# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>i</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xv</td>
</tr>
<tr>
<td><strong>CHAPTER-1: INTRODUCTION</strong></td>
<td></td>
</tr>
<tr>
<td>1.1 GENERAL</td>
<td>1</td>
</tr>
<tr>
<td>1.2 NEED OF PRESENT WORK</td>
<td>1</td>
</tr>
<tr>
<td>1.3 OBJECTIVES OF THE PRESENT WORK</td>
<td>2</td>
</tr>
<tr>
<td>1.4 ORGANIZATION OF THE THESIS</td>
<td>4</td>
</tr>
<tr>
<td><strong>CHAPTER – 2: LITERATURE REVIEW</strong></td>
<td></td>
</tr>
<tr>
<td>2.1 RECYCLED CONCRETE AGGREGATE</td>
<td>6</td>
</tr>
<tr>
<td>2.1.1 General</td>
<td>6</td>
</tr>
<tr>
<td>2.1.2 Constituent Materials in Concrete</td>
<td>6</td>
</tr>
<tr>
<td>2.1.3 Concrete Waste and Concrete Recycling</td>
<td>7</td>
</tr>
<tr>
<td>2.1.4 Properties of Recycled Aggregate</td>
<td>9</td>
</tr>
<tr>
<td>2.1.4.1 Physical</td>
<td>9</td>
</tr>
<tr>
<td>2.1.4.1.1 Adhered paste and mortar</td>
<td>9</td>
</tr>
<tr>
<td>2.1.4.1.2 Shape and surface texture</td>
<td>10</td>
</tr>
<tr>
<td>2.1.4.1.3 Bulk density</td>
<td>10</td>
</tr>
<tr>
<td>2.1.4.1.4 Specific gravity</td>
<td>12</td>
</tr>
<tr>
<td>2.1.4.1.5 Water absorption</td>
<td>12</td>
</tr>
<tr>
<td>2.1.4.2 Mechanical</td>
<td>14</td>
</tr>
<tr>
<td>2.1.4.2.1 Abrasion</td>
<td>14</td>
</tr>
<tr>
<td>2.1.4.3 Durability</td>
<td>14</td>
</tr>
<tr>
<td>2.1.4.3.1 Sulphate soundness</td>
<td>14</td>
</tr>
</tbody>
</table>
2.1.4.3.2 Chemical-mineralogical characteristics  
2.1.5 Recommendations  
2.1.6 Mix design  
2.1.7 Properties of Recycled Aggregate Concrete  
  2.1.7.1 Properties of fresh concrete  
  2.1.7.1.1 Water demand and workability  
  2.1.7.1.2 W/C Ratio  
  2.1.7.1.3 Cement quantity  
  2.1.7.1.4 Density and air content  
  2.1.7.1.5 New interfacial transition zone  
2.1.8 Mechanical Properties of Recycled Aggregate Concrete  
  2.1.8.1 Compression  
    2.1.8.1.1 Behaviour of recycled aggregate concrete produced with natural aggregate and recycled fine aggregate  
    2.1.8.1.2 Behaviour of recycled aggregate concrete produced with recycled coarse aggregate and recycled fine aggregate  
    2.1.8.1.3 Behaviour of recycled aggregate concrete produced with recycled coarse aggregate and natural fine aggregate  
  2.1.8.2 Behaviour of recycled aggregate concrete in tension  
  2.1.8.3 Behaviour of recycled aggregate concrete in flexure  
  2.1.8.4 Stress strain behavior of recycled aggregate concrete  
  2.1.8.5 Young’s modulus
vi

2.1.9 Relationships Between the Mechanical Properties 39
2.1.10 Sound Absorption Characteristics 42
2.1.11 Durability Properties 43
  2.1.11.1 Permeability and water absorption 43
  2.1.11.2 Freezing and thawing resistance 45
  2.1.11.3 Chloride diffusion/penetration 47
  2.1.11.4 Carbonation 49
  2.1.11.5 Water Sorptivity 51
  2.1.11.6 Reinforcement corrosion 51
  2.1.11.7 Creep, elastic shrinkage and drying shrinkage 52
2.1.12 Economic Comparison of Concrete Recycling 53
2.1.13 Structural Properties 55
  2.1.13.1 Flexural behaviour of recycled aggregate concrete 55
  2.1.13.2 Shear behaviour of recycled aggregate concrete 56
  2.1.13.3 Compression behaviour of recycled aggregate concrete 57
  2.1.13.4 Bond behavior of recycled aggregate concrete with steel rebar’s 57
  2.1.13.5 Seismic performance of recycled aggregate concrete 58
  2.1.13.6 Glass fiber reinforced recycled aggregate concrete 59
2.1.14 Artificial Neural Networks and Fuzzy Logic 60
2.1.15 Conclusions 60

2.2 LITERATURE REVIEW OF SLAB ELEMENTS 63

CHAPTER-3:- MATERIAL PROPERTIES AND CASTING OF TEST SPECIMENS
3.1 GENERAL

3.2 EXPERIMENTAL PROGRAM- OVERVIEW

3.2 MATERIALS USED AND ITS PROPERTIES

  3.2.1 Cement

  3.2.2 Fine Aggregate

  3.2.3 Natural Coarse aggregate

  3.2.4 Recycled Coarse Aggregate

  3.2.5 Steel Reinforcement

  3.2.6 Water

3.3 MIX DESIGN

3.4 CASTING OF SPECIMENS

3.5 MECHANICAL PROPERTIES

3.6 SUMMARY

CHAPTER-4:- PUNCHING SHEAR BEHAVIOUR OF RECYCLED AGGREGATE CONCRETE TWO WAY SLABS

4.1 GENERAL

4.2 EXPERIMENTAL PROGRAM

4.3 EXPERIMENTAL SET-UP AND EQUIPMENT

4.4 STRUCTURAL LOADING FRAME AND PLATFORM

4.5 LOADING ARRANGEMENT AND TESTING

  4.5.1 Simply Supported Edge Condition

  4.5.2 Restrained Edge Condition

4.6 TEST RESULTS AND DISCUSSION

  4.6.1 General

  4.6.2 Slab With Four Edges Simply Supported
4.6.2.1 First crack load
4.6.2.2 Ultimate load
4.6.2.3 Load deflection response
4.6.2.4 Stiffness
4.6.2.5 Energy absorption
4.6.2.6 Cracking and Failure Patterns
4.6.2.7 Evaluation of critical perimeter
4.6.2.8 Prediction of failure mode
4.6.2.9 Comparison with design codes
4.6.2.10 Punching shear strength
4.6.2.11 Regression model for punching shear stress

4.6.3 Slab With Four Edges Restrained
4.6.3.1 First crack load
4.6.3.2 Ultimate load
4.6.3.3 Load deflection response
4.6.3.4 Stiffness
4.6.3.5 Energy absorption
4.6.3.6 Cracking and Failure Patterns
4.6.3.7 Evaluation of critical perimeter
4.6.3.8 Prediction of failure mode
4.6.3.9 Comparison with design codes
4.6.3.10 Punching shear strength
4.6.3.11 Regression model for punching shear stress

4.7 EFFECT OF EDGE CONDITION
4.7.1 General
4.7.2. First Crack And Ultimate Loads 157
4.7.3 Load-Deflection Response 160
4.7.4 Regression Model 164

4.8 SUMMARY 164

CHAPTER-5:- FLUXURAL BEHAVIOUR OF RECYCLED AGGREGATE CONCRETE TWO WAY SLABS

5.1 GENERAL 166

5.2 EXPERIMENTAL PROGRAM 166

5.3 EXPERIMENTAL SET-UP AND EQUIPMENT 168

5.3.1 Structural Loading Frame and Platform 168

5.3.2 Testing Procedure 168

5.3.2.1 Application of load and loading sequence 169

5.3.2.2 Simply supported edge condition 170

5.3.2.3 Restrained edge condition 170

5.4 TEST RESULTS AND DISCUSSION 172

5.4.1 General 172

5.4.2 Slab With Four Edges Simply Supported 172

5.4.2.1 First crack load 173

5.4.2.2 Ultimate load 174

5.4.2.3 Load deflection response 176

5.4.2.4 Stiffness 179

5.4.2.5 Energy absorption 180

5.4.2.6 Cracking and Failure Patterns 182

5.4.2.7 Prediction of failure mode 189

5.4.2.8 Determination of Bending moment coefficients 191
5.4.2.8.1 General
5.4.2.8.2 Yield criteria
5.4.2.8.3 Assumptions used in selecting
the collapse Yield line pattern
5.4.2.8.4 Notations for edge conditions of slabs
5.4.2.8.5 Determination of ultimate load on a slab
5.4.2.8.6 Determination of Bending moment coefficients for
all edges fixed condition
5.4.2.8.7 Determination of Bending moment coefficients for
all edges simply supported condition
5.4.2.8.8 The bending moment coefficient for NCAC-S
5.4.2.8.9 The bending moment coefficient for RCAC-20-S
5.4.2.8.10 The bending moment coefficient for RCAC-40-S
5.4.2.8.11 The bending moment coefficient for RCAC-60-S
5.4.2.8.12 The bending moment coefficient for RCAC-80-S
5.4.2.8.13 The bending moment coefficient for RCAC-100-S

5.4.3 Slab With Four Edges Fixed
5.4.3.1 First crack load
5.4.3.2 Ultimate load
5.4.3.3 Load deflection response
5.4.3.4 Stiffness
5.4.3.5 Energy absorption
5.4.3.6 Cracking and Failure Patterns
5.4.3.7 Prediction of failure mode
5.4.3.8 The bending moment coefficient for NCAC-F
5.4.3.9 The bending moment coefficient for RCAC-20-F 227
5.4.3.10 The bending moment coefficient for RCAC-40-F 228
5.4.3.11 The bending moment coefficient for RCAC-60-F 229
5.4.3.12 The bending moment coefficient for RCAC-80-F 231
5.4.3.13 The bending moment coefficient for RCAC-100-F 232

5.5 EFFECT OF EDGE CONDITION 233
5.5.1 General 233
5.5.2 First Crack And Ultimate Loads 234
5.5.3 Load-Deflection Response 237
5.5.4 Bending Moment Coefficients 241

5.6 SUMMARY 242

CHAPTER–6: CONCLUSIONS AND RECOMMENDATIONS
6.1 GENERAL 244
6.2 CONCLUSIONS 245
6.3 SUGGESTIONS FOR FUTURE WORK 254

BIBLIOGRAPHY 255
APPENDIX-I 274
APPENDIX-II 276
APPENDIX-III 278
APPENDIX-IV 281
APPENDIX-V 284
APPENDIX-VI 286
APPENDIX-VII 291
APPENDIX-VIII 292
PUBLISHED PAPER 297