अधिक्षक अभियंता व सहसंचालक,
महाराष्ट्र अभियांत्रिकी संशोधन संस्था,
दिंडोरी रोड, नाशिक-४२२ ००४.

दूरध्वनी क्रमांक :
कार्यालय : ०२५३-२५३७२५१
फॅक्स : ०२५३-२५३०५५१
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महाराष्ट्र शासन
जलसंपदा विभाग

जा.क्र. साचवि/Plast Fibre/ ९१६३ दिनांक : १८/१०/२००७.

प्रति,

मा. सचिव (ला.क्षे.वि.)
जलसंपदा विभाग,
मंत्रालय, मुंबई - ४०० ०३२.

(लक्षवेध :- श्री. गो. महाले, कक्ष अधिकारी)

विषय :- Plast Fibre Fibrillated Polypropylene Fibre used as secondary reinforcement material for Concrete and Mortor.

संदर्भ :- १) शासनाचे पत्र क्र. संकीर्ण २००७/(५२/२००७) लासेवि / आस्था दि: १८/९/२००७.
२) शासनाचे समक्रमांकाचे पत्र दि: १/३/२००७.
३) या कार्यालयाचे पत्र क्र. साचवि / PlastFibre /१०२५ दि: १७/२/२००७.

संदर्भ पत्र क्र.२ नुसार मागविलेल्या Plast Fibre च्या अहवाला बाबतीतील चाचणी कामे पुर्ण झाली असून त्याचा अहवाल आपले माहितीसाठी सविनय सादर करण्यात येत आहे.

(वी. वो. पेंढरे)
अधीक्षक अभियंता व सहसंचालक.

सोबत : तांत्रिक अहवाल

प्रत :- झायरेकटर , ताशी इंडीया लि. इस्पावडा रोड, नागपूर- ४४००१८ (महाराष्ट्र) यांना माहितीसाठी.

सोबत - तांत्रिक अहवाल

MAHARASHTRA ENGINEERING RESEARCH INSTITUTE

NASHIK –4.

TECHNICAL REPORT NO. MT – 1/2007.

STUDY OF PLAST- FIBRE- FIBRILLATED POLYPROPYLENE FIBRES- USED AS SECONDARY REINFORCEMENT MATERIAL FOR CONCRETE AND MORTOR.

SHRI. M.S.MUNDHE

DIRECTOR GENERAL.

OCTOBER – 2007.

WATER RESOURSES DEPARTMENT

GOVT. OF MAHARASHTRA, INDIA.

INDEX

RESEARCH PERSONNEL :

1) Shri M.S. Mundhe — Director General
2) Shri V.B. Pandhare — Superintending Engineer & Joint Director
3) Shri D.P. Kulkarni — Scientific Research Officer
4) Shri H.D. Lahare — Asstt. Research Officer
5) Shri S.R. Jalana — Scientific Officer

1) INTRODUCTION :

Bajaj group of Nagpur has been manufacturing Fabrics and Polymer Compounds with wide range of application including construction industry Tashi India Ltd. Nagpur, a marketing arm of Bajaj group introduced new product as "PLAST FIBRES" Fibrillated polypropylene Fibres used as secondary reinforecement material for Concrete and Mortor.

Director Tashi India Ltd has made the correspondance with Principal Secretary (WR) Water Resources Department, Mantralaya Bombay vide letter No. TCIL/WRD/CSR/ dt. 6/2/07.

With reference to E-mail from Govt dt 1/3/07 the work of study of Plast Fibre used in concrete was entrusted to Material Testing Division of Maharashtra Engineering Research Institute, Nashik-4 by Directorate.

The Material Testing Division has taken the study for plast fibre and conducted various essential Tests on Concrete of 3 grades (M-20, M-25, M-40) as suggested by Tashi India Ltd. Nagpur.

(2) SCOPE OF WORK :

To findout the effect on properties of hardened concrete of various grades with use of Plast Fibres supplied by Tashi India Ltd. Nagpur i.e. the Compression strength, Flexural strength, Split tensile strength , Modulus of elasticity and Permeability.

(3) Material used : - Cement, Sand, Aggregate and plast fibres supplied by Tashi India Ltd. Nagpur is used for testing

i) Cement : ACC Suraksha PPC Cement used at site, same cement has been used at this Institute, for Mix proportion of 3 grades M-20, M-25, M-40 Cement properties are given in Table - No.1

ii) Sand : Natural Brown coloured locally available sand at Nagpur region is used for the study. The Sand properties are given in Table - 2

iii) Coarse Aggregate - Available coarse aggregate at Nagpur region supplied by Tashi India Ltd is used for the study. The coarse aggregate properties are given in Table –3.

iv) Plast Fibre having length 6mm, 12mm, 20mm used for the study . The Fibres are supplied by Tashi India Ltd. Nagpur and mixed as per given proportion 125 gm per 50 Kg bag of cement.
Properties of Fibres are given in Table No.4 and are supplied by Tashi India Ltd. Nagpur.

v) Test results of concrete and Plast Fibres for M-20 are given in Table-5.

vi) Test results of concrete and Plast fibre for M-25 grade are given in Table-6.

vii) Test results of concrete and Plast Fibres for M-40 grade are given in Table –7.

(4) METHODOLOGY :

The Methodology adopted for the study is as under.

i) The Design of Mixes : Concrete Mix Design for grade M-20, M-25 &M-40 using aggregate of 20 mm, 10mm and Natural Sand available in Nagpur region is used and ACC Suraksha PPC cement is used as supplied by Tashi.
Following Mix proportion is used for study of M-20 grade using Plast Fibre of 2 size 6mm and 12mm length as suggested by Tashi India Ltd Nagpur

Cement	Aggregate		Sand	Water	Absorption correction
	20 mm	10 mm			
360 Kg/cu.m	1041 Kg/cu.m	347 Kg/cu.m	694 Kg/cu.m	187.5 Lt /cu.m	20mm - 12.5 Lt/cu.m 10 mm - 7.5 Lt/cu.m

Mix Proportion : 1 : 1.92 : 3.85

ii) Following Mix Proportion is used For M-25 grade Concrete using Plast Fibre of 3 sizes 6mm, 12mm, and 20mm

Cement	Aggregate		Sand	Water content	Water Absorption correction
	20 mm	10 mm			
375 Kg/cu.m	1041 Kg/ cu.m	347 Kg/cu.m	694 Kg/cu.m	187.5 Lit/cu.m	20 mm – 12.5 Lit/cu.m 10 mm – 7.6 Lit/cu.m

Mix proportion :- 1: 1.85 : 3.70

iii) M –40 grade Mix proportion Used for M-40 grade is as below with fibres of 3 sizes using 6mm, 12mm, 20mm length.

Cement	Aggregate		Sand	Water content	Water Absorption correction
	20 mm	10 mm			
450 Kg/cu.m	983 Kg/cu.m	421 Kg/cu.m	603 Kg/cu.m	166.5 Lit/cu.m	20 mm – 11.2 Lit/cu.m 10 mm – 6 Lit/cu.m

Mix proportion (1 : 1.34 : 3.12)

iv) Sequence of Mixing : Initially half of the total quantity of all materials Water, sand, aggregate except cement was added in laboratory mixer. Then fibres of specific length in proportion of 125 gm per 50 Kg cement were slowly sprinkled in the mixer to have uniform distribution of fibres to avoid balling action. The cement was then added and also remaining quantities of aggregate, sand and water are mixed.

v) After finalizing the concrete mix , 15 x 30 cm cylinders were cast for compressive strength for control mix and then for plast fibre having length 6mm, 12mm, 20mm for compressive strength were cast and tested as per Indian standard. Results after 28 days are given in Table No. 5,6,7.

vi) Flexural Strength :- The specimen 10 x 10 x 50 cm bar were cast for M-20, M-25, M-40 grades and tested as per Indian standard @ 28 days For flexural strength. Results after 28 days are given in Table 5,6,7.

vii) Split Tensile Test :- Cylinder of 15 x 30 cm were cast for M-20, M-25 M-40 grade and tested as per Indian standard at 28 days. Results are given in Table No 5,6,7

viii) Modulus of Elasticity :- 15 x 30 cm size cylinder were cast and tested for 'E' Value @ 28 days. As per Indian standard.

ix) Permeability :- 15 x 15 cylinder were cast for permeability and tested @ 28 days as per Indian standard.

(5) LITERATURE STUDY :

i) There exist many types of concrete which have been developed for special purposes. In general cement based Matrix is modified in some way so as to improve particular properties. According to ACI 544.1 R -82 fibre reinforced concrete is defined as concrete made with hydraulic cement containing fibre or fibre and coarse aggregate and discontinuous discrete fibre. Fibres can be made from natural material (eg. Asebestos, sisal, cellulose) or a artificial product such as glass steel carbon and polymer (eg. Polypropylene)

The purpose of reinforcing the cement based matrix with fibres is to increase the toughness. There is enhancement in fibre reinforced concrete in flexure, enhancement in toughness and in Compression. Fibre reinforcement improves impact strength and fatique strength and also reduces shrinkage.

Quantity of Fibre used is small, typically 1 to 5 % by volume. To make fibre effective the tensile strength, elongation at failure and Modulus of Elasticity of the fibres need to be substantially higher than the corresponding properties of Matrix. Some other significant characteristics of the fibres are aspect ratio (i.e. ratio of length to mean diameter), shape and surface texture, length and structure. The fibre can withstand a maximum stress σf which depends on the aspect ratio (L / d)

$$\sigma f = \tau\left(\frac{L}{d}\right)$$

Where τ = interfacial bond strength
d = mean diameter of fibre
L = Length of fibre (L < Lc)

We can define Lc as : Critical length of fibre.
Such that if L < Lc the fibre will pull out of the matrix due to failure of Bond. But if L > Lc then the fibre itself will fail in tension. The length of Fibre should be greater than the maximum size of aggregate particles.
Interfacial bond strength is improved by fibres having deformed or roughned surface enlarged or hooked ends and fibres should be able to bend or Mould. For example the use of Multifilment or fibrillated fibre gives a good interfacial bond and overcomes poor adhesion of plastic to cement paste.

ii) In the Rilem Publication symposium of " Testing and Test method of fibrecomposite Published in 1978 (ref page 13) In the paper entitled " "Formulating guidance for testing of fibre concrete in ACI committee 544" By Mr. E.K. Schrader, it is stated that effect of fibres on compressive Strength is minimum compared to other properties. The compressive

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Strength test are usually intended as quality control of W/C ratio and basic paste rather that effect of fibre.

iii.) In American concrete Institute (ACI) Special publication SP-44 Published In 1974 (ref. Sp-44 ACI page 196.) The Author Gilbert R Williason have stated that in case of compressive strength, the reports vary from no increase in Compressive strength due to fibres to as much as 100 % increase in Compressive strength over the plain concrete. These in consistancies also apply to the effect of the Fibres when used with Mortor and when used in concrete because of conflicting data.

(6) General Observation :-

1) It is observed that mixing the fibres uniformely in concrete is difficult task Fibres of more length have tendency to form ball.
2) For Split Tensile Test it was observed that control specimen(without fibre) was divided in two halves. Where as fibre reinforced specimen remained together due to interlocking of fibres thus arresting the cracks (see photograph)
3) Millions of Plast fibre get uniformaly dispersed in every cubic meter of Concrete and Mortor as micro reinforcement system.

(7) Conclusion :-

1) The plast fibre used in concrete holds the Concrete material components together and gives the advantage as if it is reinforced.
2) Because of the crack arresting and crack limiting properties fibre reinforced concrete can prove better suited for additional reinforcement material for earthquake resistant structure, tunnel lining.
3) Plast Fibre increases Split Tensile and Flexural Strength in the range Of 10 to 15 %.
4) There is little effect of Plast fibre on Compressive Strength of Concrete
5) There is slight increase in Modulus of Elasticity for M-20 , M-25 grade but slight reduction for M-40 grade.

Acknowledgement :- The Institute is thankful for giving co-operation by Shri Atul Kale and Shri Sunil Verma from Tashi India Ltd. and Shri V.M. Galande for Mix Design of concrete.

(8) References :-

1) Rilcon Publication Year – 1978

2) American Concrete Institute special publication SP-44 year 1974.

3) American concrete Institute December- 1971

4) Naaman A.E., Shah S.P. and Throne J.L. some developments in Polypropylene fibres for concrete. SP-81 American concrete Institute Detroit 1984.

5) Vondram G.L. Nagbhushanam M and Ramakrishan V. " Fatique strength of Polypropylene fibre reinforced concrete" fibre reinforeced cements and concretes: Recent developments edited by R.N. Swamy and B. Barr 1990 P- 553-554

6) Concrete Technology by A.M. Neville and J.J. Brnokr 3rd indian Reprint 2003

7) Relevant Indian standards for casting and Testing.

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Table -1

Test result of CEMENT sample received from :- Tashi India Ltd. Nagpur.

Sr. No.	Identification mark with grade and type of cement	Lab Sample No.	Specific Gravity	Fineness cm^2/g	Normal Consistancy %	Setting time		Soundness		Comp. Strength			Remarks
						Initial	Final	Autoclave	Le-chatlie	3 days	7 days	28 days	
						Minutes		%	mm	kg/cm^2			
						Min.	Max.	Max.	Max.	Min.		Min.	
Limits: As per IS: 8112-1989			--	Min. 2250	--	30	600	0.8	10	160	220	330	For PPC
										230	330	430	For 43 Grade OPC
										270	370	530	For 53 Grade OPC
1	ACC Suraksha PPC	T.S	3.137	3210	32	120	380	-	-	165	270	480	

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Table -2

Test result of SAND sample received from :- Tashi India Ltd. Nagpur

Lab No	Type of Sample	Grading Individual %retained on sieves								Fineness Modulus	Specific gravity on SSD %	% Absorption	Unit weight kg/lit.	
		6.3 mm	4.75 mm	2.36 mm	1.18 mm	600 micron	300 micron	150 micron	Pan %				Loose	Rodded
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Natural Sand A(P) / TIL	Brown Colored Sand	-	1	3	7	20	49	17	-	2.385	2.365	3.13	1.368	1.562

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PHYSICAL PROPERTIES OF AGGREGATE

Table -3

Test results of Aggregate sample received from :- Tashi India Ltd. Nagpur.

Lab No. and Mark	Size of Aggregate in mm	Grading Individual % retained on sieves												Specific gravity on SSD Basis %	Water Absorption %
		50 mm	40 mm	31.5 mm	25 mm	20 mm	16 mm	12.5 mm	10 mm	6.3 mm	4.75 mm	2.36 mm	Pan		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Tashi India Ltd Nagpur A(P)	20 mm	-	-	-	4	55	16	16	8	1	-	-	-	2.385	1.720
TIL	10 mm	-	-	-	-	-	-	-	-	-	90	10	-	2.375	1.720

Table -4

Properties of Plast Polypropylene Fibre (PP) (Given by Tashi India Ltd.)

1	Material	Polypropylene
2	Form	Fibrillated Stabilised
3	Water Absorption	Nil
4	Property	Ultraviolet
5	Specific gravity	0.91
6	Denier	1050
7	Dispersion	Excellent
8	Cut length	6mm / 12mm / 20mm
9	Tensile strength	0.67 KN/Sq.mm
10	Melting point	7165° C
11	Acid and Salt Resistance	High
12	Alkali Resistance	Excellent
13	Colour	Natural crushed.
14	Dosage	0.25 to 0.40% by wt of cement 125 gms for every 50 Kgs bag of cement

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Table - 5

Test results of Concrete M- 20 grade @ 28 dyas. (Control & with use of Plast fibre)

Sr. No	Grade of Concrete	Compressive Strength (after age) Kg/ cm^2	Split Tensile Kg/ cm^2	Flexural Strength Kg/ cm^2	Modulus of Elasticity Kg/cm^2	Permeability
			% Increase with Control Mix	% Increase with Control Mix		
1	2	3	4	5	6	7
1	M- 20 (Control	219	13.4 / 0	22 / 0	1.7×10^5	Pressure applied upto 12 Kg/.cm^2 No Percolation is observed, , It is Impervious
2	6 mm Plast Fibre	219	17.0 / 12	24 / 10.9	2.0×10^5	-"-
3	12 mm Plast Fibre	219	15.4 / 13.7	28 / 12.7	1.9×10^5	-"-

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Table - 6

Test results of Concrete M- 25 grade @ 28 dyas. (Control and with use of Plast fibre)

Sr .No	Grade of Concrete	Compressive Strength (after age) Kg/ cm^2	Split Tensile Kg/ cm^2 / % increase with control mix	Flexural Strength Kg/ cm^2 / % increase with control mix	Modulus of Elasticity Kg/cm^2	Permeability
1	2	3	4	5	6	7
1	M- 25 (Control	252	14 / 0	28 / 0	1.5×10^5	Pressure applied upto 15 Kg/ cm^2 .No Percolation is observed . It is impervious
2	6 mm Plast Fibre	269	16.9 / 12	32 / 11.4	1.75×10^5	-"-
3	12 mm Plast Fibre	280	19.8 / 14.0	36 / 12.6	2.0×10^5	-"-
4	20 mm Plast Fibre	280	22.6 / 16	40 / 14.2	2.0×10^5	

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Table - 7

Test results of Concrete M- 40 grade @ 28 dyas. (Control & with use of Plast fibre)

Sr .No	Grade of Concrete	Compressive Strength (after age) Kg/ cm^2	Split Tensile Kg/ cm^2	Flexural Strength Kg/ cm^2	Modulus of Elasticity Kg/cm^2	Permeability
			% Increase with Control Mix	% increase with Control Mix		
1	2	3	4	5	6	7
1	M- 40 (Control)	408	29.3 / 0	46 / 0	3 x 10^5	Pressure applied upto 15 Kg/ cm^2 No Percolation is observed .It is impervious
2	M-40 6mm	408	31.1 / 10.6	56 / 12.7	2.25 x 10^5	--
3	M-40 12 mm	409	32.5 / 11.1	58 / 13.1	2.0 x 10^5	--
4	M-40 20 mm	409	32.6 / 11.0	64 / 14.5	1.6 x 10^5	--

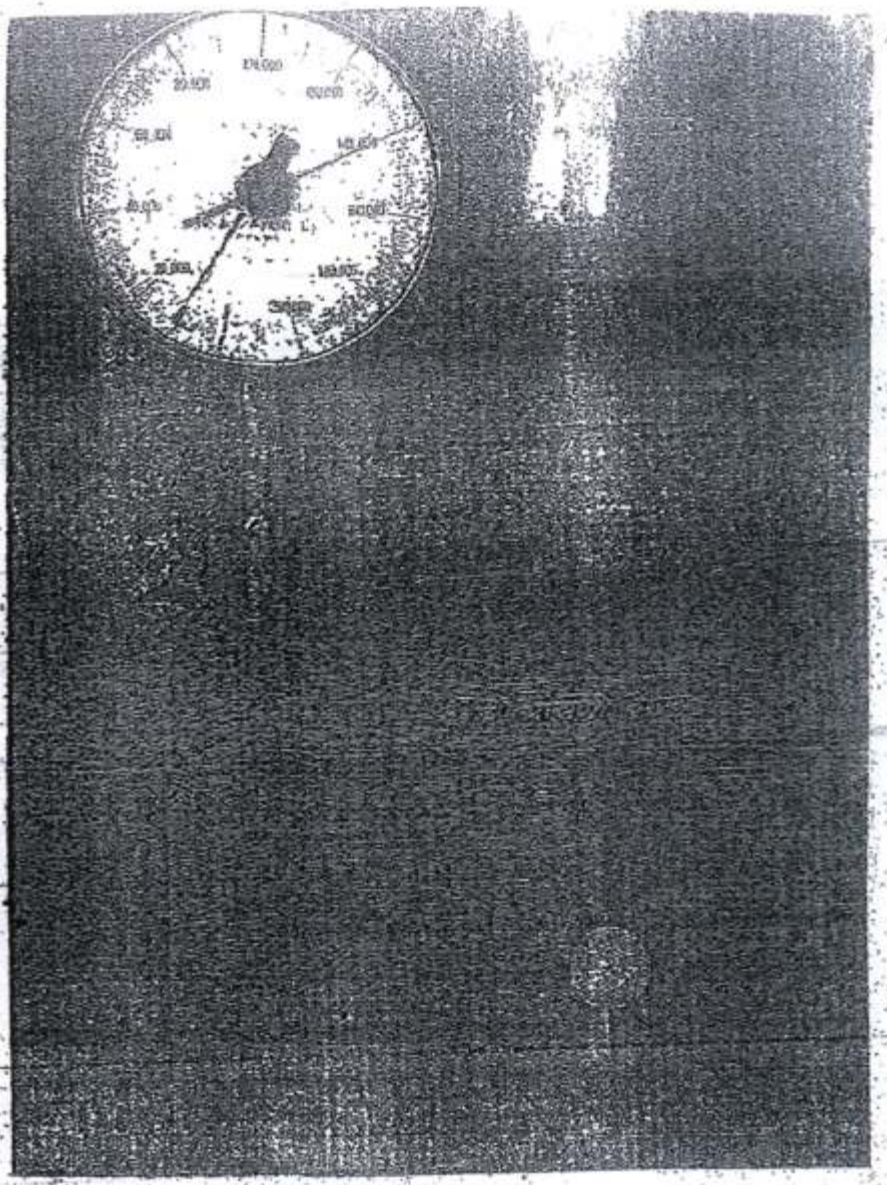

Photo- 1
'E' – Modulus of Elasticity of Concrete
(15 X 30 cm cylinder)

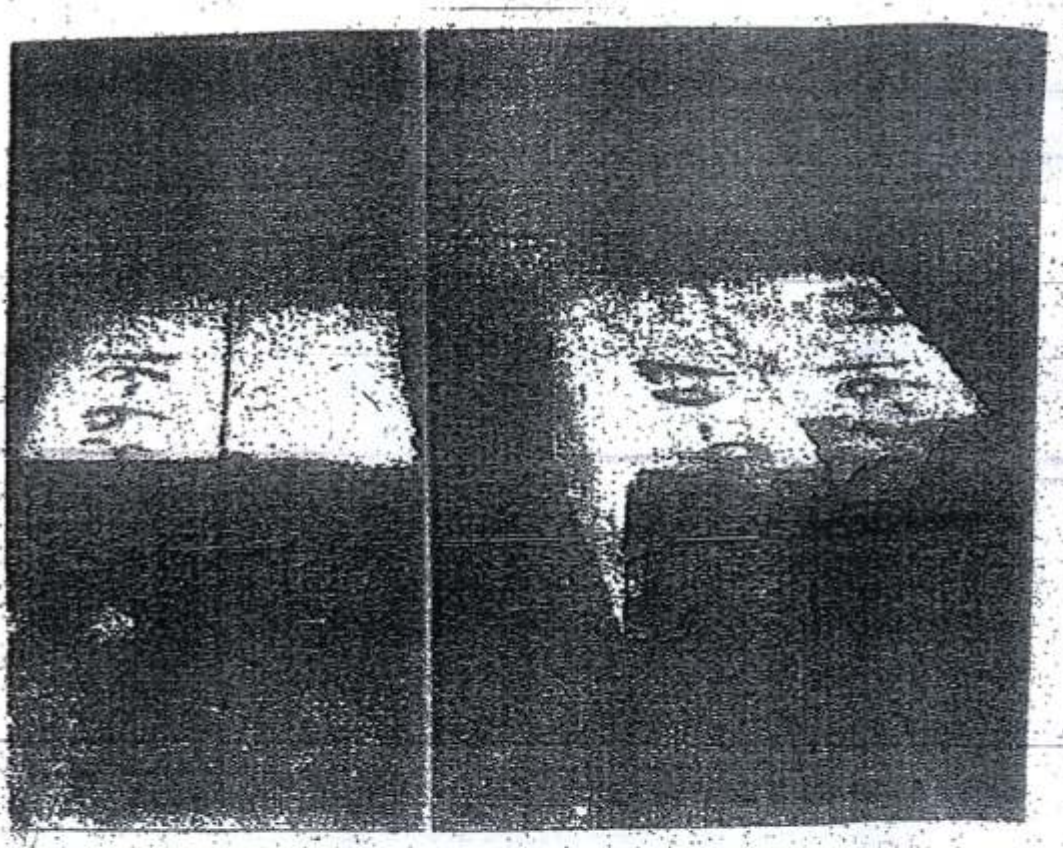

Photo- 2
Flexural Strength Specimen
(10 x 10 x 50 cm)

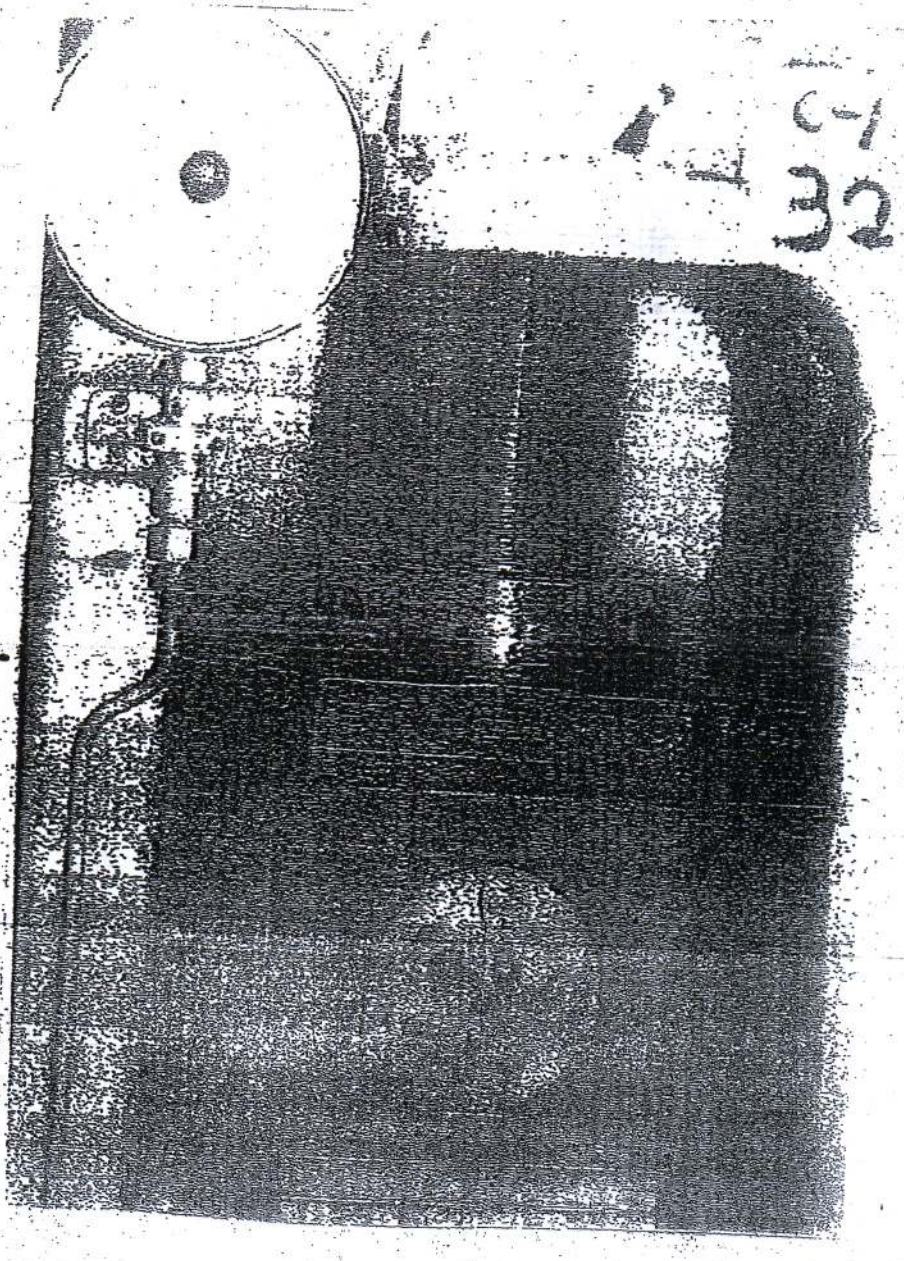

Photo- 3
Split - Test
Splitting Properties of Concrete
(15 x 30cm Cylinder)