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Slope-Rotatable Designs – A Bibliography

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Abstract

This paper represents an attempt to offer a comprehensive bibliography of references on Slope-Rotatable Designs.

Keywords

Response surface designs, Slope-rotatability, Measure of slope-rotatability, Slope-Rotatable designs with equal maximum directional variance.

1. Introduction

Response Surface Methodology is a statistical technique that is very useful in design and analysis of scientific experiments. In many applications of Response Surface Methodology, good estimation of the derivatives of the Response Function may be as important or perhaps more important than estimation of mean response. Certainly, the computation of a stationary point in a second order analysis or the use of Gradient techniques, for example, steepest ascent or Ridge Analysis, depends heavily on the partial derivatives of the Estimated Response Function with respect to the design variables. Since designs that attain certain properties in Y (estimated response) do not enjoy the same properties for the estimated derivatives (slopes), it is important for the user to consider experimental designs that are constructed with the derivatives in mind.

The concept of Rotatability, which is very important in Response Surface Designs, was proposed by Box and Hunter (1957). The study of Rotatable Designs is mainly emphasized on the estimation of differences of yields and its precision. Estimation of differences in responses at two different points in the factor space will often be of great importance.

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If differences in responses at two points close together are of interest then estimation of local slope (rate of change) of the response is required. Estimation of slopes occurs frequently in practical situations. For instance, there are cases in which we want to estimate rate of reaction in chemical experiment, rate of change in the yield of a crop to various fertilizer doses, rate of disintegration of radioactive material in an animal etc. In this context, Slope-Rotatability which is analogue to rotatability was introduced by Hader and Park (1978). This paper reviews the proposed concepts of Slope-Rotatability for Response Surface Designs.

2. Conclusions

In this paper, the design concepts of Slope-Rotatability over axial directions, Slope-Rotatability over all directions, measures of Slope-Rotatability, Slope-Rotatable Design with equal maximum directional variance, modified Slope-Rotatable Designs, Slope-Rotatable Designs with equi-spaced levels, modified Slope-Rotatable Designs with equi-spaced levels, so on are reviewed. These methods are useful in deciding a proper design for Response Surface Polynomial models for the construction of Slope-Rotatable Designs with desired properties or minimum number of design points.

3. Further Research Work

It is often necessary to choose a Response Surface Design in which the number of levels of factors are unequal and in such a case asymmetric Slope-Rotatable Designs are useful.

Another area in which one may be interested is to study Slope-Rotatability with correlated errors. Not much work is available with regard to construction of designs in this area. It may be interesting to study some new methods of constructions of Slope-Rotatability with correlated errors using Central Composite Designs, Balanced Incomplete Block Designs, Pairwise Balanced Designs and Symmetrical Unequal Block arrangements with two unequal block sizes etc.

There is scope for further research to evolve new methods of constructions of Slope-Rotatable Designs which will lead to designs with lesser number of design points for different factors compared as per the existing methods.

There is also scope for further work on measure of Slope-Rotatability and to study it in detail with reference to different designs/different methods of constructions.

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4. Bibliography

1. Al-Shiha, A. and Huda, S. (2001). On E-optimal Designs for estimating slopes. *Journal of Applied Statistical Sciences*, **10**, 357-364.
2. Al-Shiha, A. and Huda, S. (2003). Fitted Minimax Designs for estimating the slope of a third-order Polynomial model in a hypercubic region. *Pakistan Journal of Statistics,* **19 (1)**, 53-72.
3. Anjeneyulu, G.V.S.R., Dattatreyarao, A.V. and Narasimham, V.L. (1993). Embedding in second order Slope-Rotatable Designs. *Reports of Statistical Application Research, Union of Japanese Scientists and Engineers*. **40**, 1-11.
4. Anjeneyulu, G.V.S.R., Dattatreyarao, A.V. and Narasimham, V.L. (1994 and 95). Construction of third order Slope-Rotatable Designs through Doubly Balanced Incomplete Block Designs. *Gujarat Statistical Review,* **21** and **22**, 49-54.
5. Anjeneyulu, G.V.S.R., Dattatreyarao, A.V. and Narasimham, V.L. (1998). Group divisible second order Slope-Rotatable Designs. *Gujarat Statistical Review,* **25**, 3-8.
6. Anjeneyulu, G.V.S.R., Dattatreyarao, A.V. and Narasimham, V.L. (2000-01). Third order Slope-Rotatable Designs. *Journal of Indian Society for Probability and Statistics,* **5**, 65-74.
7. Anjeneyulu, G.V.S.R., Lakshmi, K.S.S. and Narasimham, V.L. (2006). Embedded type third order Slope-Rotatable Designs over all directions. *Statistical Methods,* **8**, 83-89.
8. Anjeneyulu, G.V.S.R., Naghabhushanam, P. and Narasimham, V.L. (2002). Construction of variance-sum group-divisible second order Slope-Rotatable Designs. *Statistical Methods*, **4**, 122-131.

9. Anjeneyulu, G.V.S.R., Nagabhushanam, P. and Narasimham, V.L. (2004). On third order Slope-Rotatable Designs over all directions. *Journal of Indian Society for Probability and Statistics,* **8**, 92-101.
10. Anjeneyulu, G.V.S.R., Nagabhushanam, P. and Narasimham, V.L. (2010). *On second and third order slope-rotatable designs*. V.D.M Verlag Dr. Muller e.K.
11. Anjeneyulu, G.V.S.R. and Narasimham, V.L. (2011). *On variance-sum second and third order Slope-Rotatable Designs*. V.D.M Verlag Dr. Muller e.K.
12. Anjeneyulu, G.V.S.R., Rao, P.V. and Narasimham, V.L. (2008). Quality improvement through second-order Slope-Rotatable Designs over all directions. *International Journal of Agricultural and Statistical Sciences*, **4**, 47-51.
13. Anjeneyulu, G.V.S.R., Varma, D.N. and Narasimham, V.L. (1997). A note on second order Slope-Rotatable Designs over all directions. *Communications in Statistics - Theory and Methods,* **26**, 1477-1479.
14. Atkinson, A.C. (1970). The design of experiments to estimate the slope of a Response Surface. *Biometrika*, **57**, 319-328.
15. Box, G.E.P. and Draper, N.R. (1987). *Empirical model building and Response Surfaces*. Wiley, New York, U.S.A.
16. Box, G.E.P. and Hunter, J.S. (1957). Multifactor experimental designs for exploring Response Surfaces. *Annals of Mathematical Statistics*, **28**, 195-241.
17. Das, R.N. (2003). Slope-Rotatability with correlated errors. *Calcutta Statistical Association Bulletin*, **54**, 57-70.
18. Das, R.N. (2009). Response Surface Methodology in improving mean lifetime. *Probstat Forum*, **2**, 08-21.
19. Das, M.N. and Narasimham, V.L. (1962), Construction of Rotatable Designs through Balanced Incomplete Block Designs. *Annals of Mathematical Statistics*, **33**, 1421-1439.
20. Das, R.N. and Park, S.H. (2006). Slope-Rotatability over all directions with correlated errors. *Applied Stochastic Models in Business and Industry,* **22**, 445-457.
21. Das, R.N. and Park, S.H. (2009). A measure of Robust Slope-Rotatability for second-order Response Surface experimental designs. *Journal of Applied Statistics*, **36**, 755-767.
22. Das, R.N., Park, S.H. and Aggarwal, M. (2010a). On D-optimal robust second order Slope-Rotatable Designs. *Journal of Statistical Planning and Inference,* **140**, 1269-1279.

23. Das, R.N., Park, S.H. and Aggarwal, M. (2010b). Robust second order Slope-Rotatable Designs with maximum directional variance. *Communications in Statistics – Theory and Methods,* **39(5)**, 803-814.
24. Draper, N. R. and Ying, L.H. (1994). A note on Slope-Rotatability over all directions. *Journal of Statistical Planning and Inference,* **41**, 113-119.
25. Hader, R.J. and Park, S.H. (1978). Slope-Rotatable Central Composite Designs. *Technometrics,* **20**, 413-417.
26. Huda, S. (1985). Variance of the difference between two estimated Responses. *Journal of Statistical Planning and Inference,* **11**, 89-93.
27. Huda, S. (1986). On minimizing the average variance of the estimated slope of Response Surface. *Pakistan Journal of Statistics*, **2**, 31-37.
28. Huda, S. (1987). Minimax Central Composite Designs to estimate the slope of a second order Response Surface. *Journal of the Indian Society of Agricultural Statistics,* **39**, 154-160.
29. Huda, S. (1990). Further results on Minimax Designs to estimate the slope of a Response Surface. *Biometrical Journal*, **32**, 189-194.
30. Huda, S. (1991). On performance of Minimax second order Slope-Estimating Designs under variations of the model. *Journal of the Indian Society of Agricultural Statistics,* **43**, 163-171.
31. Huda, S. (1998). On optimal designs to estimate the slope of a second-order Response Surface over cubic regions. *Parisankhyan Samikkha*, **5**, 11-19.
32. Huda, S. (1999). On optimal designs to estimate the slope of a second-order Response Surface over spherical regions. *Journal of Applied Statistical Sciences*, **8**, 217-225.
33. Huda, S. (2006). *Designs of experiments for estimating differences between Responses and slopes of the Response in Response Surface Methodology and Related Topics*. A.I Khuri, ed., World Publishing, New Jersey, 427-446.
34. Huda, S. and Ali, H. (1990). On efficiency of Rotatable Designs in estimating the slope of a second-order Response Surface. *Pakistan Journal of Statistics*-A, **6**, 125-132.
35. Huda, S. and Alqallaf, F. (2009). On D-minimax Optimal Second Order Designs for estimating slopes of second order Response Surfaces. *Journal of Quality Technology and Quality Management,* **6(4)**, 423-431.
36. Huda, S. and Al-Shiha, A.A. (1998). Minimax Designs for estimating the slope of a third-order Response Surface in a hypercubic region. *Communications in Statistics – Simulation and Computation.* **27(2)**, 345-356.
37. Huda, S. and Al-Shiha, A.A. (1999). On D-optimal Designs for estimating slope. *Sankhya*, B, **61**, 488-495.

38. Huda, S. and Al-Shiha, A.A. (2000). On D-and E-minimax Optimal Designs for estimating the axial slopes of a second order Response Surface over hypercubic regions. *Communications in Statistics - Theory and Methods*, **29**, 1827-1849.
39. Huda, S. and Al-Shiha, A. A. (2001). On D-minimax efficiency of second-order Rotatable Designs for estimating the slopes. *Journal of Statistical Studies*, **21**, 1-12.
40. Huda, S. and Al-Shingiti, A.M. (2004). On second-order A-, D- and E-minimax Designs for estimating slopes in extrapolation and restricted interpolation regions. *Communications in Statistics – Simulation and Computation*, **33**, 773-785.
41. Huda, S., Al-Shingiti, A.M. and Arwa, M. (2003). Performance of second-order A-minimax Optimal Designs for estimating slopes under model variation. *Arab Journal of Mathematical Sciences*, **9**, 47-53.
42. Huda, S., Al-Shingiti, A.M. and Arwa, M. (2004). Rotatable Generalized Central Composite Designs: A-minimax efficiencies for estimating slopes. *Pakistan Journal of Statistics*, **20**, 397-407.
43. Huda, S., Arwa, M. and Al-Shiha, A.A. (2004). Rotatable Generalized Central Composite Designs: A-minimax efficiencies for estimating slopes. *Pakistan Journal of Statistics*, **20**, 397-407.
44. Huda, S. and Chowdhury, R.I. (2004). A note on Slope-Rotatability of Designs. *International Journal of Statistical Sciences*, **3 (special issues)**, 251-257.
45. Huda, S. and Shafiq, M. (1992). Minimax designs for estimating the slope of a second order Response Surface in a cubic region. *Journal of Applied Statistics*, **19**, 501-507.
46. Jang, D.H. (2002). A graphical method for evaluating Slope-Rotatability in axial directions for second order Response Surface Designs. *Computational Statistics and Data Analysis*, **39**, 343-349.
47. Jang, D.H. (2005). Slope-Rotatability in axial directions for second order Response Surface Designs. *The Korean Communications in Statistics*, **12**, 253-264.
48. Jang, D.H. and Park, S.H. (1992). A measure of Slope-Rotatability for second order Response Surface Experimental Design. *Journal of Applied Statistics*, **19**, 391-404.
49. Jang, D.H. and Park, S.H. (1993). A measure and graphical method for evaluating Slope-Rotatability in Response Surface Designs. *Communications in Statistics - Theory and Methods*, **22**, 1849-1863.

50. Kang, H.S., Kang, K.H. and Park, S.H. (2006), Minimax Designs for the stability of slope estimation second-order Response Surfaces. *Journal of Applied Statistics*, **33**, 975-988.
51. Khuri, A.I. and Cornell, J.A. (1996). *RESPONSE SURFACES: Designs and Analyses*. Marcel Dekker, Inc., New York, U.S.A.
52. Kim, H.J. (1993). A measure of Slope-Rotatability over all directions. *Korean Journal of Applied Statistics,* **6**, 105-123.
53. Kim, H.J. and Park, S.H. (2006). Slope-rotatability of Icosahedron and Dodecahedron Designs. *Journal of the Korean Statistical Society,* **35**, 25-36.
54. Kim, H.J., Park, S.H. and Kim, T.S. (2004). Derivation of a simplified measure of Slope-Rotatability for a particular class of Response Surface Designs (in Korean). *The Korean Communications in Statistics*, **11**, 563-574.
55. Kim, H.J., Um, Y.H. and Khuri, A.I. (1996). Quantile plots of the average slope variance for Response Surface Designs. *Communications in Statistics – Simulation and Computation,* **25**, 995-1014.
56. Mukerjee, R. and Huda, S. (1985). Minimax second – and third order designs to estimate the slope of a Response Surface. *Biometrica,* **72**, 173-178.
57. Murthy, M.S.R. and Krishna, T.P. (1998). On a new type of Slope-Rotatable Central Composite Design. *Journal of the Indian Society of Agricultural Statistics,* **51**, 12-16.
58. Murthy, V.N. and Studden, W.J. (1972). Optimal designs for estimating the slope of a Polynomial Regression. *Journal of the American Statistical Association*, **67**, 869-873.
59. Myers, R.H. (1976). *Response Surface Methodology*. Blacksburg, VA, Author distributed by Edwards Brothers, Ann Arbor, MI.
60. Myers, R.H., Khuri, A.I. and Carter, Jr. W.H. (1989). Response Surface methodology: 1966-1988. *Technometrics*, **31**, 137-157.
61. Myers, R.H. and Lahoda, S.J. (1975). A generalization of the Response Surface Mean Square Error criterion with a specific application to the slope. *Technometrics*, **17**, 481-486.
62. Myers, R.H. and Montegomery, D.C. (1997). *RESPONSE SURFACE METHODOLOGY: Process and Product Optimization using designed experiments.* 2nd Edition, John Wiley, New York, U.S.A.
63. Myers, R.H., Montgomery, D.C., Vining, G.G., Borror, C.M. and Kowalski, S.M. (2004). Response Surface methodology: A retrospective and literature survey. *Journal of Quality Technology,* **36**, 53-77.
64. Ott, L. and Mendenhall, W. (1972). Designs for estimating the slope of a second order Linear Model. *Technometrics,* **14**, 341-353.

65. Park, S.H. (1987). A class of Multi-factor Designs for estimating the slope of Response Surface. *Technometrics*, **29**, 449-453.
66. Park, S.H. (2006). *Concepts of Slope-Rotatability for second order Response Surface Designs in Response Surface Methodology and Related Topics*. A.I Khuri, ed., World Publishing, New Jersey, 409-426.
67. Park, S.H., Jun, H.L. and Yasuma Baba (1993). A measure of Rotatability for second order Response Surface Designs. *Annals of the Institute of Statistical Mathematics*, **45**, 655-664.
68. Park, S.H., Jung, S.H. and Das, R.N. (2009). Slope-Rotatability of second order Response Surface Regression Models with correlated error. *Journal of Quality Technology and Quality Management*, **6(4)**, 471-492.
69. Park, S.H., Kang, H.S. and Kang, K.H. (2003). Measures for stability of slope estimation of the second order Response Surface and equally-stable Slope-Rotatability. *Journal of the Korean Statistical Society*, **32**, 337-357.
70. Park, S.K. and Kim, H.J. (1992). A measure of Slope-Rotatability for second order Response Surface Experimental Designs. *Journal of Applied Statistics*, **19**, 391-404.
71. Park, S.H. and Kim, J.I. (1982). Axis-Slope-Rotatable Designs for experiments with mixtures. *Journal of the Korean Statistical Society*, **11**, 36-44.
72. Park, S.H. and Kim, J.I. (1988). Slope-Rotatable Designs for estimating the slope of Response Surfaces in experiments with mixtures. *Journal of the Korean Statistical Society*, **17**, 121-133.
73. Park, S.H. and Kwon, H.T. (1998). Slope-Rotatable Designs with equal maximum directional variance for second order Response Surface Models. *Communications in Statistics -Theory and Methods*, **27**, 2837-2851.
74. Park, S.H. and Lee, M. S. (1995). Slope-Rotatability over all direction in third order Response Surface Models. *Journal of the Korean Statistical Society*, **24**, 519-538.
75. Park, S.H., Park, B.G. and Park, H.J. (2007). Slope-Rotatable Designs for second order Response Surface Models with block effects. *Journal of the Korean Statistical Society*, **36**, 157-173.
76. Parsad, R., Srivastava, R. and Batra, P.K. (2004). *Designs for Fitting Response Surfaces in Agricultural Experiments*. Indian Agricultural Statistics Research Institute Publication, New Delhi, India.
77. Raghavarao, D. (1971). *Constructions and Combinatorial Problems in Design of Experiments*. John Wiley, New York, U.S.A.

78. Victorbabu, B. Re. (2000). Second order Slope-Rotatable Designs over all directions using Balanced Incomplete Block Designs with unequal block sizes. *Statistical Methods,* **2**, 136-140.
79. Victorbabu, B. Re. (2002a). A note on the construction of four and six level second order Slope-Rotatable Designs. *Statistical Methods*, **4**, 11-20.
80. Victorbabu, B. Re. (2002b). Construction of second order Slope-Rotatable Designs using symmetrical unequal block arrangements with two unequal block sizes. *Journal of the Korean Statistical Society,* **31**, 153-161.
81. Victorbabu, B. Re. (2002c). Augmented second order Rotatable Designs as second order Slope-Rotatable Designs using BIBD. *Proceedings of Andhra Pradesh Akademi of Sciences,* **6**, 61-62.
82. Victorbabu, B. Re. (2002d). Second order Slope-Rotatable Designs with equi-spaced levels. *Proceedings of Andhra Pradesh Akademi of Sciences*, **6**, 211-214.
83. Victorbabu, B. Re. (2003a). On second order Slope-Rotatable Designs using Incomplete Block Designs. *Journal of the Kerala Statistical Association,* **14**, 19-25.
84. Victorbabu, B. Re. (2003b). On the efficiency of second order Response Surface Designs for estimation of responses and slopes. *Proceedings of Andhra Pradesh Akademi of Sciences,* **7**, 49-54.
85. Victorbabu, B. Re. (2005a). Modified Slope-Rotatable Central Composite Designs. *Journal of the Korean Statistical Society,* **34**, 153-160.
86. Victorbabu, B. Re. (2005b). Modified second order Slope-Rotatable Designs using Pairwise Balanced Designs. *Proceedings of Andhra Pradesh Akademi of Sciences*, **9(1)**, 19-23.
87. Victorbabu, B. Re. (2006a). Modified second order Slope-Rotatable Designs using BIBD. *Journal of the Korean Statistical Society,* **35(2)**, 179-192.
88. Victorbabu, B. Re. (2006b). Construction of modified second order Rotatable Designs and second order Slope-Rotatable Designs using a pair of Balanced Incomplete Block Designs. *Sri Lankan Journal of Applied Statistics,* **7**, 39-53.
89. Victorbabu, B. Re. (2006c). Modified second order Slope-Rotatable Designs using symmetrical unequal block arrangements with two unequal block sizes. *Mapana, Journal of Sciences,* **5**, 21-29.
90. Victorbabu, B. Re. (2006d). Modified second order Slope-Rotatable Designs using a pair of Balanced Incomplete Block Designs. *Journal of the Kerala Statistical Association,* **17**, 1-9.
91. Victorbabu, B. Re. (2007a). On second order Slope-Rotatable Designs –A Review. *Journal of the Korean Statistical Society,* **33(3)**, 373-386.

92. Victorbabu, B. Re. (2007b). A note on variance–sum group divisible second order Slope-Rotatable Designs using BIBD. *Acta Ciencia Indica*, **43**, 1-3.
93. Victorbabu, B. Re. (2008a). On modified second order Slope-Rotatable Designs using Incomplete Block Designs with unequal block sizes. *Advances and Applications in Statistics*, **8(1)**, 131-151.
94. Victorbabu, B. Re. (2008b). A note on Slope-Rotatable Central Composite Designs. *Ultra Scientist of Physical Sciences*, **20(1)** M, 81-86.
95. Victorbabu, B. Re. (2008c). Modified second order Slope-Rotatable Designs with equi-spaced levels using Pairwise Balanced Designs. *Ultra Scientist of Physical Sciences*, **20(2),** M, 257-262.
96. Victorbabu, B. Re. (2008d). A note on second order Slope-Rotatable Designs using Pairwise Balanced Designs. *Acta Ciencia Indica*, **34(4)**, M, 1567-1572.
97. Victorbabu, B. Re. (2008e). A new method of construction of Slope-Rotatable Central Composite Designs. *Proceedings of Andhra Pradesh Akademi of Sciences*, **12**, 296-300.
98. Victorbabu, B. Re. (2008f). On second order Slope-Rotatable Designs using Balanced Incomplete Block Designs. *International Journal of Agricultural and Statistical Sciences*, **4(1)**, 87-90.
99. Victorbabu, B. Re. (2008g). A note on second order Slope-Rotatable Designs using Balanced Incomplete Block Designs. *International Journal of Agricultural and Statistical Science*, **4(1)**, 213-218.
100. Victorbabu, B. Re. (2008h). Construction of second order Slope-Rotatable Designs using a pair of dissimilar Incomplete Block Designs. *Ultra Scientist of Physical Sciences*, **20(2)**, M, 385-390.
101. Victorbabu, B. Re. (2008i). A note on the construction of six level second order Slope-Rotatable Designs using symmetrical unequal block arrangements with two unequal block sizes. *Ultra Scientist of Physical Sciences*, **20(2)**, M, 493-496.
102. Victorbabu, B. Re. (2008j). A new method of construction of second order Slope-Rotatable Designs using Balanced Incomplete Block Designs. *International Journal of Agricultural and Statistical Sciences*, **4(2)**, 279-282.
103. Victorbabu, B. Re. (2008k). Modified second order Slope-Rotatable Designs using a pair of dissimilar Incomplete Block Designs. *International Journal of Agricultural and Statistical Sciences*, **4(2)**, 339-344.
104. Victorbabu, B. Re. (2008l). Second order Slope-Rotatable Designs with equi-spaced levels using symmetrical unequal block arrangements with two unequal block sizes. *ProbStat Forum*, **1 July**, 21-25.

105. Victorbabu, B. Re. (2008m). On second order Slope-Rotatable Designs using Pairwise Balanced Designs. *Journal of Andhra Pradesh Mathematical Sciences,* **12(2)**, 56-61.
106. Victorbabu, B. Re. (2008n). Second order Slope-Rotatable Designs with equi-spaced levels using Pairwise Balanced Designs. *Proceedings of Andhra Pradesh Akademi of Sciences,* **12(4)**, 399-402.
107. Victorbabu, B. Re. (2008o). Modified second order Slope-Rotatable Designs with equi-spaced levels using symmetrical unequal block arrangements with two unequal block sizes. *Journal of the Kerala Statistical Association,* **19**, 31-39.
108. Victorbabu, B. Re. (2009a). Modified second order Slope-Rotatable Designs with equi-spaced levels. *Journal of the Korean Statistical Society,* **39**, 59-63.
109. Victorbabu, B. Re. (2009b). On modified second-order Slope-Rotatable Designs. *ProbStat Forum,* **2 October**, 115-131.
110. Victorbabu, B. Re. (2009c). On modified second order Response Surface Designs, Rotatable Designs, Rotatable Designs with equi-spaced doses. *International Journal of Agricultural and Statistical Sciences,* **5(2)**, 425-435.
111. Victorbabu, B. Re. (2009d). Construction of modified second order Rotatable Designs using a pair of symmetrical unequal block arrangements with two unequal block sizes. *Acharya Nagarjuna University - Journal of Physical Sciences*, **1**, 73-80.
112. Victorbabu, B. Re. (2011a). A new method of construction of second order Slope-Rotatable Designs using Incomplete Block Designs with unequal block sizes. *ProbStat Forum*, **4**, 44-53.
113. Victorbabu, B. Re. (2011b). On modified second-order Slope-Rotatable Designs with equi-spaced levels. *JP Journal of Fundamental and Applied Statistics,* **1(1)**, 15-27.
114. Victorbabu, B. Re., Ashok, D. and Narasimham, V.L. (2009). Construction of second order Slope-Rotatable Designs. *ProbStat Forum,* **2 Jan.**, 1-7.
115. Victorbabu, B. Re. and Narasimham, V.L. (1990). Construction of second order Slope-Rotatable through Incomplete Block Designs with unequal block sizes. *Pakistan Journal of Statistics*, **6**, B, 65-73.
116. Victorbabu, B. Re. and Narasimham, V.L. (1991a). Construction of second order Slope-Rotatable Designs through Balanced Incomplete Block Designs. *Communications in Statistics -Theory and Methods*, **20**, 2467-2478.
117. Victorbabu, B. Re. and Narasimham, V.L. (1991b). Construction of second order Slope-Rotatable Designs through a pair of Balanced Incomplete Block Designs. *Journal of the Indian Society of Agricultural Statistics,* **43**, 291-295.

118. Victorbabu, B. Re. and Narasimham, V.L. (1993a). Construction of second order Slope-Rotatable Designs using Pairwise Balanced Designs. *Journal of the Indian Society of Agricultural Statistics,* **45**, 200-205.
119. Victorbabu, B. Re. and Narasimham, V.L. (1993b). Classification and parameter bounds of second order Slope-Rotatable Designs. *Reports of Statistical Application Research, Union of Japanese Scientists and Engineers,* **40**, 12-19.
120. Victorbabu, B. Re. and Narasimham, V.L. (1993c). Construction of three level second order Slope-Rotatable Designs using Balanced Incomplete Block Designs. *Pakistan Journal of Statistics*, **9**, B, 91-95.
121. Victorbabu, B. Re. and Narasimham, V.L. (1994). A new type of Slope-Rotatable Central Composite Design. *Journal of the Indian Society of Agricultural Statistics,* **46**, 315-317.
122. Victorbabu, B. Re. and Narasimham, V.L. (1994 and 95). Augmented second order Rotatable Design as second order Slope-Rotatable Design. *Gujarat Statistical Review,* **21 and 22**, 31-36.
123. Victorbabu, B. Re. and Narasimham, V.L. (1995). A new method of construction of second order Slope-Rotatable Designs using a pair of Incomplete Block Designs. *Journal of the Indian Society of Agricultural Statistics,* **47**, 273-277.
124. Victorbabu, B. Re. and Narasimham, V.L. (1996). Construction of second order Slope-Rotatable Designs using Partially Balanced Incomplete Block type designs. *Journal of the Indian Society of Agricultural Statistics,* **48**, 159-164.
125. Victorbabu, B. Re. and Narasimham, V.L. (1996and97). Construction of three level second order Slope-Rotatable Designs using Incomplete Block Designs with unequal block sizes. *Gujarat Statistical Review,* **23 and 24**, 29-36.
126. Victorbabu, B. Re. and Narasimham, V.L. (1997). Second order Slope-Rotatable Designs over all directions using Partially Balanced Incomplete Block type designs. *Gujarat Statistical Review,* **24**, 27-30.
127. Victorbabu, B. Re. and Narasimham, V.L. (2000-01). A new method of construction of second order Slope-Rotatable Designs. *Journal of Indian Society for Probability and Statistics,* **5**, 75-79.
128. Victorbabu, B. Re. and Narayanarao, E.S.V. (2007). Construction of second order Slope-Rotatable Designs using a pair of symmetrical unequal block arrangements with two unequal block sizes. *International Journal of Agricultural and Statistical Science,* **3(2)**, 289-293.

129. Victorbabu, B. Re., Narayanarao, E.S.V. and Narasimham, V.L. (1994). Construction of second order Slope-Rotatable Designs with equi-spaced levels using Incomplete Block Designs with unequal block sizes. *Proceedings of the XV Indian Society for Probability and Statistics Conference*, **21-23 December**, M.S. University, Tirunelveli-627008, 116-119.
130. Victorbabu, B. Re. Narayanarao, E.S.V. and Narasimham, V.L. (1996 and 1997). Construction of second order Slope-Rotatable Designs over all directions using Incomplete Block Designs. *Gujarat Statistical Review*, **23 and 24**, 45-49.
131. Victorbabu, B. Re. and Sateesh, Ch. (2009). A new method of construction of second order Slope-Rotatable Designs using symmetrical unequal block arrangements with two unequal block sizes. *International Journal of Agricultural and Statistical Sciences,* **5(2)**, 327-330.
132. Victorbabu, B. Re. and Seshubabu, P. (2005). Construction of four level second order Slope-Rotatable Designs using symmetrical unequal block arrangements with two unequal block sizes. *Statistical Methods,* **7**, 149-156.
133. Victorbabu, B. Re. and Surekha, Ch. V.V.S. (2010). A new method of construction of second-order Slope-Rotatable Designs using Pairwise Balanced Designs. *International Journal of Agriculture and Statistical Sciences,* **6**, 1-9.
134. Victorbabu, B. Re. and Surekha, Ch. V.V.S. (2011a). A new method of construction of second-order Slope-Rotatable Designs using Balanced Incomplete Block Designs. *Pakistan Journal of Statistics,* **27**, 221-230.
135. Victorbabu, B. Re. and Surekha, Ch. V.V.S. (2011b). Construction of measure of second-order Slope-Rotatable Designs using Central Composite Designs. *International Journal of Agriculture and Statistical Sciences,* **7(2)**, 351-360.
136. Victorbabu, B. Re. and Surekha, Ch. V.V.S. (2012). Construction of measure of second-order Slope-Rotatable Designs using Pairwise Balanced Designs. *International Journal of Statistics and Systems,* **2(2)**, 97-106.
137. Victorbabu, B. Re. and Vasundharadevi, V. (2003). On the efficiency of second order Response Surface Designs for estimation of responses and slopes. *Proceedings of Andhra Pradesh Akademi of Sciences,* **7**, 49-54.
138. Victorbabu, B. Re. and Vasundharadevi, V. (2004a). On the efficiency of second order Response Surface Designs for estimation of responses and slopes using Balanced Incomplete Block Designs. *Statistical Methods,* **6**, 210-224.
139. Victorbabu, B. Re. and Vasundharadevi, V. (2004b). Performance of second order Response Surface Designs for estimation of responses and slopes using

Pairwise Balanced Designs. *Proceedings of Andhra Pradesh Akademi of Sciences*, **8**, 223-230.

140. Victorbabu, B. Re. and Vasundharadevi, V. (2009). On the efficiencies of second order Response Surface Designs for estimation of responses and slopes using symmetrical unequal block arrangements with two unequal block sizes. *Journal of the Japan Statistical Society*, **39(1)**, 1-14.
141. Ying, L.H., Pukersheim, F. and Draper, N.R. (1995a). Slope rotatability over all directions designs. *Journal of Applied Statistics*, **22**, 331-341.
142. Ying, L.H., Pukersheim, F. and Draper, N.R. (1995b). Slope rotatability over all directions designs for $k \geq 4$. *Journal of Applied Statistics*, **22**, 343-354.