberemovedfromthebath.PlacethetestRectangular without packaging between the Rectangular and the test plates on the compressive test.

Fig6:CementCylinderforCompressiveStrengthTest

Applytheloadcontinuouslyandevenlyatarateof140Kg/cm2/minstartingfromzero.The compressive power of the specimen in the Contact Region (A) is measured as the ultimate load (P).

$$\boldsymbol{Compressivestrength} = \mathbf{P/A}$$

3.3.2 SpecificGravity

Normally, specific gravity is known as a ratio of the weight of a certain material volume to the weight of equivalent water volume. Kerosene that does not react with cement is used to assess the basic gravity of cement. Basic gravity bottles with capacity of 50 mL, kerosene, weighting balance and weighing container and sample that need to be checked are used for the specific gravity study. The empty weight is first registered and classified as w1. Then, up to a third of its volume, the particular gravity bottle is filled with kerosene and then weighedandreportedasw4inweightThentheparticularGravityBottleisfilledwithcement and weighed and reported as w2. Then you fill the remaining two thirds with kerosene and thenweighthebottleandweightw3.Thefollowingtheoremthenindicatesthebasicgravity of cement.

Fig7:SpecificGravityTestonCement

3.4

3.5 AGGREGATES

Aggregates are inter granular materials such as sand, gravel, or crushed stone that, along withwaterandPortlandcement,areanessentialingredientinconcrete.Foragoodconcrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that cloud cause the deterioration of concrete. Aggregates, which account for60 to 75 percent of thetotalvolumeofconcrete,aredivided into two distinct categories- fine and coarse. Fine aggregates generally consist of natural sandorcrushedstonewithmostparticlespassingthrougha3/8-inchsieve.Coarseaggregate are any particles greater than 0.19inch, but generally range between 3/8 and 1.5 inches in diameter.

Naturalgravelandsandareusuallydugfromapit,river,lake,orseabed.Crushedaggregate is produced by crushing quarry rock, boulders, cobbles, or large size gravel. Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular sub- bases, soil-cement, and in new concrete.

Aggregates strongly influence concrete’s freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregate is a important process. Although some variation in aggregate properties is expected, characteristics that are considered include

- Grading
- Durability
- Particleshapeandsurface texture
- Abrasionandskidresistance
- Unitweightandvoids
- Absorptionandsurfacemoisture

3.5.1 (A)COARSE AGGREGATES

Coarseaggregateareparticlesgreaterthan4.74mm,butgenerallyrangebetween9.5mmto

37.5mm in diameter. They can either be form primary, secondary or recycled sources. Primary, or virgin, aggregate is either land-marine-won. Gravel is a coarse marine-won aggregate; land-won coarse aggregate includes gravel and crushed rock. Gravels constitute themajorityofcoarseaggregateusedinconcretewithcrushedstonemakingupmostoftheremainder.

Secondaryaggregatearematerialswhicharetheby-productofextractiveoperationsandare derived from a very wide range of materials.

Recycled concrete is a variable source of aggregate and has been satisfactorily used in granularsub-basessoilcementandinnewconcrete.Recycledaggregateisclassifiedintwo way, as

3.5.2 TestsonCorseAggregate

Testsconductedonthenaturalcoarseaggregateareasfollows:-

1) AggregateImpact Valuetest
2) AggregateCrushingValue test
3) Specific Gravityand Water absorptiontest
4) LosAnglesAbrasionTest

3.5.3 AggregateImpactValueTest

This test is carried out in order to create the resistance to the impact by the gross aggregate (suddenorshockloads).Thecrusheddevicewillmovet hroughtheISSieve2.36mm.Effect values as the amount of aggregates going through the sieve is determined by the original weight of the aggregates. The testing machine consists of a metal base with lower surface supportedonthefirmstructure.Ametalhammerweigh ing13.5kgto14kgwithadiameter of10cmisfastenedwith adepthof5cmwithalowerendoftherollingcylindricalf ormin orderthatthecylindrical hammerismountedonverticalguidesandthefallinghe ightofthe

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$Impact\ Value = W2/W1*100$

Impact value is expresses as in %
Where,W1=Aggregatesampleweight
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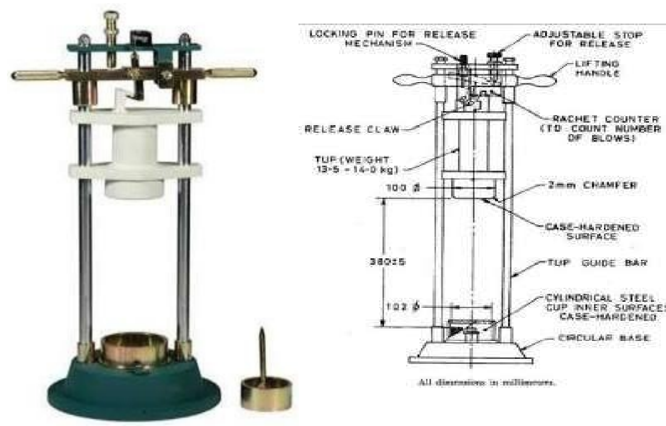
Figure8:Impactvaluetestapparatus



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Aggregatecrushingvalueisexpressedin%

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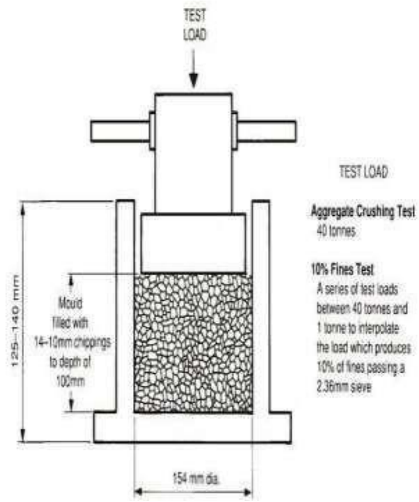

Figure9:CrushingValuetestapparatus

3.5.5 Specificgravityandwaterabsorptiontest

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basket temperature of 1000C to 1100C and a bucket. A wire basket of steel with a mesh of not more than 6.3mm for suspension. Soft tray and clothes to dry the aggregate paper. A dust-free sample of 2kg of aggregates is taken and placed in a wire basket. The pan is then submerged in a water bucket, ensuring that 5cm of water is preserved over the aggregates. Thetrappedairisseparatedfromthesampleshortlyafte rimmersionandthecanisterislifted and immersed at a rate of one drop per second. During immersion into water with a temperatureof220Cto320C,aweightofbasketwiththe aggregatesismeasuredandnoted as W1gms. Then the aggregates and the basket are separated. By using absorbent clothes, thesamplesurfaceiscleaned.Theemptied basket isthenreturned25times andweightedto the water source. W2 gms are observed. After drying with absorbent fabrics, the aggregate is weighed and specified in W3 gms. The sample is then dried into the oven with a temperatureof110^{0}Cfor24hours,thesampleweightis weighedafterremovalandreported as W4 gms. Then a formula measure the specified gravity and water absorption.

Specificgravity={w3/[w3 -(w1-w2)]} Water absorption= [(w3-w4)/w4] *100

W1 =standardaggregate suspended in water weight

W2 = basket suspended in water weight

W3 =saturated surfacedry aggregates in air weight

W4= oven dried aggregates weight

Figure10:SpecificgravityandWaterabsorptiontestapparatus

3.5.6 LosAngelesabrasiontest

The abrasion test in Los Angeles is used to assess the tolerance of the aggregates to decompositionordeterioration.Thatis,thehardnessto wearundercrushingorimpactloads against surfaces can be determined. The abrasion test losangles is based on the idea that regularsteelballscombinedwithadditionalmaterialsa ndrotatedindrumareusedtocreate abrasive activity for certain revolutions creating aggregate wear and wear. The wear percentageismeasuredasaLosAngelesabrasionvalue duetotherubbingactionofballsof steel.Anabrasionmeasuringunit,NormISsheetswiths caleof1.7mm(2.36mm),1.7mm (4.75 mm), 12.5 mm (10.23 mm), 25 mm (25 mm), 40 mm (12.3 mm) and a weighting balance of volume 5 to 10 kg (3.5 to 10 mm), drying oven (6 to 10 times) of cast-iron and steelballsandaweightof390to445gram(12to10years);.Thetestspecimeniscomposed ofacleansampledriedintheoven from1050Cto1100Candasamplewhichgoesthrough a sieve of 12.5mm and is held on a strap of 10mm. The sample is selected according to degree. ForgradesA, B,CandD,takesamplesof5kgandforgradesE, FandG.Basedon the grading of aggregates, the abrasive charge of steel balls is chosen. The aggregates and stainless steel balls are mounted in the drum and the shield is fixed. The engine is starting with 30 to 33 turns per minute, that is, 500 for grades A, B, C and D and 1000 turns for gradesE, FandG.Thesampleistakenoutofthedrumandsieved witha1.7mm sieveafterthecompletionoftherevolutions and theweight of thesampleis weighed 1.7mm by theIS sieve and registered in W2gms.

$AbrasionValue = W2/W1*100$

W1isWeightofthesampletakenandW2isWeightofth esamplepassing1.7mm sieve

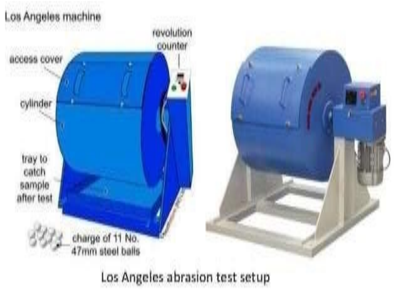


Figure11:Losangelsabrasiontestapparatus
Table3:TestResultsofCoarseAggregate

S.no	Test	Result
1	ImpactValue	27.51%
2	CrushingValue	25.28%
3	SpecificGravity	2.6
4	Bulk Density	1600 kg/m^3
5	Finenessmodulus	6.81

TABLE4:GRADATION OFCOARSE AGGREGATE

SieveSize (mm)	ntageweight retained	Cumulative percentageweight retained	Cumulative percentagepassing
40	0	0	100
20	0.5	8	92
10	3.2	63.5	36.4
4.75	1.5	98	2
2.36	0.12	100	0

3.6 FINEAGGREGATES

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregate generally consists of natural sand or crushed stone with most particles passing through a 4.75mm sieve, as with coarse aggregate these can be from primary, secondary or recycled sources.TABLE5:GRADATIONOFFINEAGGREGATE

SieveSize (mm)	ntageweightretained	Cumulative percentageweight retained	Cumulative percentagepassing
10	0	0	100
4.75	2	2	98
2.36	4.5	6	94
1.18	24	29	71
0.6	35	64	36
0.3	25	88	12
0.15	11.0	99.5	0.5

TABLE9: Resultsfor14dayscuringanddifferentthicknesspavementsofPSCfor0.55 W/C ratio:

S.No	Thicknessofpavement(mm)	Reboundnumberstrength(N/mm^2)	Compressivestrength
1	100	20	18.12
2	125	20	18.36
3	150	22	20.88
4	175	23	21.90
5	200	24	22.52

TABLE10:Resultsfor28dayscuringanddifferentthicknesspavementsofPSCfor0.55 W/C ratio:

	Thicknessofpavement(mm)	Reboundnumberstrength(N/mm^2)	Compressivestrength
1	100	23	20.01
2	125	22	19.36
3	150	26	22.88
4	175	28	24.90
5	200	29	25.52

Table 9 & 10indicates the rebound number, ultrasonic pulse velocity and compressive strength of 0.55 w/c ratio for 14 & 28 curing days after adding super plasticizer. The maximumstrengthAcquiredfor0.55w/cratioisat28daysforbothNDTandDTbyadding 0.35%ofsuperplasticizerThenon -destructivetest results having slight variation on both RH and UPV as compared to Destructive test (CTM).

TABLE11:Resultsfor14dayscuringanddifferentthicknesspavementsofPSCfor0.45 W/C ratio:

	Thicknessofpavement(mm)	Reboundnumber strength(N/mm^2)	Compressivestrength
1	100	24	21.63
2	125	22	20.67
3	150	24	21.34
4	175	23	22.62
5	200	24	23.18

TABLE12:Resultsfor28dayscuringanddifferentthicknesspavementsofPSCfor0.45 W/C ratio:

	Thicknessofpavement(mm)	Reboundnumberstrength (N/mm^2)	Compressive strength
1	100	28	24.36
2	125	27	23.76
3	150	27	24.03
4	175	28	25.2
5	200	29	25.81

Table 11 & 12 indicates the rebound number, ultrasonic pulse velocityand compressive strength of 0.45 w/c ratio for 14 & 28 curing days after adding super plasticizer. The maximum strengthAcquiredfor0.45w/cratioisat28daysforboth NDTand DTbyadding 0.25%ofsuperplasticizerThenon-destructivetestresultshavingslightvariationonbothRH and UPV as compared to Destructive test (CTM).

TABLE13:Resultsfor14dayscuringanddifferentthicknesspavementsofPSCfor0.35 W/C ratio:

S.No	Thicknessofpavement(mm)	Reboundnumberstrength(N/mm^2)	Compressivestrength
1	100	23	21.31
2	125	20	19.47
3	150	23	21.40
4	175	26	22.25
5	200	27	23.63

TABLE14:Resultsfor28dayscuringanddifferentthicknesspavementsofPSCfor0.35 W/C ratio:

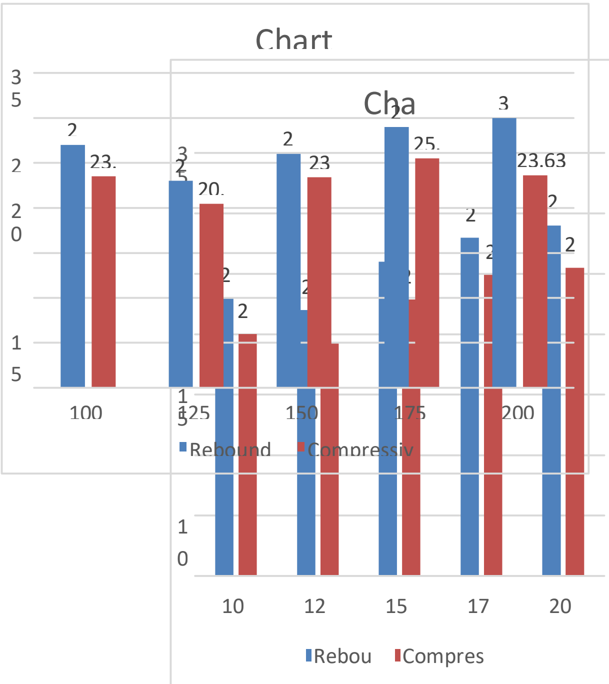
	Thicknessof pavement(mm)	Rebound numberstrength(N/mm^2)	Compressivestrength
1	100	27	23.49
2	125	23	20.47
3	150	26	23.4
4	175	29	25.52
5	200	30	27.3

Table13&14indicatesthereboundnumber,ultrasonic pulsevelocityandcompressivestrengthof 0.35w/cratiofor14&28curingdaysafteraddingsuper plasticizer.ThemaximumstrengthAcquired for 0.35 w/c ratio is at 28 days for both NDT and DT by adding 0.2% of super plasticizer.

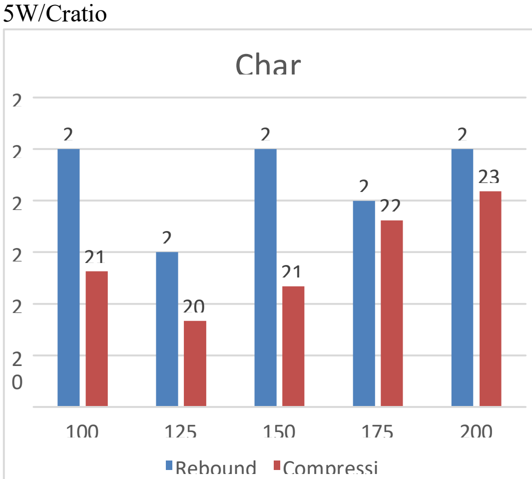
The non - destructive test results having slight variation onRH as compared to Destructive test (CTM).Amongallthreewater-cementratios0.35havinghighstrengthforallNDTand DTtestsat all curing ages (days).

TheBelowGraphsIndicatesThicknessonX-axisandCompressiveStrengthonY-axis

Resultsfor14dayscuringanddifferentthicknesspavementsofPSCfor0.55W/Cratio



Resultsfor28days curinganddifferentthicknesspavementsofPSCfor0.55W/Cratio



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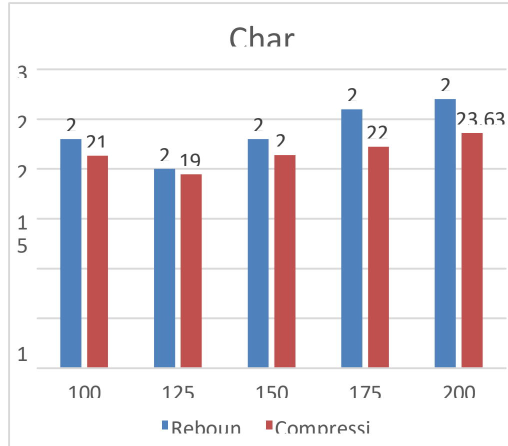

Resultsfor14dayscuringanddifferent thicknesspavementsofPSCfor0.35W/Cratio

Resultsfor28dayscuringanddifferent thicknesspavementsofPSCfor0.35W/Cratio

CONCLUSIONS

The following conclusions are drawn from the results considering the strength characteristics of concrete made with adding of super plasticizer in different w/c ratios.

- Asaresultoftheexperimentalstudychemicaladmixturefordifferentw/cratios is determined which is used to maintain workability at any temperature.
- Theobtainedresultsshowsthatslightdifferencebetween OPC,PPCandPSC. But the maximum strength obtained for OPC for all w/c ratios.
- Thefinalmixdesignsforw/cratiosof0.55,0.45and0.35areM25,M30&M35 by taking average compressive strength from the graphs.
- Non-destructive tests are very convenient and can be executed anywhere but these tests have their own limitations and these limitations may result in unavoidable errors which can't be eliminated totally. Applying proper correction factor is a must to get the reliable results.
- Highstrength is adoptedat0.35 w/cratioforallconcretes.

REFERENCES

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