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Management of Road Pavement Using High Strength Concrete and Sustainable Material

Bijeta Dash

Abstract*—Highway & Road Concrete pavement maintenance is a routine work performed to keep pavement which is exposed to normal conditions of traffic and nature such as wind, rain, show, temperature, etc. as near to its original conditions as possible, all types of concrete pavements require maintenance of cracks, potholes, depressions and other types of distress. In major cities and towns utility cuts and repaints are major contributors to the need for pavement maintenance, Repairing of pavement deteriorations at the proper time and the proper manner method can significantly increase the life of the pavement. Early detection and repair of minor defects are among the most important activates of the road maintenance department. Now – a days the use of 12 hours created mix for patching inhere traffic road way in urban areas. The current 12 Hrs benid of strength gain to 4 hours only. This work uses high early strength cement and chemical admixtures on one hand and low water cement ration and / or high conventional cement contents. Sustained materials on the other hand attain early strength, conclusive recommendations of a combination of these techniques and / or the individual techniques used based on strength criterion (compressive strength) and durability criterion is made. Admixtures like steel fibers, polypropylene fibers, aluminum pins, clips etc of non rusting metals are being used in this technique. This increases the wear and tear strength at the patch. Shrinkage reducing admixtures (SRA) one not being commonly used, now – a days. The use SRA and HPC or high strength concrete is descrying of further research Synthetic fibers are often uses to increase wearing strength. Possible benefits of use at such admixtures is increasing resistances to shrinkage, creating improved band strength. Finder reinforced concrete has been shown in several studies to be more restant to shrinkage cracking (Padron and Zolo, 1990, Gryzbowsti and shah, 1990) Conrek key word road pavement maintenance, high strength concrete, sustainable materials

Keywords: Concrete Road Pavement maintenance, High strength concrete, sustainable materials.

I. INTRODUCTION

This Paper reveals about the methods to be adopted to increase the sustainability or the concrete road pavement repairs in India by using high strength concrete and sustainable material. The application of an optimized pavement mix in road pavement maintenance will lead to substantial reduction in the user cost involved with delays in road closures. In current practice 12 hours concrete mix for patching in heavily traffic roadways in urban areas and metros is proposed to reduce up to 4 hours mix for this the use of high early strength cement and chemical admixtures on one hand and a low water cement ration / or high conventional cement content, sustainable material on the other hand to attain early strength.

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II. OBJECTIVE

The objective of the project is to design proper concrete mixes using sustainable material both designed in the lab and in the field, for composite pavements that will allow the repaired sections to be opened to traffic after four hours of concrete placement.

III. CONTRIBUTION TO THE WORK

High strength concrete mixes were changed according to strength requirement of pavement. Additional work is carried for strengthening the road pavement.

IV. LITERATURE REVIEW

Asphaltic concrete overlay is a commonly used rehabilitation technology for existing asphaltic or concrete pavements. This study used data that were collected from 449 asphaltic overlays on existing pavements. Statistical analysis results indicated that

(1) For asphaltic concrete pavements, milling is more effective in reducing alligator/block cracking, longitudinal cracking, and raveling in asphaltic overlay.
(2) For composite pavements, asphaltic concrete base patching is more effective in reducing longitudinal cracking, and doweled concrete base patching is more effective in reducing surface raveling in asphaltic overlay.
(3) For joint plain concrete pavements, undoweled concrete base patching is more effective in reducing transverse and longitudinal cracking.
(4) For continuously reinforced concrete pavements, asphaltic concrete base patching is more effective in reducing transverse and longitudinal cracking.
(5) Pavement surface condition data play a pivotal role in the analysis and design of pavement rehabilitation strategies. In project design, this information is usually used by a limited number of pavement engineering specialists who apply experience and judgment to formulate design and investment decisions.
(6) The nature of this process resists computerization using conventional computer tools. The development of a knowledge-based expert system that is based on programming concepts from the field of artificial intelligence is described.
(7) The system is called SCEPTRE, and assists highway engineers in planning cost-effective flexible pavement rehabilitation strategies at the project level.

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(8) As agencies continue looking for cost-effective methods to rehabilitate deteriorated jointed concrete pavement JCP, rubblization using a resonant breaker has been experimented by the Shanghai Municipal Roadway Authority SMRA. It was demonstrated that rubblization using a resonant breaker offers a viable option for the SMRA because the rubblized pavement sections have been performing very well with no visible distress.

(9) It was observed that it was very effective to use water during compaction on a rubblized JCP surface to improve compaction efficiency and to control dust.

V. THEORETICAL CONCEPT

- The procedure of strengthening a pavement by providing additional structural layers above the existing pavement is known as overlay.
- Two types of overlays are common for strengthening cement concrete pavements, flexible overlays and rigid overlays.
- In the case of bituminous overlays, the strengthening layers can be all bituminous or partially granular and partially bituminous.
- In the case of rigid overlays, two types are common, viz, bonded overlays and un-bonded overlays.

Overlays can be either overlays or inlays depending upon the site requirements given below:

(i) Overlay, where the concrete pavement is placed on top of the existing pavement.

(ii) Inlay, where the existing pavement is partially due to accommodate the new pavement.

- Next, the cracked PCC pavement is seated with a rubber-tired roller of at least 35 tons.
- After the breaking and seating steps are completed, a 3-to 5-inch asphalt overlay is placed directly on the prepared old pavement.

This method offers the following benefits:

1. Prevents/delays reflective cracking.
2. Extends pavement service life.
3. Reduces maintenance costs.
4. Improves riding smoothness.

VI. PROBLEM STATEMENT

- The road before work was asphalt road. As it is flexible one the road gets damaged as that is not suitable for heavy traffic.

The heavy traffic causes problems like cracks, patch damaging, pot hole

VII. RECHERCHÉ METHODOLOGY

Mix Design for Pavement Quality Concrete (PQC):

The first requirement in ensuring a good concrete road is to scientifically design the concrete mix so that it gives a strength in the field which is equal to or better than that assumed in the design.

- All the basic data needed for the project is collected.
- The target average flexural / compressive strength is determined on the basis of the minimum strength specified and quality control standards that can be expected.
- The water / cement ratio is determined to give the estimated flexural / compressive strength.
- etc.
- To remedy that rigid pavement road is proposed i.e. Concrete road.

VIII. DATA COLLECTED

Physical Tests-As Per IS:2386

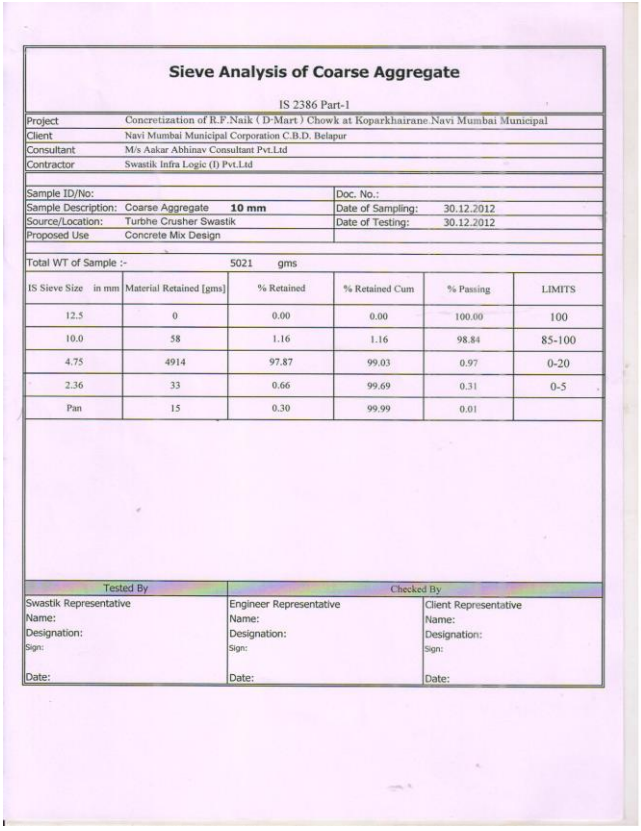
- Sieve Analysis / Fineness Modulus
- % Silt By Weight
- % Silt By Volume
- Impact Value
- Crushing Value
- Moisture Absorption
- Specific Gravity
- D.L.B.D.
- 10% Fine Value
- Flakiness / Elongation Index
- Los Angeles Abrasion Value

Chemical Tests-As Per IS:2386

- Soundness (Per Cycle)
- Alkali (Aggregate Reactivity)
- Deleterious Material
- pH
- Chloride

Field Test

- Cube testing
- Beam testing



Sieve Analysis of Coarse Aggregate

IS 2386 Part-1

Project	Concretization of R.F.Naik (D-Mart) Chowk at Koparkhairane Navi Mumbai Municipal
Client	Navi Mumbai Municipal Corporation C.B.D. Belapur
Consultant	M/s Aakar Abhinav Consultant Pvt.Ltd
Contractor	Swastik Infra Logic (I) Pvt.Ltd

Sample ID/No:		Doc. No.:	
Sample Description:	Coarse Aggregate **10 mm**	Date of Sampling:	30.12.2012
Source/Location:	Turbhe Crusher Swastik	Date of Testing:	30.12.2012
Proposed Use	Concrete Mix Design		

Total WT of Sample :- 5021 gms

IS Sieve Size in mm	Material Retained [gms]	% Retained	% Retained Cum	% Passing	LIMITS
12.5	0	0.00	0.00	100.00	100
10.0	58	1.16	1.16	98.84	85-100
4.75	4914	97.87	99.03	0.97	0-20
2.36	33	0.66	99.69	0.31	0-5
Pan	15	0.30	99.99	0.01	

Tested By	Checked By	
Swastik Representative Name: Designation: Sign: Date:	Engineer Representative Name: Designation: Sign: Date:	Client Representative Name: Designation: Sign: Date:

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Sieve Analysis of Coarse Aggregate

IS 2386 Part-1

Project	Concretization of R.F.Naik (D-Mart) Chowk at Koparkhairane.Navi Mumbai Municipal Corporation
Client	Navi Mumbai Municipal Corporation C.B.D. Belapur
Consultant	M/s Aakar Abhinav Consultant Pvt.Ltd
Contractor	Swastik Infra Logic (I) Pvt.Ltd

Sample ID/No:		Doc. No.:	
Sample Description:	Coarse Aggregate 20 mm	Date of Sampling:	30.12.2012
Source/Location:	Turbhe Crusher Swastik	Date of Testing:	30.12.2012
Proposed Use	Concrete Mix Design		

Total WT of Sample :- 10830 gms

IS Sieve Size in mm	Material Retained [gms]	% Retained	% Retained Cum	% Passing	LIMITS
40.0	0	0.00	0.00	100.00	100
20.0	746	6.88	6.88	93.12	85-100
12.5	6800	62.79	69.67	30.33	
10.0	2398	22.14	91.81	8.19	0-20
4.75	853	7.88	99.69	0.31	0-5
Pan	34	0.31	100.00	0.00	

Tested By	Checked By	
Swastik Representative	Engineer Representative	Client Representative
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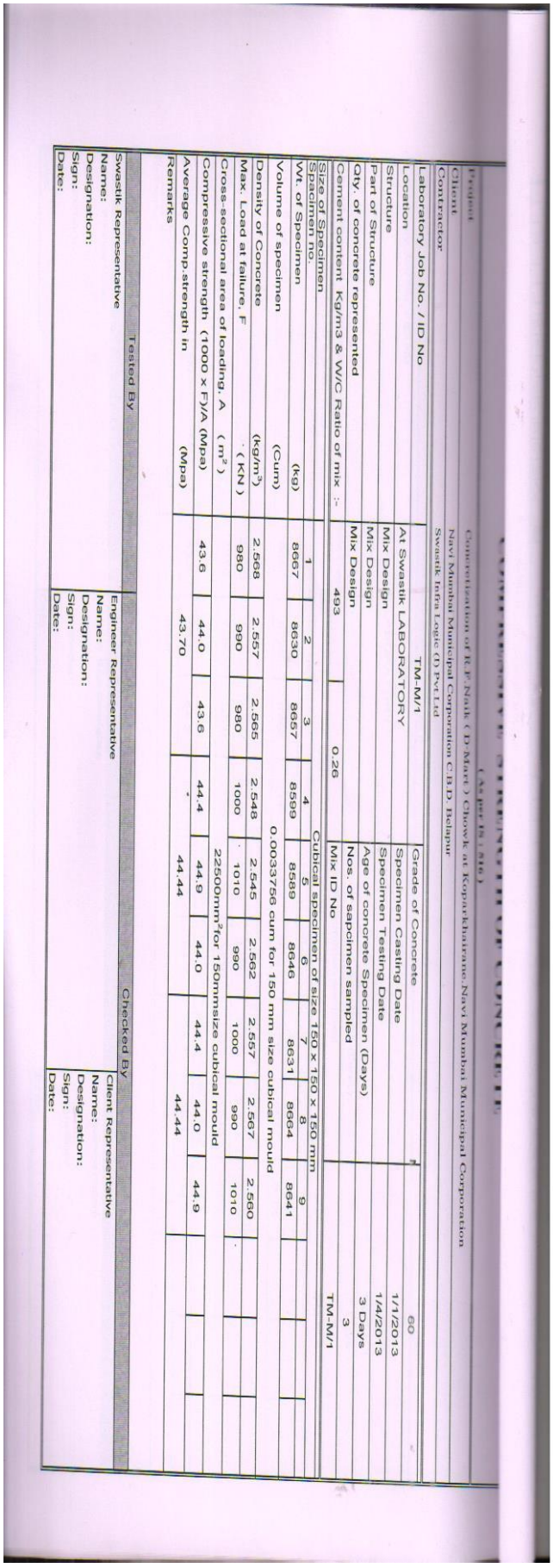
Designation:	Designation:	Designation:
Sign:	Sign:	Sign:
Date:	Date:	Date:



Project
Concretization of R.F.Naik (D-Mart) Chowk at Koparkhairane.Navi Mumbai Municipal Corporation
Client
Navi Mumbai Municipal Corporation C.B.D. Belapur
Contractor
Swastik Infra Logic (I) Pvt.Ltd

Laboratory Job No. / ID No	TM-M/1	Grade of Concrete	60							
Location	At Swastik LABORATORY	Specimen Casting Date	1/1/2013							
Structure	Mix Design	Specimen Testing Date	1/4/2013							
Part of Structure	Mix Design	Age of concrete Specimen (Days)	3 Days							
Qty. of concrete represented	Mix Design	Nos. of sapcimen sampled	3							
Cement content Kg/m3 & W/C Ratio of mix :-	493	0.26	Mix ID No	TM-M/1						
Size of Specimen	Cubical specimen of size 150 x 150 x 150 mm									
Specimen no.	1	2	3	4	5	6	7	8	9	
Wt. of Specimen (kg)	8667	8630	8657	8599	8589	8646	8631	8664	8641	
Volume of specimen (Cum)	0.0033756 cum for 150 mm size cubical mould									
Density of Concrete (kg/m^3)	2568	2557	2565	2543	2545	2562	2557	2567	2560	
Max. Load at failure, F (KN)	980	990	980	1000	1010	990	1000	990	1010	
Cross-sectional area of loading, A (m^2)	22500mm^{2}for 150mmsize cubical mould									
Compressive strength (1000 x F)/A (Mpa)	43.6	44.0	43.6	44.4	44.9	44.0	44.4	44.0	44.9	
Average Comp.strength in (Mpa)	43.70			44.44			44.44			
Remarks										

Tested By	Checked By	
Swastik Representative	Engineer Representative	Client Representative
Name:	Name:	Name:
Designation:	Designation:	Designation:
Sign:	Sign:	Sign:
Date:	Date:	Date:

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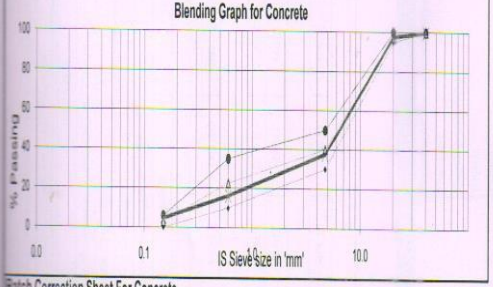
Project	Concretization of R.F.Naik (D-Mart) Chowk at Koparkhairane.Navi Mumbai Municipal Corporation
Client	Navi Mumbai Municipal Corporation C.B.D. Belapur -
Consultant	M/s Askar Abhinav Consultant Pvt.Ltd
Contractor	Swastik Infra Logic (I) Pvt.Ltd

Mix Details

Grade of Concrete	M	60	PQC	ID	TM-M/1	Date of Concrete / Trial	1-Jan-2013
W/C Ratio		0.26	Sp Gr.				
Water Content	Kg	128	1.00		Borewel Water		
Cementatitus	Kg	493					
Cement Content	Kg	453	3.15		Ambuja OPC 53 Cement		
Fly Ash	Kg	0	2.20		Dirk Flyash		
Micro silica	Kg	40	2.20		Caliper silica		
Proportion of Aggregate							
20 mm	Kg	649	2.857	32	%	Turbhe Crusher Swastik	
10 mm	Kg	559	2.811	28	%	Turbhe Crusher Swastik	
Avg.spg.			2.834				
R.Sand	Kg	0	2.721	0	%	Mahad River	
C.Sand	Kg	785	2.765	40	%	Turbhe Crusher Swastik	
Coarse Aggregate	Kg	1208		60	%		
Fine Aggregate	Kg	785		40	%		
Admix Dose	%	1.30	1.20		Construction Industry Chemicals (CIC-Concem-11)		

All in Aggregate Gradation (IS: 383-1970 Table - 5)

Aggregates Proportion	R/Sand	C.Sand	20 mm	10 mm	R/Sand	C.Sand	20 mm	10 mm	Combined % Passing	Midlimits of Sp. Limits	Specific Limits MSA 20 mm
Ratio	Individual Passing				0	40	32	28			
					0	0.4	0.32	0.28			
Sieve (mm)	% Passing										
40.0		100	100	100	0.0	40.0	32.0	28.0	100.0	100.0	100
20.0		100	93.12	100	0.0	40.0	29.8	28.0	97.8	97.5	95-100
4.75		93.14	0.31	1.0	0.0	37.25	0.10	0.27	37.6	40.0	30-50
0.600		40.45	0.00	0.00	0.0	16.18	0.00	0.00	16.2	22.5	10-35
0.150		11.81	0.00	0.00	0.0	4.72	0.00	0.00	4.7	3.0	0-6



Batch Correction Sheet For Concrete

Materials	Unit	Weight	% M.C.	W.A	Correct	T.Correct	1.00cum	0.5 Batch Qty	0.045 cum
Cement	Kg	453					453	227	20.39
Fly Ash	Kg	0					0	0	0.00
Micro silica	Kg	40					40	20	1.80
20 mm	Kg	649	0.00	1.53	1.53	9.95	639	320	28.76
10 mm	Kg	559	0.00	1.56	1.56	8.72	550	275	24.75
R.Sand	Kg	0	0.00	3.04	3.04	0.00	0	0	0.00
C.Sand	Kg	785	0.00	3.27	3.27	25.69	759	380	34.17
Water	Kg	128				44.35	173	86	7.76
Admixture	Kg	6.41					6.41	3.20	0.288

Slump	Required	30+-15	Time of Slump	Concrete Tmperature		°C	30	
Initial	mm	100	10.35	Ambient Temperature		°C	28	
30 min	mm	80	11.05	Compressive Strength	Cube cast	18	Beam Cast	---
60 min	mm	40	11.35	3 Days Strength	Mpa	44.20	Mpa	
90 min			12.05	7 Days Strength	Mpa	54.07	Mpa	
				Concrete Beheviour =	Cohesive nature			

TECHNICAL COMPLIANCE OF MIX.

Sr No.	Item	Reference MoRTH/Tech Specification Clause/Drwg	Requirement as per Specification	MIX ID NO	Achieved during Mix Design	Complying YES/NO
	CONCRETE					
A	**Aggregate Test**	Turbhe Crusher Swastik	Mahad River			
	AIV Test	As per IS 383	< 30 %		15.0	YES
	LAV Test 20mm		< 35 %		12.7	YES
	LAV Test 10 mm		< 35 %		14.7	YES
	EIFI Test 20mm		< 30%		22.5	YES
	EIFI Test 10mm		< 30%		18	YES
	WA & SP.Gravity 20mm		< 2 % WA for CA	WA	1.53	SP Gr 2.86 YES
	WA & SP.Gravity 10mm		< 2 % WA for CA	WA	1.56	SP Gr 2.81 YES
	WA & SP.Gravity R/Sand		< 15 % Mgso4 WA for FA	WA	3.04	SP Gr 2.72 YES
	WA & SP.Gravity C/Sand		< 15 % Mgso4 WA for FA	WA	3.27	SP Gr 2.77 YES
	Combined Grading		As per IS 383 MSA 20 mm Table 5		Confirming Table 5	YES
B	**Cement Test**	Ambuja OPC 53 Ceme				
	Fineness Test		< 10 %		1.64	YES
	Consistency test in %				30	YES
	IST	As per IS 12269	> 30 minutes		105	YES
	FST		< 600 Minutes		185	YES
	Compressive strength		> 53 Mpa		63.53665062	YES
C	**Mix Design for M**	60	PQC		Cement 453	YES
I	Min Cement Content & Max. W/C ratio	As per MOST Table 1700.3(A)	Min cementitious- kg	350	Fly ash 0	YES
			Max W/C Ratio	0.45	M.Silica 40	YES
II	Slump @ Mix Design	As per MOST Table 1700.3(A)	Initial Slump in mm		0.26	YES
			After 30 min Slump in mm		100	YES
			After 60 min Slump in mm		80	YES
			After 90 min Slump in mm		40	YES
III	Comp. Strength of Cubes	As per MOST Table 1700.3(A)	Target Mean Strength in Mpa	M	0	YES
				60	54.07	YES

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Cement Compressive Strength

As Per IS: 4031(Part - 6)

Project	Concretization of R.F.Naik (D-Mart) Chowk at Koparkhairane.Navi Mumbai Municipal Corporation
Client	Navi Mumbai Municipal Corporation C.B.D. Belapur
Consultant	M/s Aakar Abhinav Consultant Pvt.Ltd
Contractor	Swastik Infra Logic (I) Pvt.Ltd

Sample ID/No:	Cement-1	Doc. No.:	
Sample Description:	Ambuja Cement	Date of Sampling:	29.12.2012
Grade of cement	OPC 53 Grade	Sampled By:	Engineer
Batch No/ Lot No:	week-49	Date of Casting :	06.12.2012
Location:	Turbhe Laboratory	Date of Testing:	
Proposed Use	Concrete		

Specimen Size: Cube (70.6mm x 70.6mm x 70.6mm)

Normal Consistency of Cement (P)in % : 30 Temp. °C & Humidity % 27 69

SL. No.	Age	Date of Testing	Weight (gm)	Density gm/cm3	Breaking Load KN	Compressive Strength Mpa	Avg.comp. Strength (Mpa)	Remarks
1	3 days	09.12.2012	790	2.245	200	40.1		
2			770	2.188	190	38.1	40.1	
3			790	2.245	210	42.1		
4	7 days	13.12.2012	780	2.217	270	54.2		
5			800	2.273	280	56.2	54.8	
6			810	2.302	270	54.2		
7	28 days	03.01.2013	820	2.330	310	62.2		
8			822	2.336	330	66.2	63.5	
9			835	2.373	310	62.2		

Tested By	Checked By	
MRIPL Representative Name: Designation: Sign: Date:	Engineer Representative Name: Designation: Sign: Date:	Client Representative Name: Designation: Sign: Date:

24/3/15

DETERMINATION OF FINENESS, CONSISTENCY, INITIAL & FINAL SETTING TIME OF CEMENT

As Per IS: 4031(Part- 1, 4 & 5)

Project	Concretization of R.F.Naik (D-Mart) Chowk at Koparkhairane.Navi Mumbai Municipal Corporation
Client	Navi Mumbai Municipal Corporation C.B.D. Belapur
Consultant	M/s Aakar Abhinav Consultant Pvt.Ltd
Contractor	Swastik Infra Logic (I) Pvt.Ltd

Sample ID/No:	Cement	Doc.No.	
Sample Description:	Ambuja OPC 53 Grade Cement	Date of Sampling:	29.12.2012
Week No / Lot No	Week-52	Date of Testing:	29.12.2012
Cement Grade	OPC 53 Grade		

Temperature : 27 °C Humidity : 69 %

A) FINENESS DETERMINATION :

SL. NO.	Determination	Unit	Trial No. I	Trial No. II	Trial No. III	Remarks
1	Weight of Cement Taken (A)	Gms	100	100	100	
2	Weight of Cement Retain on 90 Micron Sieve(B)	Gms	1.6	1.7	1.63	
3	Percentage of Retain (B/A*100)	%	1.6	1.7	1.63	
4	Average Percentage of Fineness of Cement	%	1.64			
5	Specified Limit	%	<10			

A) CONSISTENCY :

Test No.	Weight of Cement in gms	Weight of Water in gm	% of Water in Mix	Needle Penetration in MM	Duration in Minutes	Remarks
1	300	90	30	5	5	

B) INITIAL SETTING TIME : From: 16.15 to 18.00 Min

1	300	76.5	25.5	5	105	

C) FINAL SETTING TIME : From: 16.15 to 19.20 Min

1	300	76.5	25.5	No mark	185	

RESULTS:

FINENESS CONTENT OF CEMENT 1.64 %

Standard Consistency of Cement : (P) 30 %

Initial Setting Time : 105 Minutes

Final Setting Time : 185 Minutes

Tested by	Checked By	
Swastik Representative Name: Designation: Sign: Date:	Engineer Representative Name: Designation: Sign: Date:	Client Representative Name: Designation: Sign: Date:

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(As per IS : 516)

Project	Concretization of R.F.Naik (D-Mart) Chowk at Koparkhairane Navi Mumbai Municipal Corporation												
Client	Navi Mumbai Municipal Corporation C.B.D. Belapur												
Consultant	M/s Aakar Abhinav Consultant Pvt Ltd												
Contractor	Swastik Infra Logic (I) Pvt.Ltd												
Laboratory Job No. / ID No	TM-M/1				Grade of Concrete								60
Location	At Swastik LABORATORY				Specimen Casting Date								1/1/2013
Structure	Mix Design				Specimen Testing Date								1/8/2013
Part of Structure	Mix Design				Age of concrete Specimen (Days)								7 Days
Qty. of concrete represented	Mix Design				Nos. of sapcimen sampled								3
Cement content Kg/m3 & W/C Ratio of mix :-	493		0.26		Mix ID No								TM-M/1
Size of Specimen	Cubical specimen of size 150 x 150 x 150 mm												
Specimen no.	10	11	12	13	14	15	16	17	18				
Wt. of Specimen (kg)	8690	8730	8766	8714	8731	8745	8719	8677	8665				
Volume of specimen (Cum)	0.0033756 cum for 150 mm size cubical mould												
Density of Concrete (kg/m^3)	2.575	2.587	2.597	2.582	2.587	2.591	2.583	2.571	2.567				
Max. Load at failure, F (KN)	1210	1200	1220	1230	1210	1230	1220	1240	1230				
Cross-sectional area of loading, A (m^2)	22500mm^{2}for 150mmsize cubical mould												
Compressive strength (1000 x F)/A (Mpa)	53.8	53.3	54.2	54.7	53.8	54.7	54.2	55.1	54.7				
Average Comp.strength in (Mpa)	53.8			54.4			54.7						
Remarks													
Tested By					Checked By								
Swastik Representative					Engineer Representative					Client Representative			
Name:					Name:					Name:			
Designation:					Designation:					Designation:			
Sign:					Sign:					Sign:			
Date:					Date:					Date:			

IX. CASE STUDY

- This is a concrete road construction project. In this project concrete road M40-M60 concrete is used for PQC. M40 for stretch roads and M60 at junctions to get early high strength so that no traffic problems to be occur.

1. Name of Project: Concretization of R.F.Naik (D-Mart) Chowk at Koparkhairane.Navi Mumbai Municipal Corporation

- Location of Project: Koparkhairane, Navi Mumbai

1. Start date of Project: 3 Nov 2014
2. Proposed finish date of Project: 28 May 2015

Estimated cost of the project: Rs.24, 51, 000 lakhs

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X. CONCLUSION

1. On the basis of data collection and by using present worth method of pavement repairing it is observed that the time for closing of road overlays is 12 Hours.
2. By adopting method of using high strength concrete and sustainable material the time period of closure of road pavement overlays is reduced to 4 hours. Only.
3. Because of dedication of road closer time the cost saved is 25% more than the routing method
4. Hence this method using high strength concrete and sustainable material is recommended.

REFERENCES

1. By Stephen G. Ritchie,1 A. M. Asce, Che-I Yeh,2 Joe P. Mahoney,3 and Newton C. Jackson4 Surface Condition Expert System For Pavement Rehabilitation Planning J. Transp. Eng. 1987.113:155-167.
2. Dar Hao Chen1; Tom Scullion, P.E.2; And John Bilyeu, P.E.3 Lessons Learned On Jointed Concrete Pavement Rehabilitation Strategies In Texas J. Transp. Eng. 2006.132:257-2605.
3. Xiaojun Li1 And Haifang Wen, Ph.D., P.E., M.Asce2 Effects Of Preoverlay Pavement Conditions And Preoverlay Repair Methods On The Performance Of Asphaltic Concrete Overlays J. Transp. Eng. 2014.140:42-49.

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