# CONTENTS

DECLARATION i
ACKNOWLEDGEMENT ii
ABSTRACT iii
CONTENT vi
LIST OF TABLES xii
LIST OF FIGURES xv
LIST OF SYMBOLS & ABBREVIATION xxvi

## CHAPTER 1 INTRODUCTION 1-11

1.1 GENERAL 1
1.2 TYPES OF FERROCHROME WASTES USED IN THIS STUDY 3
1.3 FERRO ALLOY INDUSTRIES IN ODISHA 3
1.4 PROPERTIES OF FERROCHROME SLAG 4
  1.4.1 Physical properties 4
  1.4.2 Mechanical properties 4
  1.4.3 Chemical properties 5
1.5 PROPERTIES OF FERROCHROME ASH 5
  1.5.1 Chemical properties 5
  1.5.2 Possibility of ferrochrome ash as pozzolanic material 6
1.6 RISK EVALUATION 7
1.7 MANAGEMENT OPTION 8
1.9 SIGNIFICANCE OF RESEARCH 8
1.10 GAP IN RESEARCH AREA 9
1.11 SOCIO – ECONOMIC BENEFIT OF THE RESEARCH 9
1.12 OBJECTIVE OF THE RESEARCH 10
1.13 CONCEPT OF THE STUDY 10
1.14 ORGANIZATION OF THESIS 11

## CHAPTER 2 LITERATURE REVIEW 12-24

2.1 GENERAL 12
2.2  LIME  

2.3  INDUSTRIAL WASTE  

2.4  FERROCHROME SLAG  

2.5  SUMMARY  

CHAPTER 3  EXPERIMENTAL PROGRAMME  
3.1  GENERAL  

3.2  MATERIALS USED  
3.2.1  Cement  
3.2.2  Fine aggregate  
3.2.3  Coarse aggregates  
3.2.4  Water  
3.2.5  Super plasticizer  
3.2.6  XRD studies of lime and ferrochrome ash  
3.2.7  Ferrochrome slag  

3.3  MIX PROPORTION  
3.3.1  Mix composition  

3.4  SAMPLE PREPARATION  

3.5  TESTING PROCEDURE  
3.5.1  Properties of cement and fresh concrete  
3.5.2  Mechanical properties  
3.5.3  Durability properties  
3.5.4  Non-destructive testing  
3.5.5  Flexural behaviour of concrete beams  

3.6  PROPERTIES OF CEMENT AND FRESH CONCRETE  
3.6.1  Consistency  
3.6.2  Setting time  
3.6.3  Soundness  
3.6.4  Workability
3.6.5 Fresh concrete density 43

3.7 MECHANICAL PROPERTIES 44
3.7.1 Compressive strength 45
3.7.2 Flexural strength 45
3.7.3 Splitting tensile strength 47
3.7.4 Modulus of elasticity 48
3.7.5 Bond strength 49

3.8 DURABILITY PROPERTIES 51
3.8.1 Permeability 51
3.8.2 Abrasion resistance 53
3.8.3 Acid resistance 54
3.8.4 Sulphate resistance 56
3.8.5 Sorptivity 57

3.9 NON-DESTRUCTIVE TESTS 58
3.9.1 Ultra sonic pulse velocity test 59
3.9.2 Rebound hammer test 60

3.10 FLEXURAL BEHAVIOUR OF CONCRETE BEAMS 61
3.11 SUMMARY 62

CHAPTER 4 RESULTS & DISCUSSION 63-260

4.1 GENERAL 63

4.2 PROPERTIES OF CEMENT AND FRESH CONCRETE 63
4.2.1 Effect of lime on consistency of PSC & PPC 64
4.2.2 Effect of lime on setting time of PSC & PPC 64
4.2.3 Effect of lime on soundness of PSC & PPC 65
4.2.4 Effect of lime on workability of PSC & PPC 66
4.2.5 Effect of lime and ferrochrome ash on consistency of OPC 66
4.2.6 Effect of lime on setting time of OPC blended with ferrochrome ash 67
4.2.7 Effect of lime on soundness of OPC blended with ferrochrome ash

4.2.8 Effect of lime on workability of OPC blended with ferrochrome ash

4.2.9 Effect of lime on workability of concrete with PSC, PPC & OPC using ferrochrome slag as coarse aggregates

4.2.10 Effect of lime on workability of concrete with OPC blended with ferrochrome ash using ferrochrome slag as coarse aggregates

4.2.11 Effect of lime and ferrochrome ash on density of fresh concrete containing natural coarse aggregate

4.2.12 Effect of lime and ferrochrome ash on density of fresh concrete containing slag coarse aggregate

4.2.13 Effect of lime on density of fresh concrete made of OPC, blended with ferrochrome ash, containing natural & slag coarse aggregate

4.3 MECHANICAL PROPERTIES

4.3.1 Compressive strength

4.3.2 Flexural strength

4.3.3 Splitting tensile strength

4.3.4 Bond strength

4.3.5 Modulus of elasticity

4.4 DURABILITY PROPERTIES

4.4.1 Permeability

4.4.2 Abrasion resistance

4.4.3 Acid resistance

4.4.4 Sulphate resistance

4.4.5 Sorptivity

4.5 NON-DESTRUCTIVE TESTING

4.5.1 Ultrasonic Pulse Velocity (USPV)

4.5.2 Rebound Hammer Test
4.6 FLEXURAL BEHAVIOUR OF CONCRETE BEAMS 186
4.6.1. Performance of lime and ferrochrome ash on flexural behaviour of structural member like concrete beams 186
4.6.2. Performance of lime, ferrochrome ash and ferrochrome slag on Flexural behaviour of structural member like concrete beams 191

4.7 STATISTICAL ANALYSIS OF RESULTS 197
4.7.1 Statistical analysis of concrete containing lime and ferrochrome ash containing natural aggregate 197
4.7.2 Statistical analysis of concrete containing lime, ferrochrome ash and ferrochrome slag coarse aggregate 226
4.7.3 STANDARD DEVIATION 256

4.8 SUMMARY 260

CHAPTER 5 CONCLUSIONS 260-279
5.1 GENERAL 261
5.2 PROPERTIES OF CEMENT AND FRESH CONCRETE 261
5.2.1 Consistency 261
5.2.2 Setting time 261
5.2.3 Soundness 262
5.2.4 Workability 262
5.2.5 Density 262
5.3 MECHANICAL PROPERTIES 263
5.3.1 Compressive strength 263
5.3.2 Flexural strength 264
5.3.3 Splitting tensile strength 265
5.3.4 Bond strength 266
5.3.5 Modulus of elasticity 267
5.4 DURABILITY PROPERTIES 286
5.4.1 Water Permeability 268
5.4.2 Abrasion Resistance 269
5.4.3 Acid Resistance 270
5.4.4 Sulphate Resistance 271
5.4.5 Sopitivity 273
5.5 NON-DESTRUCTIVE TESTING

5.5.1 Ultrasonic pulse velocity (USPV) 273
5.5.2 Rebound hammer 274

5.6 FLEXURAL BEHAVIOUR OF R.C.C. BEAMS

5.6.1 Beams with concrete containing lime & ferrochrome ash & natural coarse aggregate 275
5.6.2 Beams with concrete containing lime, ferrochrome ash & ferrochrome slag coarse aggregate 275

5.7 STATISTICAL ANALYSIS

5.7.1 Regression analysis 277
5.7.2 Standard deviation 278

5.8 ECONOMIC ANALYSIS 278

5.9 FUTURE STUDY 301

5.10 SUMMARY 278

REFERENCES 280-288