
CONTENTS

PART I Ergonomics, Design and Anthropometry

Chapter 1	Introduction to Ergonomic Design	3
1.1	Introduction	3
1.2	What Is Ergonomics?	4
1.2.1	What Criteria Define a Successful Match?	5
1.2.2	What If These Criteria Prove Incompatible?	6
1.3	Anthropometrics	7
1.4	Human Proportion: An Historical Perspective	7
1.5	Ergonomics and Design	9
1.6	The User-Centred Approach	13
Chapter 2	Principles and Practice of Anthropometrics	17
2.1	Introduction	17
2.2	The Statistical Description of Human Variability	18
2.2.1	Frequency Distribution of a Dimension Within a Population	18
2.2.2	Calculating Percentile Values for a Body Dimension	20
2.2.3	Effects of Deviation from a Normal Distribution	21
2.3	Design Limits: Accommodation Provided by a Design Decision	22
2.4	Design Constraints and Criteria	25
2.4.1	Clearance	26
2.4.2	Reach	26
2.4.3	Posture	26
2.4.4	Strength	27
2.5	Defining Design Requirements to Satisfy the Four Cardinal Constraints	27
2.6	Methods for Analysis of Design Problems	28
2.6.1	Fitting Trials	28
2.6.2	Analytical Application of the Method of Limits	32
2.6.3	Body Link Diagram	35
2.6.4	Workspace Simulation and Digital Human Models	37
2.7	Using Anthropometric Data	39
2.7.1	Sources of Anthropometric Data	40
2.7.2	Defining the Target User Population	41
2.7.3	Accuracy of Anthropometric Data	41
2.7.4	Clothing Corrections	42
2.7.5	Standard Anthropometric Postures	43

2.7.6	Body Proportions	44
2.8	Body Dimensions.....	47

Chapter 3 Human Diversity55

3.1	Introduction	55
3.2	Sex Differences	56
3.2.1	Variation in Body Proportions	58
3.2.2	Variation in Strength	59
3.3	Ethnic Differences.....	62
3.4	Growth and Development	66
3.5	The Secular Trend.....	70
3.6	Social Class and Occupation	76
3.7	Ageing	78

PART II Application of Anthropometry in Design

Chapter 4 Workspace Design.....85

4.1	Introduction	85
4.2	Clearance	86
4.2.1	Whole Body Access	87
4.2.2	Circulation Space	90
4.2.3	Safety Clearances	91
4.2.4	Personal Space	92
4.3	Reach: The Workspace Envelope	94
4.3.1	Zones of Convenient Reach.....	96
4.3.2	The Normal Working Area	98
4.4	Joint Ranges of Movement	102
4.5	Posture	104
4.5.1	Postural Loading	104
4.5.2	Guidelines for Work Postures	107
4.5.2.1	Encourage Frequent Changes of Posture	107
4.5.2.2	Avoid Forward Inclination of the Head and Trunk	108
4.5.2.3	Avoid Causing the Upper Limbs to Be Held in a Raised Position	108
4.5.2.4	Avoid Twisted and Asymmetrical Postures.....	109
4.5.2.5	Avoid Postures That Require a Joint to Be Used for Long Periods or Repetitively towards the Limit of Its Range of Motion.....	109
4.5.2.6	Provide Adequate Back Support in All Seats	109
4.5.2.7	Where Muscular Force Must Be Exerted, the Limbs Should Be in Their Position of Greatest Strength.....	110
4.6	Vision and the Posture of the Head and Neck	110

4.7	Working Height.....	113
4.8	Posture and Strength.....	115
4.9	Issues for Barrier-Free Workspace Design.....	117

Chapter 5 Sitting and Seating..... 121

5.1	Fundamentals of Seating.....	121
5.2	The Spine in Standing and Sitting.....	123
5.3	Forward Tilting Seats and 'Sit-Stand' Seats.....	128
5.4	Anthropometric Aspects of Seat Design	131
5.4.1	Seat Height (H)	131
5.4.2	Seat Depth (D)	131
5.4.3	Seat Width	132
5.4.4	Backrest Dimensions.....	132
5.4.5	Backrest Angle or 'Rake' (α)	134
5.4.6	Seat Angle or 'Tilt' (β)	134
5.4.7	Armrests	134
5.4.8	Leg Room.....	135
5.4.9	Seat Surface.....	136
5.4.10	Seats for More than One.....	136
5.5	Evaluating a Seat.....	137
5.6	Dynamic Seating.....	138
5.7	The Easy Chair and Its Relatives	139

Chapter 6 Hands and Handles 143

6.1	Introduction	143
6.2	Anthropometry of the Hand.....	143
6.3	Hand Dominance (Handedness)	145
6.4	Anatomical Terminology	146
6.5	Hand Strength	148
6.6	Fundamentals of Handle Design	150
6.7	Biomechanics of Tool Design.....	152
6.7.1	Gripping and Squeezing.....	152
6.7.2	Gripping and Turning.....	153
6.7.3	Pushing, Pulling, Pressing and Lifting	154
6.8	The Neutral Position of the Wrist and Handle Orientation	155
6.9	Work Tasks Using Handheld Tools	157
6.9.1	Posture and Workstation Design	157
6.9.2	Risk of Musculoskeletal Injury	158

Chapter 7 Ergonomics in the Office..... 161

7.1	Introduction	161
7.2	The Office Desk	163
7.3	The Office Chair	166

7.3.1	Seat Height.....	166
7.3.2	The Backrest	167
7.3.3	Armrests	167
7.3.4	The Usability of Adjustment Controls	167
7.4	Visual Demands of Screen-Based Work.....	168
7.4.1	Viewing Distance	168
7.4.2	Display Screen Height	169
7.4.3	Document Holder.....	170
7.4.4	The Unskilled Keyboard User	170
7.4.5	Multiple Display Screens.....	170
7.5	The Portable (Laptop or Notebook) Computer	171
7.6	Computers in Schools	173
7.7	Input Devices	174
7.7.1	The Keyboard.....	175
7.7.2	The Mouse.....	176
7.7.3	Other Input Devices	177
7.8	What Makes a 'Good Posture' in Screen-Based Work?	178
7.9	The Design of Screen-Based Working Tasks	180

Chapter 8 Ergonomics in the Home 183

8.1	Introduction	183
8.2	The Kitchen.....	183
8.2.1	Layout.....	183
8.2.2	Worktop Height.....	184
8.2.3	Storage.....	187
8.3	The Bathroom	188
8.3.1	The Bathtub.....	188
8.3.2	The Handbasin	190
8.3.3	The Toilet (or Water Closet).....	190
8.4	The Bedroom.....	192
8.5	The Staircase	194

Chapter 9 Health and Safety at Work..... 199

9.1	Introduction	199
9.2	Accidents and Human Error	202
9.2.1	The Catastrophic Failure of Complex Systems.....	204
9.2.2	Everyday Accidents.....	206
9.3	Musculoskeletal Disorders	207
9.4	Back Injury at Work.....	209
9.5	Lifting and Handling.....	212
9.5.1	Workspace Layout.....	214
9.5.2	The Load	217
9.6	Work-Related Upper Limb Disorders.....	221
9.6.1	On the Varieties of RSI/WRULD	223

9.6.2	Overuse Injuries to Process Workers.....	226
9.6.3	Keyboard Injuries.....	230
9.6.4	Assessment of Risk Factors for WRULDs.....	235

PART III The Bodyspace Tables – Anthropometric Database

Chapter 10	Anthropometric Data.....	239
10.1	Compilation of the Anthropometric Database.....	239
10.2	Populations Included in the Database	239
10.3	British Adults (Tables 10.1 to 10.6)	240
10.4	Adult Populations of Other Countries (Tables 10.7 to 10.16).....	241
10.5	Infants (Tables 10.17 to 10.21).....	241
10.6	Children and Youths (Tables 10.22 to 10.38).....	241
10.7	The Anthropometric Tables.....	242
Appendix	A Mathematical Synopsis of Anthropometrics	281
A.1	The Normal Distribution.....	281
A.2	Samples, Populations and Errors	282
A.3	The Coefficient of Variation	285
A.4	Some Indices Used in Anthropometrics.....	286
A.5	Combining Distributions from Two or More Samples	288
A.6	The Bivariate Distribution Combining Data for Two Dimensions	289
A.7	Multivariate Analysis	291
A.8	Estimating Unknown Distributions from Data Available for Similar Populations or from Data Available for Related Dimensions.....	292
A.8.1	Estimating the Parameters of the Unknown Distribution by Correlation and Regression Parameters of Data from a Similar Population.....	292
A.8.2	Sum and Difference Dimensions	293
A.8.3	Empirical Estimation of the Parameters of the Unknown Distribution by the Method of Ratio Scaling from Data for a Similar Population.....	293
A.8.4	Empirical Estimation of Standard Deviation When Only the Mean is Known.....	294
A.9	Estimating Dimensions for a Combination of People or Variables	295
References		297
Index		325