STATIC & DYNAMIC BEHAVIOR OF RUBBERIZED CONCRETE

This project report is submitted to

Yeshwantrao Chavan College of Engineering
[An Autonomous Institution Affiliated to Rashtrasant Tukdoji Maharaj Nagpur University]

In partial fulfilment of the requirement
For the award of the degree

Of
Bachelor of Engineering in Civil Engineering

By

Janvi Sarode
Shivani Namojwar
Vaidehi Bansod
Aniket Koparkar
Sarang Bhimanwar
Tejas Tipale

Under the guidance of
Prof. D. G. Agrawal

DEPARTMENT OF CIVIL ENGINEERING
Nagar Yuwak Shikshan Sanstha's
YESHWANTRAO CHAVAN COLLEGE OF ENGINEERING,
NAGPUR – 441 110
(An Autonomous Institution affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur)

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CERTIFICATE OF APPROVAL

Certified that the project report entitled **"STATIC & DYNAMIC BEHAVIOR OF RUBBERIZED CONCRETE"** has been successfully completed by **JANVI SARODE, SHIVANI NAMOJWAR, VAIDEHI BANSOD, ANIKET KOPARKAR, SARANG BHIMANWAR , TEJAS TIPALE,** under the guidance of **Prof. D. G. AGRAWAL** in recognition to the partial fulfilment for the award of the degree of Bachelor of Engineering in Civil Engineering, **Yeshwantrao Chavan College of Engineering** ***(An Autonomous Institution Affiliated to Rashtrasant Tukdoji Maharaj Nagpur University)***

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Prof. D. G. Agrawal
(Project Guide)

Signature
Prof. S. K. Kamble
(Coordinator, CE Dept.)

Signature
Dr. S. P. Raut
(HOD, CE Dept)

DECLARATION

We certify that

a. The work contained in this project has been done by us under the guidance of my supervisor[s].
b. The work has not been submitted to any other Institute for any degree or diploma.
c. We have followed the guidelines provided by the Institute in preparing the project report.
d. We have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.
e. Whenever we have used materials [data, theoretical analysis, figures, and text] from other sources, we have given due credit to them by citing them in the text of the report and giving their details in the references. Further, we have taken permission from the copyright owners of the sources, whenever necessary.

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We wish to express our immense gratitude and thanks to our Principal **Dr. U. P. Waghe** for their co-operation, understanding and goodwill.

At last but not the least we are very much thankful to all the staff members of Civil Engineering department for their direct or indirect help towards the completion of his project.

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ABSTRACT

The construction industry is one of the major industries in the world and concrete is an important part of the construction industry. Tire waste is a major threat to the environment and dumping in landfills can lead to various problems such as fire, breeding ground, land waste, etc. Therefore, if tire waste can be used in the construction industry, it will help reduce pollution. This can help reduce construction costs. For M60 grades of concrete, rubber fibers is added in different percentages [0%, 5%, 10%, 15%, 20%] of fine aggregates. Features like, Compressive Strength, Flexural Strength, Split Tensile Strength ,Cylindrical Compressive Strength are found and compare with control mix of M60 concrete. Split tensile strength was found to be greater than 0% replacement of sand by rubber fiber . Flexural strength increases up to a certain percentage of substitution and then decreases. In terms of compressive strength, flexural strength increases significantly with 10% substitution.

KEYWORDS : Rubberized Concrete , Sand Replacement (0 % ,5 % ,10 % , 15 % , 20 %) ,Workability, Compressive Strength , Split Tensile Strength , Flexural Strength

Thrust Area: Structural Analysis and Construction Materials

CO-PO Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO-1	PSO-2	PSO-3
CO-1	Illustrate a sound technical knowledge of their selected project topic.	3	3		2	2				2				3		
CO-2	Write problem identification, formulation and solution.		3	3	3	2				2		2		3		
CO-3	Design engineering solutions to complex problems utilizing a systems approach	3			3	3	2	3	2	2				3		
CO-4	Express effectively to discuss and solve engineering										3		2			1

CHAPTER 1

INTRODUCTION

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INTRODUCTION

1.1 Overview

Hazardous waste is generated and accumulated in large quantities nowadays. Tyre rubber is one of the wastes which is continuously increasing all over the world. It is difficult for municipal authorities to store and dispose the waste tyres generated from vehicles. In many countries municipal authorities have banned dumping of waste tyres into the landfills due to its non-decaying nature as it causes serious environmental problems. Over last two decades it has been seen that there is an exponential rise in number of motor vehicles. According to the report of World Health Organization 53% of motorized vehicles are in middle-income countries and only 46% are in high income countries. The tire industry is the largest consumer of natural rubber and is estimated to be currently consuming of about 12 billion tones [WHO 2015] or two-thirds of the world's production of natural rubber in the financial year of 2016-17[Tinna Rubbers 2017].About 1.5 billion of waste tire rubber is generated globally and 40% of them in emerging markets such as China, India, South Africa, South Asia, South America and Europe. In India around 0.6 million tons of scrap tire is generated annually. Annually 285 million scrap tires are added to stockpiles, landfills or illegal dumps across the United States. The United States of America is been the largest producers of waste tyre globally, an estimate of about 290 million a year.

1.2 Literature Survey

Scenario in India: -India generates about 1.5 million tons of ELT per year. Only 450,000 tons is recycled by the formal sector. The tire recycling industry in India is largely informal. It is hard to put the exact number of current volume and scale of recycle due its informality. While the tires which are made of high quality rubber are considered as a large potential source of raw material for the rubber industry. In 2011, India produced 90,000 metric tons of reclaimed rubber from waste tires [Mishra 2016]. The Indian rubber recycling industry is fixed to be second in Asia. In India there is no monitoring on tire disposal. Estimates vary across sources and are broadly based on the production and supply of tires. It has been estimated that tire industries are growing every year at the rate of 12% and hence increase in waste volume simultaneously. India current produces about 6,50,000 tires and discards 2,75,000 every day. Annually over 1.6 billion new tyres are generated and around 1 billion of waste tires are generated. However, the recycling industry processed only 100 million tires every year. India's contribution to global ELTs waste is 6% of the total. Overall about 60% of waste tyres end up being dumped and/or incinerated, causing land pollution in both urban and rural areas (Gupta, Chopra and Kumar 2013). India also imports millions of waste tyres from other countries which get used in the pyrolysis industry. About 300,000 tonnes of tyres gets imported every year from countries like Australia.

Due to increasing problem of waste tyre it is important to dispose or use it in wise manner. One of the use of waste rubber is in construction industry. Also nowadays due to increase in construction, ,resources are over exploited for sand which in turn has resulted in degradation in quality of sand as well as increase in price of sand therefore various material are being studied as replacement of aggregate. Crumbed rubber is one of the materials which can be used as replacement for aggregate.

Present scenario of tyre waste in India & World :-

Every year, over one billion tyres are manufactured worldwide, and equal number of tyres are permanently removed from vehicles, becoming waste. The U.S. is the largest producer of waste tyres, about 290 million a year, although increases in new vehicles sales in China and India are rapidly contributing to waste tyre volumes. Although modern tyres are fundamentally rubber products, they are a complex mix of natural and synthetic rubbers, and various structural reinforcing elements including metals and chemical additives.

In the world, India is the third largest producer, fourth largest consumer of natural rubber and fifth largest consumer of synthetic rubber. It is estimated that 13.5 million tonnes of tyres are scrapped every year out of which 40 % come from emerging markets such as China, India, South America, Southeast Asia, South Africa and Eastern Europe. It is found that annually, about a Million Tons (about 10 Lakh Tons) of scrap tyres are available in India, and this figure is increasing in leaps and bounds as the vehicle numbers in the passenger, commercial and industrial sectors in India too are catching up to the Western levels . The disposal of waste tyre has become a major environmental concern globally. Globally, in 2011, only 7% of waste tyres were recycled on site, 11% were burned for fuel, 5% were exported for processing elsewhere. The remaining 77%

were sent to landfills, stockpiled, or illegally dumped; the equivalent of some 765 million tyres a year wasted.

India's waste tyres account for about 6-7% of the global total. With the local tyre industry growing at 12% per annum, waste volumes are rising. India has been recycling and reusing waste tyres for four decades, although it is estimated that 60% are disposed of through illegal dumping. Despite this, India is the second largest producer of reclaimed rubber after China. In 2011, India produced 90,000 metric tonnes of reclaimed rubber from waste tyres.

Ref: https://www.researchgate.net/publication/273697291_Pyrolysis_of_waste_tyres_and_future
https://www.thehindu.com/business/Turning-waste-tyre-into-%E2%80%98green-steel%E2%80%99/article14518524.ece

1.3 Problem Statement

River sand is the universally accepted constituent of concrete as a fine aggregate, but almost every part of world is facing the acute shortage of sand as it is the natural resource. Along with this the cost for fine aggregate is also increasing every day which directly affects the cost of construction. Extraction of sand from river beds also affects the environment and the aquatic life of that specific river. In concern to problem of availability of fine aggregate, concrete industry is in need to invent an alternative in partial or as complete replacement of sand. On the other hand, the disposal/ landfilling of End-of-Life Tyres [ELT] is also a major problem for developed and developing countries. Utilization of rubber as partial replacement of fine/ coarse aggregate can be the viable solution for both the above-mentioned problems. Previous experimental work was carried out on rubber fibers treated with NaOH for mini project. Now, the rubber fiber is used as partial replacement of fine aggregate with pre-treatment of rubber fibers by NaOH and HCL separately .

1.4 Thesis Objectives

- Comparison of results between NaOH & HCL pretreated rubberized concrete
- To determine physical and mechanical properties of rubberized concrete
- To determine the flexural behavior of rubberized concrete

- □ To determine split tensile strength of rubberized concrete
- □ To determine the non-destructive properties of rubberized concrete
- □ To determine the result by simulation of rubberized concrete.

1.5 Civil Engineering Applications of Recycled Rubber from Scrap Tyres

Subgrade Insulation for Roads - Excess water is released when subgrade soils thaw in the spring. Placing a 15 to 30 cm thick tire shred layer under the road cab prevents the subgrade soils from freezing in the first place. In addition, the high permeability of tire shreds allows water to drain from beneath the roads, preventing damage to road surfaces [ASTM D6270-98].

Subgrade Fill and Embankments - Tire shreds can be used to construct embankments on weak, compressible foundation soils. Tire shreds are viable in this application due to their light weight. For most projects, using tire shreds as a lightweight fill material is significantly a cheaper alternative. [Tires manufacture's Association, 2003]

Waste Tyre Rubber in Concrete - Waste tyres have been used to partially replace the aggregates in concrete. Rubberized concrete are very weak in compressive and tensile strength. But they have very good deformation properties. Concrete with tire rubber waste has higher set deformations than non-rubberized concrete. Ultimate strains on concrete failure load are higher for concrete with tyre rubber waste additive. Due to this, rubberized concrete provides high impact resistance. This behavior is beneficial for structures which require good impact resistance properties.

Backfill for Walls and Bridge Abutments - Tire shreds can be useful as backfill for walls and bridge abutments. The weight of the tire shreds reduces horizontal pressures and allows for construction of thinner, less expensive walls. Tire shreds can also reduce problems with water and frost build-up behind walls because tire shreds are free draining and provide good thermal insulation. Recent research has demonstrated the benefits of using tire shreds in backfill for walls and bridge abutments. [Tires manufacture's Association, 2003].

Waste Tyre Rubber in Precast Concrete - The use of waste tyre in precast concrete provides lightweight panels, which can be transported quicker and easier. These precast lightweight panels are nonconductor of both noise and electricity. Due to this, these panels are use in offices and houses as non-load bearing walls/ partition walls. Waste tyre rubber also use in precast roofs for green building due to its heat resisting property.

Waste Tyre Rubber in Asphalt Mixtures - Waste tyre rubber can be used as substitutes for natural aggregates or as bitumen modifiers in asphalt mixtures. There are two ways of producing rubberized asphalt mixtures viz. wet method & dry method. In the wet process, rubber 61 Jagmeet Singh & Jaspal Singh Impact Factor [JCC]: 5.9234 NAAS Rating: 3.01 particles are mixed with bitumen at elevated temperature prior to mixing with the hot aggregates; whereas in the dry process, rubber particles replace a small portion of the mineral aggregate in the asphalt mix before the addition of the bitumen. The use of waste tyre rubber in asphalt mixtures reduces fatigue cracking, requiring less maintenance compared to conventional mixtures.

Landfills- Landfill construction and operation is a growing market application for tire shreds. Scrap tire shreds can replace other construction materials that would have to be purchased. Scrap tires may be used as a lightweight 18 backfill in gas venting systems, in leachate collection systems, and in operational liners. They may also be used in landfill capping and closures, and as a material for daily cover. [Tires manufacture's Association, 2003].

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

REVIEW OF LITERATURE

2.1 Overview

Najib N. Gerges, Camille A. Issa, Samer A. Fawaz [2018] In this Study , the effect of using recycled rubber powder as an alternate fine aggregate in concrete mixes is discussed. Natural sand in the concrete mixes was partially replaced by 5%, 10%, 15%, and 20%. Physical properties such as the density, the compressive strength, the fresh concrete properties, the split-tension, and the impact load capacity are examined. After extensively exploring this topic and studying different aspects of rubber concrete properties and behavior, a series of conclusions were derived such as replacement in concrete mix by powdered rubber leads to a reduction in the density, the reduction in the compressive strength is consistent and almost at a constant ratio with the increase in the percent of powdered rubber, rubberized concrete to behave in an elastic manner when loaded in tension, thus improving the failure manners of typical concrete.

Abhishek Rana , Khushbu Yadav [2020] In this study , an attempt has been made to identify the various properties necessary for the design of concrete mix with the course tyre rubber chips as aggregate in a systematic manner. Scrap tyre rubber chips, has been used as coarse aggregate with the replacement of conventional coarse aggregate. By the study of different experiments following results are achieved as the percentage of scrap tyre rubber increased, it decreases the workability of concrete, the replacement of the aggregates by rubber particles, the weight was reduced. The result obtained by the compressive strength test of concrete represent that the compressive strength increases with the increasing percentage of rubber crumb. At 5% replacement of rubber crumb to aggregate gives maximum strength of concrete.

Ayman Moustafa and Mohamed A. ElGawady [2007] carried out research on the Dynamic properties of High strength rubberized concrete. They prepare two sets of rubberized concrete mix design. In the first set, they determined the dynamic properties of rubberized concrete with replacement of [0%,5%,10%,15%,20% & 30%] sand by volume with crumb rubber. And In the second set to maintain the same workability of fresh concrete regardless rubber percentage they added variable amount of superplasticizer. So, in the 1st set rubber is only variable they termed it as Variable slump [VS] and in the 2nd set rubber and superplasticizer both the variable to maintain same workability they termed it as Constant Slump [CS].

They found that the compressive strength of rubberized concrete reduced with increase of rubber content for both sets. For determining Dynamic properties, they have performed various test like hysteresis analysis, free vibration test, drop weight test, etc. During the dynamic properties investigation, a hysteresis damping was found to increase with the increase in the rubber content. For impact hammer test and drop weight test, the viscous damping was found to generally increase with the increasing rubber content up to 20% replacement, the change in viscous damping between 20 and 30 % replacement is significant. The increase of viscous damping in the CS set was higher than VS due to the more uniform distribution of particles in the beams.

Their research had shown that the mix design for the CS set had better dynamic properties compared to both the VS mix and the conventional concrete, as the bond between the rubber and cement paste was higher in the CS mix compared to the VS mix.

They also recommended to replace up to 20% of sand with rubber so as to achieve both lower reduction in compressive strength and enhance dynamic properties.

Mohamad Syamir Senin, Shahiron Shahidan, Siti Radziah Abdullah, Nickholas Anting Guntor & Alif Syazani Leman [2017]are the faculties of civil engineering department of Tun Hussein Onn university in the Malaysia. They performed research on the Rubberized Concrete and to overcome the deficiencies of the bridges due dynamic loading of vehicles they presented a review paper on suitability of rubberized concrete for concrete bridges.
They replaced fine aggregates up to 30% with the rubber for concrete mix design. They have found that with the addition of rubber, workability of concrete does not affect significantly up to 10%, beyond which cause can severe reduction in workability. If the appropriate quantity of super plasticizer is used then there is control in the workability of concrete.
They observed that the compressive strength of the rubberized concrete slightly decreased compared to normal concrete. However, Obinna Onuaguluchi et al. found a significant improvement in compressive and tensile strength recorded in the mixture containing coated rubber crumb and silica fume.
Thomas et al. found that rubberized concrete is more resistant to abrasion compared to the control mix. Da Silva et al. observed an improvement in abrasion resistance with the addition of rubber.
Their research also found that most of the researchers mentioned that the abrasion resistance got improved with the addition of rubber.

Mohamed Elchalakani, Tarek Aly & Emad Abu-Aisheh [2016]conducted research on mechanical properties of rubberized concrete for the roadside barriers with the intent to reduce the injuries during crashes or accidents. They replaced fine aggregates by tyre rubber particles up to 40% of weight of fine aggregate.
They observed that the workability of rubberized concrete for the coarse rubber particles is reduce with the increasing rubber concentration & for the combination of powder and crumb rubber particles exhibit good workability when appropriate value of admixture is used. Their research found that the unit weight of rubberized concrete is lesser as compared to plain concrete and there is reduction in compressive stress and flexural strength of Rubberized concrete as compared to plain concrete after 28 days of curing.
To have adequate shear strength, it is seen that the maximum rubber replacement can be determined as 17% [R = 0.17] by weight of the fine aggregates. It may be concluded that the shear strength is more critical compared to the combined normal and bending strength.
During the determination of elastic deflection for rubberized concrete barriers. They found the deflections at the proportions of R = 0.17 [17%] and R = 0.3 [30%] that meet the shear strength criteria. It is found barrier tends to lean sideways during impact and this in turn helps reduce the severity of the accident.
Test results from this study can facilitate strength and serviceability guidelines within Bridge Design Codes. They give the idea about the optimum use of material to achieve best results for rubberized concrete

M. Emiroğlu ,S. Yildiz, O. Keleştemur , M.H. Keleştemur [2012]In this study, bonding performance of waste tires and reinforced bars were investigated on the rubberized self-compacting concrete [R-SCC] mixtures.The study infers that when the rubber content increased, there is a reduction in the slump flow spread and Compressive strength of R-SCC. The maximum bond strength values are obtained from 0% TRA included R-SCC mix at the value of 13.41 MPa while the lowest compressive and bond strength values have been measured on the 60% R-SCC mixture at the end of 7 or 28 days. It is considered that the use of high volume of finer materials such as GGBFS and other cementitious materials may improve ITZ between TRA and cement paste. The vibration process of the mortar during casting the R-NVC mixes, probably causes air voids and microcracks at the ITZ between TRA and cement paste thus bond performance of R-SCC is better than that of R-NVC concrete mixtures.

Guo Yang, Xudong Chen, Weihong Xuan, Yuzhi Chen[2018] In this study, Authors conducted Research on Dynamic compressive and splitting tensile properties of concrete containing recycled tyre rubber under high strain rates. They have replace fine aggregate up to 5%, 10%, 15%, 20% by Volume. They analyses specific energy absorption illustrates that rubberized concrete with 15% rubberreplacement has the best impact toughness. The ratios of dynamic compressive tensile strength of rubberized concrete were calculated in between 3.82 and 5.39. There is no clear tendency in relationship between the ratios of dynamic compressive tensile strength and rubber content. The analysis of specific energy absorption explains that rubberized concrete has a better impact toughness.

Dr. M. R. Wakchaure , Mr. S. S.Channa[2018] The aim of the project is to study the effectiveness of rubber as substitute for fine aggregate and utilize the waste tyre crumb rubber in concrete, to minimize global warming. Concrete specimens casted and tested for concrete mix with various percentage of replacement [0.5 to 7%] and its effectfor replacement are discussed in this project. Use ofsmaller size waste tire crumb rubber particles gives higher workability. The R1 type of crumb rubber concrete give higher value of energy absorption capacity up to 2% replacement of fine aggregate so that it can be used structure which subjected heavy shocks. The R3 type of crumb rubber concrete give good resistant to impact up to 4% replacement of fine aggregate so that it can be useful in structural members and joints where more deflection occurs also in seismic resistant structures.

Gabriel Oprisan ,Ioana-SorinaEntuc ,Petru Mihai ,Ionut-Ovidiu Toma ,Nicolae Taranu , Mihai Budescu , Vlad Munteanu [2019]The paper presents experimental and numerical investigations on the behavior of rubberized concrete short columns confined with aramid fibre reinforced polymer [AFRP] subjected to compression. The full stress-strain curve of rubberized concrete and the experimentally obtained values for the material properties of AFRPare used as input data for the numerical modelling. A good agreement is found between the results obtained for the peak stress and corresponding axialstrain from both the numerical simulations and the experimental investigations. Replacement of 40% volume fraction of fine and small coarse aggregates by rubber particles from discarded tires diminishes the compressive strength. To compensate the decrease of compressive strength, the confinement with AFRP is utilized. Normalized axial compressive stress increases up to 363% in case of confinement with 3 layers of AFRP.

Aijiu Chen ,Xiaoyan Han ,Zhihao Wang ,Tengteng Guo[2021] In this paper author think about recycling scrap tyres as alternative aggregates of concrete is an innovative option. To clarify the dynamic propertiesof the pretreated rubberized concrete with some cumulative damage, the natural frequency, flexural dynamic stiffness, and damping ratio of the specimens under incremental stress level were investigated in this paper. The results indicated that the pretreatment of rubber particles improved the strength, ductility, and crack resistance of the rubberized concrete. The reduction of the flexural dynamic stiffness was clarified with the increase of concrete stress level. The addition of the pretreated rubber particles enhanced the concrete energy dissipation capacity during the destruction, and the specimen dissipated more energy with the increase of rubber content before its failure

S. F. A. Shah, A. Naseer ,A. Shah ,M. Ashraf[2014] This paper investigates the possibility of using rubber waste from scrap tires as replacement ofcoarse aggregate in concrete. Performance of concrete mixtures incorporating 5, 10 and 15% of scrap rubber as volume replacement for coarse aggregate was investigated. Compressive strength, flexural strength, stress–strain behavior, workability, air content, water absorption and unit weight were evaluated using standard procedures. Thermal behavior for concrete was examined using hotbox technique. No remarkable changes in concrete properties up to 5% substitution were occurred. Beyond 5% substitution, concrete properties change appreciably. Compressive strength, flexure strength, workability, stiffness and unit weight of rubberized concrete decreased as rubber content increased. Rubberized concrete could be useful in slabs to improve energy efficiency of building unit.

Mohamed Elchalakani, Tarek Aly , Emad Abu- Aisheh [2016]This paper presents the mechanical properties of rubberized concrete for roadside barriers with the intent to reduce injuries and fatalities during crashes. The tire–rubber particles composed of a combination of crumb rubber and fine rubber powder were used to replace 10, 20, 30 and 40% of the total weight of the fine aggregate. The test results indicated considerable reductions in compressive and flexural strengths, and tangential modulus of elasticity. New design guidelines in accordance with the Australian Bridge Design Code AS 5100 for strength and serviceability of rubberized concrete roadside barriers were derived based on the test results. New moment-thrust interaction curves and shear strength equations were derived for the rubberized concrete. It was found that the shear strength is critical compared to the combined moment and axial thrust and the maximum rubber content was 17% max for rubberized concrete.

Praveen ,Sachin Dass ,Ankit Sharma[2013]Disposal of tires has become one of the serious problems in environments. In order to prevent the environmental problem from growing, recycling tire is one of the best method. Research has been done on this by Parveen, Sachin Das and Ankit Sharma. They have concluded that rubberized can be used in structural components by using the rubber waste as partial replacement of fine aggregate to produce rubberize concrete in M30mix. 0, 5, 10, 15, 20% replace fine aggregate by its volume. By this research, they have concluded that, higher the rubber content in the mix, the higher the reduction in compressive strength. Increase in the crumb rubber, the flexural strength decreases.Stress strain shows that concrete with a higher percentage of crumb rubber possess high toughness,since the generated energy is mainly plastic. Therefore, crumb rubber mixture is more workable compare to normal concrete. It is useful in making lightweight concrete.

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Professor Julie Mills , Associate Professor Rebecca Gravina ,Professor Yan Zhuge ,Dr Xing Ma , Professor BillSkinner[2010] The authors aim was to gain a sufficiently indepth understanding of the properties of CRC to enable itscommercial use for the first time. This material can be created by first grinding up end-of-life tyres into small particles with a similar consistency to sand. This 'crumbed' rubber can then replace a certain percentage of the sand used in the concrete mixing process – both giving the economic usefulness of tyre rubber a new lease of life while alleviating some of the demand for natural sand. CRC is more resistant to tensile stress, meaning it is slightly more flexible than traditional concrete, making it able to withstand impacts more effectively. since there is a limited cohesion between rubber crumbs and concrete particles, CRC suffers several disadvantages in its mechanical properties, including a generally lower compressive strength and workability than traditional concrete. The team discovered that crumbed rubber generally decreasesthe compressive strength and elastic modulus of concrete. However, they also showed that CRC has a higher toughness index. an increased use of CRC in global construction shows promises to reduce the significant environmental impacts caused both from waste tyres and the exploitation of natural resources.

Camille A. Issa , George Salem[2012] The increasing piles of used tires create environmental concerns. The main goal of this research is to find means to dispose of the crumb rubber by placement of the rubber in Portland cement concrete mix. Crumb rubber [CR] is a commodity made by re-processing [shredding]disposed automobile tires. CR is fine rubber particles ranging in size from 0.075-mm to no more than 4.75-mm. In the concrete mix, CR constitutes aportion of the aggregate in the concrete mix. Insieve analysis of concrete mix design, it was decidedto replace the crushed sand [in the fine aggregates] by the rubber that was procured at 15%, 25%, 50% and 100% of total crushed sand volumes. Compressive test conclude that the increase in rubber content t leads to decrease in the compressive strength and weight. Low density. Enhanced ductility of concrete, which could be positively interpreted if usage is in highway barriers or other similar shock resisting elements, Enhanced insulation properties, as proved by the conductivity test, Enhanced damping properties, since rubber absorbs vibration to a large extent.Beyond 25% rubber content in replacement of crushed sand in fine aggregates, compressive strength drops enormously such that the usage in structural and non-structural elements becomes excluded.

Agampodi S.MMendis ,Safat Al-Deen ,Mahmud Ashraf[2012] The present study aims to compare the mechanical properties of similar strength CRC mixes containing different proportion of rubber content. . For this purpose, a number of similar strength CRC mixes using different mix proportions and crumbed rubber content were developed. Ordinary Portland Cement [OPC] with 40 MPa mortar strength, conforming to AS 3972-1997 [36] was used as the binder for all concrete mixes in the current study. Two sizes of crushed stone coarse aggregates were used with maximum aggregate size of 10 mm and 14 mm, and with specific gravity of 2.45 and 2.36 respectively. Natural river sand was used as fine aggregates which satisfied the requirements of AS 1012 [37] with specific gravity of 2.6 and fineness modulus of 3.15. In this study, crumb rubber of three different size ranges, 2 mm-4 mm, 1 mm-3 mm and particle passing #30 mesh were used. This paper examined material properties of various CRC mixes of similar strengths. From the experiments this study found that by changing other mixing parameters, similar compressive strength can be achieved from different CRCs with different levelof rubber content. Similarly, CRCs of similar rubber content can have very different compressive strength due to different proportion of other constituents of the mix. Also regardless of rubber content, similar strength CRCs exhibit similar splitting tensile strength, modulus of rupture, modulus of elasticity and stress strain behavior. . This study also demonstrates that existing design guidelines for normal concrete can be used to predict the splitting tensile strength and modulus of elasticity of CRCs with similar level of accuracy of normal concrete.

Osama Youssf , Julie E. Mills , Reza Hassanli [2016]This paper investigates the mechanical properties of fifteen CRC mixes aiming to assess the mechanical performance of a 20% rubber content CRC mix by measuring the effect of the rubber pre-treatmentperiod, SF content, and cement content on its slump, short and long term compressive strength, and tensile strength. The results of this investigation are summarised as follows:

1. Using 20% rubber in concrete increased the concrete slump by 1.22, 1.27, 2.53 and 7.75 times that of 0% rubber mixes at 0%, 5%, 10%, and 15% SF content, respectively.
2. Pre-treatment of rubber particles for 0.5 h in 10%NaOH solution was the best pre-treatment period in this study. It increased the CRC slump by 22% compared to the conventional concrete slump. In addition, it recovered 15.3% and 17.2% of the compressive strength lost by using non-treated rubber at 7 and 28 days, respectively. Furthermore, it increased the CRC tensile strength by 15% compared to non-treated rubber. Increasing the rubber pre-treatment period more than 0.5 h had no significant effect on the concrete slump and tensile strength and it decreased the compressive strength. A cost analysis of the proposed CRC assessment is planned to be undertaken by the authors in future work. The upfront cost investigation of the CRC shows that it is slightly more expensive than the conventional concrete depending on the availability of shredded tyres and their local price. However, looking at the life cycle cost, a rubberized concrete structure can provide cost effectiveness performance compared to a conventional concrete structure. This is due to the advantages of using rubber in concrete that including lower maintenancecost, providing environmentally friendly solutions in structures with high dynamic properties, increasing the structure sustainability, saving energy and natural resources, and reducing/eliminating the adverse effects of dumpingend-of-life tyres to land fill.

Ruizhe Si, Shuaicheng Guo ,Qingli Dai [2017]This study experimentally investigated the durability of rubberized mortar and concrete samples with NaOH-solution treated rubber particles. The concrete samples without rubber particles were cast as control samples. The rubberized mortar or concrete samples were prepared with 15% as-received rubber and different contents of NaOH treated rubber [15%, 25%, 35% and 50% by volume of fine aggregate]. The electrical resistivity, air-void measurement, and absorption tests were first conducted to evaluate thetransport properties of rubberized concrete samples.The freeze-thaw durability tests on different concrete samples showed that the added rubber particles improved the freeze-thaw resistance of concrete. The effect was more significant for NaOHtreated rubber particles than that of as-received rubber particles. The results of the alkali-silicate reaction [ASR] expansion test suggested that the ASR expansion was decreased in rubberized mortarcompared to plain mortar. The 15% NaOH treated rubber replacement was most effective on reducing the ASR expansion among all of the rubberized mortar samples. The drying shrinkage increased with the content of rubber particles in mortar; however, the increased shrinkage in rubberized mortar appeared to be reduced when the additional rubber was treated with NaOH solution. These test results indicated that the rubberized concrete or mortar [with 15% or 25% NaOH treated rubberreplacement] samples have improved durability

M. Emiroğlu , S. Yildiz, , O. Keleştemur ,M.H.Keleştemur[2012] In this study, bonding performance of waste tires and reinforced bars were investigated on the rubberized self-compacting concrete [R-SCC] mixtures. The study infers that when the rubbercontent increased, there is a reduction in the slump flow spread and Compressive strength of R-SCC. The maximum bond strength values are obtained from 0% TRA included R-SCC mix at the value of13.41 MPa while the lowest compressive and bond strength values have been measured on the 60% R- SCC mixture at the end of 7 or 28 days. It isconsidered that the use of high volume of finer materials such as GGBFS and other cementitious materials may improve ITZ between TRA andcement paste. The vibration process of the mortar during casting the R-NVC mixes, probably causes air voids and microcracks at the ITZ between TRA and cement paste thus bond performance of R-SCC is better than that of R-NVCconcrete mixtures.

Thong M. Pham , Neil Renaud , Voon-Loong , Pang Feng Shi , Hong Hao , Wensu Chen[2021] This study experimentally examines the effect of rubber aggregate size on the static and dynamic behavior of rubberized concrete by using Split Hopkinson pressure bar [SHPB] tests. .From the study it can be concluded that the rubberized concrete with smaller rubber aggregates exhibited higher static compressive strength than thecorresponding rubberized concrete with larger rubber aggregates. The result in the Slump and Compression test study adds finding that using coarser rubber aggregates leads to a lower slump of rubberized concrete as compared to finer rubberaggregates, considering the same rubber content. Rubberized concrete with fine rubber aggregates had higher static strength and dynamic strengths at a low strain rate. For stress–strain curves rubberized concrete exhibited more ductile behavior because their curves were less stiff than that of the reference specimens. Therefore it is concluded that the use of either small or large rubber aggregate size depends on applications in which a structure is intended to resist static or dynamic loads.
Gintautas , Skripkiūn, Audrius ,Grin YS, Benjaminas, Černius[2007]The aim of investigation was to study the deformation properties of Portland cement concrete with rubber waste additive. Elastic properties of concrete, two concrete mixtures tested: concrete mixture without rubber additive and concrete with 0/1 fr. rubber additives,3.2 percent from the aggregate of rubber waste was usedin concrete mixture. By using elastic additive from tires rubber waste the entrained air content increased [from 3 % to 3.5 %] while density of concrete mixture decreased [from 2396 kg/m3 to 2380 kg/m3. The results showed that the tyres rubber waste additives have great influence on concrete deformability after loading as under set loading. Cyclic loading of 20 cycles have no influence on the prismatic compressive strength of both concrete with and without rubber waste [3.2 percent from aggregate by mass]. Ultimate strains on concrete failure load are 36 % – 47 % higher for concrete with tyre rubber waste additive. Strains of the concrete with tires rubber in the beginning of stress increasing are higher comparing with the concrete without rubber waste. Most of the deformations of rubber waste particles have plastic nature. Thus concrete with tire rubber waste has higher set deformations than non-rubberized concrete.

H.A.Alsambari ,B.H. Abu Bakar , H.M. Akil [2020]The paper discusses on the effect of rubberized concrete in the form of hybrid i.e. first [top] layer [only rubberized] and second [bottom] layer [conventional concrete with fibre. The test results shows that the hybrid structure with a rubberized layer at the top absorbed high flexural energy in an impact load than in a static load. The hybridstructure improves Spilt tensile strength from 3.6 to 4.15 MPs which represented 15.25% of improvement as the longer steel fiber helped to limit the side effect of crumb rubber particles of reducing the tensile strength. By the use of double- layered and rubber at the top and fiber at bottom there will be decreased deflection and increased load in order to absorb the load and to minimize flexural strength loss. IN contrary,other characteristics of hybrid structures showndrawback such as first cracking load and ultimate deflection.

Kristina Strukara , Tanja Kalman Šipos ,Ivana Miličević .Robert Bušić[2019] The paper aims to review the previous studies ofthe influence of rubber aggregate on the mechanicalproperties. Performance of rubberized concreteelements is summarized by their flexural and shearbehavior. The replacement natural aggregate withrubber content will reduce its compressive strengthand modulus of elasticity [up to 60% of reduction for rubber content of 40%] also the stress-straincurves indicates that the behavior of rubberizedconcrete is more nonlinear. Rubber incorporationimproved the ductility and energy absorption abilityof concrete. Concrete with 18% crumb rubberimproved the toughness index by 11.8% in regard totraditional concrete. By increasing rubber contentshear capacity of rubberized beams was increased,maximum crack width decreased as the percentage of crumb rubber increased. Better performance of rubberized columnunder the cyclic loadingattributed to the higher ductility, greater energydissipation of the rubberized concrete due toviscoelastic nature of the rubber particles, higher hysteretic damping ratio and higher initial stiffness.Overall, rubberized specimens exhibit high ductilecharacteristics that are more desirable for earthquake-resistant structures.

Thong M. Pham ,Wensu Chena ,Abdul M. Khan ,Hong Hao , Mohamed , Elchalakani ,Tung M. Tran[2015] This study experimentally examines the dynamic characteristics of concrete made of waste car tyres as both fine and coarse aggregates [rubberized concrete], resulting in light-weight concrete with the densities of 2350 kg/m3, 2091 kg/m3 and 1833 kg/m3. Rubberized concrete shows great impact resistance under high loading rate. Dynamic tests were carried out by using Split Hopkinson Pressure Bar [SHPB] to obtain the dynamic compressive strength with the strain rate up to 182 s-1.The experimental results consistently showed that rubberized concrete is sensitive to the strain rate. The higher rubber content, the more sensitive it had to strain rate. rubberized concrete is sensitive to strain rate. The increase of DIF is almost linearly proportional to the rubber content within a wide range of strain rates. The absorbed energy normalized using compressive strength of rubberized concrete was 54–79% higher than that of normal concrete. Although the results shine some lights on the dynamic material performance of rubber concrete, further studies on the dynamic material properties of rubberized concrete in a wider strain rate range.

Samar Raffoula ,Reyes Garciaa , KyprosPi lakoutasav Maurizio Guadagni ni Nelson Flores Medinab[2016]The Research was conducted on the fresh propertiesand short-term uniaxial compressive strength of 40 rubberized concrete mixes were assessed. The parameters examined included the volume [0 to 100%] and type of mineral aggregate replacement [fine or coarse]. Compared to a non-optimized concrete with 100% replacement of fine aggregates with rubber, the compressive strength of concrete with optimized binder material and moderate water/binder ratio was enhanced by up to 160% and the workability was improved workability. High strength Portland Limestone Cement CEM II – 52.5 N [10-15% Limestone] conforming to BS EN was used as main binder to reduce the carbon footprint of the mixes. Result on Mix optimization minimizes theadverse effects of rubber on the concrete fresh and hardened mechanical properties. Optimizermixes [D] enabled the use of high rubber contents while maintaining an acceptable workability and a compressive strength of 7 MPa at 7 days. Using SF and PFA to replace 20% of the cement mass increased the concrete flowability by 20% and the strength by 42 %.

Jessy Rooby ,Sulagno ,Banerjee[2019] Eldin carried out research on rubberized Concrete using tyre chips and crumb rubber as aggregate substitute of sizes 38,25mm and 19mm exhibited reduction in compressive strength by 85%. And tensile splitting strength by 50% but showed the ability to absorb a large amount of plastic energy under Tensile and compressive loads. The compressive strength of RuC reduces by up to 90% at high levels of rubber replacement. Poisson's ratioof rubber particles [nearly 0.5], the high porosity of the composite and the weak rubber- cement paste bond. Research had shown that the compressive strength, split tensile. Strength as well as the flexural strength decreases as the addition ofpercentage of rubber increases. 5 & 10 percent replacement of rubber aggregate may achieve the compressive strength as that of the normal concrete with some few alterations like adding extra silica Or by replacing cement with more fine particles such as GGBS. It can be concluded that despite the reduced compressive. Strength of rubberized concrete in comparison to conventional concrete,
there is a potential large market for concrete products in which inclusion of rubber aggregates would be feasible which will utilize the discardedrubber Tyres.

Arjun Diwakar , Dr. Vinay Pratap singh , Prof. Anand Kumar[2019] Mechanical properties of rubberized concrete change to reinforcement of crumb rubber. During the replacement of waste tire into fine aggregate decreases the compression strength of mix sample.more than 25% of fine aggregates with rubber crumb causes the compressive strength of concrete . Flexural strength and compressive strengths decreases when waste tire rubber is added in concrete due to lack of bonding between matrix andreinforcement particles. Addition of waste rubber tyre into normal concrete mix leads to decrease in workability for the various mix samples. When 10% fine aggregate was replaced by waste rubber tyre compressive. Strength decreases withincreasers the waste rubber tyre due to poor bonding strength between cement and waste rubber tyre chips. Rubcrete material can also plays very importantrole in earthquake for lightweight structure property.

G. Senthil Kumaran, , NurdinM ushule , M.Laksh mipathyl [2008]In this study, we outline the use of rubberized concrete in structural and non-structural. Members and show how it is suitable for the concrete, its uses, barriers and benefits and way to future study. Behavior, using tire chips and crumb rubber as aggregate substitute of sizes 38,25mm and 19mm exhibited reduction in compressive strength by 85%and tensile splitting strength by 50% but showedthe Ability to absorb a large amount of plastic energy under tensile and compressive loads. Biel and Lee have used recycled . The results of Compressive and tensile strength tests the reduction of compressive and Tensile strength can be increased by adding some super plasticizers and industrial wastes as partial replacement of cement will definitely increase the strength of waste tyre rubber modified concrete.

Ratthapho ngMeesit , SakdiratK aewunruen [2017]According to the literature review, the failure modes of the concrete sleeper that is always observed during the operation period can be dividedinto three main categories, which are rail seat abrasion, flexural cracking and rail fastener The compressive strengths of all Mixes seemed to be in the same trend on both 7 and 28 Days. The compressive strength of RFC was 51.2 MPaat 7 days, and it improved 19.53% to be 61.2 MPa at 28 days. However, this strength was still lower than the target mean strength around 2.94%. SFC was found as a Mixture which has the highest compressive strength of 59.9 and 73.0 MPa at both 7 and 28 days, respectively. This was relativelyhigher than RFC about 19.28% for 28 days. Thus, itcan be concluded that silica fume has a positive impact to the concrete, which can improve compressive strength significantly .The damping ratio of concrete also dramatically increased.

Ahmed Hilal Farhan, Andrew ,Robert Dawson ,Nicholas, Howard Thom [2015]The main focus of this paper is to investigate thetensile properties of virgin and rubberized cement bound granular. Evaluation of the capacity for different replacement levels revealed a decline in the effectiveness of compaction as the rubber inclusion rate increased. This can be attributed to the damping effect that the rubber particles of high elasticity possess which may absorb some of the compaction energy during vibratory compaction. Indirect tensile strength reduced due to the inclusion of rubber particles in cement-stabilized aggregates mixtures due to the weakness of these introduced particles. By observing stress–strain responses and the failure pattern and examining the internal structure of the failed specimens, the failuremechanism for a rubberized compacted system has been proposed in this paper. It assumes that the crack propagates through rubber particles which are thought to be absorbing energy on the crack tip. The Fractal analysis concept is found to permit quantitative distinguish between different failure patterns of CBGM. It is also proved the ability of this test method to distinguish between mixtures with low rubber contents and its suitability to assess the performance of these modified mixture.

B. Topqu' ,N. Avcular[1997] Rubber has a property of high resistance to impact, has a greater tendency to absorb shocks and energy in comparison with normal concrete and steel. It consistsof two studies done with the help of rubberized concrete. The first study was done by colliding a test vehicle weighing 1-Ton with a speed of 60 km/hr. In this study the static results were transformed to dynamic results. In the second study the coarse aggregates were replaced with rubber flakes at an increasing rate and the resulting blocks formed were acted upon with a 65-kg mass dropped from a height of 650 mm after which it impacted with concrete or steel specimens. The mass was dropped several times until the concrete got brokendue to impact effects. Both the studies were performed on NC [Normal Concrete], CRC [Coarse Rubberized Concrete] and FRC [Fine Rubberized Concrete] for 7 daysand 28 days. The concrete with a lowest rate [σ total/ σ total steel] was considered the concrete having highest resistance against collisions. The minimum volume formula gave which concrete is more economical and could be used on a large scale. It was found that FRC15 [Fine Rubberized Concrete with 15% rubber] was the most reliable and the most economical concrete of all and also had a greater capacity to absorb energy.

Baodong Liun , Shuzhen Yang Weilong Li.Minqiang Zhang[2019] This study aims to explore the static and dynamic properties of rubberized concrete and its possible utilization as anti-collision cladding of bridge piers. An ordinary Portland cement P.O42.5 is used in all compositions. First of all, normal concrete andrubberized concrete with different crumb rubber particle sizes and volume fractions were fabricated and tested to obtain its mechanical properties. The difference among the three models is the cladding of the pier. One was a single concrete pier without cladding [SP] and the other two were with normal concrete cladding [NC] and rubberized concrete cladding [RC]. Static mechanical tests and hysteric test were carried out on the test specimens. After the tests were performed, in conclusion, the compressive strength of rubberized concrete decreases with the increase of rubber content. Besides, specimens with larger rubber particles exhibit lower compressive strength at the same substitution amount of rubber particles. The elastic modulus decreases with the increase of rubber content and with the same rubber amount, the elastic modulus with larger particle size is lower. The conclusions of the study were stated as: rubberized concrete has a better energy dissipation capability than normal concrete. Anti-collision cladding can reduce the impact force, the vibration of the pier and the Mises stress of the impact point.

Judith C. Wang, Xiangwu Zeng[2006], In the study presented here, the material behavior of two blends of rubber-modified asphalt "Type C," and "Type E," are investigated. Newer asphalt blends, such aspolymer-modified asphalt concretes, have also been investigated for their behavior in varying temperature conditions and have been shown to soften at higher temperatures and be prone to cracking at lower temperatures. A Drnevich-type resonant column machine is used. All three asphalt blends are hot mix asphalt blends mixed using conventional asphalt liquid; for Types C and E, the conventional asphalt liquid was mixed with 20% crumb rubber and 10% crumb rubber, respectively. Four tests with varying confining pressures within the pressure vessel were performed. It is not possible to determine the dynamic properties of rubber- modified asphalt concrete at high-strain levels due to the materials' high stiffness. High-speed trains travelling at high velocities generate ground vibration and noise pollution, environmental factors which make the construction of high-speed railway systems unpopular
with the general public and potentially damaging to nearby infrastructure. To reduce these effects, the foundation must be made of a material with a high capacity for vibration attenuation. The study reportedhere indicates that rubber-modified asphalt has a significantly higher shear modulus under varying temperature and pressure conditions than a traditional asphalt concrete blend. The shear modulus and Damping ratio for all of the asphalt blends tested is highly dependent upon the temperature of the material.

David Fedroff ,Shuaib Ahmad , Banu Zeynepsavas[1996] This study evaluates the effect of ground waste-tire product on the performance of Portland cement concrete and determines the feasibility of using rubberized concrete, "rubcrete," in real-world applications. The experimental investigation included laboratory tests on plastic and hardened plain concrete and rubcrete mixtures. Tests were conducted on theplastic and hardened concrete properties to evaluatethe effects of addition of rubber to concrete. The tests on plastic concrete and rubcrete mixtures included slump, air content, and unit weight. The tests on the hardened concrete and rubcrete mixtures included compressive strength, elastic modulus, split cylinder strength, and flexural strength. . The addition of theground rubber to concrete reduced the workability that is slump, of the mix, the unit weight of the rubcrete mixtures decreased as the percent of ground rubber was increased. Compressive strength decreases with increasing amount of rubber. The stress-strain curves become more linear. The reductions seen in the split tensile strength and the flexural strength were smaller than those seen in compression. The strength increases with age. The compressive strength saw a percent reduction. The modulus of elasticity also reduced as the percent of ground rubber. Thus, by using thereplacement, the cement content can be enhanced, and the strength loss probably would not be as great as with the addition of rubber by percent weight of cement..

Ahmed S. Eisa ,Ahmed Gab Allah , Ragab Shaker ,Mahmoud [2021**]** The Authors concluded that the compressive strength of rubberized high strength reinforced concrete has reduced by 35%, and the weight was decreased by 3% on the average when 15% of sand has been replaced by 2 mm crumb rubber. Beams strengthened by CFRP have shown a decrease of 35% in deflection on average.The flexural cracking load of the strengthened beams have been significantly improved by15%, 65% and 27% for beams strengthened by single flat layer, U-shaped single layer and double flat layers, respectively with an average increase in the flexural cracking load of 36%. The ductility of rubberized high strength concrete beams tested in flexure has increased by 38% on average. While for beams strengthened using CFRP, the ductility was improved and increased by 24% on average.

2.1 CODAL PROVISION

Sr. No.	IS Code	Year	Title
1	IS 383	1970	Coarse and Fine Aggregates for Concrete- Specification
2	IS 456	2000	Plane and Reinforced Concrete- Code of Practice
3	IS 516	1959	Methods of Tests for Strength of Concrete
4	IS 5816	1999	Splitting Tensile Strength of Concrete- Method of Test
5	IS 10262	2019	Concrete Mix Proportioning- Guidelines
6	IS 1237	2012	Specification for cement concrete flooring tiles
7	IS 9284	1979	Method of test for abrasion resistance of concrete
8	IS: 13311 Part 1	1992	Non-destructive testing of concrete - methods of test
9	IS 516 Part 5	2018	Hardened Concrete Methods of Test Part 5 Non-destructive Testing of Concrete Section 1 Ultrasonic Pulse Velocity Testing [First Revision]

CHAPTER 3

WORK DONE

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WORK DONE

3.1 TEST ON MATERIALS

3.1.1 Test on Cement

3.1.1.1 Fineness test [IS 4031-1-IIT KANPUR]

Need

Cement hydrates when cement is mixed with the water and a thin layer are formed around the particle. This thin layer grows bigger and makes cement particles to separate. Because of this, the cement hydration process slows down. On other hands, cement smaller particle react much quicker than the larger particle. A cement particle with diameter 1µm will react entirely in 1 day, whereas the particle with diameter 10µm takes about 1 month but, there is a side effect of having too much of smaller particles in cement results in quick setting, leaving no time for mixing, handling and placing, therefore to increase the setting time of cement, cement is must be manufactured in a different range of particle sizes.

Apparatus

Sieve with pan of 90µm, sieve lid, weight balance.

Procedure

1) Collect a sample of cement and rub with your hands. The Fineness test sample should befree of lumps.
2) Take 100 gm of cement sample and note its weight as W1.
3) Drop 100 gm of cement in 90 µm sieve and close it with the lid.
4) Now, shake the sieve with your hands by agitating the sieve in planetary and linearmovements for 15 minutes.
5) After that take weight the retained cement on the 90 µm sieve as W2. Fineness = [W2/W1] * 100
6) Then after, calculate the percentage of Weight of cement-retained on Sieve.
7) Repeat this procedure with three different samples of cement and average the values foraccurate results.

Result

% fineness of cement is found to be 2%.

Acceptable range

The fineness of cement should not exceed 10%.

3.1.1.2 Consistency test and Initial setting time [IS: 4031 [Part 4] 1988]

Need

To know the quantity of water required to form uniform paste. If it's exceeds means bleeding willhappen, less quantity means, dry mix will happen.

Apparatus Vicat's Apparatus, Balance of capacity 1Kg and sensitivity to 1gram,Gauging trowel

Procedure

1) Take 400 g of cement and place it in the enameled tray
2) Mix about 25% water by weight of dry cement thoroughly to get a cement paste. Total time taken to obtain thoroughly mixed water cement paste i.e. "Gauging time" should not be more than 3 to 5 minutes
3) Fill the vicat mould, resting upon a glass plate, with this cement paste.
4) After filling the mould completely, smoothen the surface of the paste, making it level with top of the mould.
5) Place the whole assembly[i.e. mould + cement paste + glass plate] under the rod bearing plunger.
6) Lower the plunger gently so as to touch the surface of the test block and quickly release the plunger allowing it to sink into the paste.
7) Measure the depth of penetration and record it.
8) Prepare trial pastes with varying percentages of water content and follow the steps [2 to 7] as described above, until the depth of penetration becomes 33 to 35 mm.
9) Tapping of paste in mold
10) Penetrating needle in vicats apparatus

Fig 1: Tapping of paste in mold

Fig 2: Penetrating needle in vicats apparatus

Result

1) Normal consistency for the tested sample was found to be 31%.
2) Water required for initial setting time is 0.85 times of normal consistency
3) Initial setting time was found to be 95 min.

Acceptable range

Normal consistency should range between 22 to 35%.

3.1.1.3 Soundness test

Need

The test is designed to accelerate the expansion in cement paste by application of heat expansion beyond certain limit indicates unsound cement. It is performed to ascertain the soundness or unsoundness of cement, which affect's durability of the structure in which cement is used.

Apparatus

Le- chatelier mould, Cement, Glass sheets, Mixing pan ,Trowel, Weight

Procedure

The mould and the glass plates are oiled before conducting the test

1) Take 400 gram of cement sample.
2) For this test to be performed we need standard consistency of cement. Water is taken as 0.78 x P [Where P is water required for Standard consistency in percentage]

   [For example, Standard consistency is 30% of water, then take water percentage for soundness 0.78 x 30% = 23.4%. So water to mixed in 400 gm of cement will be 400 x [23.4/100] = 93.6ml.]

3) Make well mixed paste of cement and fill in Le- Chatelier mould taking care to keep the edgesof the mould gently together during the operation.

4) Clean upper surface and make it smooth and place a small weight over the cover plat put this assembly quickly in water at a temperature of 27º C + 2ºC and keep it there for 24 hours.

5) Take out mould from water and measure distance between the indicators points as Reading1 .[Suppose it is 2 mm]

6) Now, again put this assembly in boiling water for 25 to 30 minutes and keep at boiling for 3hours. The mould should be in boiled water during this period.

7) Remove the mould from water and allow it to cool at room temperature.

8) Measure the distance between the indicator points as Reading-2. [Suppose it is 10mm]

9) Soundness of cement = [Reading-2] – [Reading-1]
= 10 mm – 2mm
= 8 mm

Fig 1:Empty mould

Fig 2: Filled mould of Le Chateliar's apparatus for soundness test

Result

Soundness of cement is found to be 8mm.

Acceptable range

The value must not exceed 10mm

3.1 .2 TEST ON COARSE AGGREGATE

3.1.2.1 Flakiness index [IS 2386[Part 1]:1963]

Need

Particle shape and surface texture influence the properties of freshly mixed concrete more than the properties of hardened concrete. Rough-textured, angular, and elongated particles require more water to produce workable concrete than smooth, rounded compact aggregate. Consequently, the cement content must also be increased to maintain the water-cement ratio. Generally, flat and elongated particles are avoided or are limited to about 15 % by weight of the total aggregate.

Apparatus

Thickness Gauge, Balance ,Sieves

Procedure

1) A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
2) The sample shall be sieved with the sieves specified.
3) Separation of Flaky material- Each fraction shall be gauged in turn for thickness on a metal gauge of the pattern, or in bulk on sieves having elongated slots. The width of the slot used in the gauge or sieve shall be of the dimensions specified.
4) The total amount passing the gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.
5) The Flakiness Index is the total weight of the material passing the various thickness gauges or sieves, expressed as a percentage of the total weight of the sample gauged.

Result

The flakiness index is found to be 10.34%.

Acceptable range

The value should not exceed 16%.

Fig1:Coarse aggregate passed through diff. sieve

Fig 2: Thickness Gauge

3.1.2.2 Crushing strength of coarse aggregate

Need

The strength of coarse aggregates is assessed by aggregates crushing test. The aggregatecrushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. To achieve a high quality of pavement, aggregate possessing low aggregate crushing value should be preferred.

Apparatus

A steel cylinder 15 cm diameter with plunger and base plate, straight metal tamping rod 16mm diameter and 45 to 60cm long rounded at one end, balance of capacity 3 kg readable and accurateto one gram, IS sieves of sizes 12.5mm, 10mm and 2.36mm, compression testing machine, Cylindrical metal measure of sufficient rigidity to retain its from under rough usage and of 11.5cm diameter and 18cm height, Dial gauge.

Procedure:-

1) Put the cylinder in position on the base plate and weigh it **[W]**.
2) Put the sample in 3 layers, each layer being subjected to 25 strokes using the tamping rod.Care being taken in the case of weak materials not to break the particles and weighit **[W1]**.

3) Level the surface of aggregate carefully and insert the plunger so that it rests horizontally on the surface. Care being taken to ensure that the plunger does not jam in the cylinder.
4) Place the cylinder with plunger on the loading platform of the compression testingmachine.
5) Apply load at a uniform rate so that a total load of 40T is applied in 10 minutes.
6) Release the load and remove the material from the cylinder.
7) Sieve the material with 2.36mm IS sieve, care being taken to avoid loss of fines.
8) Weigh the fraction passing through the IS sieve **[W2]**.

Fig1:Tamping of aggregates in the mould.

Fig 2 Mould setup for crushing strength

Result

Crushing value of the coarse aggregate is 21.28%.

Acceptable range

It should not exceed 5% for base course and 30% for pavement.

3.1.2.3 Abrasion test on aggregate

Need

Abrasion Test is the measure of aggregate toughness and abrasion resistance such as crushing,degradation and disintegration.

Apparatus

Los Angeles Machine, Cast iron or steel balls Balance of capacity 5 kg or 10 kg, ,Drying oven,Miscellaneous like tray

Procedure

1) Select the grading to be used in the test such that it conforms to the grading to be used in construction, to the maximum extent possible.
2) Take 5 kg of sample for gradings A, B, C & D and 10 kg for gradings E, F & G.
3) Choose the abrasive charge depending on grading of aggregates.
4) Place the aggregates and abrasive charge on the cylinder and fix the cover.
5) Rotate the machine at a speed of 30 to 33 revolutions per minute. The number of revolutions is 500 for gradings A, B, C & D and 1000 for gradings E, F & G. The machine should be balanced and driven such that there is uniform peripheral speed.
6) The machine is stopped after the desired number of revolutions and material is discharged to a tray.
7) The entire stone dust is sieved on 1.70 mm IS sieve.
8) The material coarser than 1.7mm size is weighed correct to one gram.

Result

The abrasion value is 8.85%.

3.1.2.4 Impact test [IS Code 2386 part 4]

Need

Determine the relative measure of the resistance of aggregate to sudden shock or impact in which in some aggregate differs from its resistance to a slowly applies compressive load

Apparatus : Balance, sieve, impact testing machine.

Procedure

1) Aggregates for the test sample can be decided by passing it through 12.5 mm sieve and retained on 10 mm sieve.
2) The sieved aggregates should be dried in an oven and then filled in a cylindrical steel cup and tamped with 25 strokes by temping rod.
3) The test sample is filled in 3 layers and each layer is tamped for 25 numbers of blows.
4) Metal hammer [weighing approx. 14 kg] is pre-arranged to drop with a free fall of 380mm. The test specimen is subjected to 15 numbers of blows each at not less than 1 second.
5) The crushed aggregate is removed from the test specimen and sieve it through the 2.36 mm IS sieve.

6) An impact value is measured as % of aggregates passed through the 2.36mm sieve [**W2**] to the total weight of the sample [**W1]**

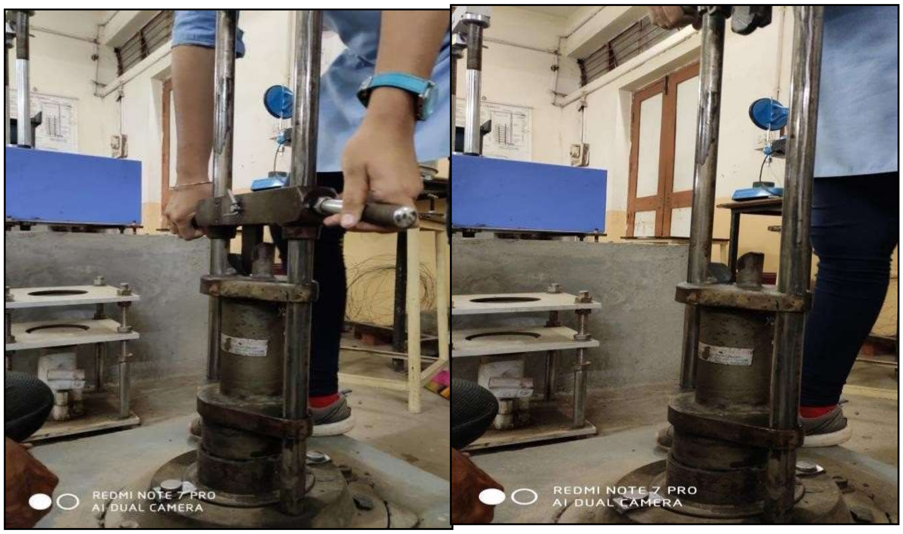


Fig 1: Lifting and dropping of drop hammer on the sample of aggregates

RESULT

The impact value is 17.07%.

Acceptable range

The value of aggregate impact test should not be more than 45% by weight of aggregates, used for concrete other than wearing surface

3.1.2.4 Water Absorption test[IS 2386 [Part 3]:1963]

Need:- Water absorption gives an idea on the internal structure of aggregate. Aggregates having more absorption are more porous in nature and are generally considered unsuitable, unless found to be acceptable based on strength, impact and hardness tests.

Apparatus:-An air tight container, A shallow tray

Procedure:-

1) About 2 kg of aggregate sample is taken, washed to remove fines and then placed in the wire basket. The wire basket is then immersed in water, which is at a temperature of 220C to 320C.
2) Immediately after immersion the entrapped air is removed from the sample by lifting the basket 25 mm above the base of the tank and allowing it to drop, 25 times at a rate of about one drop per second.

3) The basket, with aggregate are kept completely immersed in water for a period of 24 ± 0.5 hour.
4) The basket and aggregate are weighed while suspended in water, which is at a temperature of 220C to 320C.
5) The basket and aggregates are removed from water and dried with dry absorbent cloth.
6) The surface dried aggregates are also weighed.
7) The aggregate is placed in a shallow tray and heated to 100 to 1100C in the oven for 24 ± 0.5 hours. it is cooled in an airtight container and weight.

Fig 1: Wet aggregates sample.

Fig 2 :Oven dried sample

Result:- Water absorption of coarse aggregate is 8.33.

3.1.2.5 Specific gravity by pycnometer method

AIM: To find out the specific gravity of a given sample of coarse aggregate by pycnometer method.

APPARATUS: IS sieve 12mm, pan, fine and coarse aggregates, rubber, pycnometer, weights set, water, etc.

NEED:

Specific Gravity of an aggregate and rubber is considered as a measure of the quantity of strength of the material Stones having less specific gravity values generally are weaker than those having higher values. This test helps in identifying the stone specimen.

FORMULA:

$$\text{Specific Gravity, } G = \frac{W_2 - W_1}{[W_2 - W_1] - [W_3 - W_4]}$$

Where,

W_1=wt. of empty pycnometer

W_2 =wt. of empty pycnometer +aggregate

W3= wt. of empty pycnometer +aggregate +distilled Water

W4= wt. of empty pycnometer + distilled water

PROCEDURE:

(1) Take the weight of dry pycnometer Bottle [W_1].

(2) Take about 100 to 200 gm of oven-dried sample and put it in the pycnometer. Find the weight of the pycnometer [W_2].

(3) Fill the Pycnometer to half of its height with the distilled water and mix it thoroughly with the glass rod, add more water and fill the Pycnometer till the top, clean it from outside & take weight [W_1]

(4) Empty the Pycnometer, clean it neatly and fill with distilled water up to the hole of conical cap and take weight [W4]

(5) Repeat the step & take three or four reading and calculate the average specific gravity

OBSERVATIONS:

1. Weight of dry Pycnometer. [W_1] = 690 gm

2. Weight of Pycnometer +Coarse Aggregate, [W_2] = 863 gm

3 Weight of Pycnometer + Coarse aggregate + Water [W3] = 1690 gm

4. Weight of pycnometer + Water [W4] = 1580 gm

RESULT:

The specific gravity of given Coarse aggregate sample is found out to be 2.74.

3.1.3 TEST ON FINE AGGREGATE

3.1.3.1. Bulking of sand [IS 23863-1963]

Need

The main purpose of adding sand in concrete is to minimize the segregation of concrete and to fill out the pores between the cement and coarse aggregate. This test [bulking of sand or bulking of fine aggregate] is to ensure that we are using the right amount of sand while concreting.

Apparatus

250ml measuring cylinder ,Weighing balance, Fine aggregate

Procedure

1) Take 500 grams of fine aggregate over dried at a temperature of 100 to 110 degree Celsius for 24 ± 0.5 hours. This weight is measured as W1
2) The cooled sand is taken in an airtight container. This weight is measured as W2.
3) The water content of the sample is calculated as
    i. Wc= [W1-W2]x 100/W1 --------- Eq.1
4) In a pan, 250 grams of sand is taken
5) To this 2% by weight of water is added. This is properly mixed
6) The mixture is poured into a 250ml cylinder. This is consolidated by shaking
7) The surface is leveled. The reading is measured as Y1.
8) The test is repeated for the remaining quantity of sand for 2% water by weight each time. The readings are taken as Y2, Y3 .... etic until a decreasing reading of the volume is observed.
9) After this level, 4% water is added and the test is continued until the sample become fully saturated.
10) To the standard sample in the measuring cylinder, add about 50 ml water more and stir the sample well.
    i. Note down the surface level of inundated sand [Y ml]

Fig 1 : Sand Filled in the Measuring Cylinder

Result:

Table : Bulking of Sand

Quantity of water added%	Initial volume	Final volume	%bulking
2	50	55	10
4	55	59	7.2
6	59	61	3.38
8	61	64	4.91
10	64	68	6.25
12	68	62	-8.82
14	62	60	-3.22
16	60	59	-1.67
18	59	57	-3.38
20	57	55	-3.50
22	55	53	-3.63
24	53	51	-3.77

<u>3.1.3.2</u> <u>Specific gravity by pycnometer method</u>

<u>AIM:</u> To find out the specific gravity of a given sample of fine aggregate by pycnometer method.

<u>APPARATUS</u>: IS sieve 12mm, pan, fine and coarse aggregates, rubber, pycnometer, weights set, water, etc.

<u>NEED</u>:

Specific Gravity of an aggregate and rubber is considered as a measure of the quantity of strength of the material Stones having less specific gravity values generally are weaker than those having higher values. This test helps in identifying the stone specimen.

<u>FORMULA</u>:

$$\text{Specific Gravity, } G = \frac{W_2 - W_1}{[W_2 - W_1] - [W_1 - W_2]}$$

Where,

W_1=wt. of empty pycnometer

W_2 =wt. of empty pycnometer +aggregate/rubber

W3= wt. of empty pycnometer +aggregate/rubber +distilled Water

W4= wt. of empty pycnometer + distilled water

PROCEDURE:

1) Take the weight of dry pycnometer Bottle [W_1].
2) Take about 100 to 200 gm of oven-dried sample and put it in the pycnometer. Find the weight of the pycnometer [W_2].
3) Fill the Pycnometer to half of its height with the distilled water and mix it thoroughly with the glass rod, add more water and fill the Pycnometer till the top, clean it from outside & take weight [W_1]
4) Empty the Pycnometer, clean it neatly and fill with distilled water up to the hole of conical cap and take weight [W4]
5) Repeat the step & take three or four reading and calculate the average specific gravity

OBSERVATIONS:

1. Weight of dry Pycnometer. [W_1] =690 gm
2. Weight of Pycnometer +Fine Aggregate, [W_2] = 915 gm
3. Weight of Pycnometer + Fine aggregate + Water [W3] = 1720 gm
4. Weight of pycnometer + Water [W4] = 1580 gm

RESULT:

The specific gravity of given Fine aggregate sample is found out to be 2.65

Fig1:Pycnometer bottle filled with sand

Fig2; Pycnometer bottle filled with sand and water

3.1.4 TEST ON RUBBER

3.1.4.1 Specific gravity test by pycnometer method

AIM: To find out the specific gravity of a given sample of rubber by pycnometer method.

APPARATUS: IS sieve 12mm, pan, fine and coarse aggregates, rubber, pycnometer, weights set, water ,etc.

NEED:

Specific Gravity of an aggregate and rubber is considered as a measure of the quantity of strength of the material Stones having less specific gravity values generally are weaker than those having higher values. This test helps in identifying the stone specimen.

FORMULA:

$$\text{Specific Gravity, } G = \frac{W_2 - W_1}{[W_2 - W_1] - [W_1 - W_2]}$$

Where,

W_1=wt. of empty pycnometer

W_2 =wt. of empty pycnometer +rubber

W3= wt. of empty pycnometer +rubber +distilled Water

W4= wt. of empty pycnometer + distilled water

PROCEDURE:

1) Take the weight of dry pycnometer Bottle [W_1].
2) Take about 100 to 200 gm of oven-dried sample and put it in the pycnometer. Find the weight of the pycnometer [W_2].
3) Fill the Pycnometer to half of its height with the distilled water and mix it thoroughly with the glass rod, add more water and fill the Pycnometer till the top, clean it from outside & take weight [W_1]
4) [4] Empty the Pycnometer, clean it neatly and fill with distilled water up to the hole of conical cap and take weight [W4]
5) Repeat the step & take three or four reading and calculate the average specific gravity.

OBSERVATIONS:

1. Weight of dry Pycnometer. [W_1] = 621.5 gm

2. Weight of Pycnometer +Rubber [W_2] = 724.5 gm

3 Weight of Pycnometer + Rubber + Water [W3] = 1490 gm

4. Weight of pycnometer + Water [W4] =1506 gm

Fig1: <u>Weighing empty pycnometer bottle</u>

Fig 2 : <u>Weighing of pycnometer bottle filled with water and rubber fibres</u>

RESULT:

The
specific gravity of given Rubber sample is found out to be <u>0.86</u> .

3.2 MIX DESIGN FOR M60 GRADE OF CONCRETE

A) Stipulations for proportioning

a) Grade of designation : M60
b) Type of cement : OPC 53 grade
c) Maximum size of nominal size : 20mm
d) Exposure condition : Severe
e) Degree of site control : Good
f) Workability : 120mm
g) Method of concrete Placing : Pumping
h) Chemical admixture : Visco Flux-5507
i) Chemical admixture type : Super plasticizer

B) Test data for material

a) Cement used : OPC-53
b) Specific gravity of cement : 3015
c) Chemical admixture : Visco Flux-5507

d) Specific gravity of

1. Coarse aggregate : 0.5%
2. Fine aggregate : 1.0%

e) Specific gravity of

1. Coarse aggregate : 2.74
3. Fine aggregate : 2.65
4. Rubber : 0.86
5. Chemical Admixture : 1.08
6. Silica Fume : 2.20
7. Water : 1

Properties of Chemical admixture

1. High flow concrete applications.
2. Recommended for higher transit time of concrete mix
3. Recommended for special applications like self-compacting concrete.

1. Target Strength for mix proportioning

a) f ´ck = fck + 1.65S

= 60 + 1.65x5

= 68.25

N/mm^2

b) f ´ck = fck + X

= 60 + 6.5

= 66.5 N/mm^2

The higher value is to be adopted. Therefore, target strength will be 68.25 N/mm^2.As, 68.25 N/mm^2 > 66.5 N/mm^2.

2. Approximate Air Content

From Table no. 3, IS 10262-2019 the Approximate amount of entrapped air to be expected in normalconcrete is 1% for 20mm nominal maximum size of aggregate

3. Selection of Water-Cement Ratio

As per Fig1, Is 10262-2019, the water-cement ratio required for the target strength of 68.25 N/mm^2 is 0.28 for OPC53 grade which is calculated by interpolation. This is lower than the maximum value of 0.45.

As, 0.28 < 0.45, hence ok.

4. Selection of water content

Free water Cement Ratio is 0.28 as per fig. 1 IS 10262-2019 From table 4, Water Content for 50mm Slump = 186 kg/m^3 [for 50mm slump withoutplasticizer]

Estimated Water Content for 120mm slump= 186 + 15.624

= 201.6 kg ≈ 202 kg

As Super plasticizer is used, the water content may be reduced. The water content reductionof 30 % is considered while using super plasticizer @ 1.0 percent by weight of cement. Hence, the actual water content = 141 kg.

5. Calculation of cement content

Water–cement ratio =

0.28

Water content = 141

kg/m^3

Cement content = $\frac{141}{0.28} = 504.00$ kg/m^3

For High Strength Concrete we have to increase the cementitious material @ 10%

= 504 x 1.10 = 554 kg/m^3

As per Is456-2000 maximum cement Content is 450 kg/m^3

Add 5% Silica Fume by mass of cement content = 28 kg/m^3

Add 15% Fly Ash by mass of cement content = 83 kg/m^3

Actual OPC Cement Content = 443.00 kg/m^3 As Per Table 5 of IS456-2000

Criteria for Minimum Cement Content., Hence OK

Mass of Super plasticizer = 5.54 kg/m^3

Revised Water-Cementitious Material Content = 0.255

6. Proportion of volume of coarse aggregate and fine aggregate content

As Per Table 5/ Table 10 of IS 10262-2019 for Coarse Aggregate if W/C Reduced increase Coarse Aggregate

Volume of Coarse Aggregate for actual Water Cementitious Material Ratio is 0.049

Total Volume of Coarse Aggregate = 0.669

Total Volume of Fine Aggregate = 1-0.669

=0.331

7. Mix Calculation

a) Total Volume= $1m^3$

b) Volume of entrapped air in wet concrete = 0.010 m^3

c) Volume Of Cement = [443/3.15] X [1/1000] = 0.141 m^3

d) Volume of Water = [141/1] X [1/1000] = 0.141 m^3

e) Volume of Silica = [2.8/2.2] X [1/1000] = 0.01 m^3

f) Volume of Fly ash [83/2.22] X [1/1000] = 0.038 m^3

g) Volume of total aggregate = [[a-b]-[c+d+e+f+g]]

= [[1- 0.010]-[0.141+0.141+0.013+0.038+0.005]]

= $0.653m^3$

h) Mass of coarse aggregate = Volume of total aggregate x Specific Gravity of Coarse Aggregate x Volume of coarse aggregate x 1000

= 0.653 x 2.74 x 0.669x 1000

= 1197 kg/m^3

i) Mass of fine aggregate = Volume of total aggregate x Specific Gravity fine aggregate x Volume of fine aggregate x 1000

= 0.653 x 2.65 x 0.331 x 1000

= 584 kg/m^3

MIX CALCULATION

Replacement	Cement	Fine Aggregates	Coarse Aggregates	Rubber	Silica Fume	Chemical Admixture	Fly Ash	Water
	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3
RF 0	450	584	1197	0	37	6.090	122	155
RF 5	450	555	1197	9	37	6.211	122	155
RF 10	450	526	1197	19	37	6.333	122	155
RF 15	450	497	1197	28	37	6.455	122	155
RF 20	450	467	1197	37	37	6.577	122	155

As the rubber fibre are gradually added in concrete mix , workability of concrete decreases as rubber fibres absorb the water from the mix.

In order to maintain the workability of concrete, the chemical admixture [Visco flux 5570] is added in 2 % increasing order

3.3 TEST ON SPECIMENS

3.3.1 Compressive strength test on cubes specimen

OBJECTIVE :- To determine compressive strength of the specimen.

APPARTUS:- Compressive testing machine [CTM-2000KN]

SCALES:- The scales used in weighing materials for mortar mixes shall confirm to the following requirement-

On the scales in use, the permissible variation at load of 2000g shall be + 2.0g of the permissible variation on new scales shall be one – half of this value, the sensibility reciprocal shall not be greater than twice the permissible variation.

SPECIMENS AND MOULDS – The test specimens for cubes of size - 150*150*150 mm

CUBE MOULDS

The mould shall be of metal, preferably steel or cast iron, and stout enough to prevent distortion.It should not be attacked by cement , cement- pozzolana ,etc. It shall be constructed in such a manner as to facilitate the removal of the molded specimen without damage, and shall be so machined that, when it is assembled ready for use, the dimensions and internal faces shall be accurate within the following limits:

The height of the mould and the distance between opposite faces shall be 150 + 0·2 mm . The angle between adjacent internal faces and between internal faces and top and bottom planes of the mould shall be 90$\pm$0.5 degrees . The interior faces of the mould shall be plane surfaces with apermissible variation of 0·03 mm. Each mould shall he provided with a metal base plate having a plane surface machined to tolerance of 0.10mm . The base plate shall be of such dimensions as tosupport the mould during the filling without leakage and it shall be preferably attached to the mould by springs or screws. The parts of the mould when assembled shall be positively and rigidly held together.

In assembling the mould for use, the joints between the sections of mould shall be thinly coated with mould oil and a similar coating of mould oil shall be applied between the contact surfacesof the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the assembled mould shall be thinly coated with mould oil to prevent adhesion of the concrete .

MIXING APPARTUS

Machine Mixing : The concrete shall be mixed in a laboratory batch mixer, the ingredients need to be introduced in following order - Calculated water, 50% coarse aggregates, fine aggregates,cement,50% coarse aggregates as to avoid loss of water or other materials. The period of mixing shall be not less than 2 minutes after all the materials are in the drum, and shall continue till the resulting concrete is uniform in appearance.

TAMPING ROD

The tamping bar shall be a steel bar 16 mm in diameter, 0·6 m long and bullet pointed at the lower end.

TROWEL

A steel blade of 100 to 150 mm in length with straight edges.

PREPARATION OF SPECIMENS

The test specimens shall be made as soon as practicable after mixing, and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within the mould. After the top layer bas been compacted, the surface of the concrete shall be finished level with the top of the mould, using a trowel. Each specimen shall be compacted by vibration or hand compaction . When compacting by vibration, each layer shall be vibrated by means of an electric or pneumatic hammer or vibrator or by means of a suitable vibrating table until the specified condition is attained.

The test specimens shall be stored in a place, free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of 27° ± 2°C for 24 hours ± ½ hour from the time of addition of water to the dry ingredients.

CURING - The specimens shall be marked and removed from the mould and, unless required for test within 24 hours, immediately submerged in clean, fresh water or saturated lime solution and kept there until taken out just prior to test. The water or solution in which the specimens are submerged shall be renewed every seven days and shall be maintained at a temperature of 27° ± 2°C. The specimens shall not be allowed to become dry at any time until they have been tested.

TESTING

COMPRESSION TESTING MACHINE The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified . The permissible error shall be not greater than ± 2 percent of the maximum load. The testing machine shall be equipped with two steel bearing plates with hardened faces. One of the plates [preferably the one that normally will bear on the upper surface of the specimen] shall be fitted with a ball seating in the form of a portion of a sphere, the center of which coincides with the central point of the face of the platen. The other compression platen shall be plain rigid bearing block. The bearing faces of both platens shall be at least as large as, and preferably larger than the nominal size of the specimen to which the load is applied.

Age at Test - Tests shall be made at recognized ages of the test specimens, the most usual being 28 days. Ages of 13 weeks and one year are recommended if tests at greater ages are required. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± 1 hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients.

Number of Specimen - At least three specimens, preferably from different batches, shall be made for testing at each selected age.

PROCEDURE : Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the nearest 0.2 mm and their weight shall be noted before testing.

Placing the specimen in testing machine- The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen which are to be In contact with the compression platens. In the case of cubes, the specimen shall be placed In the machine In such a manner that the load shall be applied to opposite sides of the cubes as cast, that is not to the top and bottom . The axis of the specimen shall be carefully aligned with the center of thrust of the spherically seated platen . No packing shall be used between the faces of the test specimen and the steel platen of the testing machine As the spherically seated block is brought to bear on the specimen. the movable portion shall be rotated gently by hand so that uniform seating may be obtained. The load shall be applied without shock and Increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the Increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

Crack Scope :-

The Crack Scope can be used for accurate measurement of the width of surface opening cracks as well as measurement of the depth of surface holes or irregularities.

It is a small size, lightweight and conveniently portable microscope with a 25× magnification. It has a build-in scale for crack-width measurement and another scale on the focusing adjustment ring for depth indication.

Purpose :- The Crack Scope CS-100 can be used for accurate measurement of the width of surface opening cracks as well as measurement of the depth of surface holes or irregularities.

Principle:- The Crack Scope is a small size, lightweight and conveniently portable microscope with a 25× magnification. It has a build-in scale for crack-width measurement and another scale on the focusing adjustment ring for depth indication.

Resolution :- The magnification of the Crack Scope is 25 times. The built-in 3-mm scale has a least division of 0.05 mm, allowing the width of cracks to be estimated within ±0.025 mm. Depth measurement is achieved by focusing at the bottom of a depression and then focusing at the perimeter of the depression. By reading the scale engraved on the focusing ring and the needle of the lens barrel, depths can be measured with an accuracy of ±0.05 mm.

Fig1 Crack Scope

Fig 2: Longitudinal Crack

Crack Depth Calculation :-

Crack Depth = [Div. at Bottom – Div. at Top] x 0.1

Calculation - The measured compressive strength of the specimen shall be calculated by dividingthe maximum load applied to the specimen during the test by the cross-sectional area. Calculated from the mean dimensions of the section and shall be expressed to the nearest kg per sq cm. Average of three values shall be taken as the representative of the batch provided the Individual variation is not more than ± 15 percent of the average. Otherwise repeat tests shall be made

Observation (For NaOH pretreated rubberized concrete)

Sample	Div. at bottom	Div. at Top	Crack Depth [mm]
0 %	80	70	1.0 mm
5 %	110	96	1.4 mm
10 %	123	106	1.7 mm
15 %	131	112	1.9 mm
20 %	136	116	2.0 mm

Observation (For HCL pretreated rubberized concrete)

Sample	Div. at bottom	Div. at Top	Crack Depth [mm]
0 %	80	70	1.0 mm
5 %	112	97	1.5 mm
10 %	125	107	1.8 mm
15 %	133	113	2.0 mm
20 %	138	115	2.3 mm

Fig 1:Results on compressive testing machine

Fig 2 : Cubes after testing

Fig 3:Cubes tested over compressive strength testing machine

Fig 4: Silica fume bag

Fig 5: Cement bag

<u>TEST RESULT</u> **<u>[For NaOH Treatment]</u>**

<u>Table</u> : Values of Compressive Strength for sand replacement of 0% to 20 % for NaOH Pretreated Rubberized Concrete

REPLACEMENT %	SAMPLE	LOAD APPLIED [KN]	COMPRESSIVESTRENGTH [MPa]	AVGERAGE COMPRESSIVESTRENGTH [MPa]
0	Sample 1	1388	61.69	62.13
	Sample 2	1396	62.04	
	Sample 3	1410	62.67	
5	Sample 1	1390	61.78	61.11
	Sample 2	1365	60.67	
	Sample 3	1370	60.89	
10	Sample 1	1332	59.20	59.02
	Sample 2	1330	59.11	
	Sample 3	1322	58.76	
15	Sample 1	1150	51.11	51.78
	Sample 2	1135	50.44	
	Sample 3	1210	53.78	
20	Sample 1	1080	48.00	48.22
	Sample 2	1110	49.33	
	Sample 3	1065	47.33	

TEST RESULT [For HCL Treatment]

Table : Values of Compressive Strength for sand replacement of 0% to 20 % for HCl Pretreated Rubberized Concrete

REPLACEMENT %	SAMPLE	LOAD APPLIED [KN]	COMPRESSIVE STRENGTH [MPa]	AVGERAGE COMPRESSIVE STRENGTH [MPa]
0	Sample 1	1398	62.13	61.90
	Sample 2	1400	62.22	
	Sample 3	1380	61.33	
5	Sample 1	1386	61.60	61.05
	Sample 2	1370	60.89	
	Sample 3	1365	60.67	
10	Sample 1	1352	60.09	59.88
	Sample 2	1350	60.00	
	Sample 3	1340	59.56	
15	Sample 1	1170	52.00	52.74
	Sample 2	1180	52.44	
	Sample 3	1210	53.78	
20	Sample 1	1040	46.22	46.52
	Sample 2	1035	46.00	
	Sample 3	1065	47.33	

Extensometer :-

It Consists of a frame with a bottom ring and a top ring with tightening screws to firmly clamp the Extensometer over the cylinder. A dial gauge 0.002 mm x 5 mm is mounted on the upper ring and the tie of the dial gauge rests on an anvil. The zero on the dial gauge can be set by adjusting the anvil screw.

Fig1:Extensometer

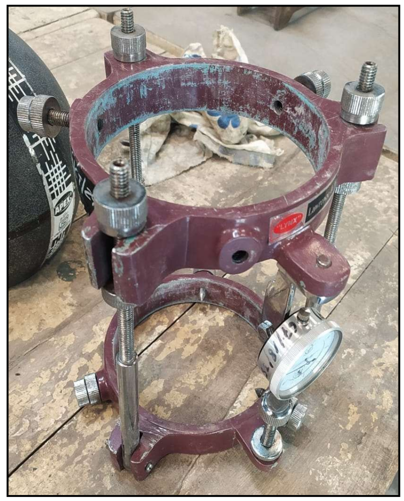


Fig 2: Extensometer with Dial Gauge

Fig 3: Extensometer set in CTM

- **Observation**

  Table : Values of deflection for replacement of 0 % to 20 % for NaOH treatment

Load[KN]	Corresponding Values of deflection				
	0%	5%	10%	15%	20%
60	0.03	0.30	0.04	0.07	0.08
150	0.06	0.06	0.09	0.18	0.27
240	0.08	0.07	0.13	0.27	0.42
330	0.10	0.16	0.20	0.40	0.49
420	0.12	0.20	0.25	0.50	0.60
510	0.13	0.23	0.30	0.59	0.72
600	0.16	0.27	0.39	0.69	0.84
690	0.18	0.30	0.46	0.74	0.89
780	0.20	0.33	0.52	0.80	-
870	0.22	0.39	0.61	-	-

3.3.2 Flexural strength test :

OBJECTIVE

To Determine flexural Strength of the specimen.

APPARTUS- FLEXURAL TESTING MACHINE

SCALES – The scales used in weighing materials for mortar mixes shall confirm to the following requirement-

On the scales in use, the permissible variation at load of 2000g shall be + 2.0g of the permissible variation on new scales shall be one – half of this value, the sensibility reciprocal shall not be greater than twice the permissible variation.

SPECIMENS AND MOULDS –The size shall be 10 × 10 × 50cm.

BEAM MOULDS

The mould shall be of metal, preferably steel or cast iron, and stout enough to prevent distortion.It should not be attacked by cement , cement- pozzolana ,etc. It shall be constructed in such a manner as to facilitate the removal of the molded specimen without damage, and shall be so machined that, when it is assembled ready for use, the dimensions and internal faces shall be accurate within the following limits:

The angle between adjacent internal faces and between internal faces and top and bottom planes of the mould shall be 90±0.5 degrees . The interior faces of the mould shall be plane surfaces with a permissible variation of 0·03 mm. Each mould shall he provided with a metal base plate having a plane surface machined to tolerance of 0.10mm . The base plate shall be of such dimensions as to support the mould during the filling without leakage and it shall be preferably attached to the mould by springs or screws. The parts of the mould when assembled shall be positively and rigidly held together.

In assembling the mould for use, the joints between the sections of mould shall be thinly coated with mould oil and a similar coating of mould oil shall be applied between the contact surfacesof the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the assembled mould shall be thinly coated with mould oil to prevent adhesion of the concrete .

In assembling the mould for use, the joints between the sections of mould shall be thinly coated with mould oil and a similar coating of mould oil shall be applied between the contact surfacesof the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the assembled mould shall be thinly coated with mould oil to prevent adhesion of the concrete .

MIXING APPARTUS

Machine Mixing : The concrete shall be mixed in a laboratory batch mixer the ingredients need to be introduced in following order - Calculated water,50% coarse aggregates, fine aggregates,cement,50% coarse aggregates as to avoid loss of water or other materials. The period of mixing shall be not less than 2 minutes after all the materials are in the drum, and shall continue till the resulting concrete is uniform in appearance.

TAMPING ROD

The tamping bar shall be a steel bar 16 mm in diameter, 0·6 m long and bullet pointed at the lower end.

TROWEL

A steel blade of 100 to 150 mm in length with straight edges.

PREPARATION OF SPECIMENS

The test specimens shall be made as soon as practicable after mixing, and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within the mould. After the top layer has been compacted, the surface of the concrete shall be finished level with the top of the mould, using a trowel. Each specimen shall be compacted by vibration or hand compaction . When compacting by vibration, each layer shall be vibrated by means of an electric or pneumatic hammer or vibrator or by means of a suitable vibrating table until the specified condition is attained.

The test specimens shall be stored in a place, free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of 27° ± 2°C for 24 hours ± ½ hour from the time of addition of water to the dry ingredients.

CURING - The specimens shall be marked and removed from the mould and, unless required for test within 24 hours, immediately submerged in clean, fresh water or saturated lime solution and kept there until taken out just prior to test. The water or solution in which the specimens are submerged shall be renewed every seven days and shall be maintained at a temperature of 27° ± 2°C. The specimens shall not be allowed to become dry at any time until they have been tested.

TESTING

FLEXURAL TESTING MACHINE The testing machine may be of any reliable type of sufficient capacity for the tests and capable of applying the load at the rate specified in The permissible errors shall be not greater than ± 0.5percent of the applied load where a high degree of accuracy is required and not greater than ± 1.5 percent of the applied load for commercial typeof use. The bed of the testing machine shall be provided with two steel rollers, 38 mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from center to center is 60 cm for 15.0 cm specimens or 40 cm for 10.0 cm specimens. The load shall be applied through two similar rollers mounted at the third points ofthe supporting span that is, spaced at 20 or 13.3 cm center to center. The load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsional stresses or restraints.

Age at Test - Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Ages of 13 weeks and one year are recommended if tests at greater ages are required. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± 1 hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients.

Number of Specimen - At least three specimens, preferably from different batches, shall be made for testing at each selected age.

PROCEDURE

Test specimens stored in water at a temperature of 24° to 30°C for 48 hours before testing, shall be tested immediately on removal from the water whilst they are still in a wet condition. The dimensions of each specimen shall be noted before testing. No preparation of the surfaces is required.

Placing the specimen in testing machine- The bearing surfaces of the supporting and loading rollers shall be wiped clean, and any loose sand or other material removed from the surfaces of the Specimen where they are to make contact with the rollers. The specimen shall then be placed in the machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould, along two lines spaced 20.0 or 13.3 cm apart. The axis of the specimen shall be carefully aligned with the axis of the loading device. No packing shall be used between the bearing surfaces of the specimen and the rollers. The load shall be applied without shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 7 kg/sq cm/min, that is, at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded. The appearance of the fractured faces of concrete and any unusual features in the type of failure shall be noted.

Calculation –

The flexural strength of the specimen shall be expressed as the modulus of rupture fb, which, if 'a' equals the distance between the line of fracture and the nearer support, measured on the Centre line of the tensile side of the specimen, in cm, shall be calculated to the nearest 0.5 kg/sq cm as follows:

$$f_b = \frac{p \times l}{b \times d^2}$$

when 'a' is greater than 20.0 cm for 15.0 cm specimen, or greater than 13.3 cm for a 10.0 cm specimen, or

$$f_b = \frac{3p \times a}{b \times d^2}$$

when 'a' is less than 20.0 cm but greater than 17.0 cm for 15.0 cm specimen, or less than 13.3 cm but greater than 11.0 cm for a 10.0 cm specimen

where ,

b = measured width in cm of the specimen,
d = measured depth in cm of the specimen at the point of failure,
l = length in cm of the span
p = maximum load in kg applied to the specimen.

If '*a*' is less than 17.0 cm for a 15.0 cm specimen, or less than 11.0 cm for a 10.0 cm specimen,the results of the test shall be discarded

Fig 1: Load applied on concrete beam

Fig 2: Readings on Flexural testing machine

Fig 3:Beams at failure load

TEST RESULT [For NaOH Treatment]

Table : Values of Flexural Strength for sand replacement of 0% to 20 % for NaOH Pretreated Rubberized Concrete

REPLACEMENT %	SAMPLE	LOAD APPLIED [KN]	FLEXURAL STRENGTH [MPa]	AVG. FLEXURAL STRENGTH [MPa]
0	Sample 1	11	5.50	5.75
	Sample 2	13.5	6.75	
	Sample 3	10	5.00	
5	Sample 1	12	6.00	6.17
	Sample 2	14	7..00	
	Sample 3	11	5.50	
10	Sample 1	14.5	7.25	7.25
	Sample 2	16	8.00	
	Sample 3	13	6.50	
15	Sample 1	13	6.50	5.92
	Sample 2	12	6.00	
	Sample 3	10.5	5.25	
20	Sample 1	9	4.50	5.42
	Sample 2	12.5	6.25	
	Sample 3	11	5.50	

TEST RESULT [For HCL Treatment]

Table : Values of Flexural Strength for sand replacement of 0% to 20 % for HCL Pretreated Rubberized Concrete

REPLACEMENT %	SAMPLE	LOAD APPLIED [KN]	FLEXURAL STRENGTH [MPa]	AVG. FLEXURAL STRENGTH [MPa]
0	Sample 1	12.00	6.00	6.00
	Sample 2	13.00	6.50	
	Sample 3	11.00	5.50	
5	Sample 1	13.00	6.50	7.08
	Sample 2	15.50	7.75	
	Sample 3	14.00	7.00	
10	Sample 1	13.50	6.75	7.17
	Sample 2	15.00	7.50	
	Sample 3	14.50	7.25	
15	Sample 1	14.00	7.00	6.58
	Sample 2	13.00	6.50	
	Sample 3	12.50	6.25	
20	Sample 1	9.50	4.75	4.58
	Sample 2	10.00	5.00	
	Sample 3	8.00	4.00	

3.3.3 Split tensile strength test :

OBJECTIVE To determine splitting tensile strength of the specimen.

APPARTUS compression testing machine

SCALES – The scales used in weighing materials for mortar mixes shall confirm to the following requirement-

On the scales in use, the permissible variation at load of 2000g shall be + 2.0g of the permissible variation on new scales shall be one – half of this value, the sensibility reciprocal shall not be greater than twice the permissible variation.

SPECIMENS AND MOULDS –The cylindrical specimen shall have diameter not less than fourtimes the maximum size of the coarse aggregate and not less than 150 mm. The length of the specimens shall not be less than the diameter and not more than twice the diameter. For routine testing and comparison of results, unless otherwise specified the specimens shall be cylinder 150 mm in diameter and 300 mm long.

In assembling the mould for use, the joints between the sections of mould shall be thinly coated with mould oil and a similar coating of mould oil shall be applied between the contact surfacesof the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the assembled mould shall be thinly coated with mould oil to prevent adhesion of the concrete .

MIXING APPARTUS

Machine Mixing : The concrete shall be mixed in a laboratory batch mixer the ingredients need to be introduced in following order - Calculated water,50% coarse aggregates, fine aggregates,cement,50% coarse aggregates as to avoid loss of water or other materials. The period of mixing shall be not less than 2 minutes after all the materials are in the drum, and shall continue till the resulting concrete is uniform in appearance.

TAMPING ROD

The tamping bar shall be a steel bar 16 mm in diameter, 0·6 m long and bullet pointed at thelower end.

TROWEL

A steel blade of 100 to 150 mm in length with straight edges.

PREPARATION OF SPECIMENS

The test specimens shall be made as soon as practicable after mixing, and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within the mould. After the top layer has been compacted, the surface of the concrete shall be finished level with the top of the mould, using a trowel. Each specimen shall be compacted by vibration or hand compaction . When compacting by vibration, each layer shall be vibrated by means of an electric or pneumatic hammer or needle vibrator or by means of a suitable vibrating table until the specified condition is attained.

The test specimens shall be stored in a place, free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of 27° ± 2°C for 24 hours ± ½ hour from the time of addition of water to the dry ingredients.

CURING - The specimens shall be marked and removed from the mould and, unless required for test within 24 hours, immediately submerged in clean, fresh water or saturated lime solution and kept there until taken out just prior to test. The water or solution in which the specimens are submerged shall be renewed every seven days and shall be maintained at a temperature of 27° ± 2°C. The specimens shall not be allowed to become dry at any time until they have been tested.

TESTING

COMPRESSION TESTING MACHINE The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified . The permissible error shall be not greater than ± 2 percent of the maximum load. The testing machineshall be equipped with two steel bearing plates with hardened faces. One of the plates [preferablythe one that normally will bear on the upper surface of the specimen] shall be fitted with a ball seating in the form of a portion of a sphere, the center of which coincides with the central pointof the face of the platen. The other compression platen shall be plain rigid bearing block. The bearing faces of both platens shall be at least as large as, and preferably larger than the nominal size of the specimen to which the load is applied.

Age at Test - Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Tests at any other age at which the tensile strength is desired may be made, if so required. The ages shall be calculated from the time of the addition of water to the dry ingredients. The age at test shall be reported along with the results.

Number of Specimen - At least three specimens, preferably from different batches, shall be made for testing at each selected age.

PROCEDURE Specimens when received dry shall be kept in water for 24 h before they are taken for testing. Unless other conditions are required for specific laboratory investigation specimen shall be tested immediately on removal from the water whilst they are still wet. Surface water and grit shall be wiped off the specimens and any projecting fins removed from the surfaces which are to be in contact with the packing strips.

Marking Central lines shall be drawn on the two opposite faces of the cube using any suitable procedure and device that will ensure that they are in the same axial plane.

Measurement The mass and dimensions of the specimen shall be P = maximum load in Newtons applied to the noted before testing. The sides of the specimen, lying specimen, in the plane of the pre-marked lines, shall be measured near the ends and the middle of the specimen and the average taken to the nearest 0.2 mm. The length of the specimen shall be taken to the nearest 0.2 mm by averaging the two lengths measured in the plane containing the pre-marked lines.

Placing of the Specimen in the Testing Machine The bearing surfaces of the testing machine and of the loading strips shall be wiped clean.

Positioning The test specimen shall be placed in the centering jig with packing strip and/or loading pieces carefully positioning along the top and bottom of the plane of loading of the specimen. The jig shall then be placed in the machine so that the specimen is located centrally. Inthe case of cubic specimens, the load shall be applied on the molded faces in such a way that thefracture plane will cross the troweled surface.

For cylindrical specimen it shall be ensured that the upper platen is parallel with the lowerplaten.

Rate of Loading The load shall be applied without shock and increased continuously at anominal rate within the range 1.2 N/[mm*/min] to 2.4 N/ [mm Vmin]. Maintain the rate, once adjusted, until failure. On manually controlled machines as failure is approached the loading rate will decrease; at this stage the controls shall be operated to maintain as far as possible the specified loading rate. The maximum load applied shall then be recorded. The appearance of concrete and any unusual features in the type of failure shall also be noted.

The rate of increase of load may be calculated from the formula:

[1.2 to 2.4] x 7r/2 x I x d N/min

Calculation -The measured splitting tensile strength fc, of the specimen shall be calculated to the nearest 0.05 N/mm2using the following formula :

$$f_{ct} = \frac{2\,p}{\pi l d}$$

where,

P = maximum load in Newtons applied to the specimen,

I = length of the specimen [in mm], and

d = cross sectional dimension of the specimen

Fig 1: Load Applied on the cylindrical Specimen   Fig 2 :Load at which failure occurs

Fig 3:Compression Testing Machines

TEST RESULT [NaOH Treatment]

Table : Values of Split Tensile Strength for sand replacement of 0% to 20 % for NaOH Pretreated Rubberized Concrete

REPLACEMENT %	SAMPLE	LOAD APPLIED [KN]	SPLIT TENSILE STRENGTH [MPa]	AVERAGE SPLIT TENSILE STRENGTH [MPa]
0	Sample 1	397	5.60	5.58
	Sample 2	402	5.67	
	Sample 3	388	5.47	
5	Sample 1	438	6.18	6.27
	Sample 2	449	6.34	
	Sample 3	446	6.29	
10	Sample 1	486	6.86	6.89
	Sample 2	491	6.93	
	Sample 3	488	6.89	
15	Sample 1	450	6.35	6.41
	Sample 2	454	6.41	
	Sample 3	458	6.46	
20	Sample 1	429	6.05	6.00
	Sample 2	420	5.93	
	Sample 3	426	6.01	

TEST RESULT [For HCL Treatment]

Table : Values of Split Tensile Strength for sand replacement of 0% to 20 % for HCL Pretreated Rubberized Concrete

REPLACEMENT %	SAMPLE	LOAD APPLIED [KN]	SPLIT TENSILE STRENGTH [MPa]	AVERAGE SPLIT TENSILE STRENGTH [MPa]
0	Sample 1	450	6.35	5.83
	Sample 2	400	5.64	
	Sample 3	390	5.50	
5	Sample 1	430	6.07	5.90
	Sample 2	425	6.00	
	Sample 3	400	5.64	
10	Sample 1	435	6.14	6.24
	Sample 2	440	6.21	
	Sample 3	452	6.39	
15	Sample 1	415	5.86	5.86
	Sample 2	420	5.93	
	Sample 3	410	5.78	
20	Sample 1	400	5.63	5.58
	Sample 2	408	5.76	
	Sample 3	380	5.36	

3.3.4 Ultrasonic pulse velocity test

OBJECTIVE:

An ultrasonic pulse velocity [UPV] test is an in-situ, nondestructive test to check the quality of concrete and natural rocks. In this test, the strength and quality of concrete or rock is assessed by measuring the velocity of an ultrasonic pulse passing through a concrete structure or natural rock formation.

REQUIREMENTS :

Ultrasonic testing equipment includes a pulse generation circuit, consisting of electronic circuit for generating pulses and a transducer for transforming electronic pulse into mechanical pulse having an oscillation frequency in range of 40 kHz to 50 kHz, and a pulse reception circuit that receives the signal.

PROCEDURE:

1. Ultrasonic testing consists of measuring the travel time of an ultrasonic pulse or wave of 25 to 60 kHz.
2. The ultrasonic pulse or wave is produced and received by an electro-acoustical transducer.
3. The transducer is held in contact with one surface of the concrete member and receiving the same by a similar transducer in contact with the surface at the other end.
4. The speed of the pulse or wave is the function of the density of the material. It allows the estimation of the porosity and the detection of discontinuities like cracks in the house. Once the distance between two probes [path length] and time of travel is known, it is possible to determine the average pulse velocity by the following equation.
5. The higher pulse velocity indicates higher elastic modulus, density and integrity of the concrete.
6. Pulse velocity also depends on the method of propagation and the arrangement of transducers. There are three primary ways in which the transducers may be arranged.

Arrangement of Transducers in Ultrasonic Testing

01. Opposite Faces [Direct Transmission]:

If one transducer is placed at one end, and the other one is placed exactly at the opposite end, it is the direct method.

02. Adjacent Faces [Semi-Direct Transmission]:

In this method, both transducers are placed on the same surface of the concrete. The receiver receives the ultrasonic pulse coming after striking the molecules of the concrete.

03. Same Face [Indirect Transmission]:

It is mostly used for corners of the concrete members.

The maximum pulse energy is transmitted at right angles to the face of the transmitter.

The direct transmission method is considered to be the most reliable way.

FORMULA:

Pulse velocity= Distance between the two probes [Path Length]/ Time of travel

General Guidelines for Concrete Quality based on the UPV Test Results:

Pulse Velocity in Concrete [Km/Sec]	Concrete Quality [Grade]
> 4.0	Very Good to Excellent
3.5 – 4.0	Good to Very Good, Slight Porosity may Exist.
3.0 – 3.5	Satisfactory but Loss of Integrity is Suspected
< 3.0	Poor and Loss of Integrity Exist

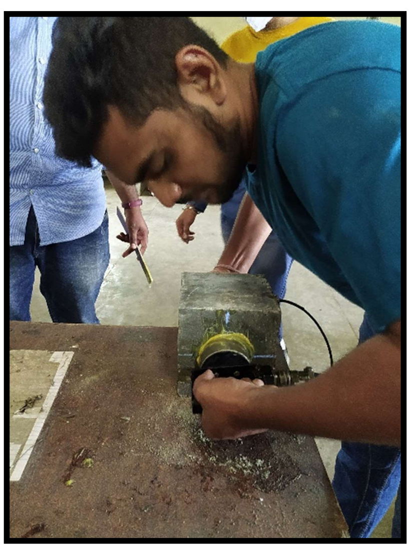


Fig 1:Direct transmission on cube

Fig 2: Reading on gauge in micro sec

OBSERVATION TABLE:

Table : Direct Transmission [for cube]

REPLACEMENT %	SAMPLE	Time [Micro Second]	Distance [mm]	Velocity [Km/sec]	Concrete Quality [Grade]
0	Sample 1	31.6	150	4.74	Very Good to Excellent
	Sample 2	34.7	150	4.32	
	Sample 3	34.8	150	4.31	
5	Sample 1	33.5	150	4.48	Very Good to Excellent
	Sample 2	34.1	150	4.39	
	Sample 3	35.9	150	4.18	
10	Sample 1	35.5	150	4.22	Very Good to Excellent
	Sample 2	35.7	150	4.2	
	Sample 3	36.4	150	4.12	
15	Sample 1	35.4	150	4.24	Very Good to Excellent
	Sample 2	34.3	150	4.37	
	Sample 3	36	150	4.17	
20	Sample 1	37.3	150	4.02	Very Good to Excellent
	Sample 2	35.5	150	4.22	
	Sample 3	35	150	4.28	

Table : Diagonal Transmission [for cube]

REPLACEMENT %	SAMPLE	Time [Micro Sec]	Distance [mm]	Velocity [Km/sec]	Concrete Quality [Grade]
0	Sample 1	24.2	10.60	4.38	Very Good to Excellent
	Sample 2	24.5	10.60	4.33	
	Sample 3	26.3	10.60	4.03	
5	Sample 1	23.5	10.60	4.5	Very Good to Excellent
	Sample 2	20.5	10.60	5.17	
	Sample 3	21.5	10.60	4.93	
10	Sample 1	24.5	10.60	4.32	Very Good to Excellent
	Sample 2	24.8	10.60	4.27	
	Sample 3	23.6	10.60	4.49	
15	Sample 1	23.7	10.60	4.47	Very Good to Excellent
	Sample 2	24.3	10.60	4.36	
	Sample 3	25	10.60	4.24	
20	Sample 1	27.9	10.60	3.79	Very Good to Excellent
	Sample 2	25.3	10.60	4.19	
	Sample 3	24.5	10.60	4.33	

Table : Direct Transmission [for cylinder]

REPLACEMENT %	SAMPLE	Time [Micro Second]	Distance [mm]	Velocity [Km/sec]	Concrete Quality [Grade]
0	Sample 1	73.7	300	4	Very Good to Excellent
	Sample 2	72.3	300	4.15	
	Sample 3	72.7	300	4.14	
5	Sample 1	68.1	300	4.4	Very Good to Excellent
	Sample 2	72.7	300	4.14	
	Sample 3	73.7	300	4	
10	Sample 1	75.4	300	3.97	Good to Very Good, Slight Porosity may Exist.
	Sample 2	83.7	300	3.6	
	Sample 3	75.4	300	3.97	
15	Sample 1	87	300	3.45	Good to Very Good, Slight Porosity may Exist.
	Sample 2	83.7	300	3.6	
	Sample 3	86.2	300	3.5	
20	Sample 1	76.2	300	3.93	Good to Very Good, Slight Porosity may Exist.
	Sample 2	75.6	300	3.97	
	Sample 3	75.3	300	3.98	

3.3.5 Simulation by using Ansys software

About

Ansys, Inc. is an American company based in Canonsburg, Pennsylvania. It develops and markets CAE/Multiphysics engineering simulation software for product design, testing and operation and offers its products and services to customers worldwide.

Ansys was founded in 1970 by John Swanson, who sold his interest in the company to venture capitalists in 1993. Ansys went public on NASDAQ in 1996. In the 2000s, the company acquired numerous other engineering design companies, obtaining additional technology for fluid dynamics, electronics design, and physics analysis. Ansys became a component of the NASDAQ-100 index on December 23, 2019

Engineering simulation software:

Ansys develops and markets engineering simulation software for use across the product life cycle. Ansys Mechanical finite element analysis software is used to simulate computer models of structures, electronics, or machine components for analyzing the strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes. Ansys is used to determine how a product will function with different specifications, without building test products or conducting crash tests. For example, Ansys software may simulate how a bridge will hold up after years of traffic, how to best process salmon in a cannery to reduce waste, or how to design a slide that uses less material without sacrificing safety.

Specimens examined:

- Cube
- Beam
- Railway Sleepers

Parameters calculated:

- Deformed shape
- Displacement
- Von mises stress
- Von mises Elastic Strain

All the cubes and beams of 0, 5, 10, 15 and 20% replacement were designed and the above stated parameters of the same were simulated under a constant load of 1.1e6kN/m^3

Simulation for railway sleepers

Railway sleeper is a main component of railway track structure. Its function is to distribute loads from the rail foot to the underlying ballast bed , concrete sleepers are less elastic.

Adding rubber fibre to the concrete mix causes significant increase in its toughness, so impact resistance. It is also observed that the utilization of discarded rubber tyres in concrete to replace a part of the fine aggregate has resulted in a concrete which has high impact resistance, improved elastic properties and considerable fatigue strength.

Here, the Static loading applied & the Dead weight of Concrete sleeper 250 kg and the Dynamic load of 22.30 t Axel load - according to AS5100.2 Cl.8.2 Running of " Broad Gauge Bogie Open wagon type BOXN [CC+6T+2T]" having maximum axle load of 22.32t on UP and DN lines of Northern Railway at a maximum permissible speed of 80kmph in empty condition and 60 kmph in loaded condition for a duration of 1-10 sec.

Material Properties used : Modulus of elasticity [E]
Density [ρ]
Poisons ratio [μ]

Parameters Calculated :Total Deformation ,
Equivalent [von-Mises] Stress

Application :

The advantage of using rubberized concrete for the construction of railway sleepers instead of conventional concrete was done in order to predict the stress it can bear without failing and the displacement in the new material due to all the load acting on the sleepers.

It was mainly done to inspect weather RC railway sleepers could or couldn't replace the NC sleepers and how varied or similar are the results for both the types.

SIMULATION RESULTS FOR CUBE

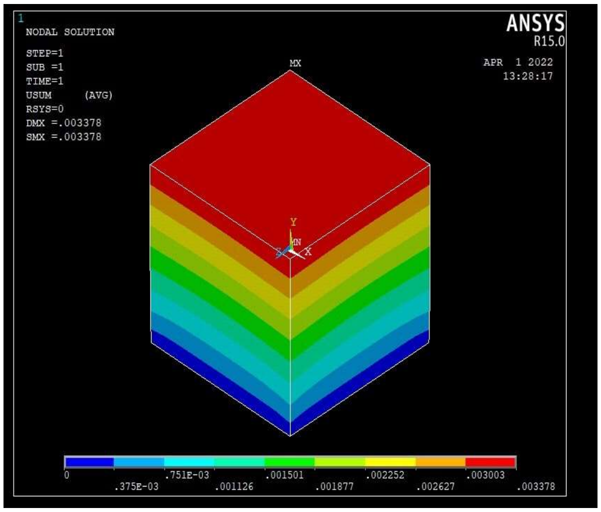


Fig 1: Displacement

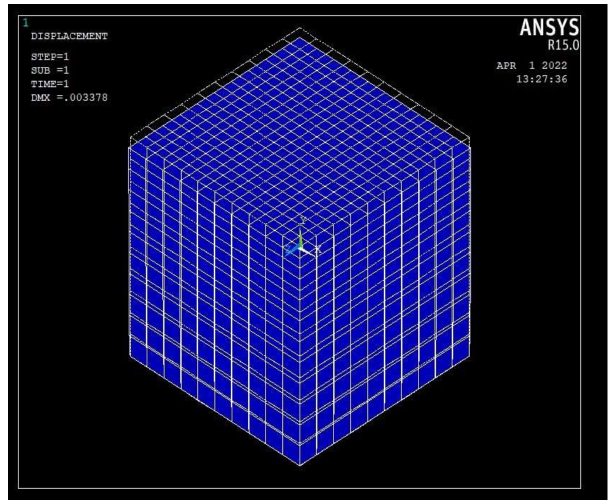


Fig 2: Deformed shape

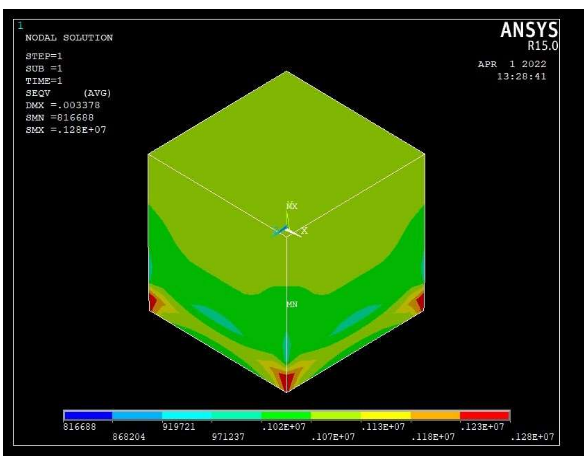


Fig 3 :Von mises stress

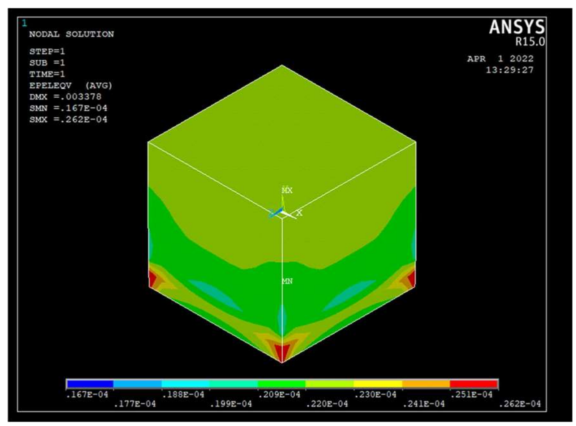


Fig 4: Von mises elastic Strain

- The pictures shows the results of displacement , deformed shape , von mises stress & von mises strain for cube model after the application of load.
- The pictures of all these samples show the color variations on the basis of the effects of the load on different parts of the specimen. The red color indicates where maximum stress or deflection is occurring while the blue color shoes where minimum stress or deflection is occurring. The colors in between follow the same pattern.

SIMULATION RESULTS FOR BEAM

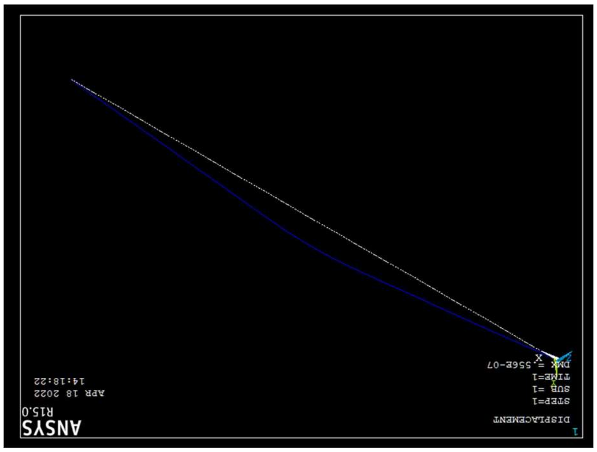


Fig 1 :Deformed shape

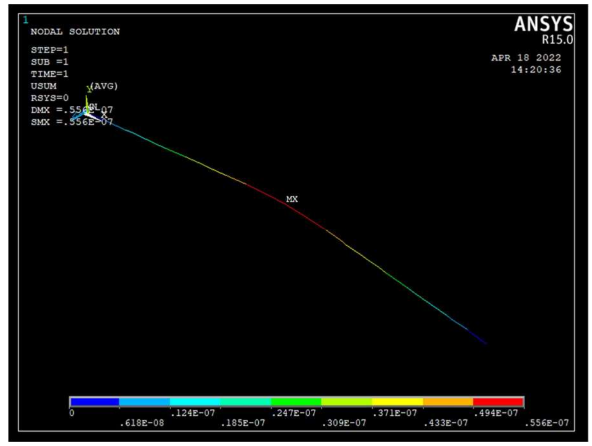


Fig 2: Displacement

Fig 3: Von mises stress

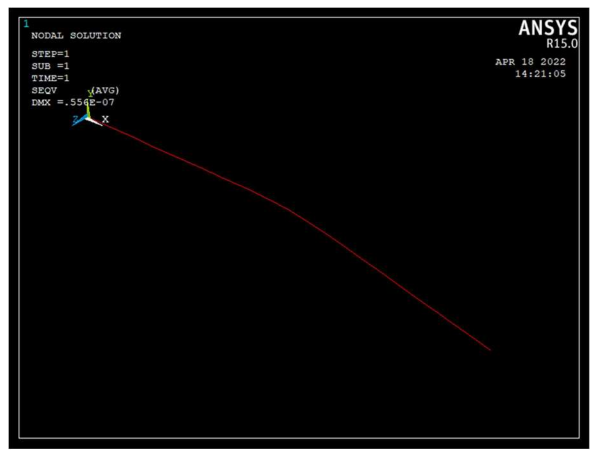


Fig 4: Von mises elastic strain

- The pictures shows the results of displacement , deformed shape , von mises stress & von mises strain for beam model after the application of load.
- The pictures of all these samples show the color variations on the basis of the effects of the load on different parts of the specimen. The red color indicates where maximum stress or deflection is occurring while the blue color shoes where minimum stress or deflection is occurring. The colors in between follow the same pattern.

SIMULATION RESULTS FOR RAILWAY SLEEPERS

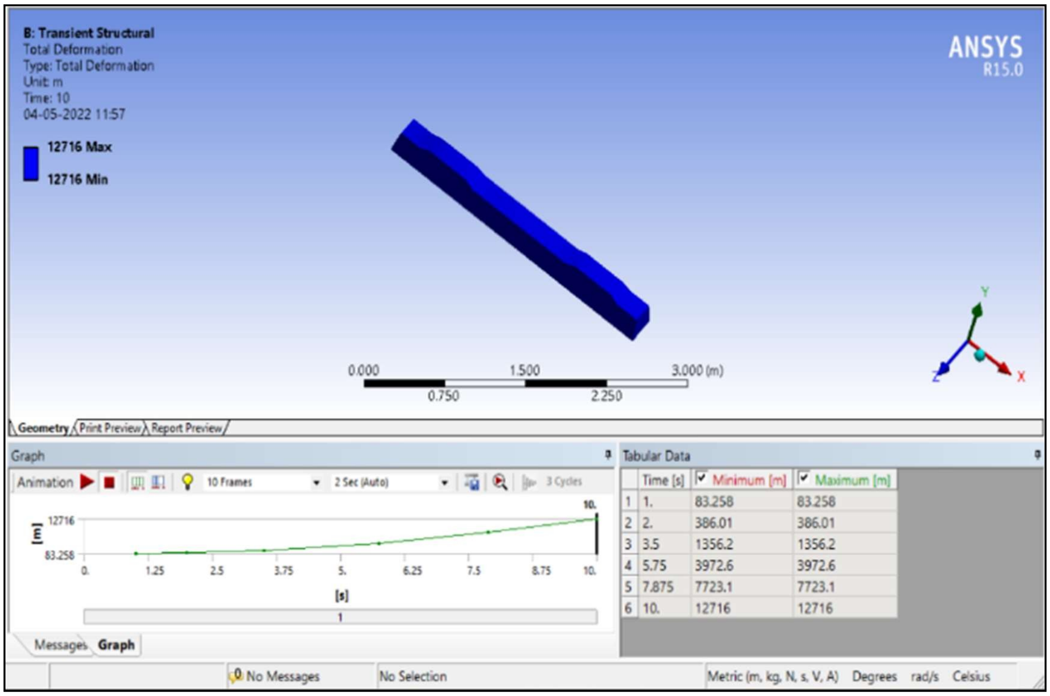


Fig 1: Displacement

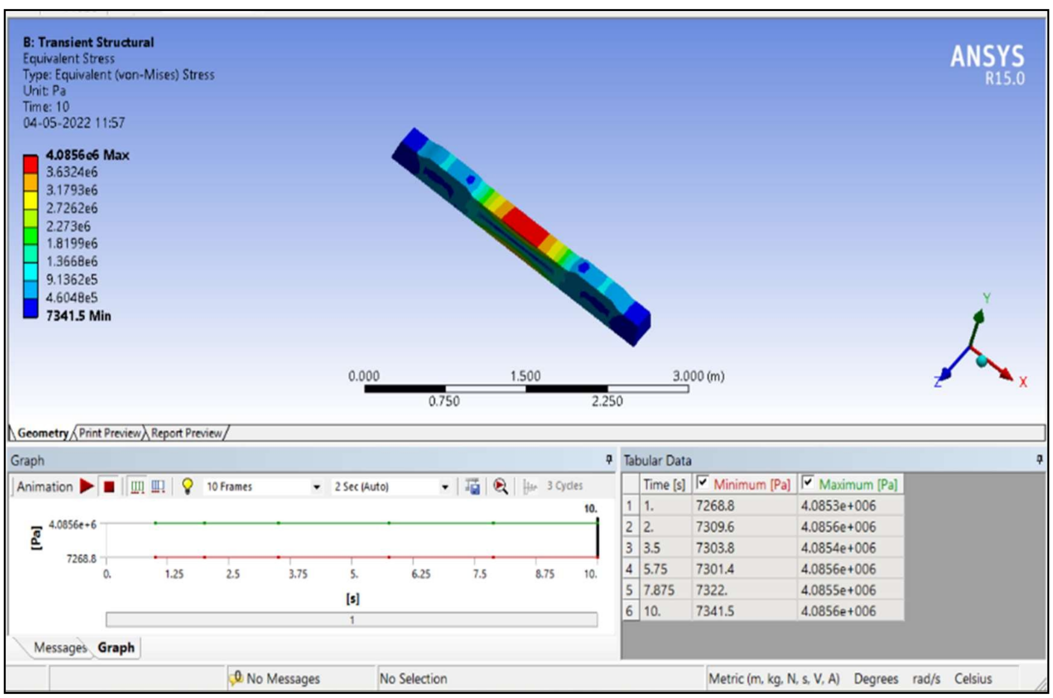


Fig 2: Equivalent Stress

Table : Equivalent Displacement (Nodal Result)

NODES	R0		R5		R10		R15		R20	
	(Meters)		(Meters)		(Meters)		(Meters)		(Meters)	
Specimen	Cube	Beam	Cube	Beam	Cube	Beam	Cube	Beam	Cube	Beam
	10^{-2}	10^{-7}	10^{-2}	10^{-7}	10^{-2}	10^{-7}	10^{-2}	10^{-7}	10^{-2}	10^{-7}
1	0.33779	0.556	0.35283	0.616	0.37667	0.656	0.36399	0.633	0.39686	0.700
2	0.30437	0.551	0.31795	0.610	0.33945	0.649	0.32804	0.619	0.35770	0.683
3	0.27116	0.535	0.28331	0.599	0.30250	0.627	0.29235	0.592	0.31885	0.661
4	0.23836	0.511	0.24912	0.582	0.26604	0.603	0.2571	0.553	0.28057	0.647
5	0.20609	0.486	0.21553	0.557	0.23024	0.581	0.22263	0.517	0.24304	0.619
6	0.17444	0.459	0.18263	0.538	0.19520	0.555	0.18884	0.496	0.20639	0.583
7	0.14341	0.432	0.15041	0.511	0.16090	0.521	0.15580	0.456	0.17058	0.552
8	0.11281	0.409	0.11865	0.498	0.12711	0.509	0.12326	0.438	0.13535	0.523
9	0.81882	0.401	0.86522	0.485	0.92903	0.486	0.90293	0.413	0.99587	0.495
10	0.49103	0.390	0.52342	0.467	0.56444	0.465	0.55093	0.393	0.61273	0.481
11	0.33779	0.411	0.35283	0.492	0.37667	0.500	0.36399	0.426	0.39686	0.503
12	0.33701	0.407	0.35194	0.483	0.37568	0.479	0.36299	0.382	0.39568	0.477

Table : Von Mises Stress (Nodal Results)

Nodes	R0		R5		R10		R15		R20	
	Cube	Beam	Cube	Beam	Cube	Beam	Cube	Beam	Cube	Beam
	10^7	10^3	10^7	10^3	10^7	10^3	10^7	10^3	10^7	10^3
1	0.10996	0.98221	0.10996	0.98221	0.10996	0.98221	0.10995	0.98219	0.10995	0.98219
2	0.12569	0.99756	0.12602	0.99854	0.12616	0.99760	0.12629	0.99756	0.12648	0.99756
3	0.10977	0.98111	0.10976	0.98110	0.10975	0.98108	0.10974	0.98111	0.10973	0.98111
4	0.10898	0.98065	0.10893	0.98061	0.10890	0.98060	0.10887	0.98065	0.10882	0.98065
5	0.10771	0.97849	0.10758	0.97844	0.10752	0.97849	0.10746	0.97849	0.10733	0.97849
6	0.10606	0.96801	0.10584	0.96775	0.10573	0.96839	0.10562	0.96801	0.10540	0.96801
7	0.10417	0.93999	0.10384	0.93882	0.10368	0.93999	0.10351	0.93999	0.10318	0.93999
8	0.10221	0.91345	0.10176	0.91340	0.10153	0.91345	0.10130	0.91345	0.10083	0.91345
9	0.10120	0.90156	0.10067	0.90156	0.10040	0.90156	0.10013	0.90156	0.099598	0.90156
10	0.10149	0.99999	0.10085	0.99991	0.10053	0.999876	0.10020	0.99768	0.099534	0.99692
11	0.12803	0.98221	0.12911	0.98221	0.12965	0.98221	0.13019	0.98221	0.13128	0.98219

Table : Von mises Stress

	Specimens	Maximum stress [Pa]	Minimum stress [Pa]
RO	Cube	0.128E+07	816688
	Beam	0.976E+06	768941
	Railway Sleepers	1.8199E+07	32505
R5	Cube	0.129E+07	798901
	Beam	0.1062E+07	734453
	Railway Sleepers	1.8196E+07	32970
R10	Cube	0.130E+07	789934
	Beam	0.1064E+07	694873
	Railway Sleepers	1.8197E+07	32809
R15	Cube	0.130E+07	780918
	Beam	0.1062E+07	652872
	Railway Sleepers	1.8195E+07	32715
R20	Cube	130E+07	778361
	Beam	0.1061E+07	605822
	Railway Sleepers	1.8194E+07	32505

Table : Total Displacement

	Specimens	Maximum Displacement (Meters)
R0	Cube	0.00378
	Beam	0.00248
	Railway Sleepers	0.00127
R5	Cube	0.00401
	Beam	0.00256
	Railway Sleepers	0.00546
R10	Cube	0.00413
	Beam	0.00281
	Railway Sleepers	0.00554
R15	Cube	0.00424
	Beam	0.00297
	Railway Sleepers	0.00563
R20	Cube	0.00512
	Beam	0.00304
	Railway Sleepers	0.00565

- A load of 1.1 MPa was applied to all the cubes and the beam models and it was seen that as the rubber percentage increased in the samples , the deformation also increased by a certain amount.

- Railway sleepers is an application of using rubberized concrete in construction purpose. Before creating and actual railway sleeper, a simulation analysis was performed to interpret the results. After applying a dynamic loading of 222.396 KN , it was seen that as the rubber percentage in the sleeper samples went on increasing, the deformation also increased by a certain amount.

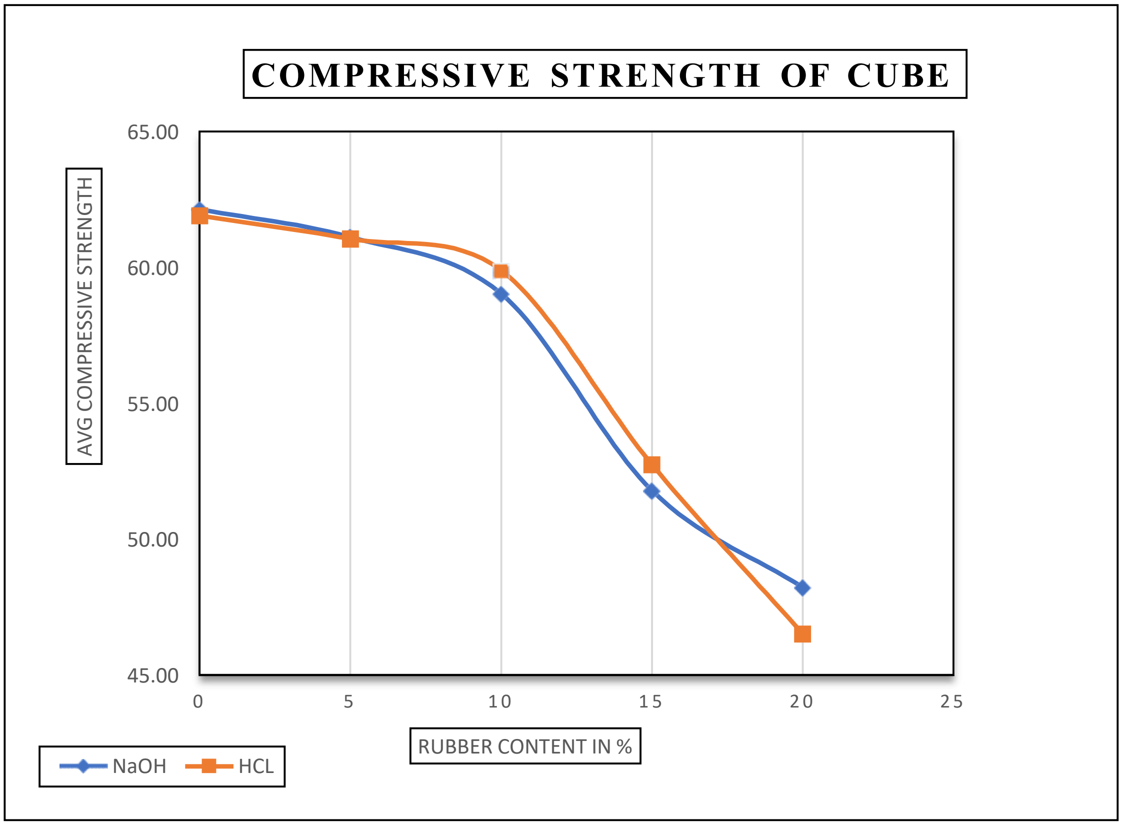
CHAPTER 4

RESULT & DISCUSSION

CHAPTER 4

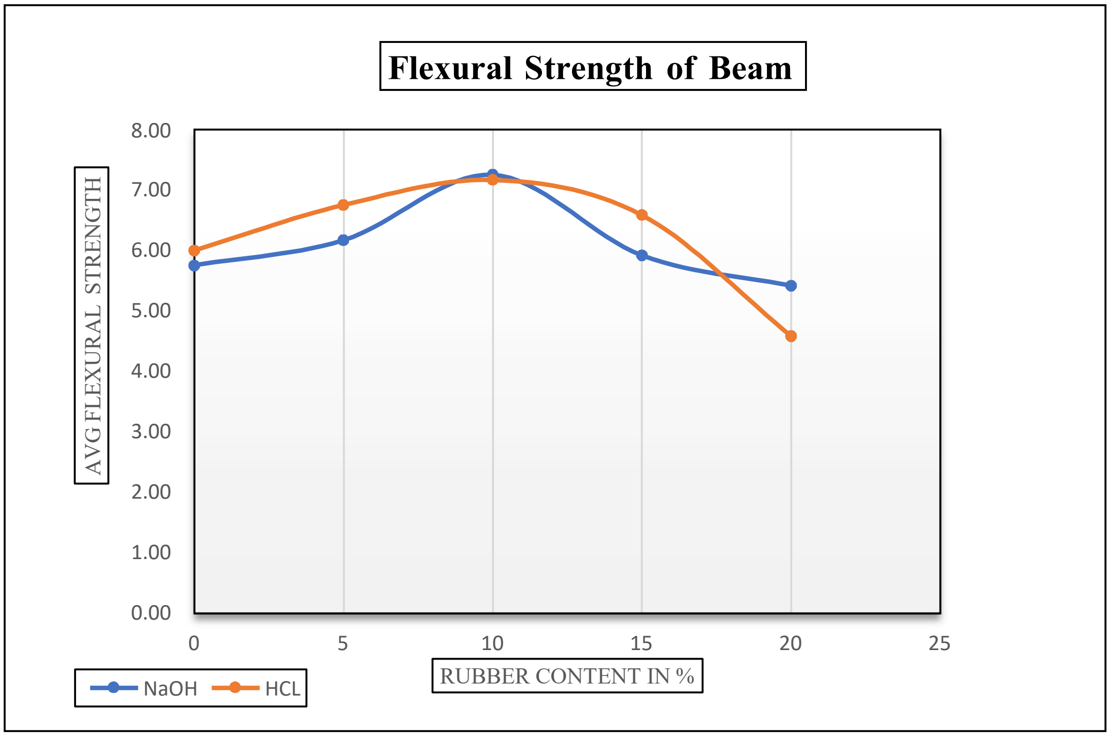
RESULT AND DISCUSSION

- **Comparison of values of compressive strength for cube specimens at 28 days for various % replacement of Sand with rubber**



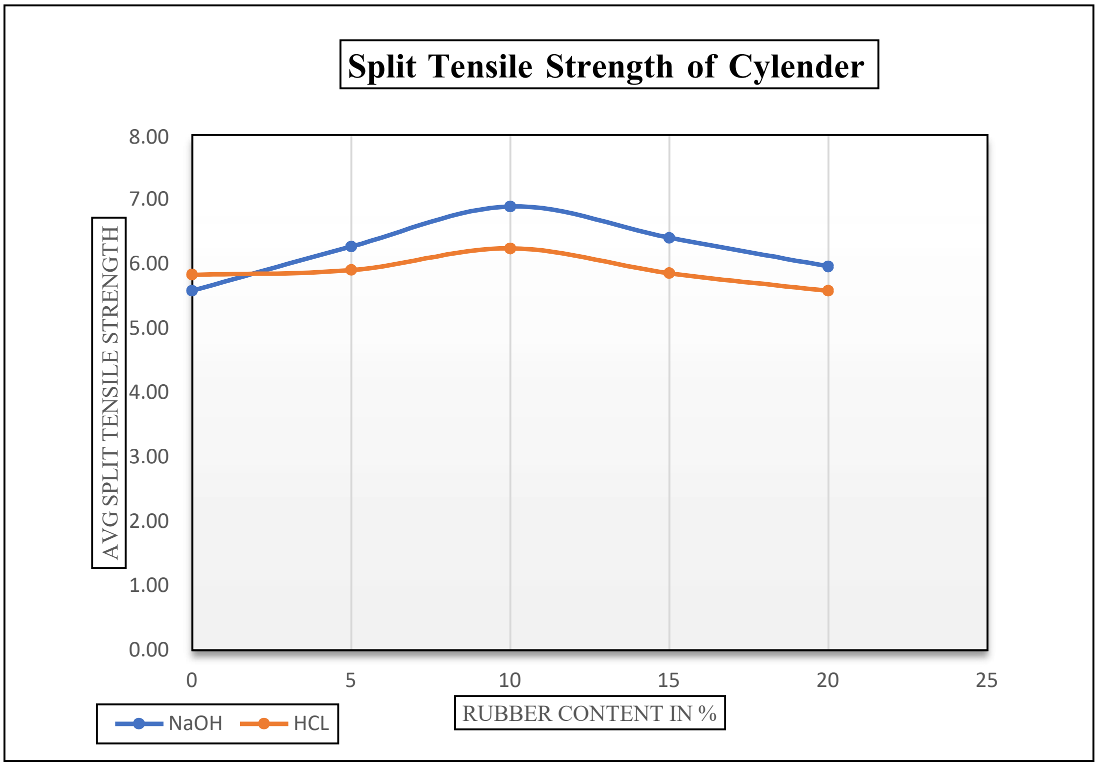
- From Graph it is seen that , the maximum value of Compressive Strength is obtained at 0 % replacement for NaOH & HCL Pretreated Rubberized Concrete.
- The value of Compressive Strength for NaOH Pretreated Rubberized Concrete is slightly higher than HCL Pretreated Rubberized Concrete at 0 % replacement.

- **Comparison of values of Flexural strength at 28 days for various % replacement of sand with rubber**



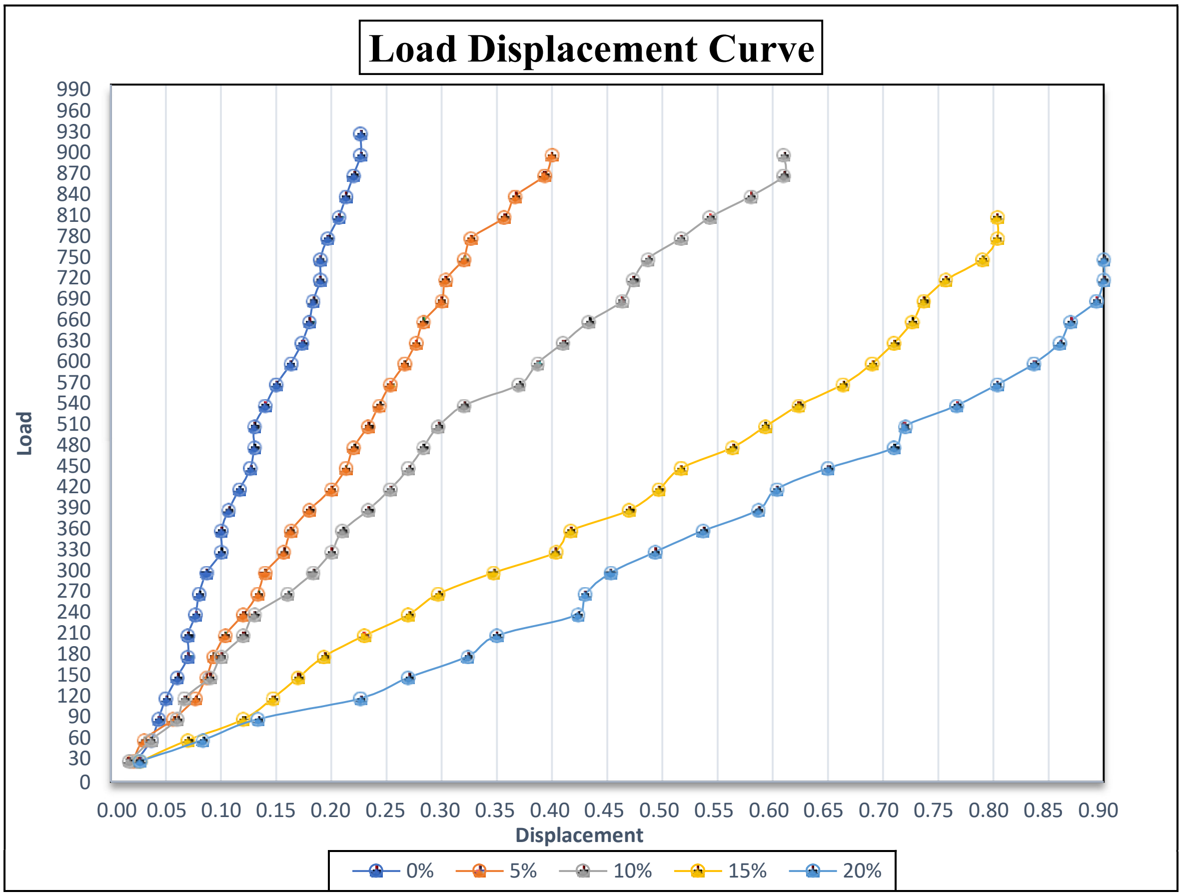
- From Graph it is seen that , the maximum value of Flexural Strength is obtained at 10 % replacement for NaOH & HCL Pretreated Rubberized Concrete.
- The value of Flexural Strength for NaOH Pretreated Rubberized Concrete is slightly higher than HCL Pretreated Rubberized Concrete at 10 % replacement.

- **Comparison of values of Split tensile strength for cylindrical specimens at 28 days for various % replacement of sand with rubber**



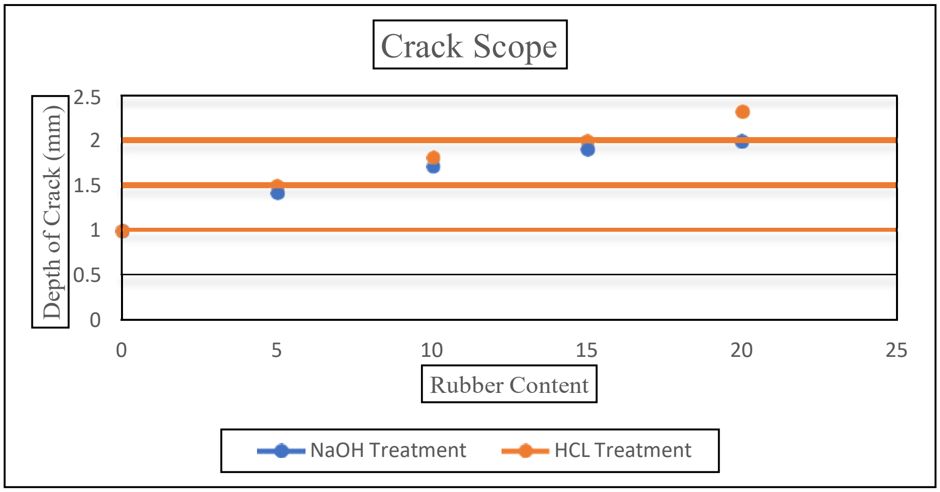
- From Graph it is seen that , the maximum value of Split Tensile Strength is obtained at 10 % replacement for NaOH & HCL Pretreated Rubberized Concrete.
- The value of Split Tensile Strength for NaOH Pretreated Rubberized Concrete is much higher than HCL Pretreated Rubberized Concrete at 10 % replacement.

- **Comparison of values of Load and Deflection for cylindrical specimen at 28 days for various % replacement of sand with rubber**

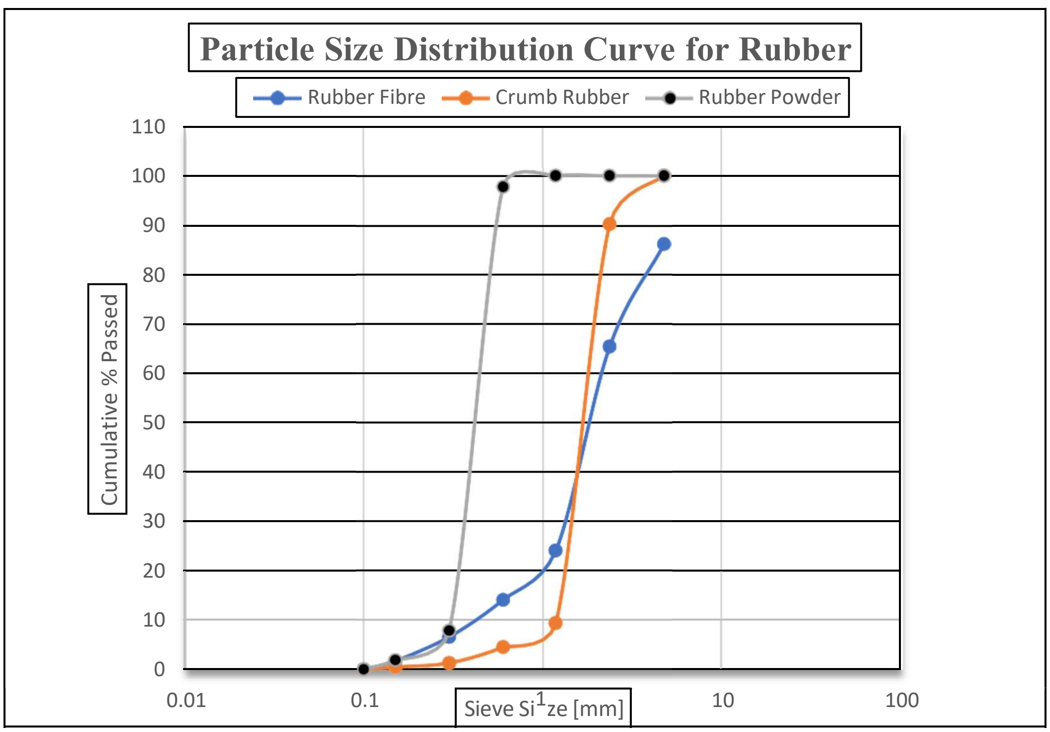


- From the graph it is seen that the value of deflection geos on increasing as per increase rubber content .
- The minimum & maximum value of deflection occurs at 0% & 20 % replacement .

- **Comparison of values of depth of cracks for cube specimens at 28 days for various % replacement of Sand with rubber**



- **Particle Size Distribution Curve For Rubber**



CHAPTER 5
CONCLUSION

CHAPTER 5

CONCLUSION

- The workability of the concrete decreases with the addition of rubber fibres.
- The result obtained from pre-treatment of rubber fibres with NaOH Solution & HCL Solution gives approximately same values.
- Compressive strength of concrete with the addition of rubber fibers up to 5% to 10%
  gives equivalent strength as compare to conventional concrete while further addition will decrease the strength
- The value of compressive strength for 10% replacement of HCL pretreated rubberized concrete was slightly higher than that of NaOH pretreated rubberized concrete
- Split tensile strength of rubberized concrete with replacement of rubber for 5% & 10% was greater than 0% replacement, but then further addition of rubber decreased the strength.
- The value of split tensile strength for 10% replacement of NaOH pretreated rubberized concrete was higher than that of HCl pretreated rubberized concrete.
- The Flexural strength of the concrete with rubber replaced with 10% was more than the conventional concrete and the strength decrease with increase in rubber fibers.
- The values of flexural strength for 10% replacement of HCL pretreated rubberized concrete and NaOH pretreated rubberized concrete were almost same
- From Ultrasonic Pulse Velocity test the velocities obtained lies between 3.5 km/sec to 4.5 km/sec indicating the Concrete of Excellent and Good Quality.
- From Simulation it is seen that , the total deformation increase with increasing percentage of rubber fiber under the applied loading.

HOW THE PROJECT UNDERTAKEN BY UG STUDENTS IS RELEVANT TO SOCIETY/ COMMUNITY AND HOW IT MAY BE USEFUL TO SOCIETY

- Rubberized concrete is economical , saving a large cost of sand consumption and reducing global warming.
- Tyre rubber is one of the wastes which is continuously increasing all over the world. It is difficult for municipal authorities to store and dispose the waste tyres generated from vehicles. In many countries municipal authorities have banned dumping of waste tyres into the landfills due to its non-decaying nature as it causes serious environmental problems.
- The properties of such as elasticity, resistance to high impacts, higher energy absorption, it can be used more and more in future for road construction, parfait designs, pavements design, constructing the walls of nuclear reactor.

  Thus, rubberized concrete can be considered as a great alternative in respect to environmental and future aspect.
- Rubberized concrete has potential advantages in structural applications in high seismic zones through providing good damping and energy absorption properties
- It has potential advantage in structural applications where impact and collision resistance are needed such as road barriers, bridge piers, nuclear power plants etc.

CHAPTER 6

REFERENCE

CHAPTER 6

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LIST OF PUBLICATION

Sr.No.	Authors	Title of Paper	Name of International Journal / International Conference	Place and Date of Publication with Citation Index
01.	1. Tejas Tipale 2. Sarang Bhimanwar 3. Shivani Namojwar 4. Janvi Sarode 5. Vaidehi Bansod 6. Aniket Koparkar	PROPERTIES OF RUBBERIZED CONCRETE	SPANDAN 2022 : A National Conference on Advances in Engineering , Technology and Applied Science	Yeshwantrao Chavan College of Engineering. Nagpur 08/04/2022