A STUDY ON STRENGTH AND DURABILITY PROPERTIES OF CONCRETE USING GRANITE WASTE AS CEMENT REPLACEMENT

[1]M ASIF RAZA,[2]G RAJESH
[1]Student,[2]Assistant Professor
Department of Civil Engineering
PVVKIT

ABSTRACT

Granite stones processing industry from Tamilnadu state produces tons of non-biodegradable fine powder wastes and utilization of that hazardous waste in concrete production will lead to green environment and sustainable concrete technology. The main objective of this study is to experimentally investigate the suitability of granite powder (GP) waste as a substitute material for fine/natural aggregate in concrete production. The experimental parameter was percentage of granite powder substitution. Concrete mixtures were prepared by 0%, 5%, 10%, 15%, 20% and 25% of fine/natural aggregate substituted by GP waste. Various mechanical properties such as compressive strength, split tensile strength, flexural strength; ultrasonic pulse velocity (UPV) and elastic modulus were evaluated. To ensure the reliability of its usage in aggressive environments, the durability properties such as water permeability, rapid chloride penetration (RCPT), carbonation depth, sulphate resistance and electrical resistivity was also determined. The obtained test results were indicated that the replacement of natural sand by GP waste up to 15% of any formulation is favorable for the concrete making without adversely affecting the strength and durability criteria however it is recommended that the GP waste should be subjected to a chemical bleaching process prior to blend in the concrete to increase the sulphate resistance.

I. INTRODUCTION

1.1General:

Concrete is compound and homogeneous material that is compound mainly of water, aggregate and cement. In general additives and reinforcements are included in the mixture to get the desired physical properties of the finished material. When the ingredients mixed together, they form a fluid mass that can be simply mould into the required shape. Over time goes on, the cement form a hard matrix which binds the rest of the ingredients into a durable stone like material so with many uses.

Concrete has been a leading construction material for over a century. Its annual global production is about 3.8 billion m3 - roughly 1.6 tonnes per capita which is from Portland Cement Association. For the last few years, great emphasis was chosen on green concrete as the results of sustainable development. Green concrete is implies by an application of industrial wastes to reduce consumption of natural resources, to save energy and minimize pollution in environment. In the various varieties of industrial wastes produced the marble or granite wastes, having potentiality in utilisation as the one of the element in the concrete.

These wastes can be used as a filler material to reduce the total voids content in concrete and pozzolonic material like as cement in the concrete as mix while containing its of the physical and mechanical properties. Granite or marble waste is an industrial waste which obtain from the granite industry in a powder form. As from the data total waste from these industries in this region may be approximately 2100

Tonnes per week. This waste is easily carried away by the air and hence causes problems to human beings as in case of health and environment.

With the greater increase in the quantity of waste disposal, coupled with shortage of dumping sites, increase in the transportation and dumping costs the quality of environment, has got seriously deteriorated preventing sustainable development. As granite powder waste (GPW) is a very finer material, it will easily carried away in the air and it causes nuisance causing health problems and also environmental pollution. Granite powder waste (GPW) is a fine material; it gets easily carried away by air and causes nuisance and health problems as well as environmental pollution.

The major effects of air pollution are lung diseases and inhaling problems with the majority of people living in and around being affected the worst. In this present work, GPW to cement. To find in this investigation have used granite waste as partial replacement to different percentage the compressive strength, split tensile strength and flexural strengths of concrete have been determined. By doing so, the objective of reduction of cost construction can be met and it will help to overcome the environmental problem associated with its disposal including the environmental problems of the region

1.2 SIGNIFICANCE:

In structural construction, the usage of cement is most prominent material of concrete. Resources having granite have no problem in construction industry, but places with the other type of aggregate is also available as equal to the granite. We need to preserve the natural granite material for upcoming generations, it is very important to use other available resources as construction material up to some percent. Because of this reason this study should be carried out to overcome the problem as well as to the benefits of coming generations.

1.3 OBJECTIVES:

1. To provide some details about the use of granite powder.
2. To examine the suitability of locally granite powder as replacement of cement.
3. To be examine the shear strength of concrete with replaced granite powder.
4. Beneficial and economic value to the local people.
5. To make explore the usage of locally available materials in structural constructions.

II. LITERATURE REVIEW

2.1 introduction:

Since numerous years granite stone allocated as coarse aggregate in structural construction works, even the materials accessible in vast amount. The people aren't able to use the other quality materials like lime stone, marble stone etc within the industry as concrete materials. We must always go to improve some awareness regarding this kind of materials by performing some research works on this kind of materials. Attributable to this affiliation a small research work has been performed on the cube specimen and cylinder specimen to found compressive strength and tensile strength of a concrete severally.

2.2 Theory of Cement Replacements:

Granite powder

The word granite comes from Latin word Granum, a grain, in reference to coarse grained structures. Granite is a igneous rock with at least 20% quartz and 65% alkali feldspar by volume. The specific gravity of granite powder is between 2.6 to 2.9. It is a good frost resistant and low fire resistant. It occurs mostly in light colours light like white, red, etc

Fly Ash:

Fly ash is composed of the non-combustible mineral portion of coal. Particles are glassy, spherical 'bal bearings' finer than cement particles. Sizes of particle are 0.1Gm-150 Gm. it is a pozzolonic material which reacts with the free lime in presence of water, converted as calcium silicate hydrate (C-S-H) which can be strongest and durable portion of the gel in concrete. The fly ash can be procured from the Maize Products Power plants.

Wood ash:

Wood ash is comes as a product in combustion from wood-fired boilers, at a typical paper mills and other wood burning localities. Merely three million tons of wood ash is produced annually in the United States. Near by 70% of the wood ash is being landfilled, around 22% is being used as soil supplement, and the remaining 8% is being used in miscellaneous works. Wood ash is of composed of both inorganic and organic compounds. The physical and chemical properties of wood ash very significantly depending upon various factors such as type or species of trees, method and manner of combustion, efficiency of the boiler, and other supplementary fuel used with wood.

Marble powder:

Marble powder is collected from the dressing and processing unit in Jalgaon. It was initially in little wet form after that it will be dried off by exposing in the sun and finally sieved by IS-90 micron sieve before mixing in the concrete.

Ceramic waste:

The principle waste coming from the ceramic industry is the ceramic powder, specifically in the powder formations. Ceramic wastes are generating as a waste during the dressing and polishing processes. It is estimated that 20 to 30% waste are produced of total raw material used, and although a portion of this waste will be utilized on-site, such as for excavation pit refill, The disposals of these waste materials acquire large land areas and remain scattered all around, spoiling the aesthetic of the entire region. It is very difficult to find out use of ceramic waste produced. Ceramic waste can used in concrete to improve its strength and other durability factors. Ceramic waste can be used as a partial replacement of cement or as a partial replacement of fine aggregate sand as a supplementary addition to achieve different properties of concrete.

Condensed Silica Fume :

Silica fume, also called as microsilica, it is a byproduct of the reduction of high-purity quartz with coal in electric furnaces in the production of silicon and ferrosilicon alloys. Silica fume is also collect as a byproduct in the production of other silicon alloys such as ferrochromium, ferromanganese, ferromagnesium, and calcium silicon. Before the mid-1970s, nearly all silica fume was discharged into the atmosphere. After environmental concerns necessitated the collection and landfilling of silica fume, it became economically justified to use in various applications.

2.3 Aggregate Bonding:

Cement paste a significant role to provide smart bonding between the concrete materials. Whenever there's smart bonding between the aggregate and cement paste combination, it provides smart strength to the total concrete combine. Attributable to this reason cement is additionally named as bonding material within the engineering science language.

III. OBJECTIVES,MATERIALS AND METHODS

3.1 INTRODUCTION

Concrete is the most popular well known building material in the world. After the aggregate, cement is the main component of concrete. The annual production of cement is nearly 3.5 billion tons. Emissions from industry adversely affect the earth's climate sequence. Mostly 7% of the total global Co_2 emission is coming out by cement industries. Reducing the utilisation of cement in concrete will thus reduce the emission. Using of supplementary binding materials such as fly ash and granulated slag offers reduction utilisation of cement. If an industrial or agricultural by-product which is waste material can replace cement partially it will minimize the emission. It will also be an eco friendly method of disposal of vast quantities of materials that would if not pollute land, water and the air. Rock dust or sludge which abundant waste material from granite rock quarries and granite stone polishing factories is such a material. Disposal of sludge by land filling is causing serious environmental concern. If that waste can be used as partial cement replacement material in concrete it will be valuable resource.

SIGNIFICANCE OF PROJECT:

Lot of research works are taken out on fines passing through 150 micron sieves used for replacing fine aggregates. Most of the construction specifications today reduce the proportion of materials finer than 150 micron to 5% to 10% or less. The permissible limitation is the fines passing the 150 micron sieve is 20% in the case of manufactured or robo sand as per IS 383-1970. Detailed research works needs to be carried in using granite dust of fines less than 150 micron is replace the proportion of cement.

3.2 OBJECTIVES OF PROJECT WORK:

- Compare the properties of conventional concrete mix M20 with theproperties of concrete with granite dust partially replacing cement.
- Find the optimum % of granite dust the can be replaced for cement.

Study the effect of strength properties with optimum % cement replacement and on adding Galvanized iron fibre.

SCOPE OF PROJECT WORK:

Make use of locally available granite quarry dust as partial replacement ofcement.

METHODS

Parameters tested in this study

- Normal consistency,
- Initial setting &Final setting time
- Workability
- Compressive strength
- Split tensile strength

3.2.1 TESTS ON CEMENT

3.2.1.1 Fineness of Cement by Dry Sieving Method: The degree of fineness of cement is a measure of the mean size of grains in cement. The finer cement has quicker action with water and gains early strength through its ultimate strength remains unaffected. However, the shrinkage and cracking cement will increase with the fineness of cement. Apparatus used to determine the sieve analysis are I.S. Sieve No. 9 (90 Microns), Weighing Balance capacity 5 kg as per IS: 4031(part 1)1996.Weigh 100 grams of the given cement and sift it continuously for 15 minutes on IS. Sieve 9 no air set lumps may be broken down by fingers but nothing should be rubbed on the sieves. Find the weight of residue of the sieved after the sifting is over and report the values as a percent of the original sample taken.

3.2.1.2 Normal Consistency: About 400g of cement was initially mixed with 30 percent mixing of water. The paste was filled in the mould of Vicat's apparatus and care was taken such that the cement paste was not pressed forcibly in the mould and the surface of filled paste was smoothened and leveled. A square needle 1mm×1mm of size is to be attached to the plunger and then lowered gently on to the surface of the cement paste and is released quickly. As plunger pierces the cement paste, reading on scale was recorded. The experiment was performed carefully away from vibrators and the other disturbances. The test procedure was repeated by increasing the percentage of mixing water at 0.5% increment until the needle reaches 5 to 7 mm from the bottom of the mould. When this condition is fulfilled, the amount of water added was taken as the correct percentage of water for normal consistency. The entire test was completed within 3 to 5 minutes, if the time taken to complete the experiments exceeds 5 minutes, the sample was rejected and fresh sample was taken and the operation was repeated again. Fresh cement was taken for each repetition of the experiment. The plunger was cleaned each time the experiment is done.

3.2.1.3 Initial and Final Setting Time: Cement paste was prepared by mixing cement with 0.85 times appropriate mixing water required to give a paste of standard consistency. The stop watch was started at the instant the mixing water was added to the cement. After half-a-minute, the paste was thoroughly mixed with fingers for one minute. The mould resting on a nonporous plate was filled completely with cement paste and the surface of filled paste was leveled smooth with the top of the mould. The test was conducted at room temperature of 27±20C at a relative humidity of 60%. The mould with the cement paste was placed in the Vicat's apparatus and the needle was lowered gently to make contact with the test block and was then quickly released. The needle thus penetrates the block and the reading on the graduated scale of Vicat's apparatus was recorded. The procedure was repeated until the needle fails to pierce the block by about 5 to 7 mm measured from the bottom of the mould. The stop button of stop watch was pushed down and the time was recorded which give the initial setting time. The cement paste was considered finally set when upon applying the needle gently to the surface of test block, the needle makes an immersion, but fails to penetrate and the time was noted which gives the final setting time. The needle was cleaned after every repetition and also care was taken such that there could not any vibrations.

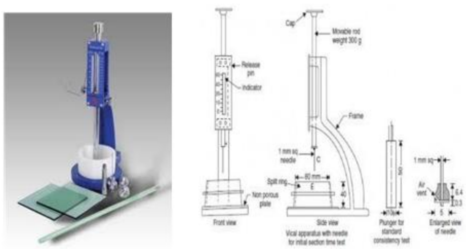


Figure: 3.1: Vicat apparatus with dimensions

3.2.1.4 Soundness: It consists of a small split cylinder of spring brass of 0.5mm thickness, forming a mould with 30mm internal diameter and 30mm high. On either side of the split are attached two indicators are attached with pointed ends AA, the distance from these ends to the Centre of cylinder being 165mm. the mould was placed on a glass sheet and was filled with cement paste formed by gauging 100g of cement with 0.78 times the mixing water required to give a paste of standard consistency. The mould was covered with a glass sheet and a small weight was placed on its top. The mould was then submerged in the water at a temperature of 27 ± 20C. After 24hours, the mould was taken out and the distance separating the indicators points was measured. The mould was again submerged in water. Using the water heaters the water was brought to boiling point within 25 to35 minutes and the specimen was kept for 3 hours at a boiling point. The mould was removed from water and was allowed to cool down to 270C. The distance between the indicator points was measured again. The difference between the two measurements represents the unsoundness of cement. For each concentration of mixing water, three samples were tested and the mean value was taken as the unsoundness of cement sample.

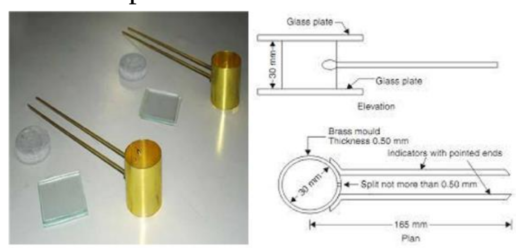


Figure: 3.2: Le Chatelier Apparatus with dimensions

3.4 Details of Cube specimens:

Figure 3.4 Cube mould

IV. EXPERIMENTAL INVESTIGATION AND RESULTS

4.1 GENERAL:

Few experimental works has been done on following materials to attain the specified objectives, which were mentioned in the previous chapters.

4.1.1 CEMENT:

Ordinary Portland cement of 53 GRADE was used. The physical and chemical Properties of cement are represented in following table 4.1 & 4.2

Table 4.1 Physical properties of cement

S.NO	PARTICULARS	RESULTS	BIS SPECIFICATIONS (IS 12269-2013)
1	SPECIFIC GRAVITY	3.15	-
2	NORMAL CONSISTENCY	33%	-
3	FINENESS OF CEMENT(M^2 /KG)	289	225min
4	SETTING TIME(MIN):		
	A. INITIAL SETTING	125	30 min
	B. FINAL SETTING	185	600 max
5	SOUNDNESS:		
	A. LE- CHATELIER EXPANSION (mm)	1.0	10 max
	B. AUTOCLAVE EXPANSION (%)	0.03	0.80% max
6	COMPRESSIVE STRENGTHG (MPA):	39	27
	A. 72 (3 DAYS)	50	37
	B. 168 (7 DAYS)	UT	53
	C. 672 (28 DAYS)		

TABLE 4.2 CHEMICAL PROPERTIES OF CEMENT

S.NO	PARTICULARS	RESULTS	BIS SPECIFICATIONS (IS 12269-2013)
1	Soluble silica (%)	19.96	-
2	Alumina (%)	5.20	-
3	Iron oxide (%)	5.65	-
4	Lime (%)	60.79	-
5	Magnesia (%)	1.72	Not more than 6.0%
6	Insoluble Residue	0.96	Not more than 4.0%
7	Sculpture calculated as SO_3 (%)	2.61	Not more than 3.5%
8	Loss on ignition (%)	1.47	Not more than 4.0%
9	Lime saturation factor	0.92	In between 0.80& 1.02
10	Proportion of alumina to iron oxide	0.92	Not less than 0.66
11	Tri calcium aluminate	4.25	-

4.1.2 Fine Aggregate:

Generally near accessible pit sand, which is passing through 4.75mm I.S sieve, was used. The physical properties and sieve analysis results are listed in the following table 4.3 and 4.4

Table 4.4 physical properties of Fine Aggregate

S.NO	PARTICULARS	RESULTS
1	Specific gravity	2.62
2	Fineness modulus	4.7852
3	Bulk density	16.70 KN/m^3
4	Bulking of sand	21.015 %
5	Grading of sand	Zone –ii

Figure 4.1:sample of fine aggregate

Sieve analysis and physical properties of fine aggregate which are accounted in the above table 4.3 and 4.4 have been carried out as per the processes given in the code books IS 2386(part-1) -1963 and IS 2386(part-3)-1963. The above figure 4.1 shows sample of fine aggregate which was used in the experimental work of the study.

4.1.3. Natural Coarse Aggregate:

Natural granite aggregate which is accessible in the local sources has been used during this study all-in-all size coarse aggregate which passing through the 20mm IS sieve and retained in the 10mm IS sieve has been used for the effective utilization and smart inserting of coarse aggregate. It is very essential to know the specific gravity, density and water absorption of the coarse aggregate in order to determine the mix proportions of the concrete. The following tables 4.5 and 4.6 shows the various properties of granite aggregate.

V. TEST RESULTS AND DISCUSSION

5.1 Introduction:

Mainly in this chapter focused on the experimental results attained from the each test and analysis of the test results. The experimental tests were carried out to attain the mechanical properties and behavior of fibre reinforced concrete, while alsorelated to the conventional plain concrete. The comparisons of mechanical properties and behavior include the workability, compressive strength and split tensile strength. With this analysis and results attained from the experimental tests, it is very clear to know the effect of Granite powder and Galvanized iron Fibres for structural construction works.

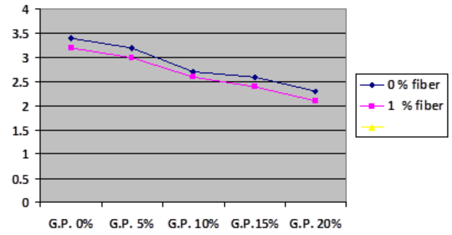
5.2 Workability of Concrete Mix:

5.2.1 Slump Test:

Table 5.1 Slump values recorded for each mix batch

S.No	Nomenclature	Slump value with 0% fibres In cm	Slump value with 1% fibres In cm
1.	G.P -0	3.40	3.20
2.	G.P -5	3.20	3.0
3.	G.P -10	2.70	2.60
4.	G.P -15	2.60	2.40
5.	G.P-20	2.30	2.10

The slump test expresses improving trend when percentage replacement of cement with granite powder increased. Table 5.1 above shows the slump height recorded at the time of casting for all batches. Figure 5.1 below shows a graphical representation of slump height for concrete consist of no fibres and 1 %&2% of fibres.the empirical results expressed that the slump value of fibre reinforced concrete has a declining trend when fibres volume percentage increases. The below figure 5.1 expresses that workability of concrete mix Improves as percentage of fibres rate increases.



% of Replacement Vs slump

Figure 5.1 % replacement vs slump

Durability Properties:

SORPTIVITY RESULTS

The sorptivity was performed to have an idea about the water permeation of concrete particularly at the concrete surface. Concrete cover is the weakest, most permeable and absorptive part of the concrete matrix as compared to the internal microstructure. The near surface concrete is highly heterogeneous in nature, due to the relative movement of cement paste and aggregates during the compaction of fresh concrete and bleeding of mix water in the early stages of cement hydration. As a result, there is a porosity gradient in the near surface concrete, where the porosity of near surface is higher than that of internal part of concrete. Therefore, the durability of the whole concrete can be characterized by simply determining the permeation characteristics of the concrete surface, which is considered as the most critical and vulnerable part towards external fluid ingress.

The results of the sorptivity conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. For a particular curing age, the absorption was measured at 3 different time periods i.e. 10, 30 and 60 minutes. The absorption of water or flow of water decreased with time. This was because the rate of absorption of water becomes less as time increases when the outer zone of the surface is saturated and it is more difficult for water to be absorbed by the inner pores. It was found that the flow data at interval of 10 minutes give a more representative trend of the surface absorption characteristics. Flow rate at less than 10 minutes might not represent a stable and constant flow of water into the concrete, and the flow rates at 30 and 60 min. intervals would not be suitable since the concrete surface would already be in a saturated state and the data obtained will not be suitable for comparative purposes.

The s sorptivity of various mixes at different curing ages is shown below in Table. From the values it can be seen that the absorption decreases with increase in curing time.

Table4.17 Sorpivity results at different curing periods

Concrete Mix	Surface Absorption [ml/(m^2.Sec)]at 10 min.	
	28 days	56 days
G.P-0 0% replacement	0.354	0.325
G.P-5 5% replacement	0.362	0.340
G.P-10 10% replacement	0.373	0.365
G.P-15 15% replacement	0.370	0.356
G.P-20 20% replacement	0.362	0.354
G.P-0-1 0% replacement with 1% fibre	0.356	0.357
G.P-5-1 5% replacement with 1% fibre	0.362	0.363
G.P-10-1 10% replacement with 1% fibre	0.378	0.381
G.P-15-1 15% replacement with 1% fibre	0.365	0.364
G.P-20-1 20% replacement with 1% fibre	0.358	0.360

the variation in sorptivity values of mixes at 10, 30 and 60minutes for curing age of 28 and 56 days. The lowest values of sorptivity i.e. 0.354 and 0.325 ml/(m2.Sec) at curing period of 28and 56 days respectively are observed for a concrete mix containing 10% of granite waste, whereas, the highest values of sorptivity are observed as 0.378 and 0.325 ml/(m2.Sec) at 28 and 56 days of curing for a concrete mix containing. Upto 10% replacement of cement with Granite waste sorptivity values are considerable.

VI. CONCLUSIONS

i. The Compressive strength of Cubes are increased with addition of granite powder up to 10% with +5.92% and further any addition of granite powder the compressive strength decreases till 20% with -1.3%. Addition of 1% fibres improves the compressive strength value of concrete +6.32%.

ii. The Split Tensile strength of Cylinders are increased with addition of granite powder up to 10% with 33.18% and further any addition of granite powder till 20% the Split Tensile strength decreases with +7.07%.Addition of 1% fibres improves the split tensile strength value +36.38%.

iii. Workability of concrete mix decreased with replacement of cement with granite powder. But up to some extent even replaced concrete mixes got optimum results. Addition of fibres decreases the workability properties of mix even it replaced with Granite Powder.

iv. Thus we found out the optimum percentage for replacement of granite powder and fibre with cement and it is almost 10% cement for both cubes and cylinders

v. By considering all the above parameters like slump cone value, compaction factor value, compressive strength and split tensile strength, it is concluded that it is better to limit the replacement level of “Granite Powder up to 10%” only.

vi. Failure pattern of cube specimens and cylindrical specimens is almost similar to all mix batches.

vii. We put further a simple step to have minimize the costs for construction with

viii. Usage of Granite Powder which is freely or cheaply available.

ix. We have also stepped into a realm of saving the environmental pollution by cement production being our main objective as Civil Engineers.

x. The durability properties of granite waste are moderate for RCPT Values and sorptivity decreases with increase in curing time.

xi. Upto 10% replacement of cement with Granite waste the sorptivity values are considerable.

REFERENCES

1. TelmaRamosa, Ana MafaldaMato a, Bruno Shmidt, Joao Rio, Joana Sousa-coutinho “granitic quarry sludge waste in mortor: effect on strength and durability,” construction and building materials, 47(2013),1001-1009 TelmaRamosa, Ana MafaldaMato a, Bruno Shmidt, Joao Rio, Joana Sousa-coutinho.
2. AbukershS.A , Fairfield C.A ,”Recycled aggregate concrete produced with red granite dust as a partial replacement “ construction and building materials, -vol.540/32-2011.
3. Balaguru P.N. and Shah S.P., 1992, “Fiber-Reinforced Cement Composites”, New York, United State of America.
4. Chuanmeinwong, 2004, “ Use Of Short Fibres In Structural Concrete To Enhance Mechanical Properties”.
5. Abdoladelshoaid, 2012, “Shear in Steel Fiber Reinforced Concrete Members without Stirrups”, university of Alberta.
6. Klaus Holschemacher, Torsten Müller, “ Influence Of Fibre Type Properties Of Steel Fibre Reinforced Concrete “,Leipzig University of Applied Sciences (HTWK Leipzig), Department of Civil Engineering, Germany.
7. Balaguru, [1992], “Behaviour of high performance concrete”.
8. M.S.Shetty [2012], “Concrete Technology, Theory and Practice”, S.Chand publications.
9. N ChennaKesavulu, “Engineering Geology “, Published by Rajiv Beri for Macmilan India
10. A.M.Neville, “properties of concrete”, fifth edition.
11. Indian Standard Recommended guidelines for Concrete Mix Design, IS 10262: 1982,
12. Bureau Of Indian Standard, New Delhi.
13. Indian Standard Recommended guidelines for Concrete Mix Design, IS 10262: 2000, Bureau Of Indian Standard, New Delhi.
14. Indian Standard Code Practice for Plain and Reinforced Concrete, IS 456: 2000, Bureau Of Indian Standard, New Delhi.
15. Indian Standard specification for coarse aggregate and fine aggregate from natural sources for Concrete, IS 383: 1970, Bureau Of Indian Standard, New Delhi.
16. www.civilengineering.com
17. www.googlescholar.com