

CONTENTS

	<i>PARTICULARS</i>	<i>PAGE NO.</i>
	CERTIFICATE	
	ACKNOWLEDGEMENT	
	ABSTRACT	
	LIST OF TABLES	
	LIST OF FIGURES	
	LIST OF GRAPHS	
1	INTRODUCTION	
1.1	General Introduction	1
1.1.1	Shallow Beam	1
1.1.2	Moderate Deep Beam	2
1.1.3	Deep Beam	2
1.2	Behavior of Deep Beam	2
1.3	History of Reinforced Concrete and Fiber Reinforced Concrete (FRC)	4
1.3.1	History of Reinforced Concrete	4
1.3.2	History of Fiber Reinforced Concrete	4
1.4	Fibrous Concrete	4
1.4.1	Necessity of Fiber Reinforced Concrete (FRC)	5
1.4.2	Behavior of Fiber in Concrete	6
1.5	Types of Fibers	6
1.5.1	Asbestos Fiber	7
1.5.2	Carbon Fiber	7
1.5.3	Aramid Fiber	7
1.5.4	Glass Fiber	7
1.5.5	Natural Fiber	8
1.5.6	Metallic Fiber	8
1.5.7	Polypropylene, Polyethylene, Nylon Fiber	8
1.6	Steel Fiber Reinforced Concrete (SFRC)	9
1.7	Polypropylene Fiber Reinforced Concrete (PFRC)	11
1.8	Advantages of Fibers in Concrete	12
1.9	Application of Fibers	13
1.10	Application of Moderate Deep Beam	13
1.11	Crack	14
1.11.1	Role of Fibers in Crack Control	14

2	LITERATURE REVIEW	
2.1	General	16
2.2	Literature Survey	16
2.3	Objective	59
3	SIZE EFFECT	
3.1	Size Effect	60
3.2	Importance of Size Effect	60
3.3	Classical History of Size Effect	60
3.4	Factors Influencing Size Effects	64
3.5	Size Effect in Reinforced Concrete	65
	3.5.1 Bond Characteristics	65
	3.5.2 Cracks in Service Conditions	66
	3.5.3 Ultimate Strength and Deformation	67
3.6	Influence of Size Effect on Structural Strength	68
	3.6.1 Boundary Layer Effect	68
	3.6.2 Diffusion Phenomenon	69
	3.6.3 Hydration of Heat	69
	3.6.4 Statistical Size Effect	70
	3.6.5 Fracture Mechanics Size Effect	70
	3.6.6 Fractal Nature of Crack Surfaces	70
3.7	Size Effect in Shear Strength of Concrete	70
3.8	Size Effect Parameters Considered for Shear Strength and Crack Width for Moderate Deep Beam	74
4	EXPERIMENTAL WORK	
4.1	Details of Test Specimens	76
4.2	Beam Notation	83
4.3	Materials	83
	4.3.1 Cement	83
	4.3.2 Coarse and Fine Aggregates	84
	4.3.3 Water	84
	4.3.4 Reinforcement	84
	4.3.5 Properties of Fibers	86
	4.3.6 Concrete Mix	87
	4.3.7 Form Work	87
	4.3.8 Loading and Support Plates	88
4.4	Sieve Analysis	89
4.5	Mix Proportioning	92
4.6	Mixing Casting and Curing	95
	4.6.1 Mixing	95

	4.6.2	Casting	96
	4.6.3	Curing	97
4.7		Pre-Testing Arrangements	97
4.8		Instruments	97
	4.8.1	Universal Testing Machine	97
	4.8.2	Lifting Crane	98
	4.8.3	Digital Vernier Gauge	98
4.9		Testing Procedure	99
5		DEFLECTION CHARACTERISTIC OF BEAMS	
5.1		Control Specimen for Plain Series	100
5.2		Control Specimen for RCC Series	100
5.3		Control Specimen for RCC + Fiber Series	101
5.4		Load Deflection Characteristics for Beams	101
5.5		Comparison of Load Deflection Characteristics of Plain, RCC and Fibrous Beams (1P)	124
5.6		Comparison of Load Deflection Characteristics of Plain, RCC and Fibrous Beams (2P)	132
5.7		Reserved Strength	139
5.8		Ductility Factor	139
5.9		RCC 1P Reserved Strength and Ductility Factor	140
5.10		Fiber 1P Reserved Strength and Ductility Factor	140
5.11		RCC 2P Reserved Strength and Ductility Factor	141
5.12		Fiber 2P Reserved Strength and Ductility Factor	141
6		MODIFICATION OF MR P. J. ROBBIN'S SHEAR STRENGTH FORMULA BY INCORPORATING SIZE EFFECT PARAMETER	
6.1		Size Effect	144
6.2		Comparison of Experimental Test Results of Ultimate Load With Various Formula	144
6.3		Comparison of Ultimate Load Between RCC and Fibrous Series	146

6.3.1	RCC Series and Graphical Representation (1P)	147
6.3.2	Size Effect for Fibrous Series and Graphical Representation (1P)	148
6.4	Comparison of Ultimate Load Between RCC and Fibrous Series (2P)	151
6.4.1	Size Effect for Plain Series and Graphical Representation (2P)	151
6.4.2	Size Effect for RCC Series and Graphical Representation	152
6.4.3	Size Effect for Fibrous Series and Graphical Representation	153
6.5	Incorporation of Size Effect Parameter in Original Mr P. J. Robbin's Formula for Shear Strength of Beam	154
6.6	Linear Regression Analysis	156
6.6.1	Result of Linear Regression Analysis for Constant λ_o	157
6.7	Comparison of Experimental Results with Modified P. J. Robin's Formula and Graphical Representation	160
7	MODIFICATION OF ULTIMATE SHEAR STRENGTH OF S N PATEL AND S K DAMLE IN CORPORATING SIZE EFFECT PARAMETER	
7.1	Incorporating Size Effect Factor in Original Equation	169
7.2	Non-Linear Regression Analysis Procedure	172
7.3	Comparison of Ultimate Shear Strength Test Results with Different Equations	176
7.3.1	RCC Series of Beams (R)	176
7.3.2	Layered RCC Series of Beams (RL)	178
7.3.3	Fibrous RCC Series of Beams (RF)	179
7.3.4	Fibers Layered RCC Series of Beams (RLF)	181
7.4	Comparison of Ultimate Shear Strength Ratio (Wu Test/ Wu Theo) For Different Equation	182
7.4.1	RCC Series of Beams (R)	182
7.4.2	Layered RCC Series of Beams (RL)	184
7.4.3	Fibrous RCC Series of Beams (RF)	185

7.4.4	Fibrous Layered RCC Series of Beams (RLF)	187
7.4.5	Overall Comparison of Ultimate Shear Strength Ratio (Wu test/ Wu theo) for Different Equations	188
7.4.6	Overall Comparison of % Difference for Ultimate Load With Various Formula	189
7.5	Size Effect	190
7.5.1	Size Effect (Shear Stress) of Tested Beams	191
7.5.2	Graphical Representation of Size Effect for Tested Beams	192
7.6	Comparison of Size Effect (Ultimate Shear Stress Vs. Depth) For “R” Beam Series with Original Formula and Modified Formula	194
7.6.1	Comparison and Graphical Representation of Ultimate Shear Stress Ratio For “R” Beam Series with Original Formula And Modified Formula	195
7.6.2	Comparison of Size Effect (Ultimate Shear Stress Vs. Depth) For “RL” Beam Series with Original Formula and Modified Formula	196
7.6.3	Comparison and Graphical Representation of Ultimate Shear Stress Ratio For “RL” Beam Series with Original Formula and Modified Formula	197
7.6.4	Comparison of Size Effect (Ultimate Shear Stress Vs. Depth) For “RF” Beam Series with Original Formula and Modified Formula	198
7.6.5	Comparison and Graphical Representation of Ultimate Shear Stress Ratio For “RF” Beam Series with Original Formula and Modified Formula	199
7.6.6	Comparison of Size Effect (Ultimate Shear Stress Vs. Depth) For “RLF” Beam Series with Original Formula and Modified Formula	200
7.6.7	Comparison and Graphical Representation of Ultimate Shear Stress Ratio For “RLF” Beam Series with Original Formula And Modified Formula	201

8	MODIFICATION OF SHEAR STRENGTH EQUATION BY INCORPORATING SIZE EFFECT PARAMETER IN EUROCODE (02:2004)	
8.1	Shear Stress In Beam	203
8.2	Shear Stress of Tested Beams (RCC, PFRC, SFRC)	203
8.2.1	Graphical Representation of Size Effect for RCC Beams	204
8.2.2	Graphical Representation of Size Effect for PFRC Beams	204
8.2.3	Graphical Representation of Size Effect for SFRC Beams	204
8.3	Modification of Euro Code Equation by Incorporating Size Effect Parameter	205
8.3.1	Assumptions	206
8.4	Incorporation of Size Effect Parameter (SF) By Non-Linear Regression Analysis Method	206
8.4.1	Non-Linear Regression Analysis	207
8.5	Iterative Data Analysis in SPSS For Model Equation	208
8.6	Modified Shear Strength Formula for Prediction of Shear Strength of Moderate Deep Beams Eurocode 02:2004.	209
8.7	Derived Equation for Prediction of Shear Strength for RCC Moderate Deep Beam	209
8.8	Modified Equation for Prediction of Shear Strength for PFRC Moderate Deep Beam	209
8.9	Derived Equation for Prediction of Shear Strength for SFRC Moderate Deep Beam	210
8.10	Graphical Representation of Experimental Shear Strength, Shear Strength by Original Equation and Shear Strength by Modified Equation	211
8.11	Comparison of Ultimate Shear Strength of Various Past Thesis Beam Data by Test Results, Original Ec-	214

	02 Equation and Various Other Researcher's Equations.	
8.12	Graphical Representation Comparison of Ultimate Shear Strength of Various Past Thesis Beam Data by Original Ec-02 Equation, Modified Equation And Test Results.	219
9	MODIFICATION OF SHEAR STRENGTH FORMULA BY INCORPORATEING SIZE EFFECT PARAMTER IN CSACODE	
9.1	Comparison of Ultimate Load For Different Series of Beam	220
9.2	Size Effect for RCC Series and Graphical Representation	221
9.3	Size Effect for PFRC series And Graphical Representation	222
9.4	Size Effect for SFRC series And Graphical Representation	223
9.5	Comparison of Nominal Stress Between RCC, PFRC And SFRC Series	223
9.6	Modification of Shear Strength Formula from Canadian Code	224
9.6.1	Canadian Standard Association Csa-A23.3-04	224
9.6.2	Modification of Formula with Size Effect Parameter	225
9.6.3	Regression Analysis	225
9.6.4	Data Analysis by SPSS Software	227
9.7	Modified Formula for Prediction of Shear Strength of Reinforced Concrete Moderate Deep Beam	228
9.8	Modified Formula for Prediction of Shear Strength of Fibrous Concrete Moderate Deep Beam	229
9.8.1	Graphical Representation of Shear Strength Predicted By Original Equation, Experimental Value And Modified Equation	230
9.9	Comparison of Experimental Test Results of Ultimate Load With Various Original Formula	234
10	CRACK CHARECTERISTICS	
10.1	Crack Patterns	239
10.2	Modes of Failure	239
10.2.1	Flexure Failure	240

10.2.2	Flexure-Shear Failure	240
10.2.3	Shear Failure	240
10.2.4	Local Compression Failure	241
10.2.5	Anchorage Failure	241
10.3	Observation Tables for Crack Width Analysis	242

11 MODIFICATION OF CRACK WIDTH FORMULA BY INCORPORATING SIZE EFFECT PARAMETER

11.1	Computation of Maximum Crack Width Formula	272
11.2	Size Effect Parameters Considered for Modification of Crack Width Equation.	273
11.3	Non-Linear Regression Analysis for Crack Width Equation	275
11.4	Non-Linear Regression Analysis	275
11.5	Iterative Data Analysis in SPSS For Model Equation	276
11.6	Derived Crack Width Formulas for Prediction of Maximum Crack Width	278
11.6.1	Derived Equation for Prediction of Maximum Crack Width For RCC Moderate Deep Beam	278
11.6.2	Derived Equation for Prediction of Maximum Crack Width for PFRC Moderate Deep Beam	279
11.6.3	Derived Equation for Prediction of Maximum Crack Width for SFRC Moderate Deep Beam	280
11.6.4	Crack Widths Obtained Analytically and Experimentally	281
11.7	Results of First Crack Loads and Ultimate Load	287
11.8	Results of Crack Width Obtained Experimentally and Theoretically	290
11.9	Comparison of Crack Width for Conventional and Fibrous Concrete.	292
11.9.1	Based on Ultimate Load of RCC	292
11.10	Crack Development in Specimens With $a/d=2$ (One Point Loading)	295

11.11	Crack Pattern crack Development in Specimens With a/d=1 (Two Point Loading)	299
12	DISCUSSION OF TEST RESULTS	304
13	CONCLUSION AND SUMMARY	312
13.1	Suggestion	317
13.2	Future Scope of Work	317
14	REFERENCE	319
15	APPENDIX I	325
16	APPENDIX II	338
17	APPENDIX III	350
18	APPENDIX IV	358
19	APPENDIX V	366
20	APPENDIX VI	370
21	APPENDIX VII	381