

BREATHING WALLS

*A Biological Approach to
Healthy Building Envelope
Design and Construction*

**George Swanson
Oram Miller
Wayne Federer, Editor**

Copyright © 2008 by George P. Swanson, Oram Miller, and Wayne D. Federer
All rights reserved.

Inquiries regarding requests to reprint or translate all or part of *Breathing Walls: A Biological Approach to Healthy Building Envelope Design and Construction* should be addressed to the Editor:

Wayne Federer
c/o Breathing Walls
767 160th Avenue
New Richmond, WI 54017-7132 USA
wfederer@hotpop.com

As you use this manual to conceptualize, design and build your own projects, we authorize and do anticipate you will make and share single copies of *limited* excerpts with your colleagues, clients or contractors, consistent with both the spirit of [U.S. copyright law](#) and its [fair use stipulations \(section 107\)](#) that apply to librarians and educators. However this limited authorization does not include making second-generation copies in any form. Furthermore, the authors request that, if you quote or cite this unpublished draft in your own publications, you kindly do so only with the authors' explicit permission.

Table of Contents

Disclaimer.....	iii
List of Tables	ix
List of Figures	x
Acknowledgments	xii
Preface.....	xv
Co-author’s Note for Pre-publication Draft 2008-04-14.....	xvii
Editor’s Note for Pre-publication Draft 2008-04-14.....	xviii
Part One. INTRODUCTION.....	1
Chapter 1. Historical Background	2
Chapter 2. The Origins of Building Biology®.....	7
Chapter 3. Our Offer to the Building Trade.....	8
Chapter 4. Our View of “Green Building”	14
Chapter 5. The Basic Principles of Bau-Biologie®.....	17
Part Two. THE BREATHABLE BUILDING ENVELOPE	19
Chapter 6. Desired Properties of a Wall System.....	20
6.1 Introduction	20
6.2 What is a “Breathing Wall?”.....	21
6.3 Vapor Permeability and Diffusion.....	22
6.4 Hygroscopic Adsorption/Desorption.....	28
6.5 Capillary Absorption/Desorption.....	37
6.6 Thermal Mass, “Out”sulation and Energy Efficiency.....	40
6.7 Radiant Heat Transfer.....	46
6.8 Structural Integrity.....	50
6.9 Protection from Incoming Radio Frequencies (RF)	51
6.10 Natural Materials and Subtle Energies.....	54

Chapter 7. Water Intrusion and Condensation Problems in Conventional, Energy-Efficient Wood Frame Construction	58
7.1 Introduction	58
7.2 Mycology.....	59
7.3 The extent of the problem	62
7.4 Historical background	65
7.5 Why We Recommend No Plastic Vapor Diffusion Retarder	66
7.6 Rainwater Intrusion into Wall Cavities	69
7.7 The Capillarity of Plastic House Wrap	75
7.8 The Downsides of Fiberglass as an Insulator	78
7.9 Mold Growth from Wet Materials Stored on the Job Site	79
7.10 Comparing Conventional and Breathable Wall Systems.....	81
7.11 Conclusion.....	84
Chapter 8. Breathable Envelope Materials	86
8.1 Introduction	86
8.2 Earth and Clay.....	89
8.3 Straw and Other Plant Fibers	89
8.4 Straw-Clay.....	89
8.5 Wood.....	89
8.6 Concrete Made with Portland Cement	89
8.7 Autoclaved Aerated Concrete (AAC)	93
8.8 Low-Density Fiber-Cement, Made with Portland Cement.....	100
8.9 Healthy Alternative Cements	127
8.10 Low-Density Fiber-Cement, Made with Alternative Cement	143
8.11 Magnesium Oxychloride Composite Sheeting	149
8.12 European Options	163
8.13 Choosing the Right Materials	165
Chapter 9. How to Construct a Breathable, Thermally Massive Envelope ..	166
9.1 Use of Low-Density Fiber-Cement Wall Forms on the Job Site	166
9.2 Low-Density Fiber-Cement Wall System Protocol	174
9.3 Alternative Protocol for Low-Density Fiber-Cement Wall Forms	176
9.4 First-Hand Experiences of Builders Using Low-Density Fiber-Cement Wall Forms	177
9.5 How to Use Breathable, Solid Blocks on the Job Site	180
9.6 Window Detailing.....	184
9.7 Breathable Finishing Treatments, Above Grade	184
9.8 Breathable Waterproofing, Below Grade.....	195
Chapter 10. Breathable Options for Thin-Wall Construction	197
10.1 Introduction	197
10.2 Wood Framing Alternatives.....	197
10.3 Magnesia-Based Sheeting on the Construction Site	198

10.4 Alternative Wood Frame / MgO Board Protocol	200
10.5 Cotton Batting as an Insulation Alternative	201
10.6 Cellulose Infill Insulation.....	203
10.7 Magnesia-based Mineral Blown-in Insulation.....	204
Chapter 11. Slab	206
11.1 Introduction	206
11.2 Benefits of Using Low-Density Fiber-Cement as a Sub-Slab Material	206
11.3 Use of an Air Gap Membrane under a Concrete Slab.....	209
11.4 Radon Mitigation	210
11.5 Strategies to Mitigate “Concrete Sickness”	211
Chapter 12. Foundation	213
12.1 Introduction	213
12.2 Performance Goals.....	213
12.3 Waterproofing with a Cementitious Parging Layer and External Foundation Drainage Membrane.....	215
12.4 The Physics of Vapor Pressure and Vapor Migration.....	222
12.5 Waterproofing Homes with Hydronic Heating Systems without Forced Air Pressurization.....	223
12.6 Wicking of Moisture from Foundation Footing	224
12.7 Crawl Space Considerations	225
12.8 Frost-Protected Shallow Foundation	227
Chapter 13. Roof and Attic	229
13.1 Introduction	229
13.2 Attic.....	229
13.3 Roofing	231
Chapter 14. Additional Design Considerations	233
14.1 Introduction	233
14.2 Moisture Control (Adjunctive to Breathable Envelope Materials)	233
14.3 Ventilation.....	235
14.4 Passive Solar	238
14.5 Windows and Doors	238
14.6 Heating.....	239
14.7 Healthier Forced-Air Systems.....	248
14.8 Cooling	252
14.9 Integration with Ancient Traditions of Design	254
Chapter 15. Examples of Homes Built with Low-Density Fiber-Cement Wall Forms	257

Part Three. CONSTRUCTION PROTOCOLS.....	262
Chapter 16. Worker and Environmental Protection during Construction	263
Chapter 17. Below-Grade Envelope	264
17.1 Slab	264
17.2 High Water Table and Radon Control Slab	265
17.3 Alternatives to Steel Rebar	266
17.4 Foundation and Stem Wall.....	267
17.5 Crawl Space	270
17.6 Finishing Within the Basement	271
Chapter 18. Above-Grade Envelope	273
18.1 Low-Density Fiber-Cement Wall Forms, Made with Portland Cement	273
18.2 Low-Density Fiber-Cement, Made with Alternative Cement	274
18.3 Autoclaved Aerated Concrete (AAC)	275
18.4 Magnesia-Based Sheeting	275
18.5 Alternative Wood-Frame with MgO Board.....	275
18.6 Finishes, Interior and Exterior, for Thick-Wall Envelopes	276
18.7 Roofing.....	277
Part Four. CONCLUSION	278
About the Contributors.....	279