Contents

Preface xi

1 Block designs 1
  1.1 Introduction 1
  1.2 Balanced incomplete block designs 4
  1.3 Intra-block model 7
  1.4 Least squares analysis 10
  1.5 Estimability 14
  1.6 Analysis of variance 15
  1.7 Intra-block analysis of a balanced incomplete block design 19
  1.8 Connectedness 21
  1.9 Orthogonality 25

2 Efficiency factors 27
  2.1 Introduction 27
  2.2 Pairwise efficiency factors 28
  2.3 Canonical efficiency factors 28
  2.4 Optimality criteria 31
  2.5 Simple counting rules for producing near-optimal designs 34
  2.6 Efficiency factors for unequally replicated designs 37
  2.7 Duality 39
  2.8 Upper bounds for the average efficiency factor 41

3 Cyclic designs 47
  3.1 Introduction 47
  3.2 Cyclic designs 48
  3.3 Efficiency factors of cyclic designs 50
  3.4 Construction of efficient designs 52
3.5 n-Cyclic designs 55
3.6 Generalized cyclic designs 59

4 Resolvable block designs 63
4.1 Introduction 63
4.2 Square lattice designs 64
4.3 Rectangular lattice designs 66
4.4 α-Designs 68
4.5 Choice of α-design 71
4.6 Latinized block designs 72
4.7 Two-replicate designs 77
4.8 Paired comparison designs 80
4.9 Unequal block sizes 80
4.10 Upper bounds for the average efficiency factor 81

5 Row–column designs 87
5.1 Introduction 87
5.2 Model and information matrix 88
5.3 Canonical efficiency factors 89
5.4 Orthogonality and connectedness 90
5.5 Upper bounds for the average efficiency factor 92
5.6 Latin square designs 94
5.7 Row-orthogonal designs 95
5.8 Non-orthogonal row–column designs 98
5.9 Nested row–column designs 102

6 Resolvable row–column designs 107
6.1 Introduction 107
6.2 Lattice square designs 108
6.3 Construction using α-designs 112
6.4 Interchange algorithms 114
6.5 Latinized row–column designs 118
6.6 Two-replicate row–column designs 123
6.7 Upper bounds for the average efficiency factor 125

7 Recovery of inter-block information 131
7.1 Introduction 131
7.2 Orthogonal block structure 131
7.3 Error covariance structure 136
7.4 Generalized least squares analysis 138
7.5 Estimation of stratum variances 139
7.6 Block designs 141