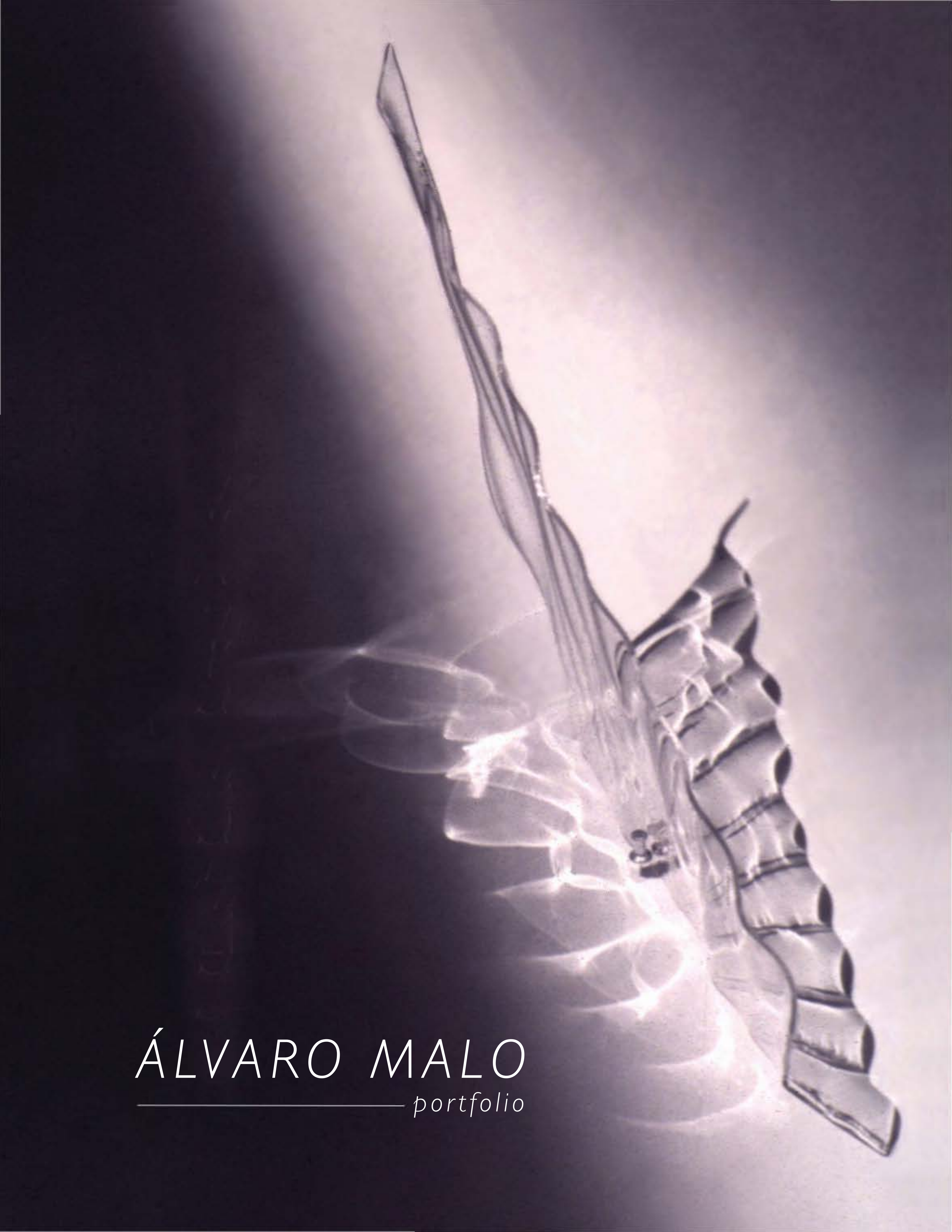


ÁLVARO MALO

portfolio

ÁLVARO MALO

CURRICULUM VITAE

Álvaro Malo

Registered Architect, NCARB
Director & Professor, Emerging Material Technologies Graduate Program
School of Architecture, University of Arizona
Tucson, AZ 85721-0075
Phone 520.621.6752 Fax 520.621.8700
malo@u.arizona.edu http://architecture.arizona.edu/people/faculty/node/77

EDUCATION

Degrees and Diplomas

1971 University of Pennsylvania, Philadelphia
Master of Architecture, Master's Studio Louis I. Kahn

1969 Bouwcentrum, Rotterdam, Holland
Post-graduate Design Diploma

1967 Facultad de Arquitectura, Universidad de Cuenca, Ecuador
Professional Architect's Degree and Diploma

Continuing Education

1990 Columbia University, New York City
Graduate Seminar on Aesthetics, Department of Philosophy

1989 Columbia University, New York City
Graduate Seminar on Criticism, Department of Philosophy

1988 Columbia University, New York City
Graduate Seminar on Aesthetics, Department of Philosophy

AWARDS & HONORS

2011 Association of Collegiate Schools of Architecture (ACSA), Creative Achievement Award, presented at the 2012 ACSA 100th Anniversary Meeting, Boston, Massachusetts

2003 Association of Collegiate Schools of Architecture (ACSA), Service Award, chair of Urban Design topic at 2002 ACSA International Conference, Havana, Cuba

1998 Distinguished Public Service Award
City of Miami Beach, Florida

1994 Distinguished Visiting Professor
University of Florida, Gainesville, Florida

1969-1971 Fulbright Scholarship, Graduate Studies in Architecture
University of Pennsylvania, Philadelphia

1969-1971 University Scholarship, Graduate Studies in Architecture
University of Pennsylvania, Philadelphia

1969 Netherlands Government Fellowship, Postgraduate Studies
Bouwcentrum, Rotterdam, Holland

1967 Decoration, Casa de la Cultura, Ecuador

1967 Decoration, best graduating architecture student
Universidad de Cuenca, Ecuador

1965 Sponsored Architectural travel in the USA
Department of State, USA

ACADEMIC APPOINTMENTS

2006-date Professor & Director, Emerging Material Technologies Graduate Program
School of Architecture, The University of Arizona, Tucson, Arizona

1998-2006 Director & Professor, School of Architecture
The University of Arizona, Tucson, Arizona

1994-1998 Director & Associate Professor, Miami Architecture Research Center
University of Florida, Miami, Florida

1990-1993 Associate Professor of Architecture
University of Pennsylvania, Philadelphia, Pennsylvania

1986-1990 Associate Professor of Architecture
Columbia University, New York City, New York

1979-1986 Assistant Professor of Architecture
State University of New York at Buffalo, Buffalo, New York

1976-1979 Assistant Professor of Architecture
University of Colorado at Denver, Denver, Colorado

1971-1974 Professor of Architecture
Universidad de Cuenca, Cuenca Ecuador

ACADEMIC ADMINISTRATION

2006-date Director, Emerging Material Technologies Graduate Program
School of Architecture, University of Arizona, Tucson, Arizona

1998-2006 Director, School of Architecture
University of Arizona, Tucson, Arizona

1994-1998 Director, Miami Architecture Research Center
University of Florida, Miami, Florida

1992 Director, Spain Summer Program
University of Pennsylvania, Madrid, Spain

1986 Director, Advanced Building Design Program
Columbia University, New York City, New York

1976-1979 Director, Architecture Community Design Center
University of Colorado at Denver, Denver, Colorado

TEACHING

1998-date **University Arizona**
Materials: Modeling, 2007-date
Materials: Properties & Tests, 2006-date
Emerging Material Technologies Design Lab, 2005-date
Land Ethic Studio, 2003
Capstone Project/Studio, 1999-date
Capstone Seminar, Theory: Ethics ~ Aesthetics, 2002

1994-1998 **University of Florida**
Advanced Research & Thesis Studio, 1994-1998
Construction Materials Research, 1994-1998

1990-1993 **University of Pennsylvania**
Design Studio, Master's Core & Advanced, 1990-1993
Master's Thesis, 1990-1993
Scaffoldings, 1990-1993
Matter & Memory, 1993
Models: Instrumental & Iconic, 1990

1986-1990 **Columbia University**
Design Studio, Master's Core, 1987-1990
Advanced Building Design Studio, 1986
Seminar: Louis I. Kahn, 1987-1990
Architectural Drawing, 1986

1979-1986 **SUNY at Buffalo**
Design Studio, Core Director, 1979-1986
Seminar: Louis I. Kahn, 1979-1985
Architectural Drawing, 1979-1986

1976-1979 **University of Colorado**
Programming & Community Design Studio, 1976-1979
Thesis Studio, 1977-1979

Thesis Director/Advisor at U. of Arizona

2011 M. Williams, M.Sc. Arch/EMT, "(Re) Conceptualizing the Ecology of Dwelling Through the Design and Fabrication of a Semi-Biotic Screen Wall"
2009 B. Vander Werf, M.Sc. Arch/EMT, "Elastic Systems for Compliant Shading Structures"
E. Hall, B.Arch/EMT, "Plastics and Architectural Ecologies: Polymer Trombe Wall"
A. Toth, B.Arch/EMT,"Bamboo—Flexegrity"
2008 J. Laver, M.Sc. Arch/EMT, "High Performance Building Envelopes"
B. McDonald, M.Sc. Arch/EMT, "Sensitive Apertures"
B. Hall, B.Arch/EMT, "Heliotropic Grid Shell"
2007 W. Jenski, M.Sc. Arch/EMT, "Porous Adaptive Membranes: Thermostatic Composite Systems for a Self-Regulating Architecture"
T. Watson, B.Arch/EMT, "Self-Rigidizing Foam Emergency Shelter"
M. Rees, B.Arch/EMT, "Eco-Clean Dwelling"
2006 J. Buswell, B.Arch/EMT, "Fabric Formed Concrete"
A. Falco, B.Arch/EMT, "Architecture New Textile: Woven Composite Construction"
W. Jenski, B.Arch/EMT, "Adaptive Structure: Clinic for Doctors Without Borders"
2004 E. Marchalonis, B.Arch/EMT, "Aerial Theater"
E. Nebel, B.Arch/EMT, "Canyon Wall Cantilever"
2003 S. Beidler, B.Arch/EMT, "Heuristic Laboratory: Investigating Nature"
C. Bien-Wilner, B.Arch/EMT, "Nomadic Body Gear"
A. Kennedy, B.Arch/EMT, "Navajo Linguistic Transmission to Architecture"
2002 D. Arena, B.Arch/EMT, "On-Site Tilt-Slab Construction"
R. Smith, B.Arch/EMT, "Temporary Scaffolding"
2001 T. Reiner, B.Arch/EMT, "Hydro-Morphological Structures'
J. Phillips, B.Arch/EMT, "Underground Parking Structure"

Thesis Director/Advisor at U. of Florida, Miami Architecture Research Center

1997 J. Linares, M.Arch, "Miami Intermodal Center/Miami International Airport"
E. Blumberg, M.Arch, "Bayside Station/Intermodal Transportation Center"
1996 H. Rodriguez, M.Arch, "Miami Beach Station/Intermodal Transportation Center"
T. Baughn, M.Arch, "Miami SW 2nd Avenue Drawbridge/Hydraulic Park"

Thesis Director/Advisor at U. of Pennsylvania

1993 A. Nyhart, M.Arch, "Philadelphia Shipyards Naval Reuse"
D. Zaccheo, M.Arch, "Wharton Esherick Woodcraft Center/Museum at Valley Forge"
D. Bergmann, M.Arch, "Tensile steel~textile deployable anthropometric module"
1992 J. Trafficonte, M.Arch, "Boat repair yard at Bay of Fundy"
D. Horowitz, M.Arch, "Cast on-site, form-work reuse dwelling"
1991 C. Mitchell, M.Arch, "Santa Catalina Island: air, water and land transportation connectors"

RESEARCH

Sponsored Projects

2010 "Autonomous Adaptive Performance in a Sensitive and Integrative System (AAPSIS) for a Telemedicine Unit, matching federal funds earmark, 01/10. Value $1,200,000; funding

University of Arizona FY11, design/ build energy efficient prototype for delivery of Native American Health Services Program in Arizona. Co-PI's: Á. Malo (Architecture); P. Deymier (Sustainable Engineered Systems); A.M. López (Medicine); E. Enikov (Aerospace & Mechanical Engineering); M. Peterson (Psychology).

2010 "Autonomous Adaptive Performance in a Sensitive and Integrative System (AAPSIS) for a Telemedicine Unit." Final proposal, 03/31/10. Value $2,068,430 over 4 years; funding National Science Foundation/Emerging Frontiers in Research and Innovation (NSF/EFRI) design/ build energy efficient prototype for delivery of Native American Health Services Program in Arizona. Co-PI's: Á. Malo (Architecture); P. Deymier (Sustainable Engineered Systems); A.M. López (Medicine); E. Enikov (Aerospace & Mechanical Engineering); M. Peterson (Psychology).

2008 "Solar Decathlon '09," effective dates: 01/08-06/09. Value $100,000; funding grant US Department of Energy/National Renewable Energy Laboratory to design and build energy efficient solar-powered home on the mall in Washington DC in 2009. CoPI's: J. Simmons, D. Clifford, Á. Malo, L. Medlin, J. Vollen.

2008 "Solar Decathlon '09," effective dates: 01/08-06/09. Value $100,000; funding matching grant Arizona Research Institute for Solar Energy Grant to design and build energy efficient solar-powered home on the mall in Washington DC in 2009. CoPI's: J. Simmons, D. Clifford, Á. Malo, L. Medlin, J. Vollen.

2003 First International Design Symposium on Urban Design in Arid Zones," effective date: 05/25/03. Value $ 5,000; Office of the Vice Provost for Research, U. of Arizona. Co-PI's: Álvaro Malo and Ignacio San Martin.

2001 "Rio Nuevo MFD: Graduate and/or Married Student Urban Housing with Ancillary Mixed Uses," effective dates 08/24/01-12/14/01. Value $21,048.22; funding, City of Tucson/Rio Nuevo MFD. Co-PI's: Álvaro Malo and\ Ignacio San Martin.

2001 "Rio Nuevo MFD: Sustainable Urban Design – Outdoor Space Analysis," effective dates 01/17/01-05/14/01. Value $18,195.00; funding, City of Tucson/Rio Nuevo MFD. Co-PI's: Álvaro Malo and Fred Matter.

2000 "Rio Nuevo Multipurpose Facilities District: Urban Design Proposals," effective dates 08/29/00-12/11/00. Value $11,582; funding, City of Tucson/Rio Nuevo MFD. Co-PI's: Álvaro Malo and Robert Hershberger.

1998 "Collins Avenue/Indian Creek Corridor: Transportation & Urban Design Projects," effective dates 10/30/97-06/30/98. Value $15,000; funding, City of Miami Beach. PI: Álvaro Malo.

1997 "Miami Intermodal Center (MIC): Hi-Speed Rail Terminal," effective dates 09/03/96-06/28/97. Value $71,650; funding, Florida Department of Transportation, District VI. PI: Álvaro Malo.

1997 "Landscaping of Kennedy Causeway," effective dates 10/20/96-06/28/97. Value $11,000; funding, City of North Bay. Co-PIs: Álvaro Malo and Terry Schnadelbach.

1997 "Bayside / Arena 2 Station of the E-W S.R. 836 Multimodal Corridor," effective dates 09/03/96-06/28/97. Value $71,650; funding, Florida Department of Transportation District VI, PI: Álvaro Malo (Co-Investigator: Peter McCleary, U. of Pennsylvania).

1997 "27^{th} Avenue Station of the E-W S.R. 836 Multimodal Corridor," effective dates 09/03/96-06/28/97. Value $67,450; funding, Florida Department of Transportation, District VI. PI: Álvaro Malo.

1996 "Miami Intermodal Center / Miami International Airport," (spatial and structural design of building envelope responsive to multi-modal transportation technologies), effective dates 09/03/95-06/28/96. Value $25,830.00; funding, Florida Department of Transportation, District VI. PI: Álvaro Malo.

1996 "East-West S.R.836 Multimodal Corridor," (urban elevated train structural guideway and selected stations), effective dates, 09/03/95-06/28/96.Value $34,755; funding, Florida Department of Transportation District VI. PI: Álvaro Malo.

1995 "Built Form Analysis: Miami Beach," (AutoCad models of existing urban form, form permitted by current zoning, and desirable form), effective dates, 01/03/95-05/15/95. Value, $8,000; funding, City of Miami Beach and Division of Sponsored Research U. of Florida. PI: Álvaro Malo.

1995 "Coral Gables: Design District," (light industry and housing development profile and building design guidelines), effective dates, 01/03/95-03/15/95. Value, $6,000. funding, City of Coral Gables/Division of Sponsored Research U. of Florida. PI: Álvaro Malo.

1993 "Scaffoldings: interim structures and formwork," effective dates, 07/91-07/93. Value, $5,000; funding: University of Pennsylvania Research Foundation. PI: Álvaro Malo.

1989 "Louis I. Kahn: case studies in tectonic form," effective dates,1985/1987 Value, $3,000; funding, Research Development Grant SUNY at Buffalo. PI: Álvaro Malo.

1979 "Normalization in housing for people with mental disabilities," effective dates, 07/77-07/79. Value,$10,000; funding agency, Colorado State Department of Developmental Disabilities. PI: Álvaro Malo.

PUBLICATIONS

Peer-reviewed papers

2011 "Adaptive Autonomous Performance in a Sensitive Integrative System," 4th International Multi-Conference on Engineering and Technological Innovation (IMETI), Orlando, FL, July, 2011

2011 "Adaptive Autonomous Performance in a Sensitive Integrative System," 7th International Conference on Technology, Knowledge and Society, Bilbao, Spain, March 25 – 27, 2011.

2010 "Sensitive Apertures," 14th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2010, Orlando, FL, June 2010.

2010 "Sensitive Apertures," Third International Conference on Harmonisation Between Architecture and Nature, La Coruña, Spain, April 2010.

2010 "Emerging Materials," Hawaii International Conference on Arts and Humanities, Honolulu, Hawaii, January 2010.

2007 "A desert land ethic: aesthetic research," Hawaii International Conference on Arts and Humanities, Honolulu, Hawaii.

2003 "Matter and Memory," Proceedings ACSA 2003 International Conference, Helsinki, Finland, July 2003.

2000 "Intermodalities of Miami: Public Transportation Projects," Proceedings ACSA 2000 International Conference, Hong Kong, China, June 2000.

1997 "Precast Concrete: Urban Transportation Structures," Proceedings Conference of Architectural Research Centers Consortium, Atlanta, GA, April 1997.

1996 "Intermodalities of Miami: Water Land, Air…," Technical Seminar: Interactions Between Airport and Town, XIX Congress International Union of Architects, UIA 96 Barcelona, Spain, July 1996.

1995 "The Miami River: A Working River," Canadian Society of Landscape Architects, Congress '95, Winnipeg, Canada, September 1995.

1995 "Through the Looking Glass," Proceedings 83rd ACSA Annual Meeting, Seattle, Washington, April 1995.

1993 "Visions of Technology," Technology Symposium, Pratt Institute, New York City, NY, April 1993.

1992 “Models: Instrumental & Iconic,” Proceedings International Research Symposium, Carleton University, Ottawa, Canada, February 1992.

1991 “The Order of Institutions: Forms of Desire,” ACSA/AIA Conference, Philadelphia, PA, October 1991.

1987 “The Culture of the Eye,” ACSA Technology Conference, San Francisco, CA, February 1987.

1986 “The Question Concerning Technology,” ACSA Conference, Newark, NJ, October 1986.

Articles, essays, and book chapters

2010 “A Desert Land Ethic: Aesthetic Research,” *Divinity, Creativity, Complexity: Center 15,* A Journal for Architecture in America book series, Austin: UT Austin, 2010, p. 94-101

2010 “Sensitive Apertures,” *Eco-Architecture III: Harmonisation Between Architecture and Nature*, Southampton: WITPress, 2010, p.73-84.

2008 Preface, *Thinking the Present: Urban Design in Arid Regions*, Tucson: U. of Arizona, 2008, p. XIII-XVI

2007 “Tucson ~ Zaragoza,” *Casa Tucson*, Madrid: TF Editores, 2007, p. 10-23

2005 “Casa Tucson, en Zaragoza, España”*, ARQUITECTURA COAM 340*, Colegio de Arquitectos Madrid, Madrid: Ex-Profeso, 2005, p. 79-85

2005 “El arte de vivir” (“The art of living”), *Tasavallan Presidentti: Ángel Fernández-Alba,* Madrid, AFA Arquitectos, 2005, p. 32-36

2004 “Una ética del desierto: investigación estética,” *ARQ 57 - Zonas áridas / Arid zones*, Santiago, Chile: Ediciones ARQ: Pontificia Universidad Católica, August 2004.

2002 “Instinct and Intelligence,” *Robert Marino*, Rockport: Rockport Publishers, 2002.

1994 “La Tectónica de las Formas,” *Louis I. Kahn*, Barcelona: Ediciones del Serbal, Estudios Críticos, 1994, p. 57-68

1994 “Álvaro Malo,” *Arquitectura del Ecuador: Panorama Contemporáneo*, Bogotá: Editorial Escala, Colección Somosur, 1994, p.144-147

1994 “El Sentido de la Obra: Louis Kahn,” *Trama*, Quito, Editorial Fraga, 1994, p. 36-39

1994 *Architecture Review* 1992-1993, Philadelphia: U. of Pennsylvania, 1994,p. 38-39, 44-45, 74-75

1993 *Architecture Review* 1991-1992, Philadelphia: U. of Pennsylvania, 1994,p. 22-24, 29-31, 65, 80-81, 83

1992 *Architecture Review* 1990-1991, Philadelphia: U. of Pennsylvania, 1994,p. 20-21, 25, 42-43, 55, 58, 74-75, 78

1992 “The Hand: Organ of Knowledge”, *On Making*, New York: Rizzoli / Pratt, 1992, p. 46-51

1990 *ABSTRACT 1989-1990*, New York: Columbia University, 1990, p. 13, 21, 74

1989 *ABSTRACT 1988-1989*, New York: Columbia University, 1990, p. 20, 73

1988 *ABSTRACT 1988-1989*, New York: Columbia University, 1990, p. 49, 65

1987 “Louis I. Kahn,” *The Legacy of the Masters*, New York: AIA/New York Chapter, 1987, p. 29-31

Research and design reports

1998 “Collins Avenue / Indian Creek Corridor: Transportation and Urban Design Study,” Miami: U. of Florida, 1998, 108pp

1997 “Pedestrian and Bicycle Bridges between Hialeah and Miami Springs,” Miami: U. of Florida, 1997, 38pp

1997 "Miami Intermodal Center (MIC) & E·W SR 836 Intermodal Corridor," Miami: U. of Florida, 1997, 128pp

1996 "Precast Concrete: Urban Transportation Structures," Miami: U. of Florida, 1996, 30pp

1995 "Miami Beach: Built Form Analysis," Miami: U. of Florida, 1995, 102pp

1995 "Coral Gables: Design District," Miami: U. of Florida, 1995, 44pp

1979 "Pueblo Regional Center," Denver: U. of Colorado/CCDD, 1979, 40pp

1979 "Grand Lake Design Proposal," Denver: U. of Colorado/CCDD, 1979, 64pp

1978 "A Community for Ridge Home," Denver: U. of Colorado/CCDD, 1978, 24pp

1978 "Círculo Infantil Playground," Denver: U. of Colorado/CCDD, 1978, 36pp

1978 "Steamboat Depot Restoration," Denver: U. of Colorado, 1978, 26pp

1978 "Hayden Medical Facility," Denver: U. of Colorado/CCDD, 1978, 64pp

1976 "Downtown Windsor Urban Design," Windsor, Ontario: Planning Department, 1976, 48pp

Citations

2010 M. Benedikt, "Introduction," *Divinity, Creativity, Complexity: Center 15,* A Journal for Architecture in America book series, Austin: UT Austin, 2010, p. 12-13

2010 B. Wheeler, "The University Of Arizona Solar Energy Experimental Dwelling: SEED[pod]," *B·1Magazine*, vol. 3, issue 31, April 2010, Bangkok: Sirivatana Interprint, p. 40-45

2010 B. Wheeler, S. Ning, "The University Of Arizona Solar Energy Experimental Dwelling," *Chinese & Overseas Architecture*, Changsha, P.R. China2010 02 No.106, p. 24-33

2009 Á. Fernández-Alba, *El Laberinto de la Arquitectura y la Aventura de la Vida,* Madrid: Mairea Libros/DPA/ETSAM, 2009, p. 45

2009 J. Laver, K. Winn, "EcoCeramic Research," *Archiprix: World's Best Graduation Projects,* Hunter Douglas Awards, Rotterdam/Montevideo: 010 Publishers, 2009 http://www.archiprix.org/2013/index.php?project=2577

2007 Fernando Quesada, "In and Out," *Casa Tucson*, Madrid: TF Editores, 2007, p. 25-35

2007 W. Jenski, "Porous Adaptive Membranes," *Archiprix: World's Best Graduation Projects,* Hunter Douglas Awards, Rotterdam/Shanghai: 010 Publishers, 2007, p. 114-115 http://www.archiprix.org/2013/index.php?project=2279

2006 W. Tilson, "Place and the Electrate Situation", *rhizomes 13*, fall 2006, http://www.rhizomes.net/issue13/tilsonfreeman/index.html#iii

2005 "Modernism Comes Home to Tucson"*, Architectural Record*, November 2005, p. 69

2005 J. Pallasmaa, "La gravitación de la amistad" ("The gravitation of friendships"), *Tasavallan Presidentti: Ángel Fernández-Alba,* Madrid, AFA Arquitectos, 2005, p. 13

2005 R. McCarter, *Louis I. Kahn*, London: Phaidon, 2005, p. 122

1996 K. Vander Linden, "The Miami River: Past, Present and Future," University of Miami, Rosenstiel School of Marine and Atmospheric Science, 1996, p. 5-6, 20-36

1986 A. Latour, *Louis I. Kahn: l'uomo, il maestro*, Roma: Edizioni Kappa, 1986, p.177-179

1985 M. Sabini, "Tra Ordine e Forma: Frammenti di una'idea e archittetura", *Rassegna 21: Louis I. Kahn 1901-1974*, Milano: C.I.P.I.A., 1985, p.19

1979 "Círculo Infantil Playground", *Progressive Architecture*, Cleveland: IPC/Penton, June 1979, p

LECTURES AND PRESENTATIONS

2010 "Braided Ecologies: Bioenergetics and Ecosophy," Faculty of Architecture, University of Manitoba, Winnipeg, Manitoba, February 2010.

2009 "Emerging Materials," Declination 9º 42' – Solar Fusion 2009, Arizona Research Institute for Solar Energy, University of Arizona, Tucson, Arizona, August 2009.

2008 "Perspectives: On Glass," Interdisciplinary Symposium with Material Sciences & Engineering, sponsored by W&W Glass/Pilkington and TriPyramid Structures, Inc., organizer, Tucson, Arizona, November 2008.

2008 "Institut für Entwerfen und Bautechnik," Fakultät für Architektur, Technische Universität München, guest critic, Munich, Germany, October 2008.

2008 "Material Ecologies," School of Architecture and Community Design, University of South Florida, Tampa, Florida, October 2008.

2008 "Architecture and Engineering: asymptotic paths," School of Design, University of Pennsylvania, Philadelphia, Pennsylvania, October 2008.

2008 "Architecture and Engineering: twin ecologies," Department of Civil Engineering & Mechanics, College of Engineering, University of Arizona, Tucson, September 2008.

2008 "Heuristics," College of Design, North Carolina State University, Raleigh, North Carolina, February 2008.

2005 "The Role of Higher Education in Transforming Communities," Urban Design in Arid Zones, 2nd International Symposium, Tucson, Arizona, January 2005.

2004 "A desert land ethic: longitude ~ latitude," Escuela Técnica Superior de Arquitectura de Madrid (ETSAM), Universidad Politécnica de Madrid, Spain, November 2004.

2003 "A desert land ethic: aesthetic research," Proceedings International Design Symposium on "Urban Design in Arid Zones", Pontificia Universidad Católica, Santiago, Chile, May 2003.

2001 "Tradición ~ Experimentación," Facultad de Arquitectura, Universidad de Cuenca, Cuenca, Ecuador, July 2001.

2001 "A Desert Land Ethic," Universidade Estácio de Sá, Campus, Tom Jobim, Rio de Janeiro, Brazil, June 2001.

1999 "The Future of Architecture Education," panelist at round table at AIA Western Regional' Meeting, Tucson, Arizona, October 1999.

1998 "Louis I. Kahn: Formwork in the Kimbell Art Museum", Speaker and panelist, Sarasota Design Conference, Longboat Key, Florida, June 1998.

1996 "Intermodalities of Miami: Water, Land, Air…", XIX Congress of the International Union of Architects, Technical Seminar, "The Airport and the City: Interactions", Barcelona, Spain July 1996.

1994 "Gravity ~ Levity", University of Michigan, Ann Arbor, Michigan, May 1994.

1994 "Forgetful Memory", University of Florida, Gainesville, Florida, October 1994.

1993 "Gravity ~ Levity", RISD, Providence, Rhode Island, April 1993.

1992 "In Search of the Present", Cornell University, Ithaca, New York, October 1992.

1992 "Fabrication and Materiality", University of Pennsylvania, Philadelphia, Pennsylvania, September 1992.

1989 "The Model of Models", Barnard College, New York City, New York, October 7, 1989.

1988 "Scaffoldings", Columbia University, New York City, New York, October 21, 1989.

EXHIBITIONS

2003 “Faculty Work Exhibition”, School Of Architecture, The University of Arizona, Tucson, Arizona, September, 2003.

1998 “Imaging Miami”, Art Gallery, University of Miami, Coral Gables, Florida (invited 10 exhibitors), May 1998.

1996 “Intermodalities of Miami: Water, Land, Air: Intermodal Projects”, XIX Congress International Union of Architects, UIA 96 Barcelona, Spain (invited 12 exhibitors), June 1996.

1991 “The Legacy of the Philadelphia School”, AIA/GSFA, Meyerson Hall, University of Pennsylvania, Philadelphia, Pennsylvania (invited and refereed), October 1991.

1987 “Built Work”, Avery Hall, Graduate School of Architecture, Columbia University, New York City, New York (invited 4 exhibitors), September 1987.

1987 “The Legacy of the Masters – student work under Louis I. Kahn”, AIA Gallery, New York City, New York (invited, 10 exhibitors), April 1987.

1986 “Scaffoldings”, ACSA Diamond Jubilee Conference, New Jersey Institute of Technology, Newark, New Jersey (refereed 3 exhibitors), October 1986.

PROFESSIONAL PRACTICE

Licenses

1981 Registered Architect, New York.
1980 NCARB Certificate.
1978 Registered Architect, Colorado
1967 Registered Architect, Ecuador.

Built work

2007 Malo House, renovation, Tucson, Arizona.

1993 Apartment building, 9 units, Cuenca, Ecuador.

1989 Keppler Farms Inn, addition and renovation, Medina, New York.

1989 Moloney House, Craneridge, New York.

1988 S.B. Whistler & Sons, industrial conversion, Akron, New York.

1988 Malo House, addition, Williamsville, New York.

1979 Círculo Infantil Playground, Denver, Colorado.

1975 Shayne Beach House, Punta Blanca, Ecuador.

1975 Escuela de Arquitectura, Universidad de Cuenca, Cuenca, Ecuador.

1973 Terrace apartments, 4 units, Quito, Ecuador.

1973 High-rise apartments, Quito, Ecuador.

1971 Workers subsidized housing, 24 units, Cuenca, Ecuador.

Manufacture: Arts and Crafts

1998 Post-tensioned concrete probes.

1995 Post-tensioned glass joist, glass & steel cable.

1993 Pre-stressed wood laminations.

1974 Fireplace tools and andirons, wrought iron.

1971 Funicular polygon of revolution, aluminum and steel cable.

Employment

1982-1998 Self employed architect, USA.

1981 Cannon Design, Inc., Grand Island, New York.

1974-1976 Planning Department, Windsor, Ontario, Canada.

1971-1974 Self employed architect, Ecuador.

1970 Louis I. Kahn, Architect, Philadelphia.

SERVICE

University-Wide Committees at Arizona

2003 Five Year Review of Head of Civil Engineering.
2002 University-Wide Teaching Award for Meritorious Departmental Achievement.
2001 Architect Selection Committee, Architecture Building Expansion.
2001 Architect Selection Committee, UA Chemistry Laboratory Building.
2000 University-Wide Teaching Award for Meritorious Departmental Achievement.
1998-2003 University-Wide Public Art.

College-School Committees at Arizona

1998-date College Administrative Council, School of Architecture: Faculty Status P&T (chair 2007-08), Graduate Executive (chair 2007-08), Academic Events, Admissions, Curriculum & Standards, Faculty Status, Laboratories & Space Planning, Student Affairs.

College-School Committees at other universities

1990-1993 Admissions, Awards, Faculty Search, Student Affairs (U. of Pennsylvania).
1986-1990 Admissions, Curriculum, Awards (Columbia University).

Public and Institutional Service

2009-2010 Indian Health Services/Tohono O'odham Nation, technical information regarding Telemedicine building research and design.
2007 Fulbright Senior Specialists Program, Referee
2006 The MacArthur Fellows Program, Nominator.
2004 The MacArthur Fellows Program, Peer Reviewer.
2003 ACSA 2002 International Conference, Havana, Cuba, June 2002, Topic Co-Chair: Urban and Regional Planning.
2002 The MacArthur Fellows Program, Peer Reviewer.
2001 National Endowment for the Humanities, Peer Reviewer.
2001 Architect Selection Committee, Quincy Douglass Library, City of Tucson, Arizona.
2001 ACSA 89th Annual Meeting, Baltimore, Maryland, March 2001, Technology Paper Reviewer and Session Moderator.
1999 National Endowment for the Humanities, Peer Reviewer.
1998-2003 Civitas Sonoran, Board of Directors.
1998 Architect Selection Committee, New World School of the Arts, Miami, Florida.
1995-1998 Transportation Aesthetics Review Committee, Metropolitan Planning Organization, Dade County, Miami, Florida.
1995-1998 Design Guidelines Task Force, Miami Beach Planning Commission, Miami Beach, Florida, Technical Advisor.
1995-1998 Architectural Advisory Committee, Miami Beach Housing Authority, Miami Beach, Florida.
1994 AIA Design Awards / Miami Chapter, Miami, Florida, Juror.
1986 National Council Architectural Registration Boards, Professional Exam Grader, Boston, Massachusetts.

TEACHING at COLUMBIA

MS Arch and Building Design
Design Studio

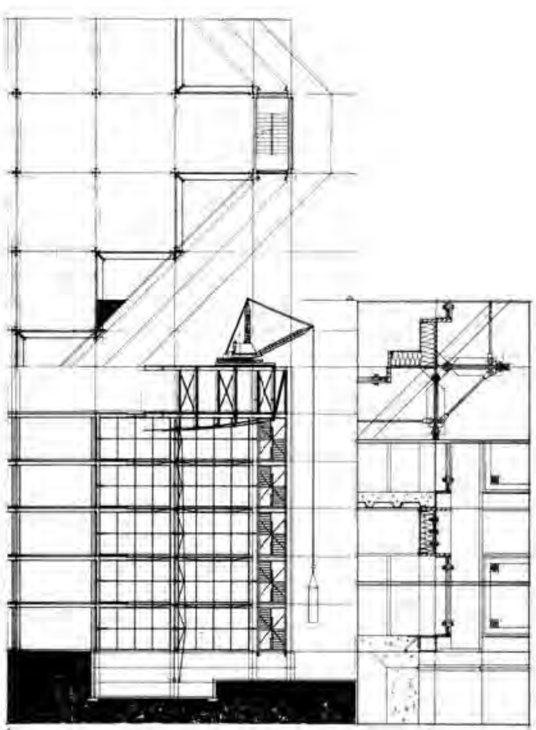
Fall 1987

Alvaro Malo, studio critic

I am teaching myself Architecture–and, hopefully, students if we are together–as if I must every day wake up to the reality that I know little of it, and let it teach me how to teach.

The model for today is Aristotle's "Metaphysics": the 'formal cause', is the desire for order, an internal order made external, and vice versa; the 'material cause' is the measured presence, the tangible boundary of light-reflecting matter; the 'efficient cause' is the maker's active will, the hand opening the material to revelation of its new constructed presence ('the laminated image of the will'); the 'final cause' is the inevitable destiny of things so produced: to be poetic or prosaic, to be used or abused, to be excused, and released into the silence of their own internal possibilities, and let them be.

Wall
Todd Achelpohl 1 2 3



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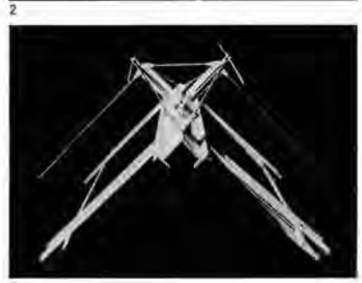

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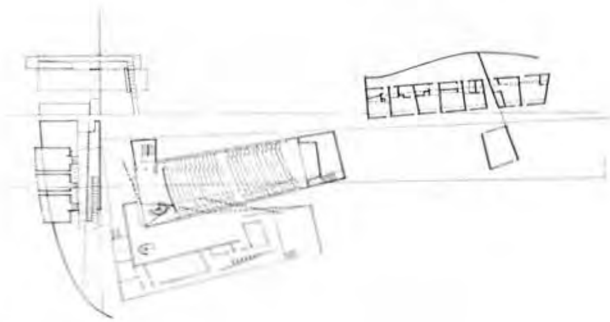
First Year M Arch
Design Studio

Alvaro Malo,
studio critic

Spring 1988

Music School,
Palisades Park,
New Jersey

Mario Gooden 1 2 3



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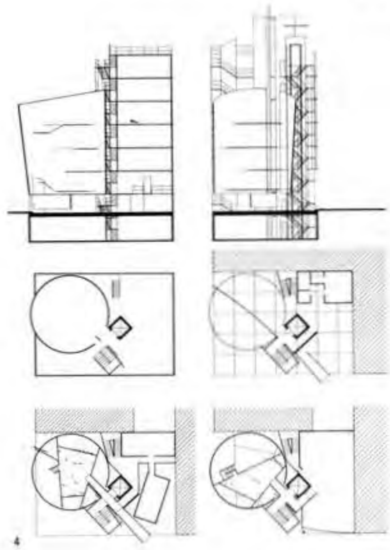
Spring 1988

Photography Gallery/
Studios/Lofts,
New York, New York

Tomasz Kowalski 4 5



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Fall 89

Alvaro Malo
studio critic

Gate/Garden/Basin
Stacey Greenwald,
M Arch, 3

Courtyard/Hearth
Jodi Sheldon,
M Arch, 1

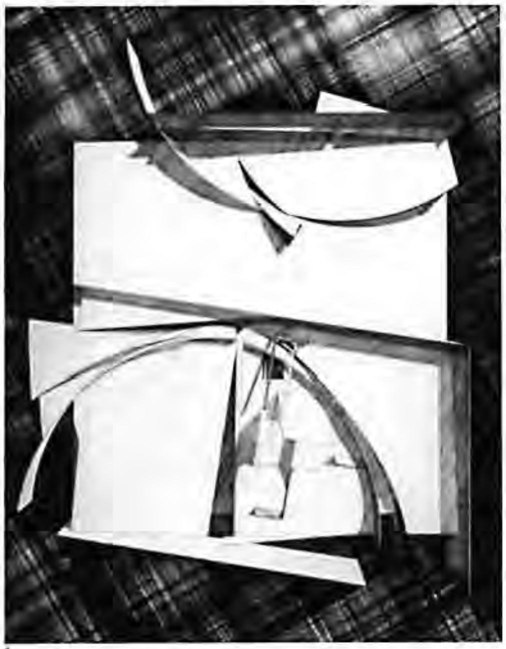
Tower/House/Observatory
Willaim Yoon,
M Arch, 2

Are there two kinds of worlds: the imaginary and the real?
Can we say that the imaginary world is the one we live in?
And, that the real world is the one we imagine we live in?

The question is, whether, in this twin phenomena, of which Kant spoke, we have a disposition towards action, and want to make again the world: the artificial world.
If pure possibility advances by intuitive vision, an introspective vision of the mind by the mind, without recourse of objects or language – a silent vision – in the movement of the mind towards the external world,we break up this silence with elements laid side-by-side: the utterance of words and the spatiality of things.

What is the model that the mind proposes for the world?
How is the world rearranged by the effective action of the hand?
Why meddle with the world – where is the license and authority?

We may let the poet, Wallace Stevens, speak, and hear that:
"Poetry is the subject of the poem
From this the poem issues and
To this returns. Between the two
Between issue and return, there is
An absence in reality
Things as they are. Or so we say."
Here is the model, an image of the mind deposited in matter – two-sided mirror, made of a materialized idea and idealized matter. The hand, where the mind's will and the body's energy meet, is the mirror-maker, the place of passage and imprimatur, that keeps on writing the concrete calligraphy of stone.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First Year M Arch Design Studio

20

Alvaro Malo, studio critic

Spring 1989

Pilot Plant,
Stevens Institute of Technology,
Hoboken, New Jersey

Leslie Morris 2 4 5

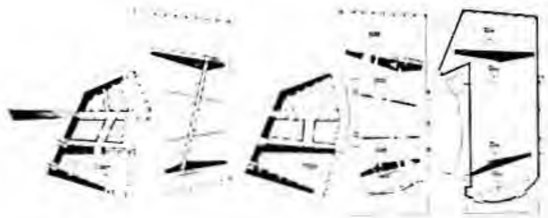
Scott Slarsky 1 3

Why manufacture? Perhaps, because it is a way to threaten or thrill ourselves with infinity: having touched matter with our hands, we must reconstruct the world with a sense of magical necessity.

Since we cannot draw a limit to thinking, for to do so, Herr Wittgenstein, has said that: "We should be able to think on both sides of this limit (we should therefore have to be able to think what cannot be thought)"; then we must draw a limit to expression, in our actions.
If our destiny is to be seated, among other things, we should allow ourselves to fix the limbs of a maple to the seat, to the back rest of a chair, turning the naturalness of wood and the rite of shadowy trees into an artifact of elegant and luminous bricolage.

Why architecture? If Monsieur Pascal, has said that: "All the unhappiness of men derives from one single thing, which is their inability to be at peace in a room." Perhaps, it may serve to give our brutal wills some pause.

Between the cradle and the cemetery there is a block of time, between the mind and matter there is perpetual oscillation, positioned in the middle is the abstract loom of space: there we must stretch the ontological net of geometry, and weave, the lighter, diaphanous order of ideas on side X, and the tangible, colored threads of materials on side Y. Here is the magic carpet, woven from nothingness, within its vital boundary we shall make our dwelling in the air, we shall sleep by night, we shall awake by day, and mix the blue to come with the blue that has vanished.



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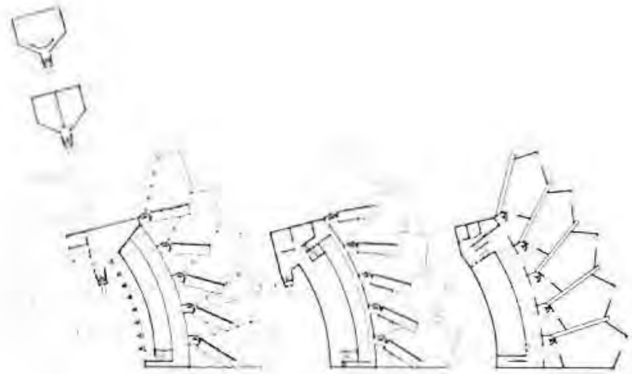

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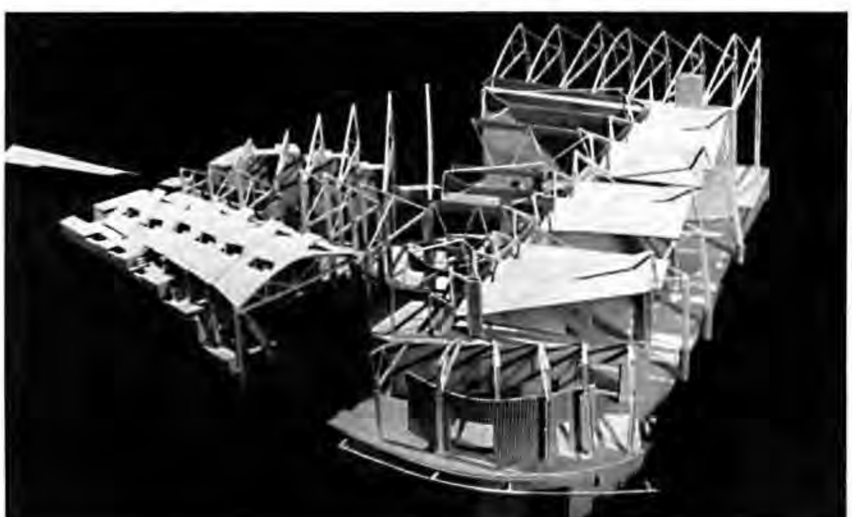

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Spring 90

Alvaro Malo
studio critic

Photography Gallery and Loft Studio/Apartments, New York, New York
Eric Robinson, M Arch, 1 2 3

In late January, we had a droll affair: a lottery! We, 'the critics', were doing our usual bit: self-promotion! This is what I said: Remember Heraclitus – Fragment 91 – "You will not go down twice to the same river," and Erik Satie, "Every act is a virgin act, even the repeated one."

Experience is a mode of censorship, by which we prejudge the world and do not let it manifest itself to us, fully, as it is. There is an even more pervasive mode of judgement, by which we take the collective experiences, systematize them, and call it history.

As a counterpoint, I want to argue for the virtues of memory. Or Bergson's two kinds of memory: the sensory-motor memory of repetitive acts which is encoded in the body, turning it into "an ever advancing boundary between the future and the past;" and, the imaginative memory of the mind, which is the faculty of "the inner energy which allows the being to free itself from the rhythm of the flow of things and to retain in an ever higher degree the past in order to influence ever more deeply the future."

It is by memory, as the sedimentation, collection, and recollection of individual acts – the virgin acts – that I come to my own senses, and the senses of the foreworld, the world as I found it, the world revisited, and the world after.

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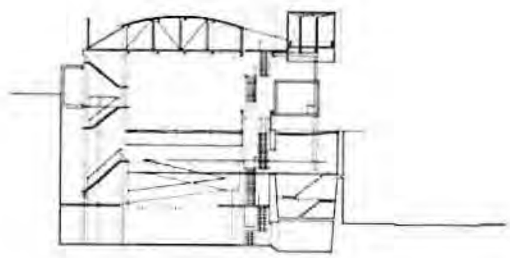

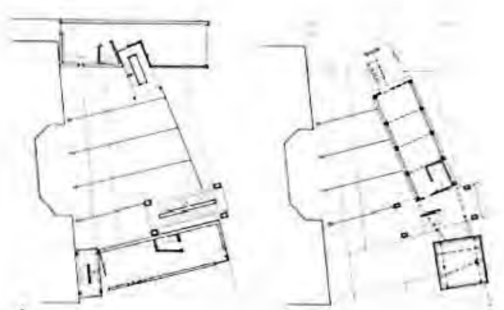

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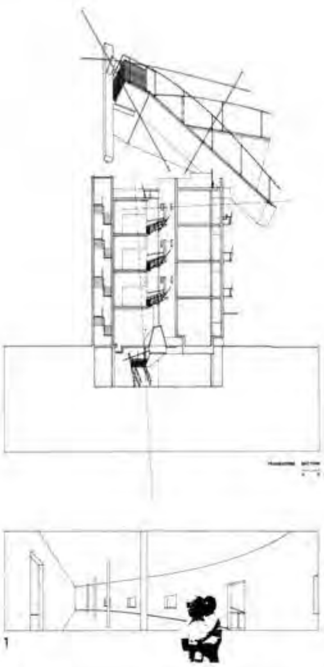
Photo Institute
Mario Gooden
Alvaro Malo, critic 1 3 4 5

Photography Institute
Elena Constantinidou



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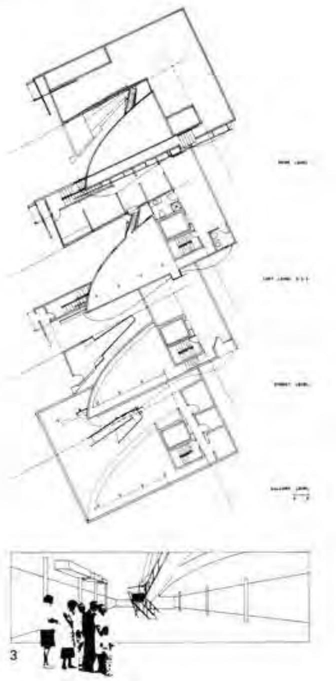

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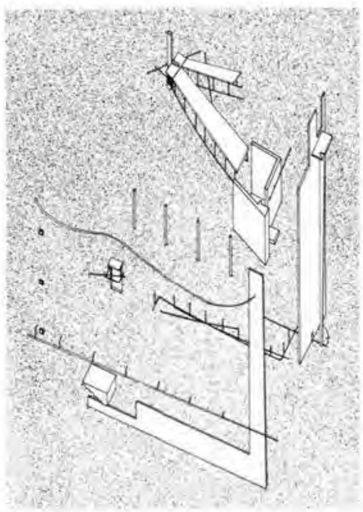

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Core Program

600 Level Studios–*Resolution of the Inside/Outside Wall*

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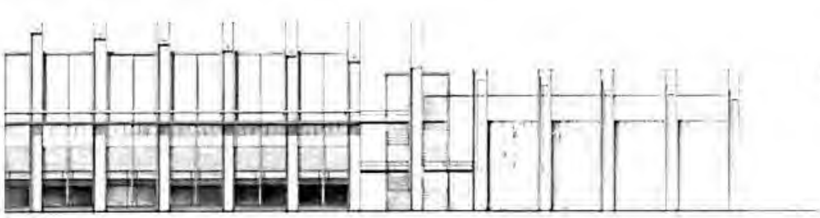

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"Living in the world, man finds that the world surrounds him as an intricate net woven of both facilities and difficulties."
— Ortega Y Gasset

Once you cut the fabric you must sew the net back with a sense of magic realism, anticipating the still unreal: a vision of the goal of work and the forms of desire.

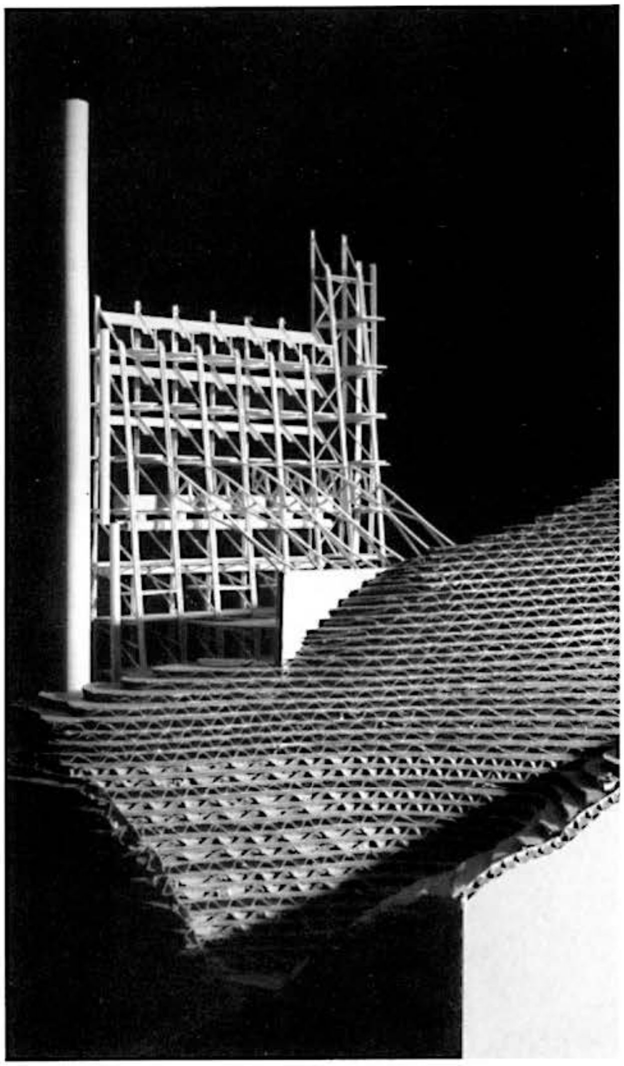
Critic: Alvaro Malo

1: **Nina Boyd**
Critic: Alvaro Malo
2: **Kimball Robinson**
Critic: Alvaro Malo
3, 4: **Cynthia Crozier**
Critic: Alvaro Malo

Advanced Elective Studios

600 & 700 Level

"Laboratory of Materials"
Critic: Alvaro Malo



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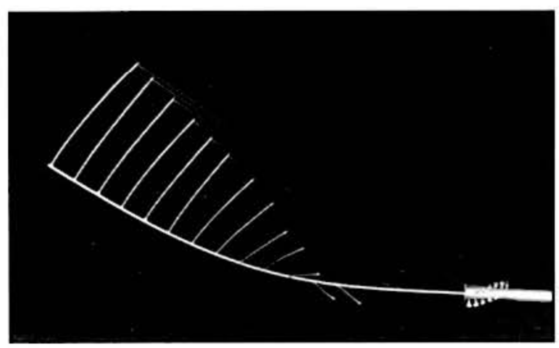
[Before the students we stood as in a police line-up: we collected ourselves like accomplices to a crime, a crime yet to be committed.]

"The dialectical culmination of all of this is the concept of nature as 'the inorganic body of man', the naturalization of man and the humanization of nature."
— Baudrillard

The intention is to touch materials and make experimental probes. These probes may then become a point of contact and coincidence for the architect: a crucible for the sense of building, conjuring up a dual sensibility, heuristic and poetic.



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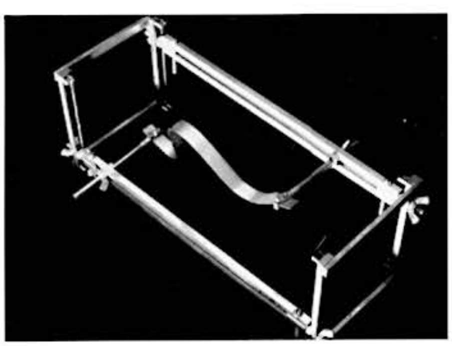

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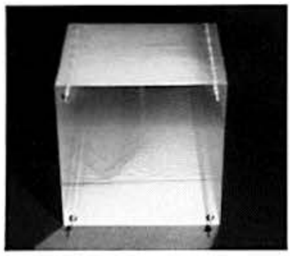
1, 2. **Bill McCullough**
3. **David Hess**

602, 701

Spring 91

Advanced Elective Studios

600 & 700 Level



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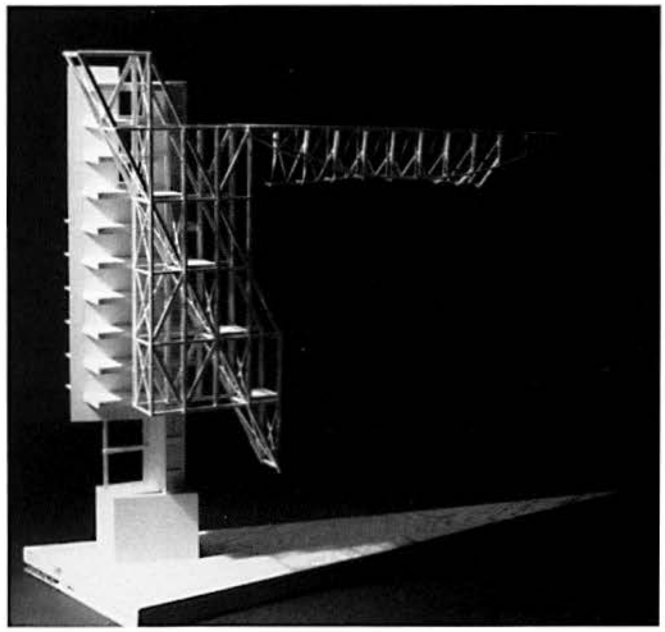

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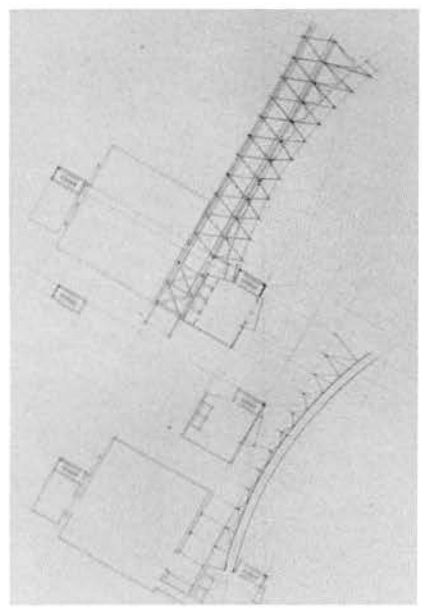

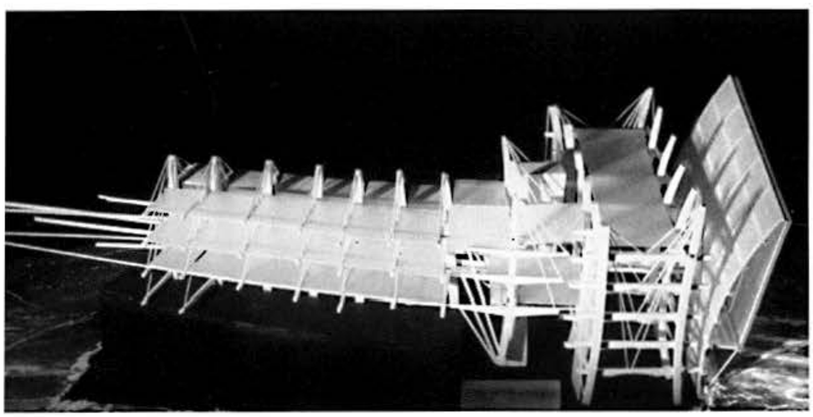

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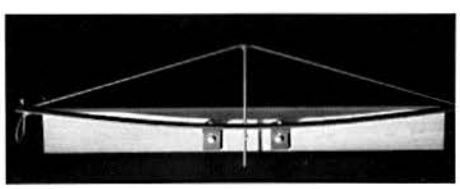

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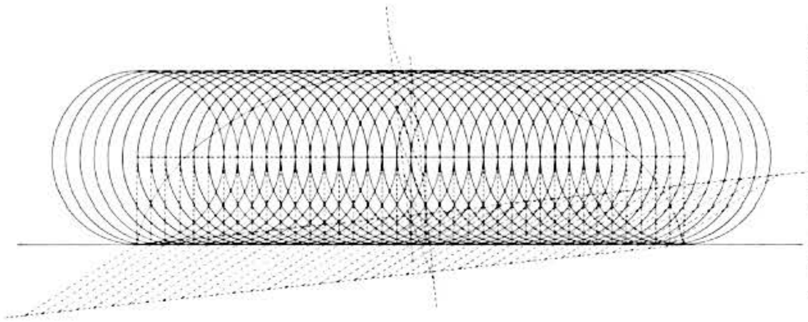
1, 2, 3 **Lee Coyle**
4, 5 **Thor Thors**

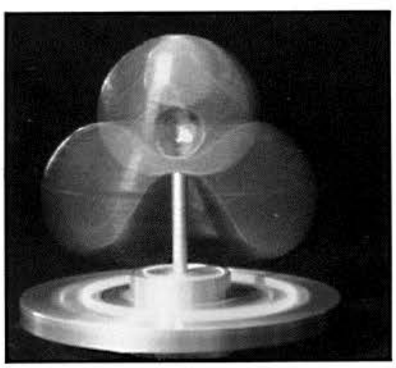
Advanced Elective Courses

"Models: Instrumental and Iconic"
Critic: Alvaro Malo



A model is to be taken as a proposition of a possible order of things, real or imaginary.

Instrumental is that which explores and defines the elemental constitution and physical boundaries of things, in view of their functional capacity.
Iconic is that which intuits and internalizes the metaphysical character of things as primary signs of aesthetic mythology.



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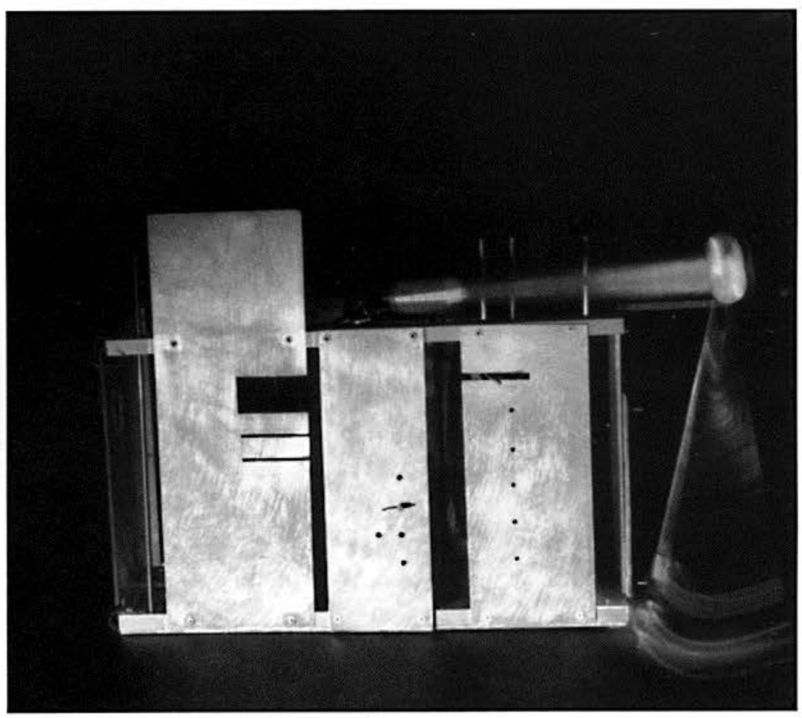

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1: **Kenneth Boyd**
2: **Alice Chun**

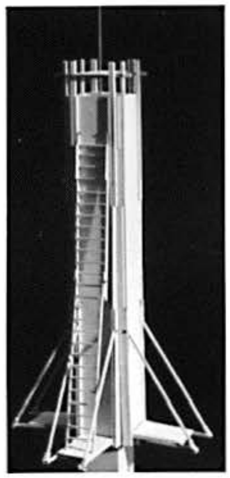
Spring 91

Advanced Elective Courses

"Scaffoldings"
Critic: Alvaro Malo

What is sufficient and necessary for construction?

Understanding, concerning forms not as immutable entities, but formation as a dialectical process. Making, as the metamorphosis of materials becoming instruments of human desire and dexterity. Judging, what is interim and what is permanent in the functional and aesthetic exchange between material and memory.



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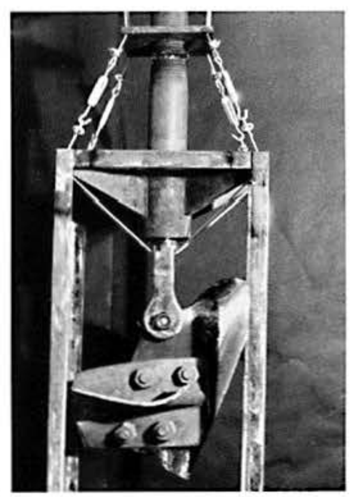

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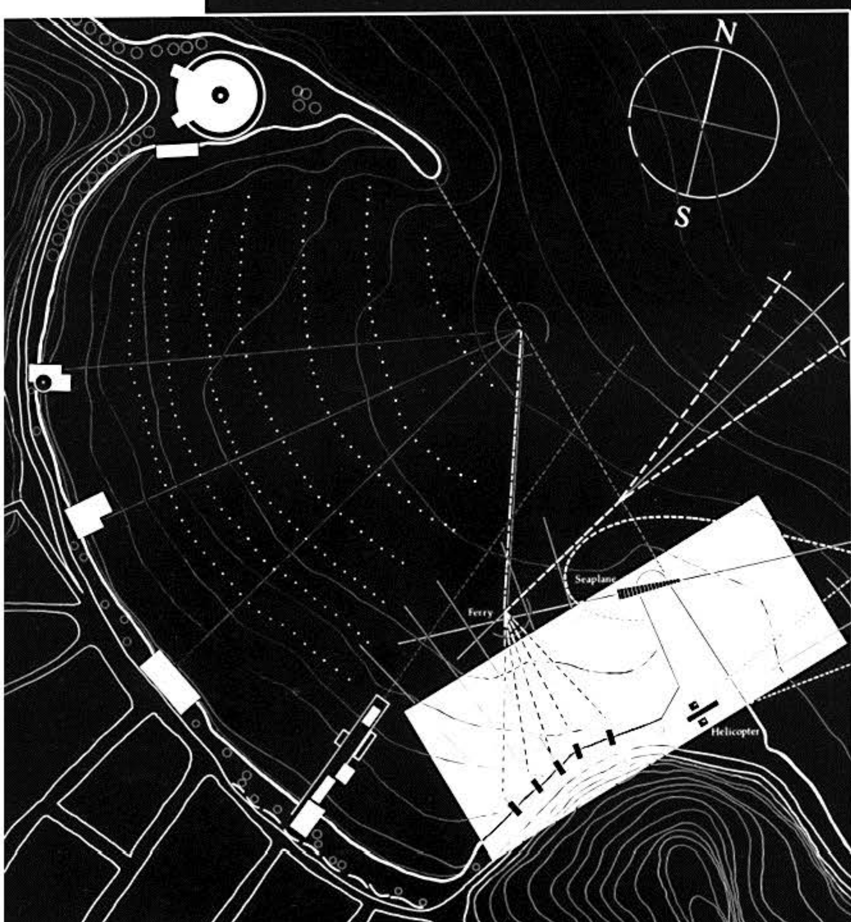
1: **Daniel Horowitz**
2, 3: **Kimball Robinson/Jon Traficonte**
4: **Elihu Siegman/James Biek**

Spring 91

Thesis



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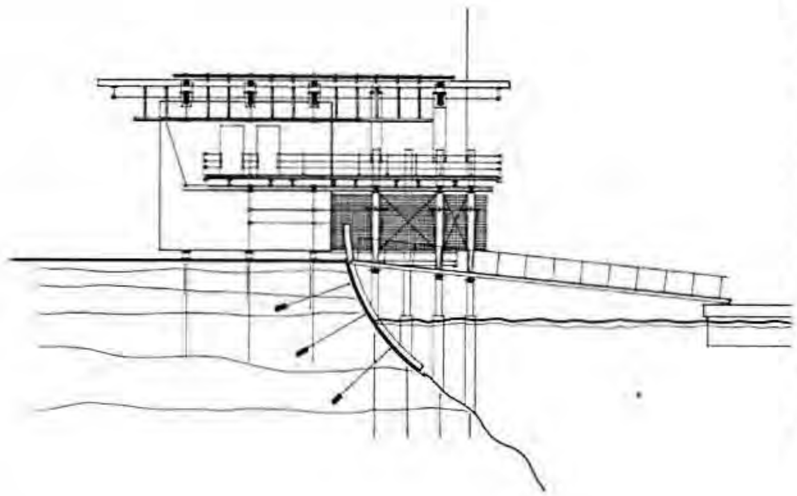
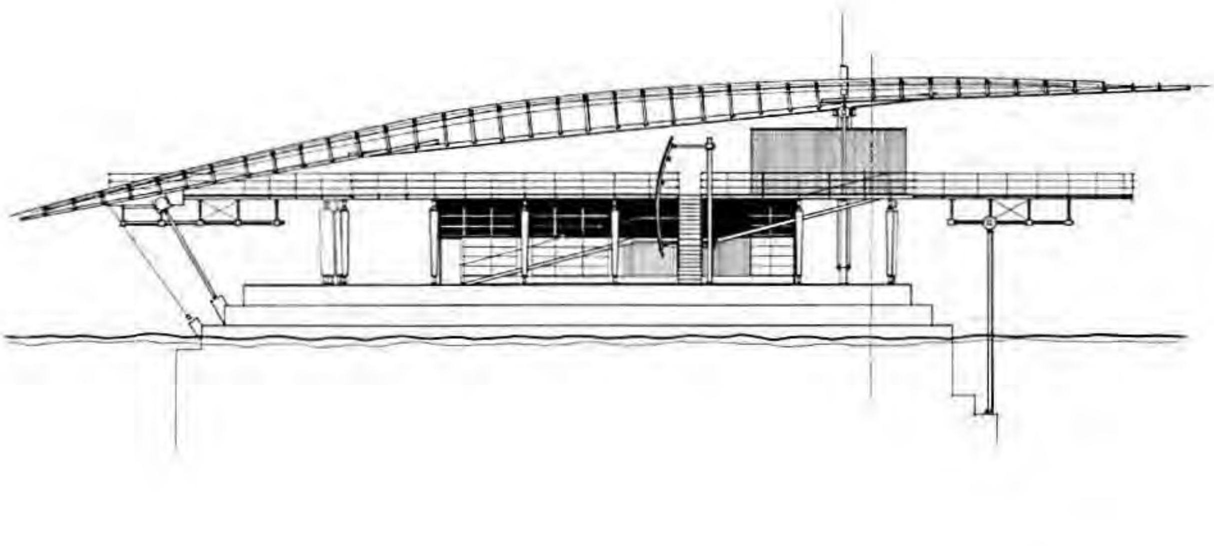
Christopher Mitchell
"Transportation Pavilions and an Investigation of Boundary"
Critic: Alvaro Malo

Functional requirements for the site require a reworking and extension/integration of several modes of transport as a way of arrival and departure to and from the island of Santa Catalina. Physiognomic requirements call for the intended intervention to address boundary at a series of levels and points in order to establish a coherent dialogue between the island and the harbor, the harbor and its adjacent urban center, the harbor as a edge unto itself, and as a series of buildings which again relate back to the mode of transport which each ultimately serves. In this way the ferry pavilions address the connection between water, sea wall, and land, the helicopter pavilion addresses the connection between land and air; and finally the seaplane pavilion breaks down the seaplane's interrelationship between land, sea and air, into a series of dual relationships based on its land to sea and sea to air connections.





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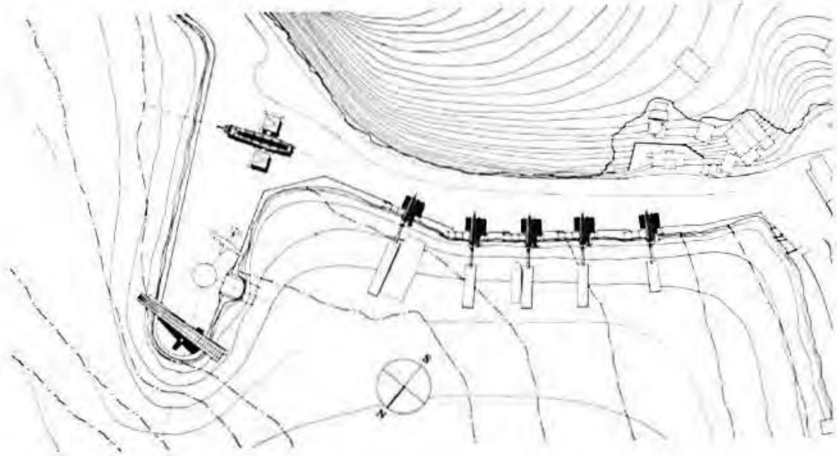
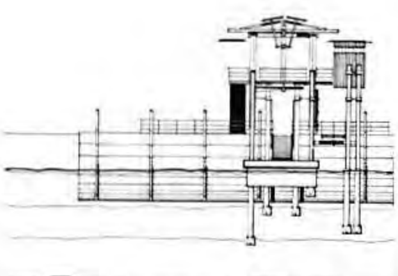
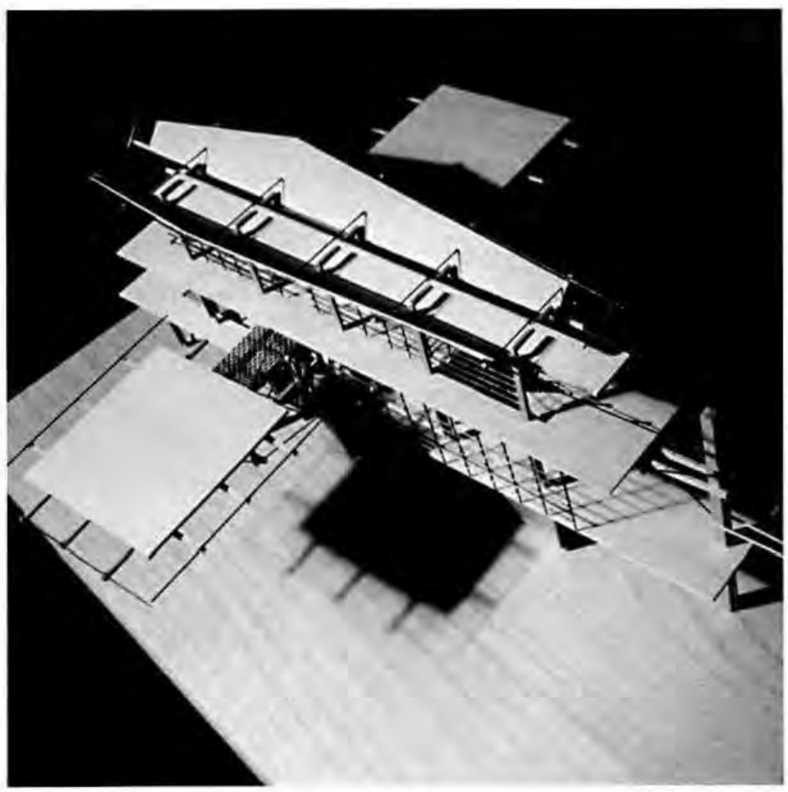






We have the past as memory. .We have the **future as desire.** In the **present we make** history...
-Carlos Fuentes

The words of Fuentes are a compelling call for a modern program: finding a proper sense of the present. They are a call for actuality, and a call for action - action being always a mode of definition of the present.

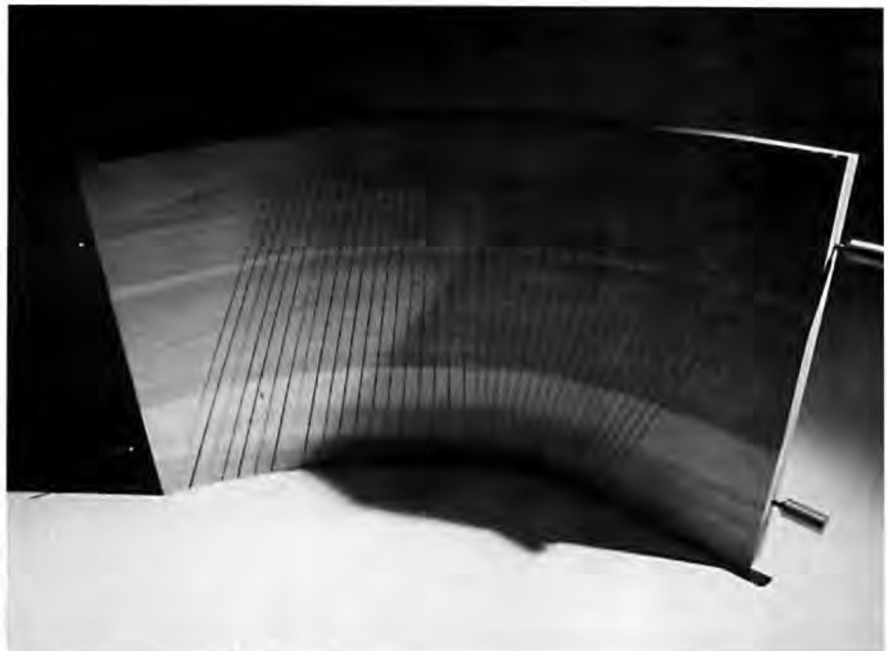
The ideal state of mind for this research of the present is one of critical innocence: it is being intentionally ahistorical and atheoretical. We may listen to the words of Novalis, and have it as an aim: "to make the familiar strange and the strange fa-

Archery Range
Critic: Alvaro Malo

miliar". Or consider Satie's suggestion that: "every act is a virgin act, even the repeated one".

The radical proposition of this studio is the recognition that the most primitive architectural program, but also a truly modern program, is that of **transformation of materials**. This is not being primitive in a historical sense, but primitive ontologically. It is having a disposition to begin the work of architecture as a reformation of raw materials into architectural materials, letting the play of forces and the resulting forms, invested with memory and desire, be the grounds of tectonic sensibility.

The immediate task is not a predetermined use of the



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1-3 James Branch

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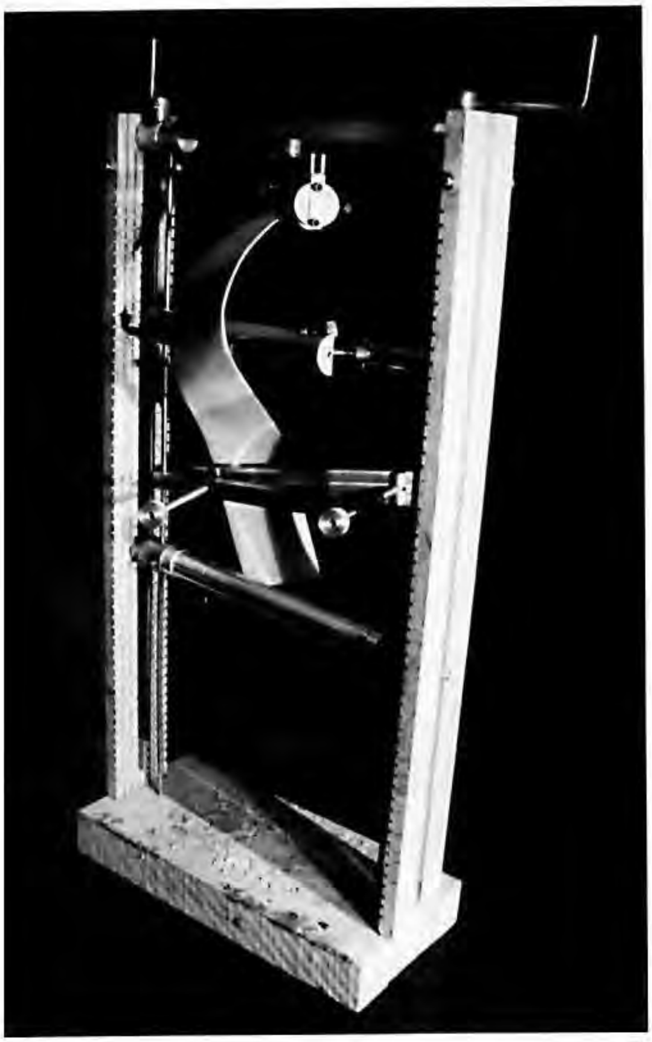

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material, which often becomes abuse and prejudice. It is making the material work by setting in it a **force**, and continuing to make a series of experimental **probes**, as variations of force in one-dimensional, two-dimensional, and three-dimensional orders.

Joseph Jenkins 1
Jeanne Holland 2
Scott Broaddus 3, 4

— 5

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702

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1

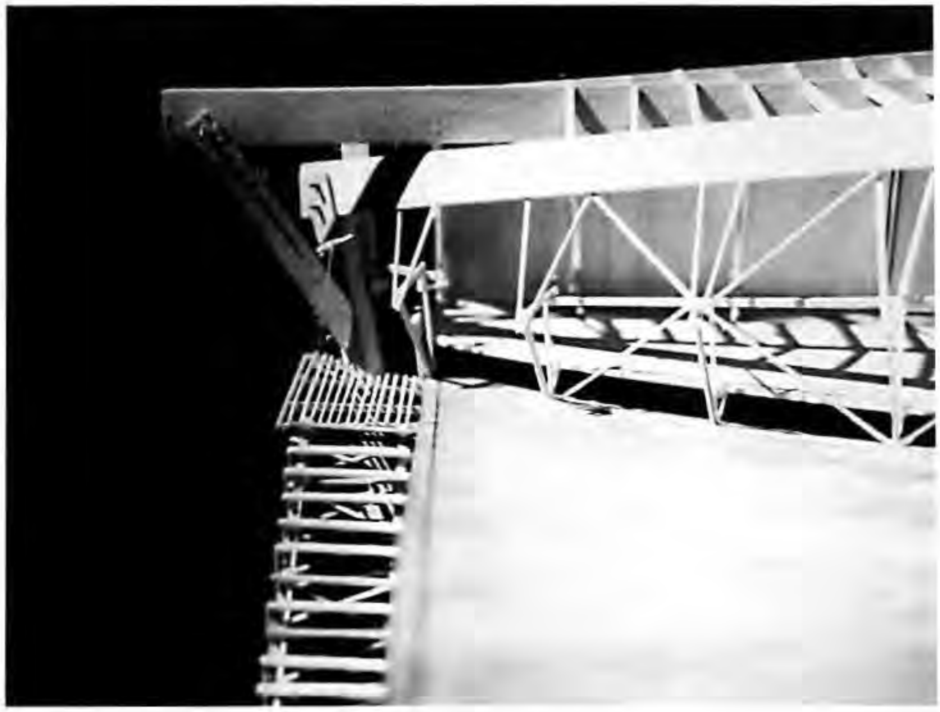
A house may be considered as the construction of a body,

House

Critic: Alvaro Malo

extended beyond our own natural body. The construction of a house, as a project for life, is a concrete example of a life lived not on the basis of need, but according to a desire, a production, a destiny (Spinoza). Following the mollusk's motto: "One should not build one's house to live in, but live to build one's house" (Valery). Here the full meaning of the philosopher's solitude becomes apparent: making a temple of his body, and letting the work carry him from the "state of nature": beyond to the "state of grace". (Leibiniz)

What is sufficient and necessary for construction? Perhaps light, if we accept that "material is spent light" (Kahn). and, that the mate-



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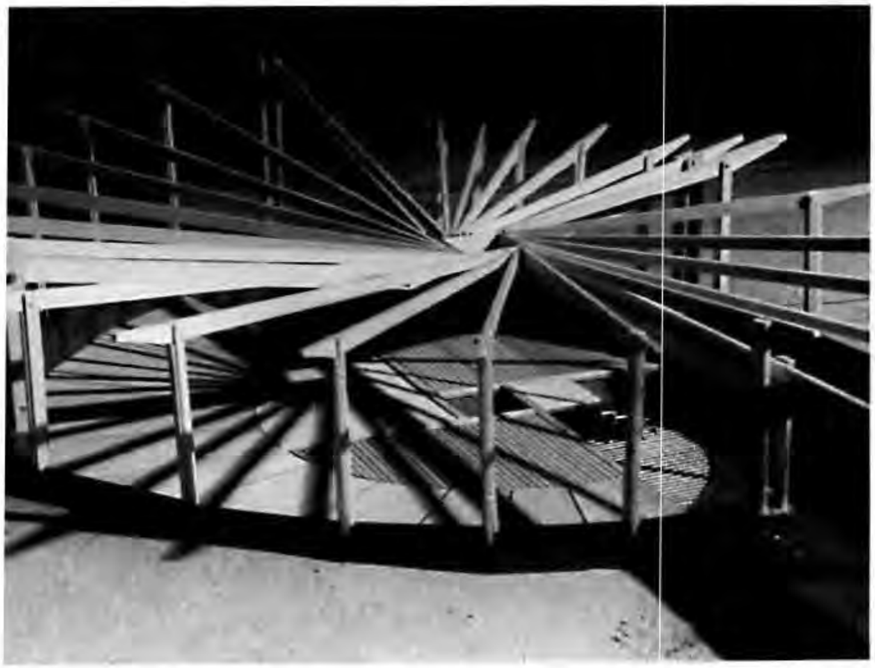
1 Eric Nothdurft
2, 3 Ann Goldhirsch

1, 2



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rial worked by our hands is spent desire. Then we may proceed with the work by proposing to establish the body as a model, in response to the ethical questions of Spinoza: "What is the structure (fabrica) of the body?" and, "What can a body do?" Further on, I suggest a tri-focal means of vision: by "understanding", by "making", and by "judgment". Understanding, concerning forms, not as immutable entities, but formation as a dialectical process. Regarding making as the metamorphosis of materials becoming instruments of human dexterity and desire. And, letting judgment give the true measure of "common sense" between reason and imagination, between matter and memory.

Craig Bouck 1-4
Roger Anderson 5

1

2

Matter & Memory
Critic: Alvaro Malo

This course is taught as a laboratory intending to engage the free and ordered play of the imagination as a practical transaction between **matter** and **memory.** It seeks the enactment of memory as a **body experience**, and it reflects on memory as source of internal sensibility. Proposed as an experiment, it carried out methodically, through the enactment, recognition and materialization of a diagram of movement: i.e. body of a stair.

1, 2 Andrew Nyhart, Saul Jabbawy Christopher Trumble

Glass Works
Philadelphia

Critic: Alvaro Malo

602 STUDIO, SPRING 92

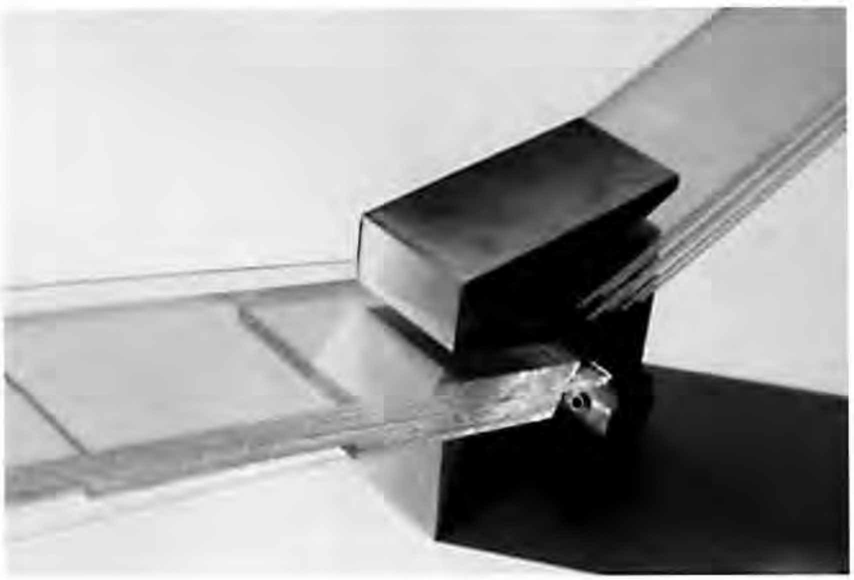
Intention

This topic is given as a double provocation: one which may be termed *heuristic*, which proceeding along lines of experimentation with glass, suggests an appropriation of the experiments when designing a building—as a coherent *order of experiments;* and another which may be termed *poetic*, which by reflecting critically on the nature of the material, suggests a tectonic assembly and aesthetic appearance that emerges out of its structural and optical properties—when viewed *"through the looking glass."*

Program

A series of *'optical instruments'*, for sites still undetermined, in the city of Philadelphia. The term *'optical instruments'*, here, refers to imaginative and veritable new urban foci, that reflect upon the life of the city, and further the sense of discrete cultural institutions, emerging at the threshold of the third millennium—in the hometown of Benjamin Franklin.

The proposition of the program, the selection of the site, and the architectural definition will be the individual responsibility of each participant in the studio.



1: **Scott Gerwig**

2, 3: **Michael Tobin**

4 - 8: **Michael Holleman**

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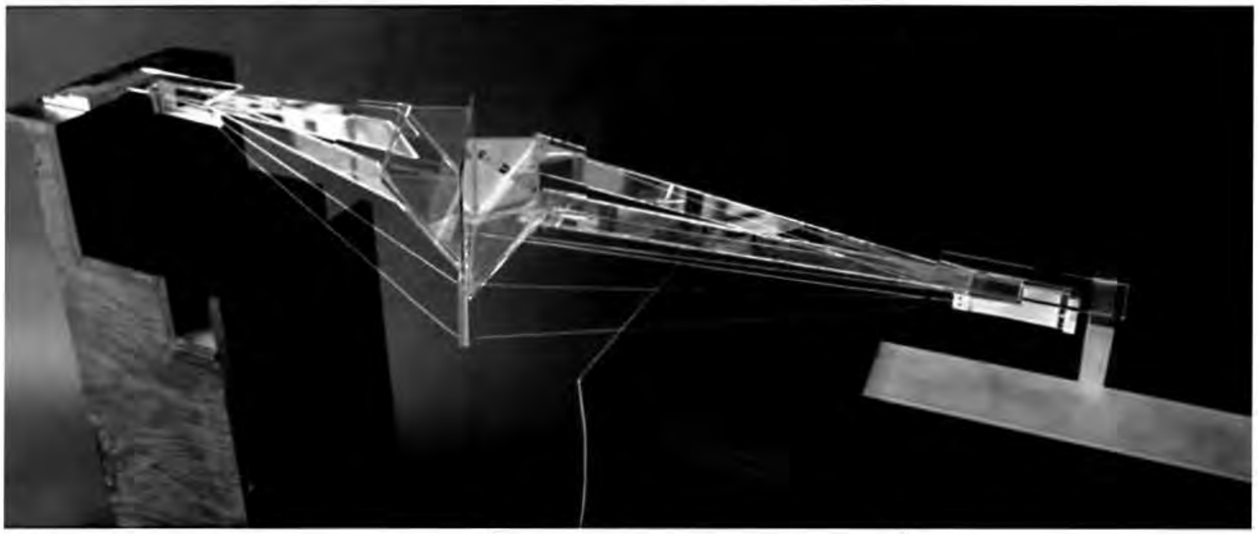

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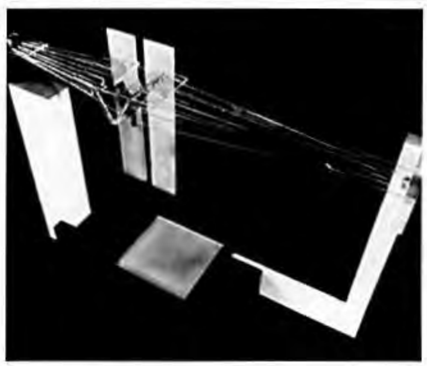

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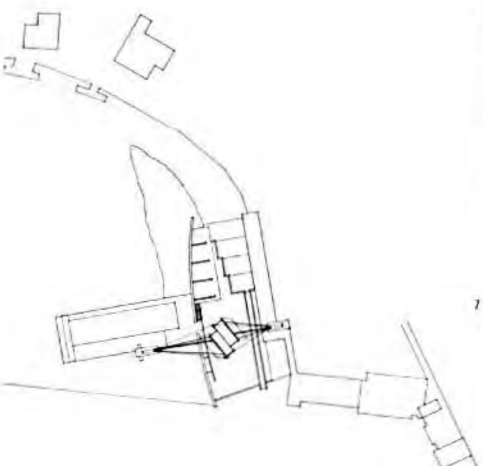
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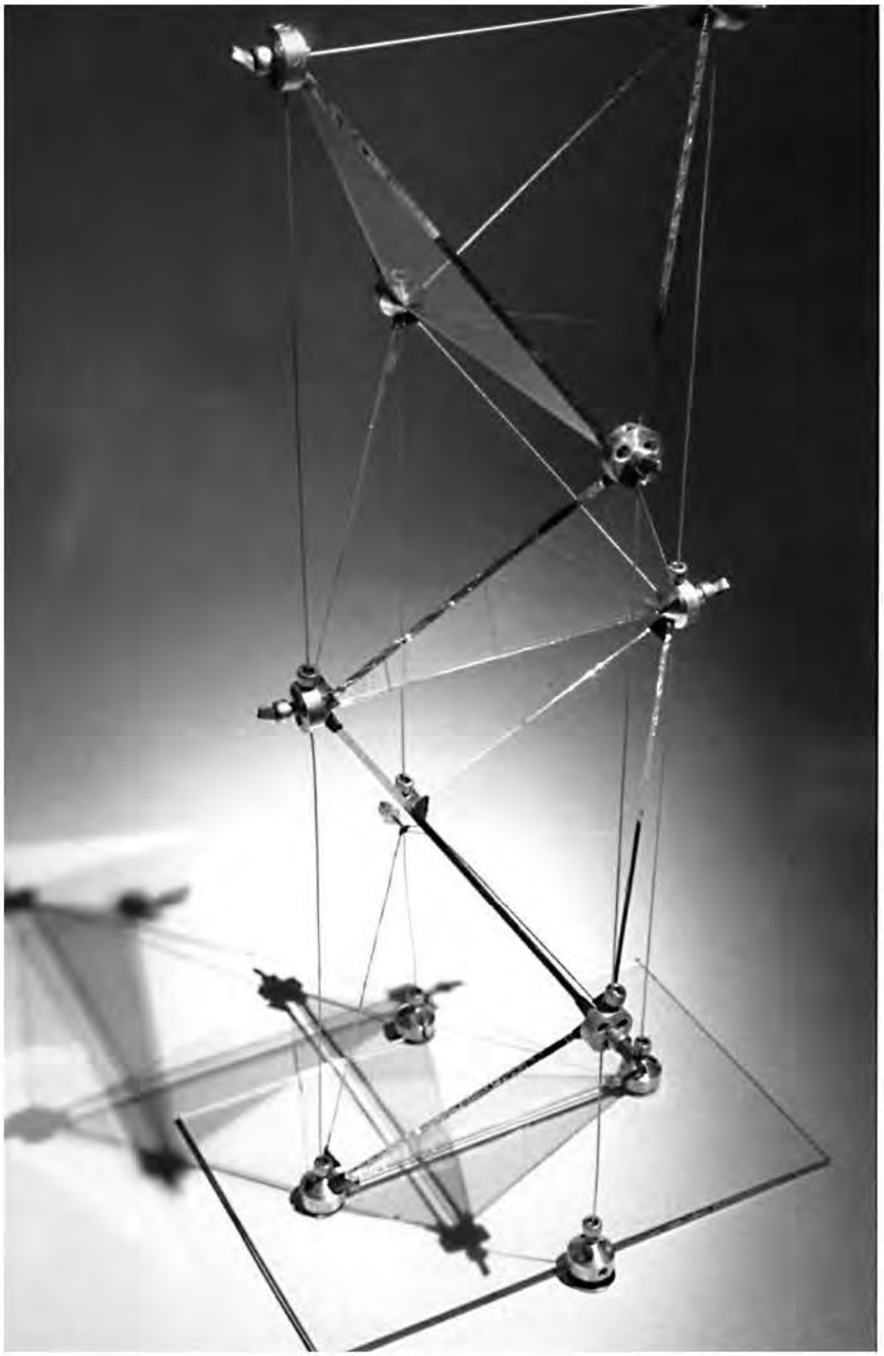


I was the shadow of the waxing slain
By the false azure in the window pane;
I was the smudge of ashen fluff—and I
Lived on, flew on, in the reflected sky.
And from the inside, too, I'd duplicate
Myself, my lamp, an apple on a plate:
Uncurtaining the night, I'd let dark glass
Hang all the furniture above the grass,
And how delightful when a fall of snow
Covered my glimpse of lawn and reached
up so
As to make chair and bed exactly stand
Upon that snow, out in that crystal land!

— Vladmir Nabokov
Canto One, Pale Fire

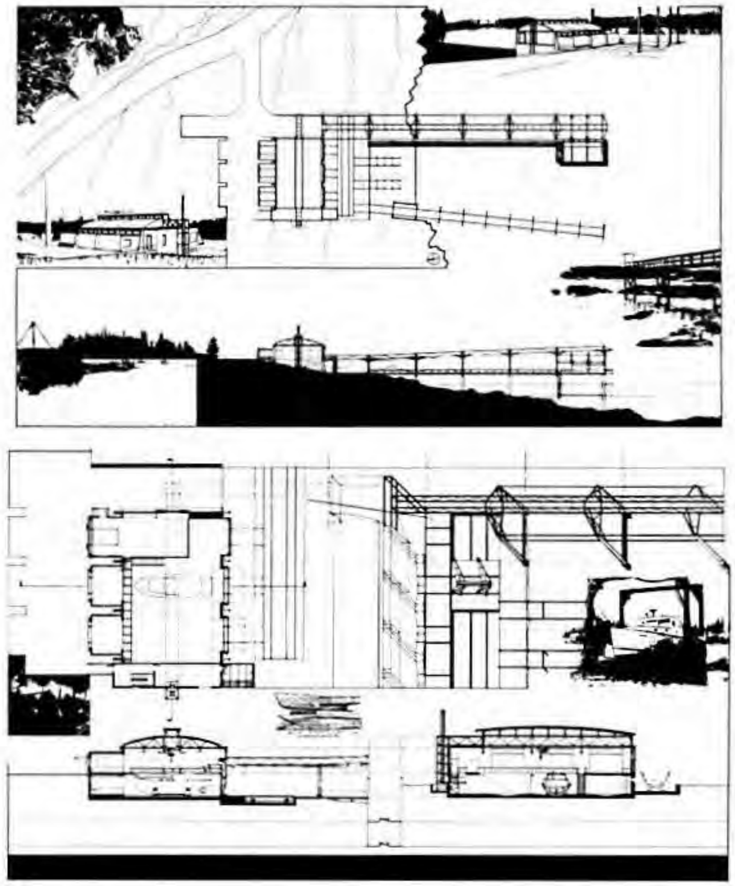
Joseph Jenkins
Glass Works
Alvaro Malo

Jonathan Traficonte

Boatyard for Repair and Maintenance of Wooden Hulled Fishing Vessels.

Critic: Alvaro Malo

THESIS, SPRING 92

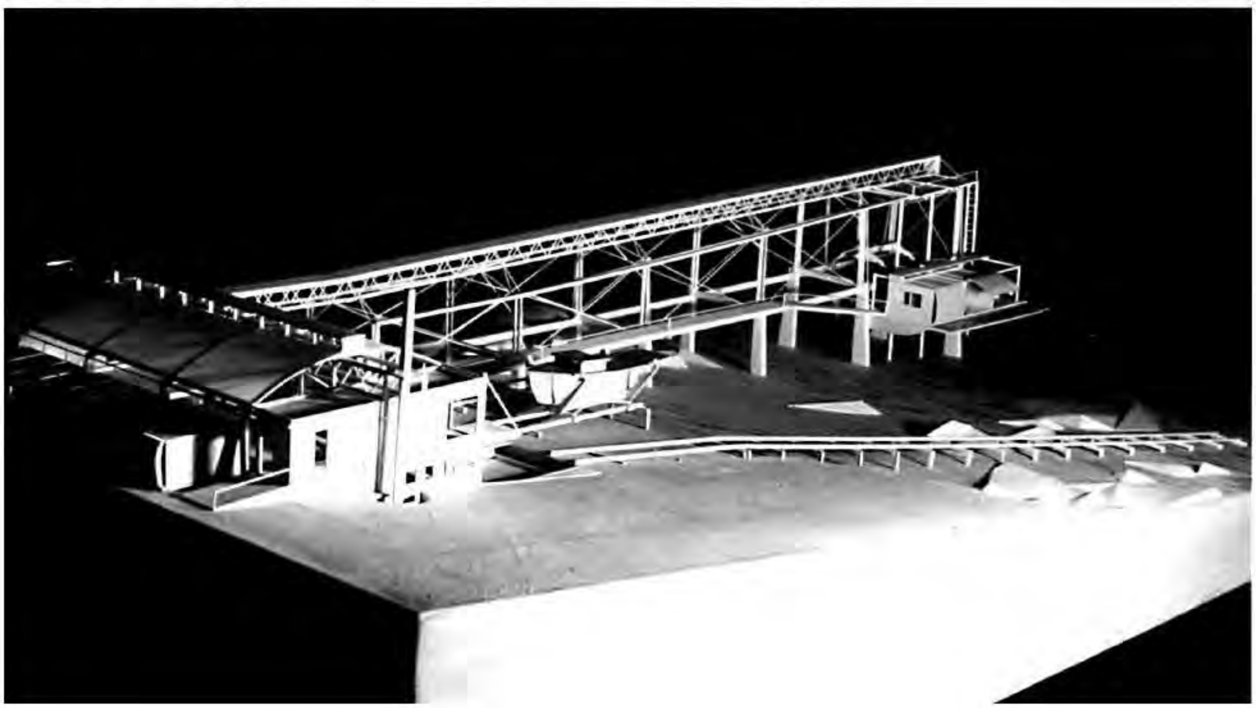


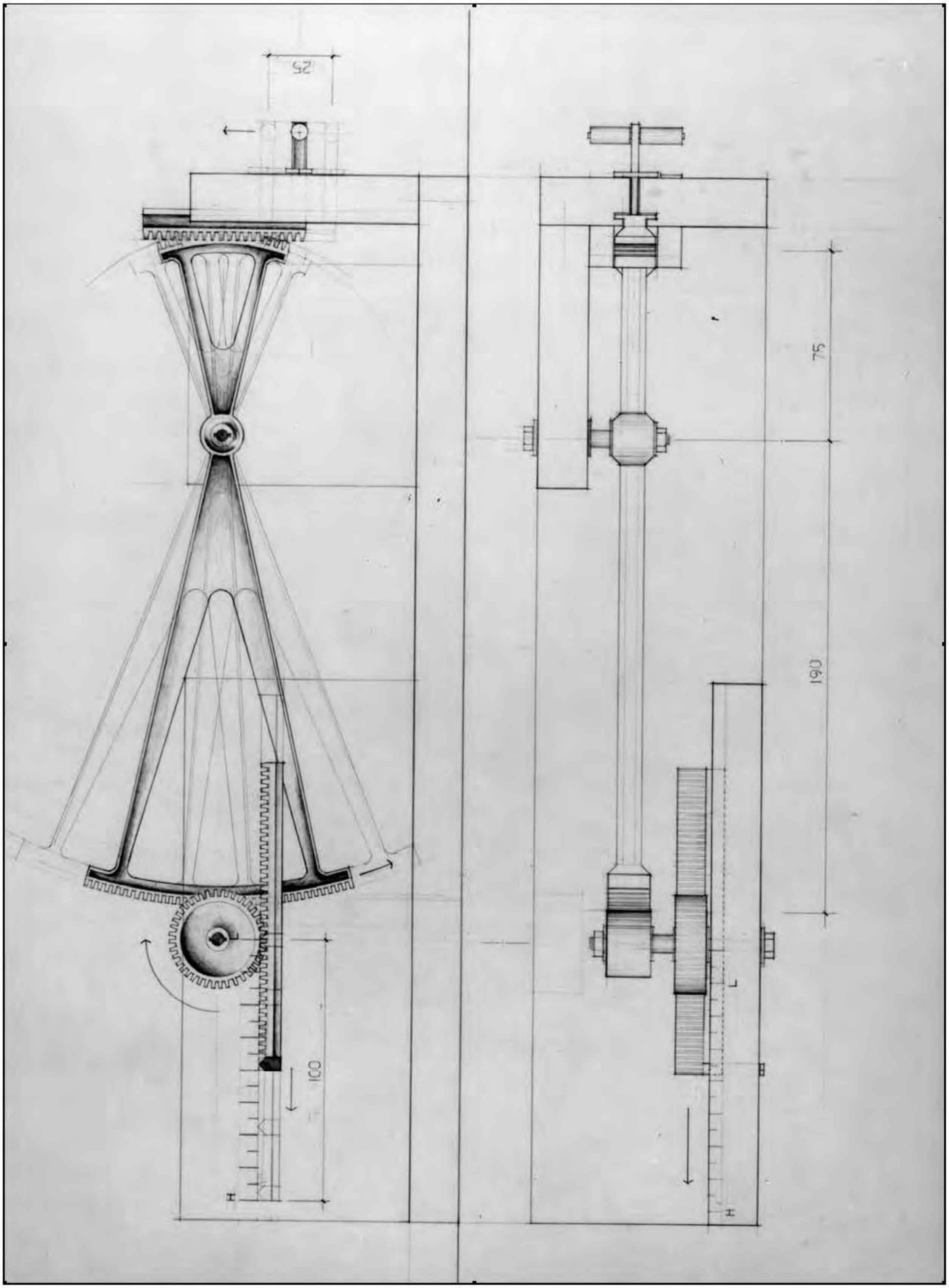
This project is an exploration into bridging the conceptual gap between change and permanence opened by Heraclitus and Parmenides.

This exploration manifested itself in the manipulation of natural, tidal, forces into an artificial, mechanical, advantage. Through this harnessing of forces the ability to bring distressed fishing vessels across the wide expanse of tidal flats into the boat yard for repair was made possible. In the end, the building became a mechanism spanning between the permanent granite coast line and the changing tidal condition.

—*Jonathan Traficonte*

(photos by the student)




25
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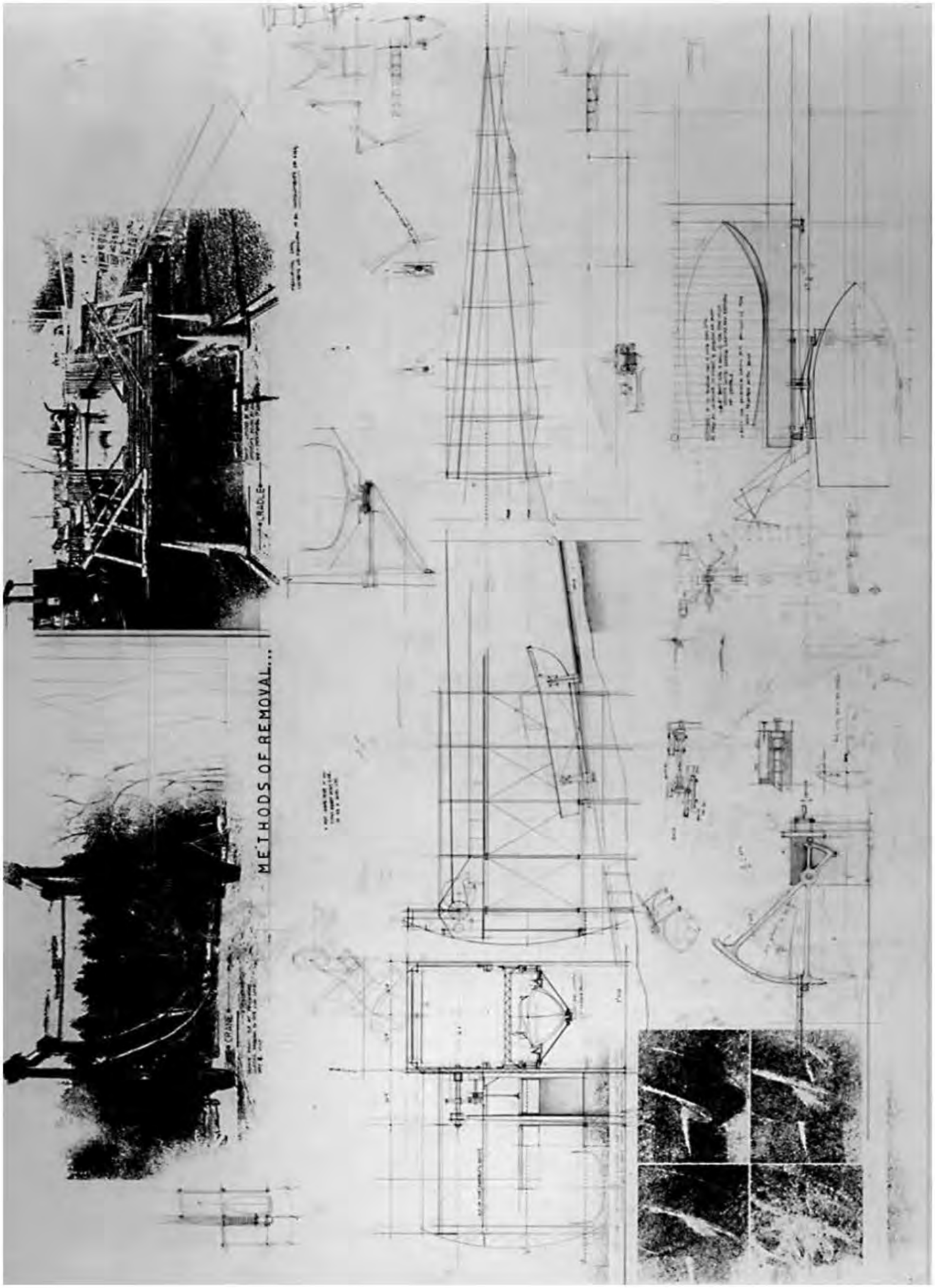

METHODS OF REMOVAL...
CRADLE
CRANE

1

2

Scaffoldings

Crtitics: Alvaro Malo & Dennis Pierattini

What is sufficient and necessary for construction?

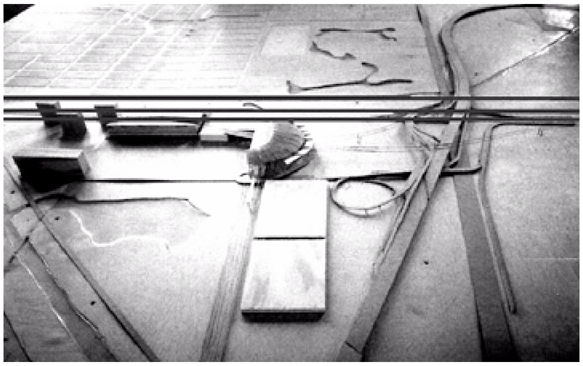
Understanding, concerning forms not as immutable entities, but formation as a dialectical process.

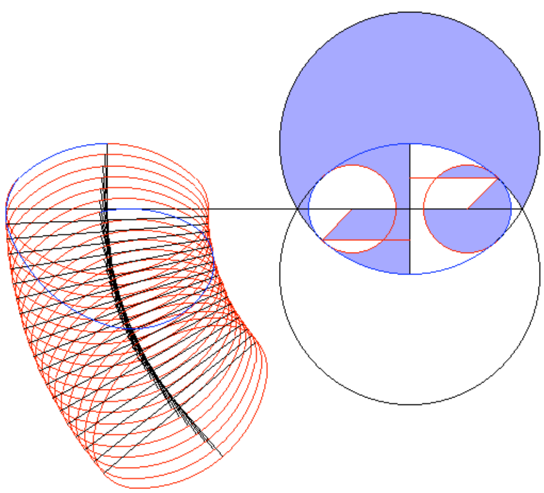
Making, as the metamorphosis of materials becoming instruments of human desire and dexterity.

Judging, what is interim and what is permanent in the functional and aesthetic exchange between material and memory.

Mitchell Fine 1, 2

TEACHING at FLORIDA



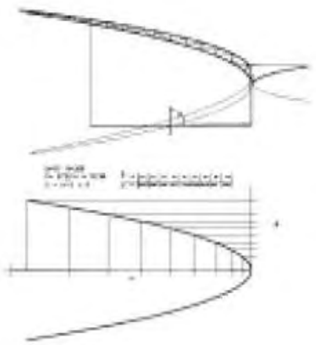


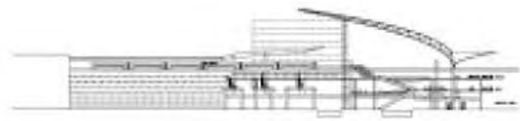
MIAMI INTERMODAL PROJECTS :
Miami Intermodal Center/ Miami International Airport
MIC • MIA

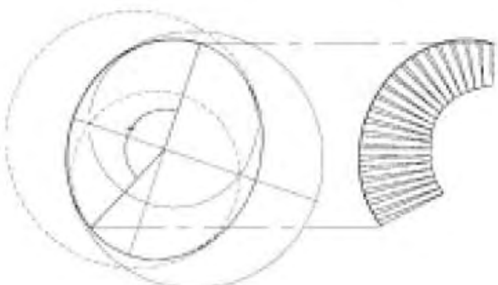
The MIC is to be considered as an *asymmetrical twin* of the MIA, handling the landside expansion of the airport, and a *grand central station*, collecting the regional and local train circulation, including Amtrak, Metro-Rail, Tri-Rail, E-W and Airport-Seaport Rail, MIC-MIA APM-Connector, and the proposed hi-speed rail Florida Overland Express (FOX), local public and private ground transportation, and possibly water-taxis.

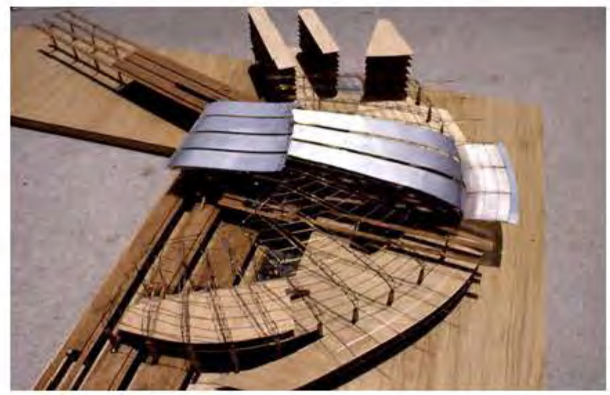
Principal Investigator: Álvaro Malo
Co-Investigator: Carlos Zapata

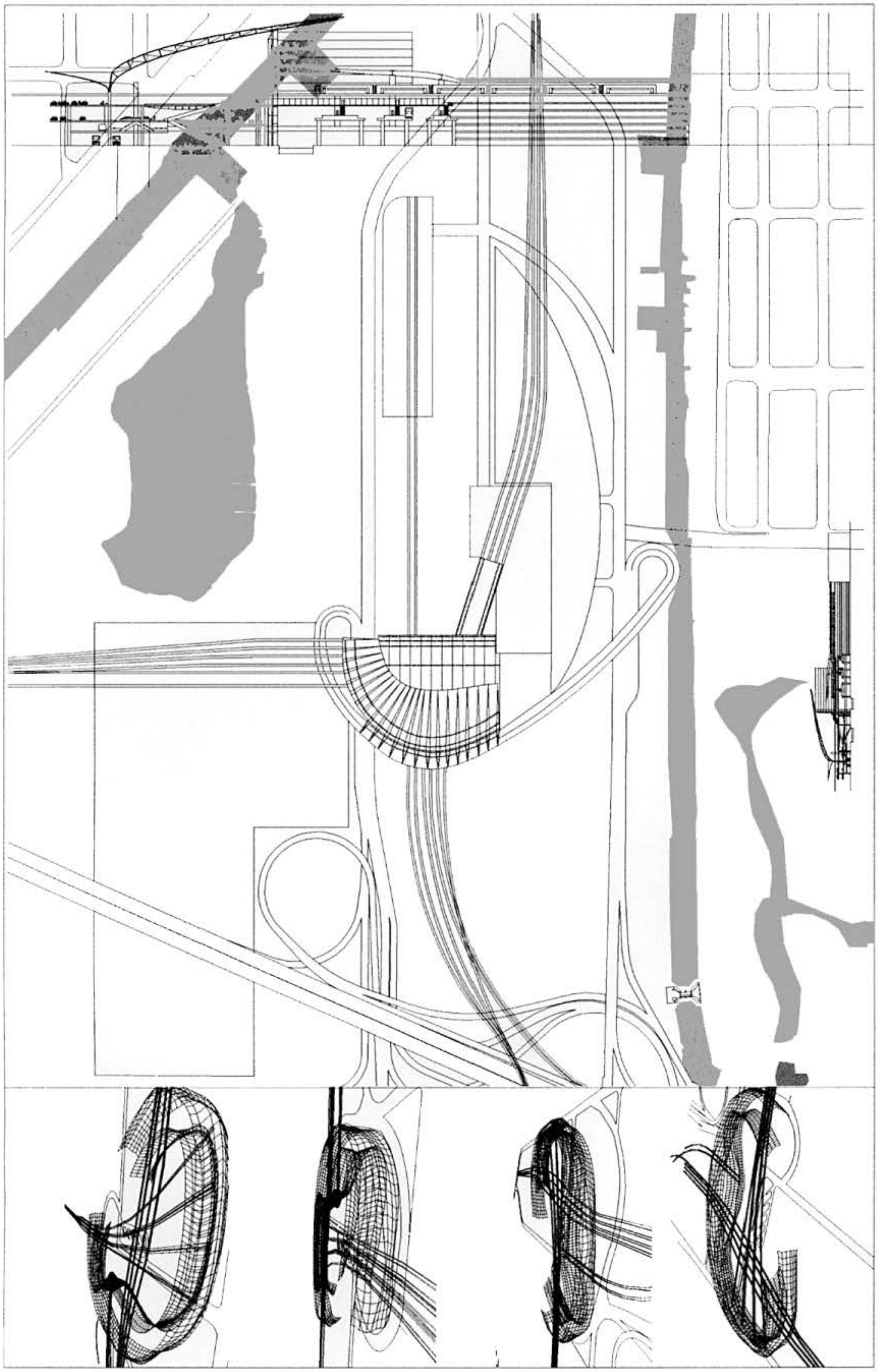
Research Assistant: Juan Linares





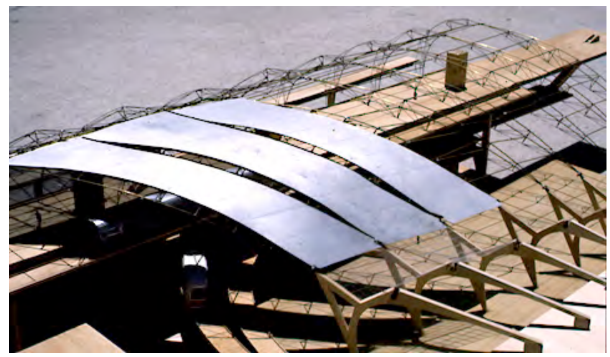






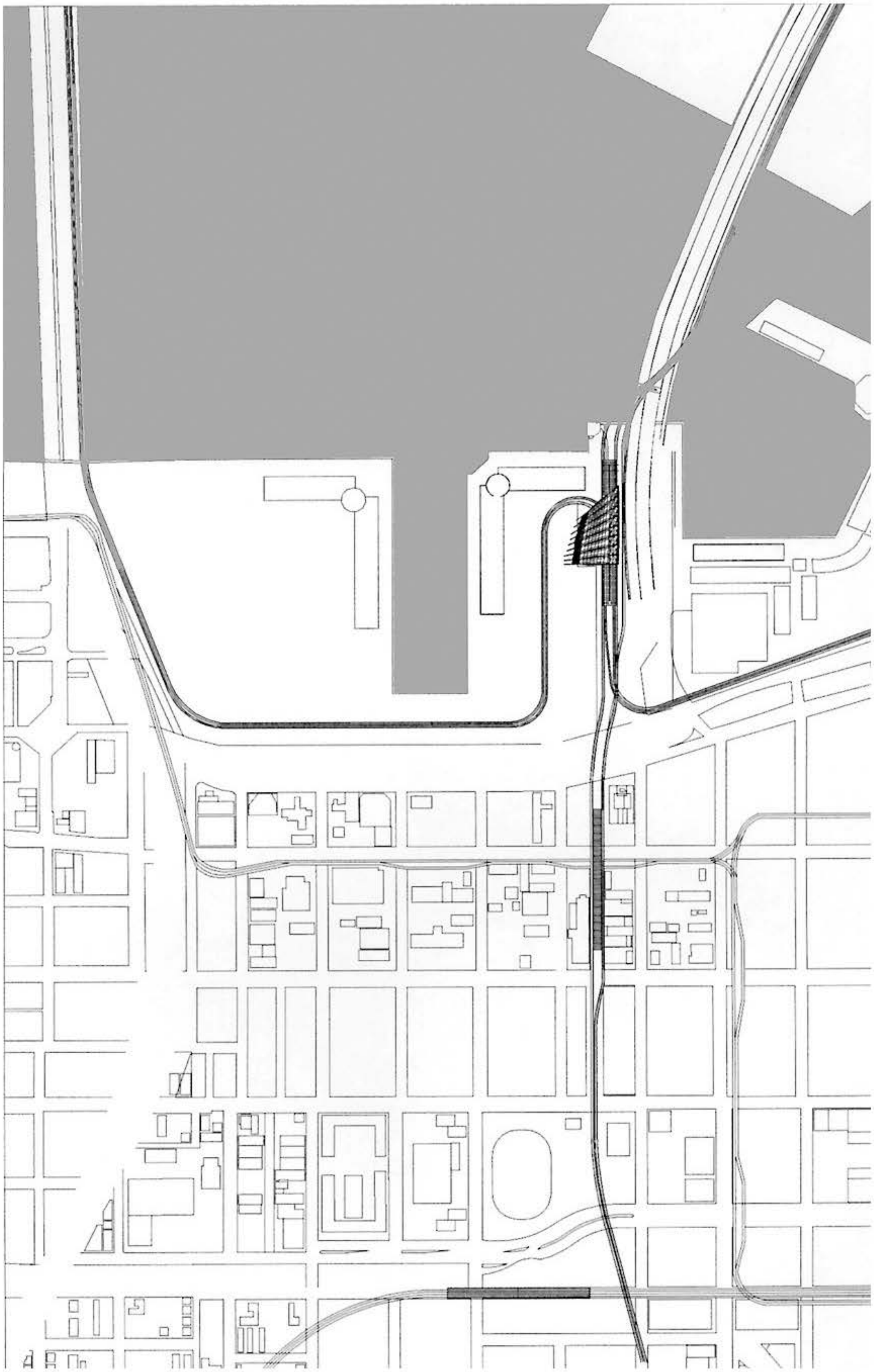
MIAMI INTERMODAL PROJECTS
Bayside Station

Boundaries are addressed at a series of levels, resulting in *similar differences* and *different similarities* : the perception of the elevated trains adjacent to the lagoons and over the river, the high platforms at the edge of the harbor and within view of the cruise ships refer to the vector of movement of each mode of transportation. The 600 foot long rail platform at 61 above sea level provides a 360° panoramic view of the harbor, amplifying the feeling of movement — through the water — by the spectacle of the ships anchored within walking distance.



Principal Investigator: Álvaro Malo
Co-Investigator: Carlos Zapata

Research Assistant: Eric Blumberg

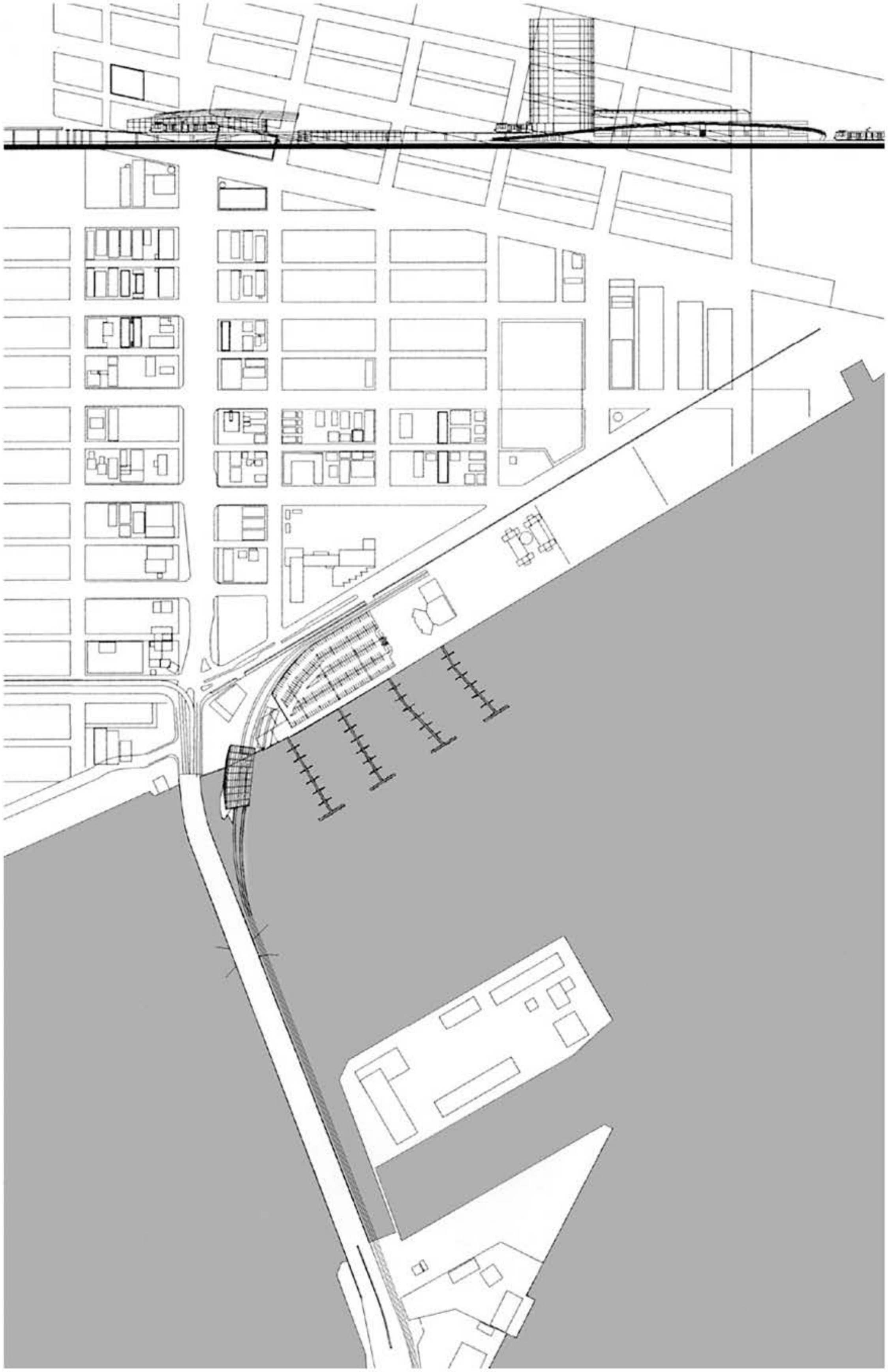


INTERMODAL PROJECTS
Miami Beach Gateway Station • Light-Rail

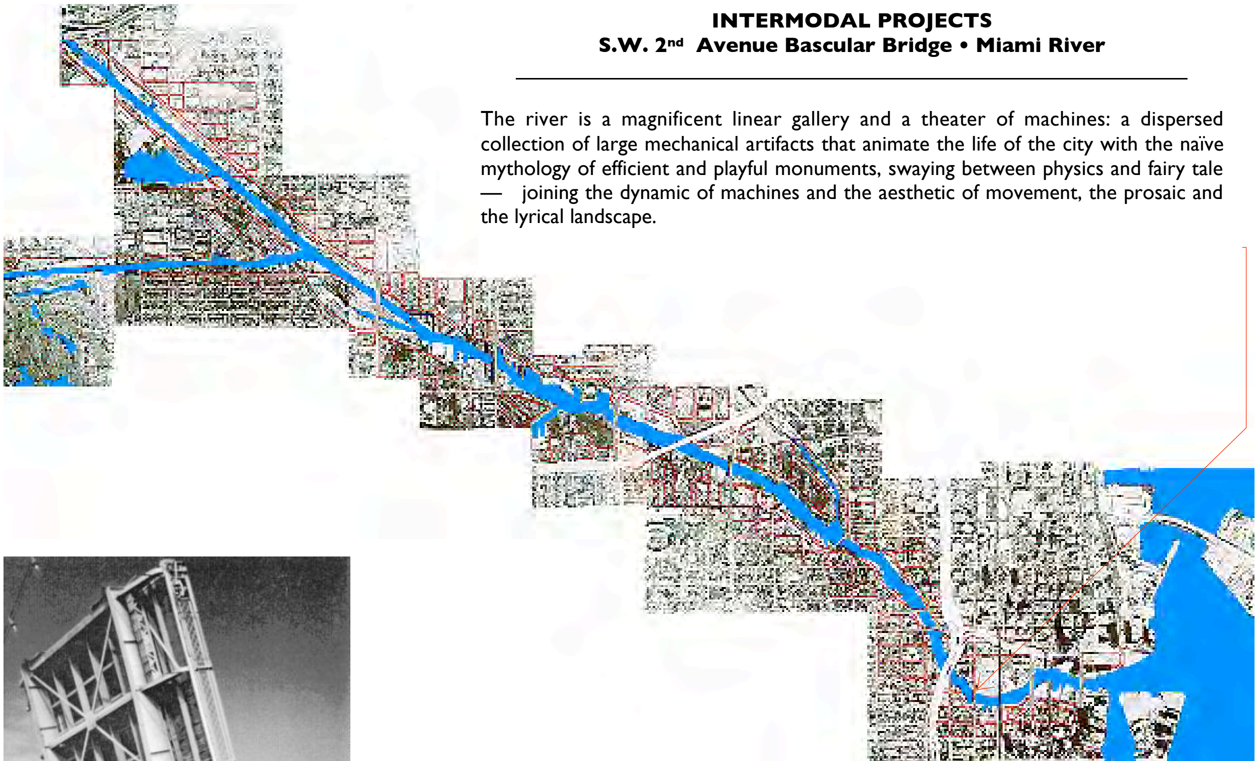
As a gateway to Miami Beach, the site has a privileged position at the edge of Biscayne Bay, permitting true intermodal connections between land and water based modes of transportation. The transparency of the light-rail, as it leaves the causeway and enters the beach, refers back to the vectors and inflections of intermodality: land to water, air to water, and land to air connections

Principal Investigator : Álvaro Malo
Co-Investigator : Carlos Zapata

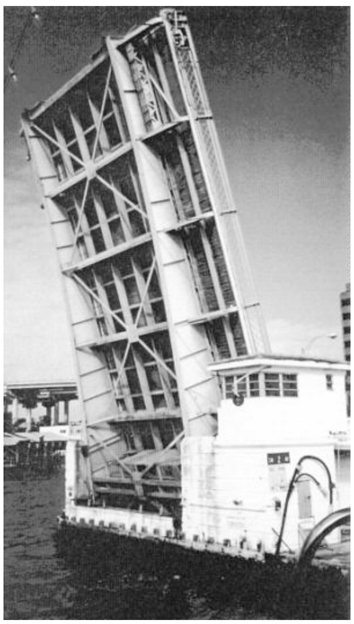
Research Assistant : Hamed Rodriguez



INTERMODAL PROJECTS
S.W. 2nd Avenue Bascular Bridge • Miami River

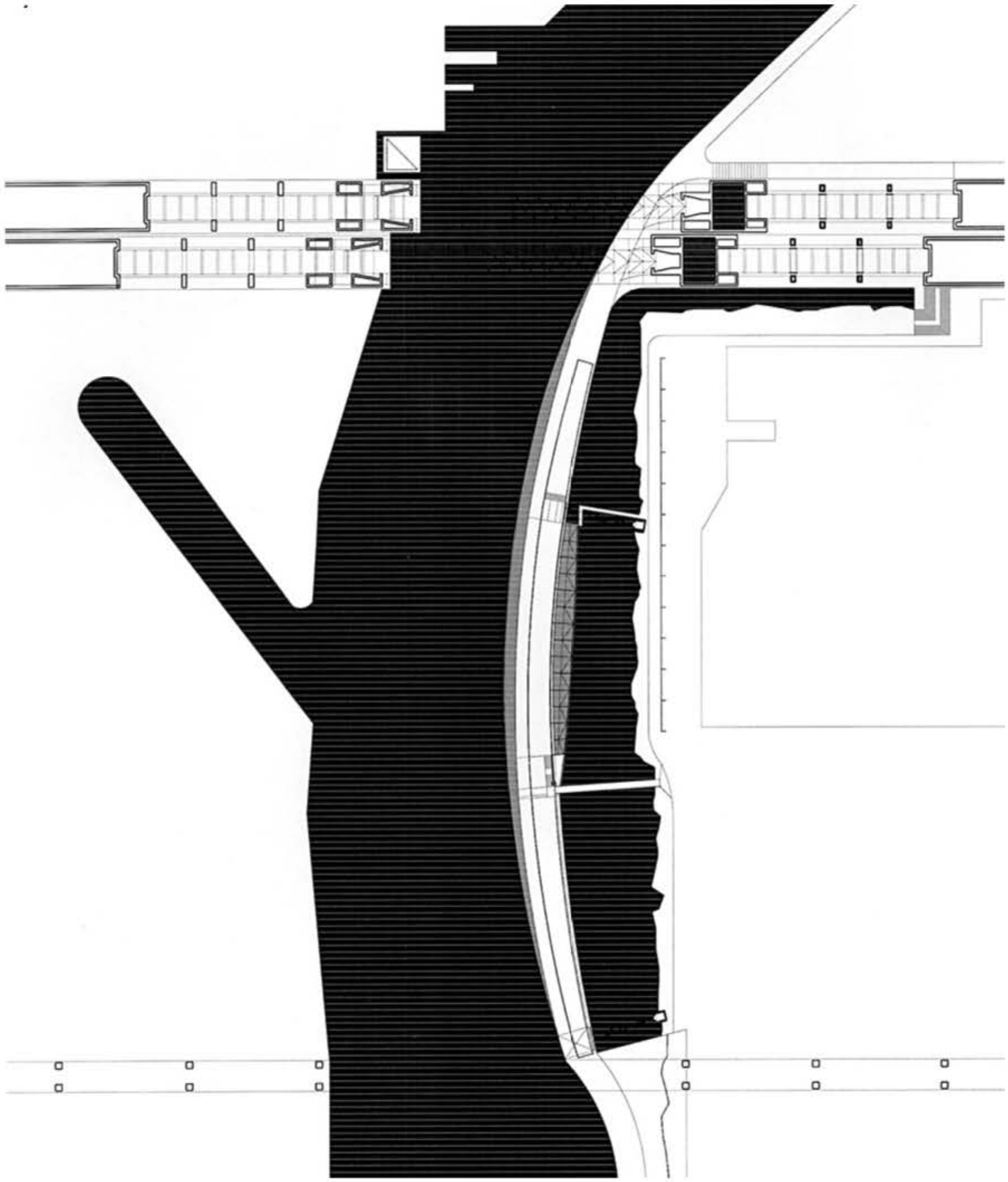


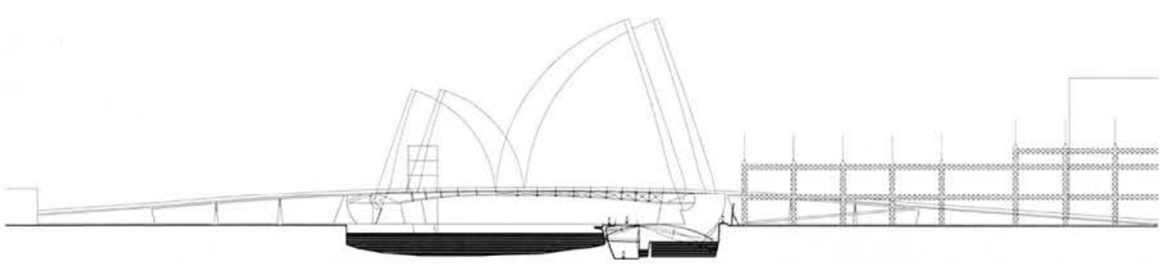
The river is a magnificent linear gallery and a theater of machines: a dispersed collection of large mechanical artifacts that animate the life of the city with the naïve mythology of efficient and playful monuments, swaying between physics and fairy tale — joining the dynamic of machines and the aesthetic of movement, the prosaic and the lyrical landscape.

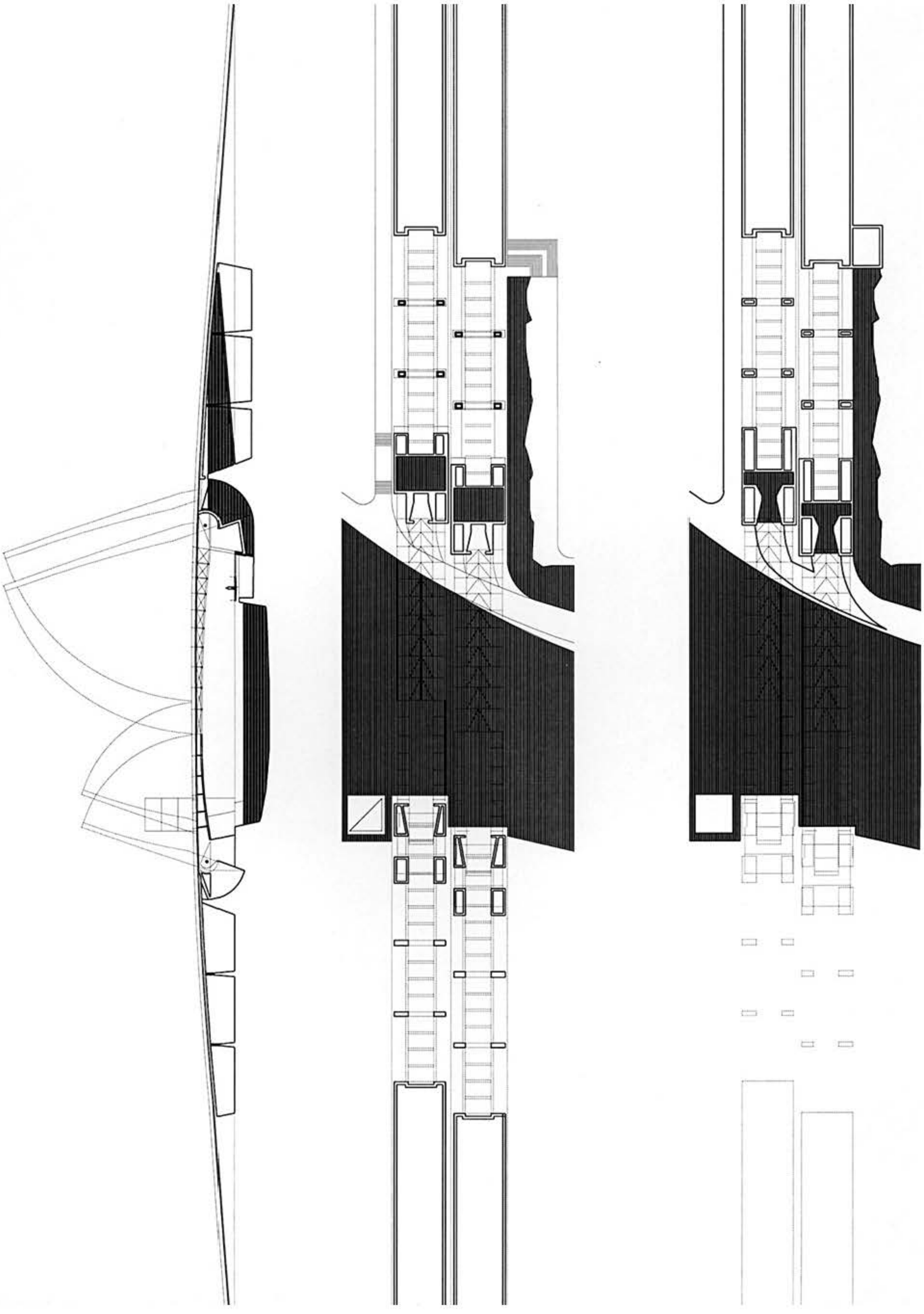


Principal Investigator: Álvaro Malo

Research Assistant: Trent Baughn



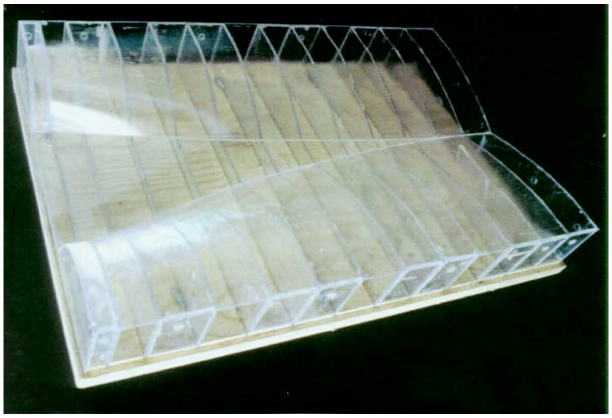




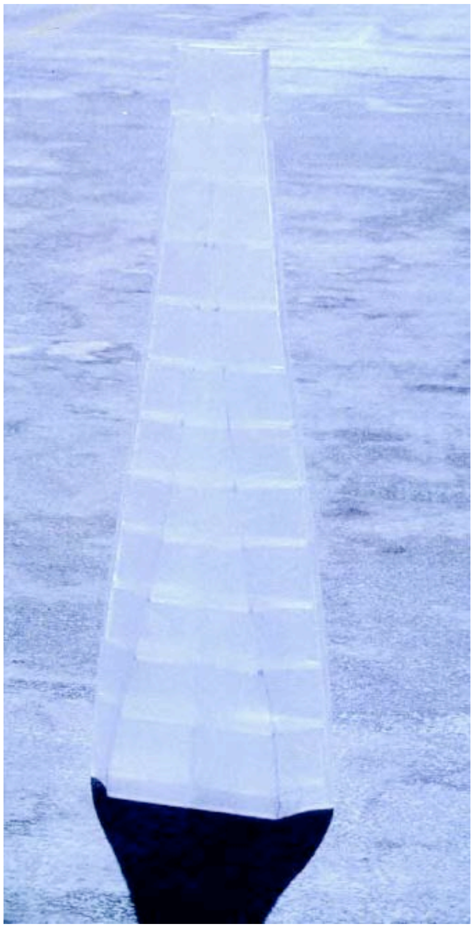
MIAMI INTERMODAL PROJECTS
Precast Post·Tensioned Concrete for Urban Transportation

• Technical intention: experiment with state-of-the-art techniques of reinforced concrete design and fabrication, using admixtures for increased strength, plasticity and durability.

• Aesthetic intention: aimed at liberating the physical structure and its spatial perception from expedient solutions, taking advantage of the fluency and potential visual elegance of the material.

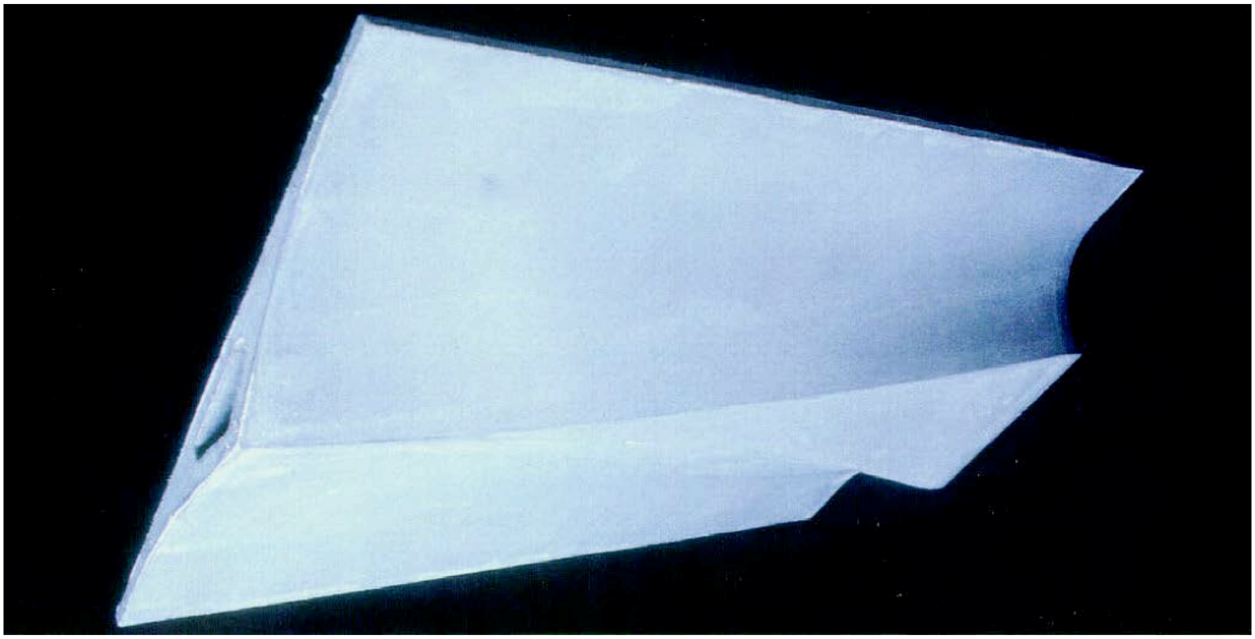


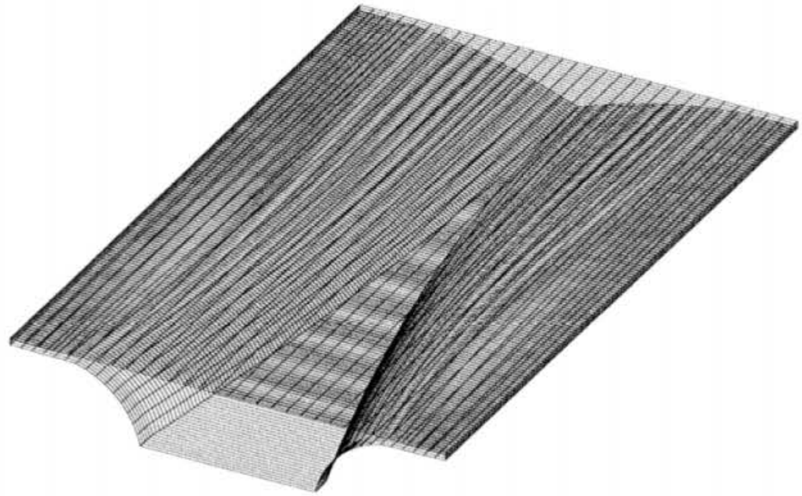
Plexiglas formwork, bottom pan.

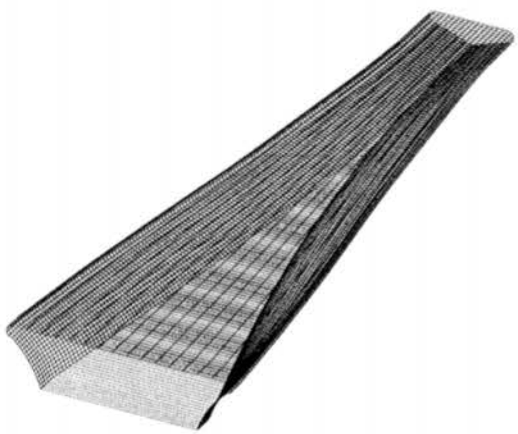


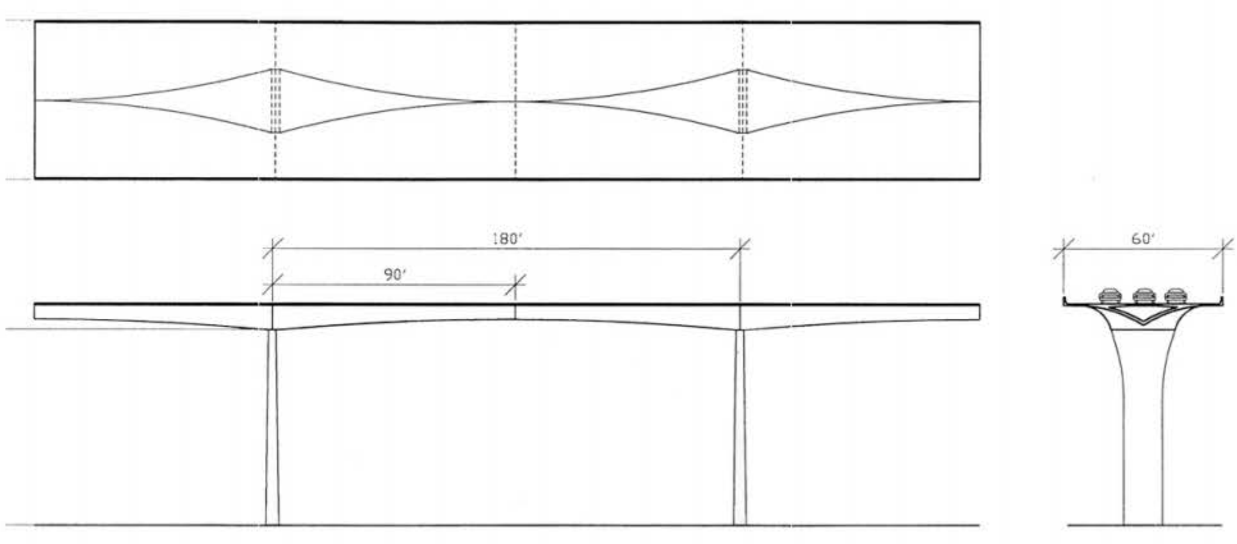
Principal Investigator: Álvaro Malo

Research Assistant: Trent Baughn







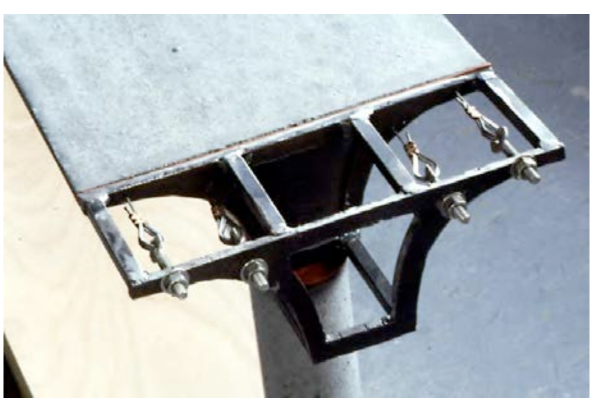

180'
90'
60'

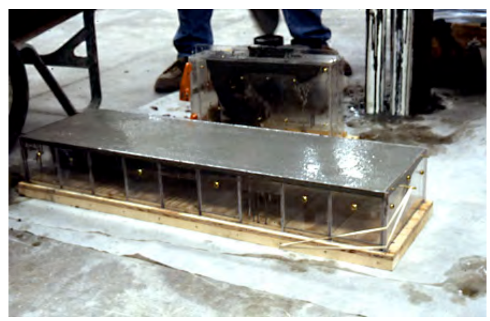
MIAMI INTERMODAL PROJECTS

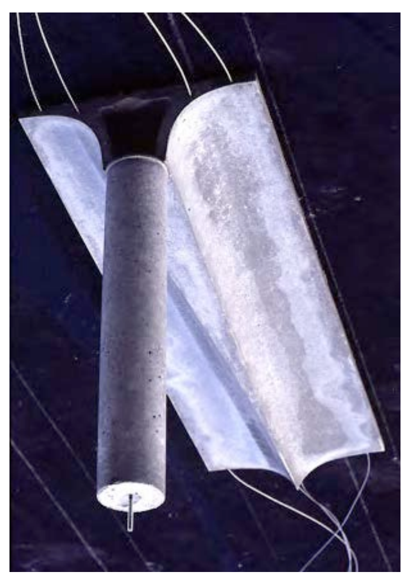
Airport·Seaport Elevated Train Post·Tensioned Guideway

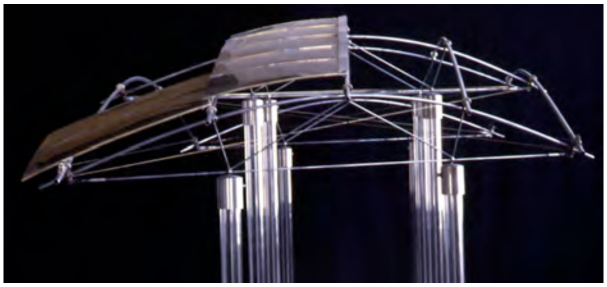
- Technical intention: experiment with continuous post-tensioning techniques of reinforced concrete design.
- Aesthetic intention: streamlining of structural profiles.

Principal Investigator:	Álvaro Malo
Research Assistant:	J.J. Bruyning









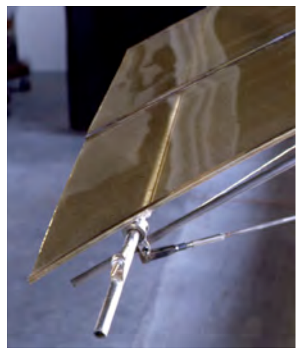
MIAMI INTERMODAL PROJECTS
Train Station : steel, glass and photovoltaic canopy

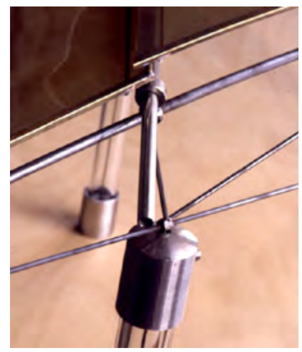
The surface of the station canopy is configured structurally in response to wind flow, rainfall and longitudinally adapted to the vector of movement of trains.

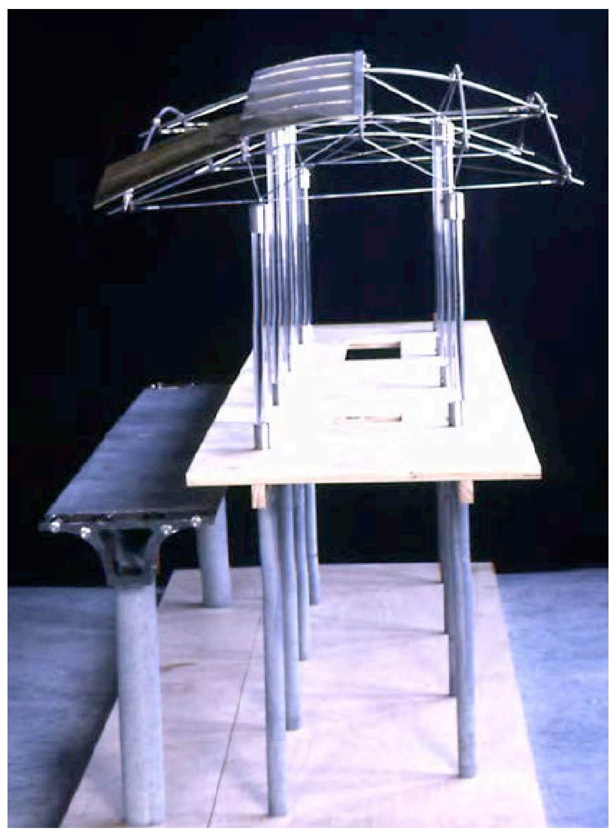
The material use is experimentally and aesthetically aimed at natural lighting, ventilation, acoustics and perceptual lightness.

Principal Investigator: Álvaro Malo

Research Assistant: J.J. Bruyning





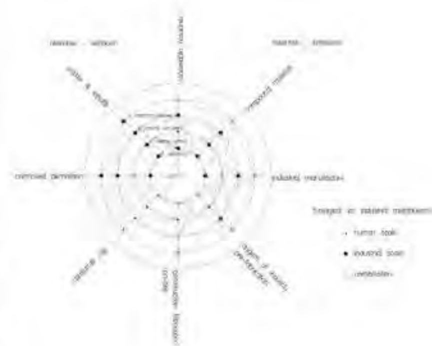


TEACHING at ARIZONA

eco_clean dwelling

_small scale housing typology
_bamboo + plastic as materials
_site responsive
_ low embodied energy
_cradle to cradle

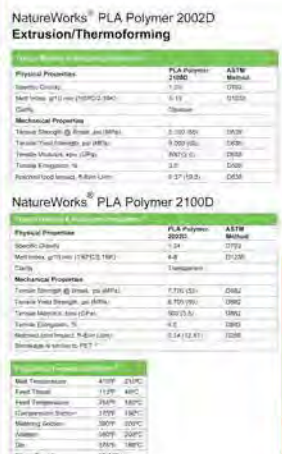
Material	Competing Family	Biodegradable	Inert	Chemical Composition	Low Embodied Energy	Off-gassing	Renewable	Cross-sectional Capacity
Infill								
Polylactic Acid	Polystyrene	Yes	No	Dextrose	Yes- Windmill power	No	Yes	Tensile
Polylactic Acid Fiber	Cotton	Yes	No	Dextrose	Yes- Windmill power	No	Yes	Tensile
Wool	Synthetics	Yes	No	Animal	Yes- Hand tools	No	Yes	Tensile
Plyboo	Plywood	Mostly	No	Bamboo, soy-resin	Mostly- petroleum machinery	No	Yes	Compressive
Earth brick	Ceramica veneer	Yes	No	clay dirt, fine gravel, coffee grind, water	Yes- If Unbaked-hand tools	No	Yes	Compressive
Paper-crete	NA	Mostly	No	paper, cardboard, cement, water	Yes- If Unbaked-hand tools	No	Mostly	NA
Cork	Ceramic Tile	Yes	No	Cork tree bark	Mostly- petroleum machinery	No	Yes	NA
Lime Plaster	Stucco	Yes	No	Gypsum water	Yes- Hand tools	No	Yes	Compressive
Earth bag	Earth bag	Yes-PLA Bag	No					
Structural								
Bamboo	Wood/Steel	Yes	No	Grass	Yes- Hand tools	No	Yes	Compressive
Eco-timber	Wood	Yes	No	Wood from Managed Forest	Mostly- petroleum machinery	No	Yes	Compressive
Paper Tubes	Wood/Steel	Mostly	No	Paper, concrete, adhesives	Mostly- petroleum machinery	No	Mostly	Compressive
Pressed earth	CMU	Mostly	No	clay dirt, fine gravel, coffee grind, water	Yes- If Unbaked-hand tools	No	Mostly	Compressive
Adhesives								
Natural Rubber	Silicone/ Resin/ Epoxy	Mostit		latex, water	Mostly- petroleum machinery	No	Yes	Mechanical
Soy-resin	Silicone/ Resin/ Epoxy	Yes	No	soy dextrose, water	Mostly- petroleum machinery	No	Yes	Mechanical
Inherent								
	heating/melting	NA	NA		Yes- Hand tools	NA	NA	Mechanical
	joinery				Yes- Hand tools	NA	NA	Mechanical
	-friction fitting							



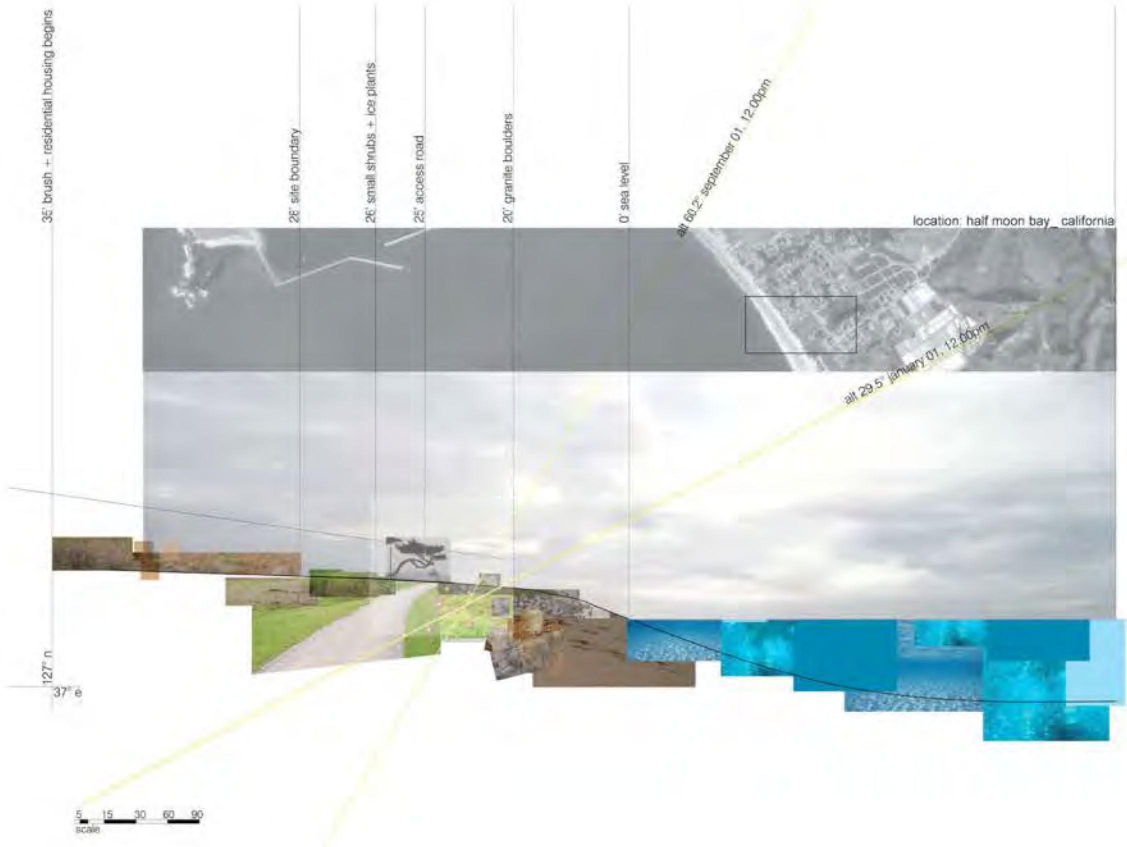
bamboo_structural

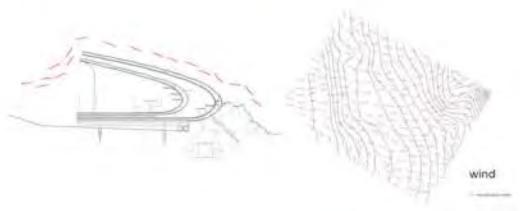
Building material	Energy of production MJ/kg	Density kg/m³	Energy of production MJ/m³	Stress kN/cm²	Relationship energy per unit stress
(1)	(2)	(3)	(4)	(5)	(4)/(5)
Steel	30.0	7800	234 000	1.600	150 000
Concrete	0.8	2400	1920	0.080	24 000
Lumber	1.0	600	600	0.075	8 000
Bamboo	0.5	500	300	0.100	3.000

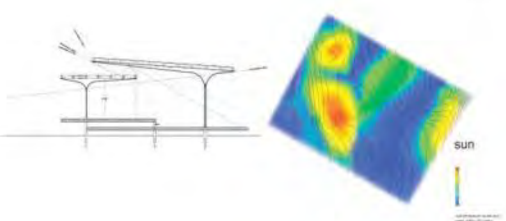
polylactic acid plastic_ infill

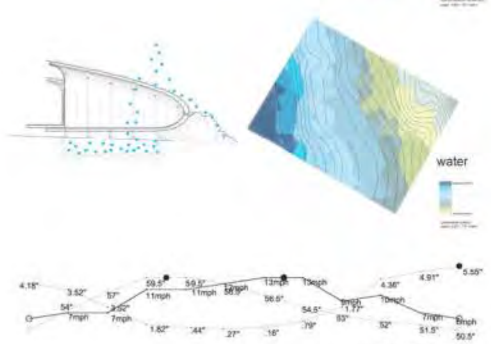


Melody Rees
ARC 452 – Capstone, Spring 2007

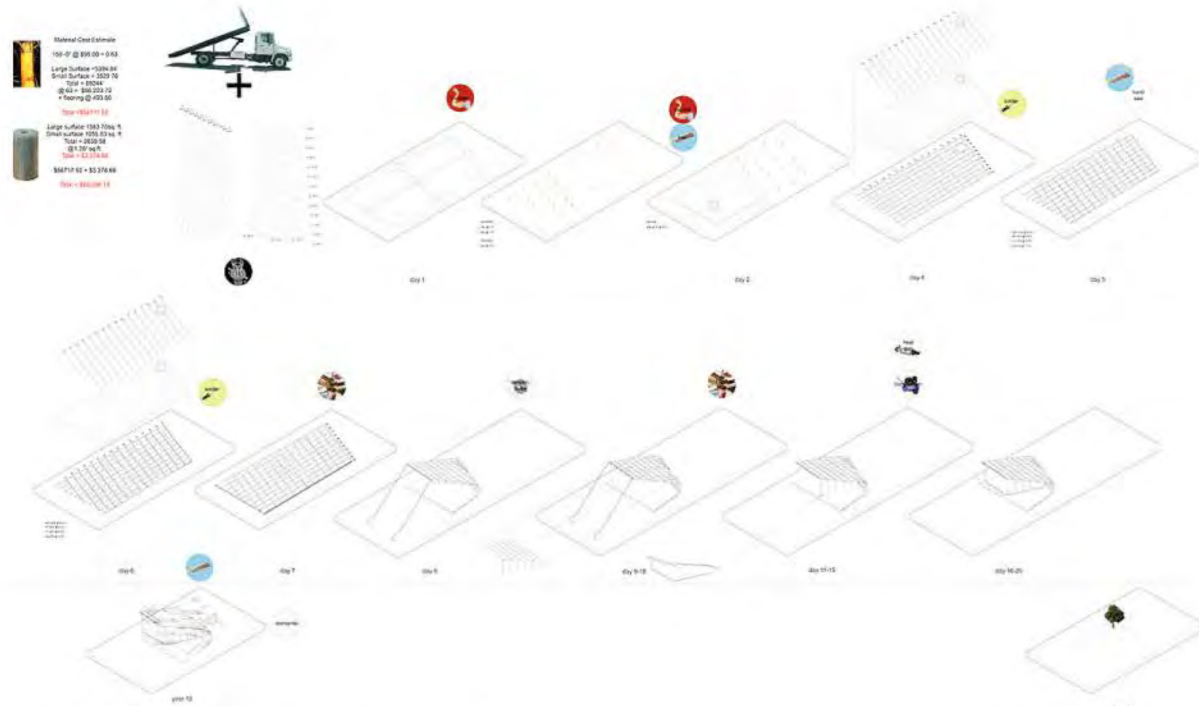

35' brush + residential housing begins
28' site boundary
26' small shrubs + ice plants
25' access road
20' granite boulders
0' sea level
alt 60.2° september 01, 12.00pm
alt 29.5° january 01, 12.00pm
location: half moon bay_ california
127° n
37° e
5 15 30 60 90
scale

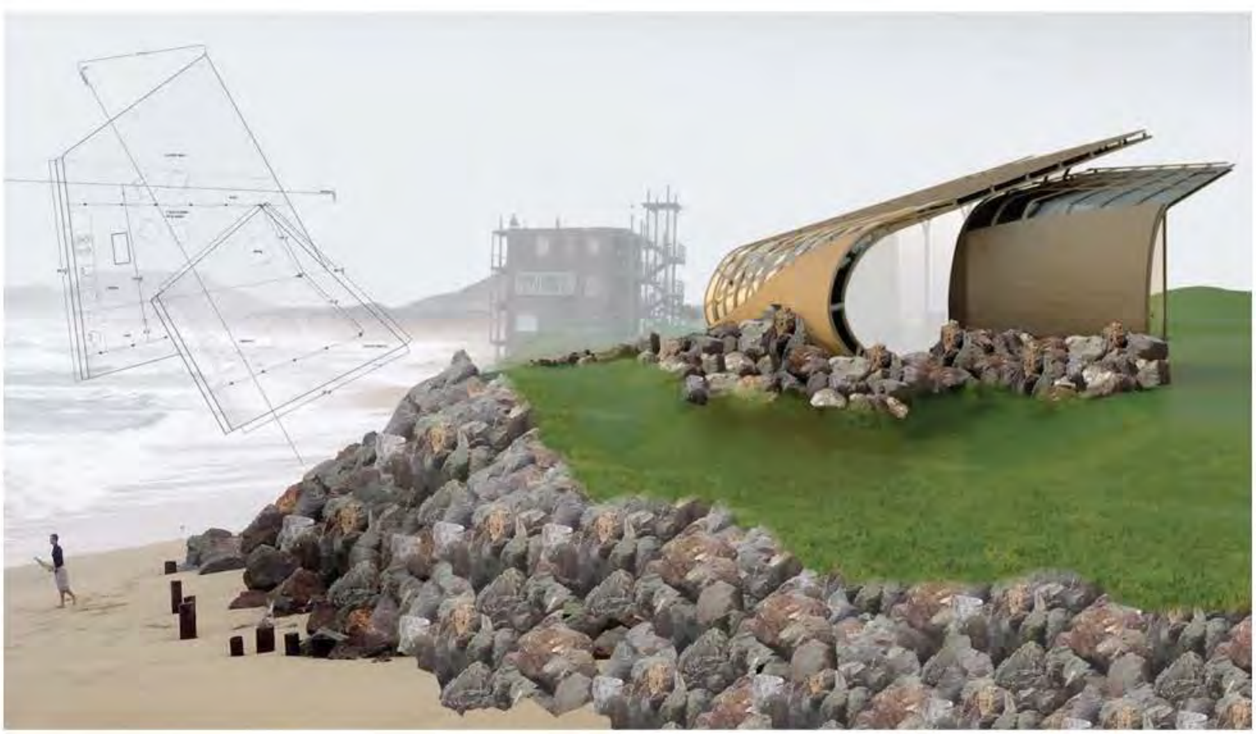

wind

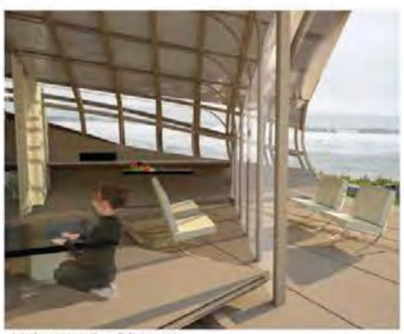

sun


water


wind speed_ mph
temperature_ F°
precipitation_ inches



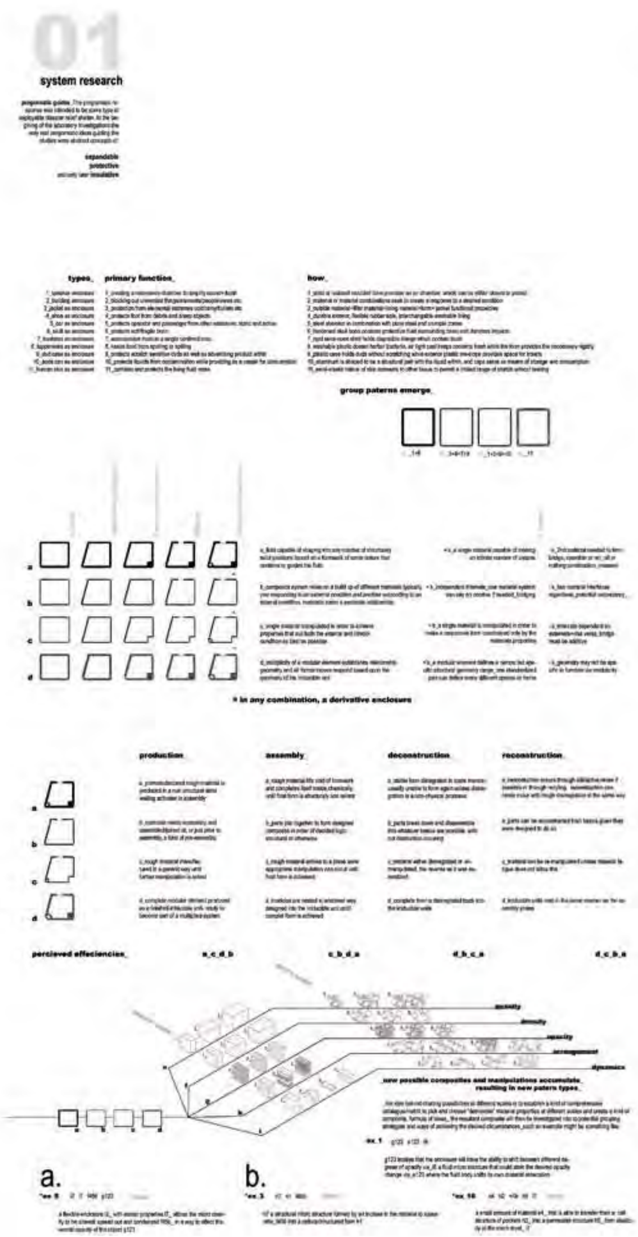




interior perspective_ living space

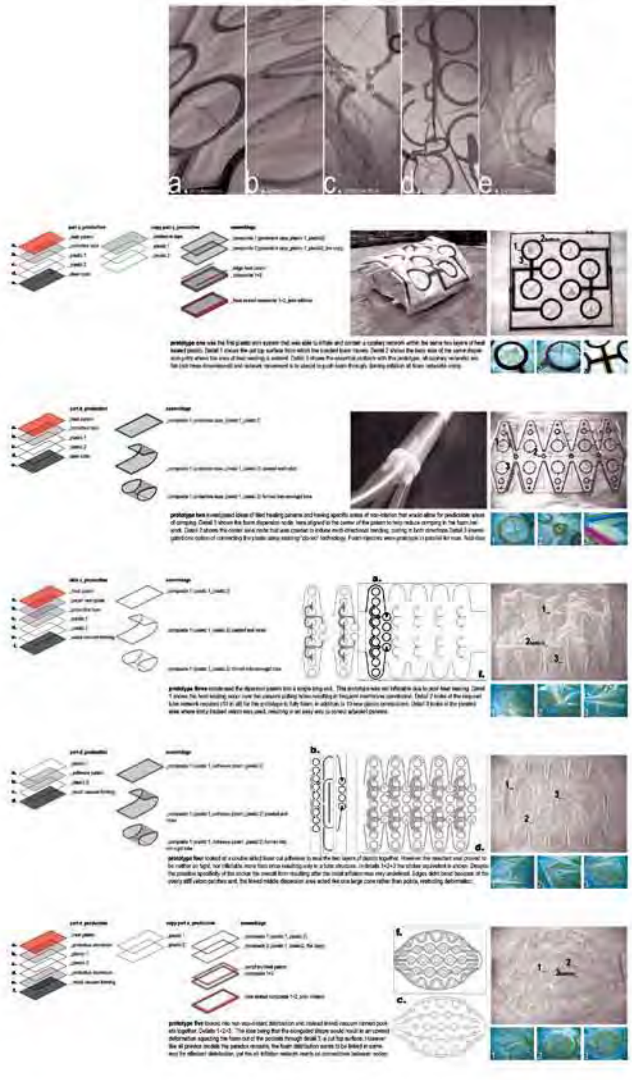
interior perspective_ bedroom space

1:1 detailing for material
assembly and control of light

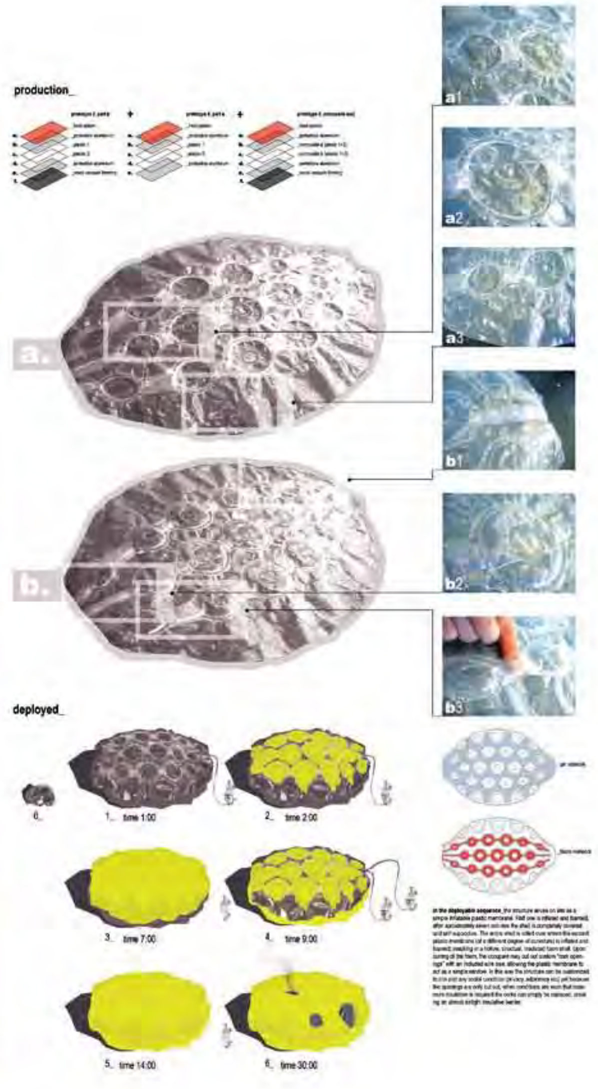


Trevor Watson
ARC451 - Emerging Material Technologies Lab, Fall '07

03
prototype research



04
prototype 6 +
logistics/deployment

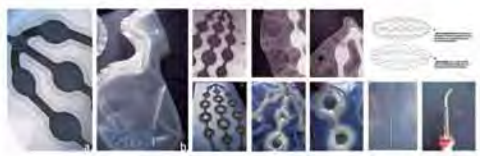


05
material manipulation+ through method refinement

semester one unresolved issues_

1_the inflatable_

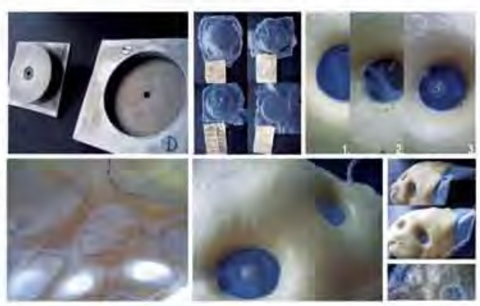
2_foam exposure_

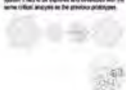


3_adhesive surface_

4_aperture+the shell_

5_however_





06
double layer method+ logics

simple bag with lip_

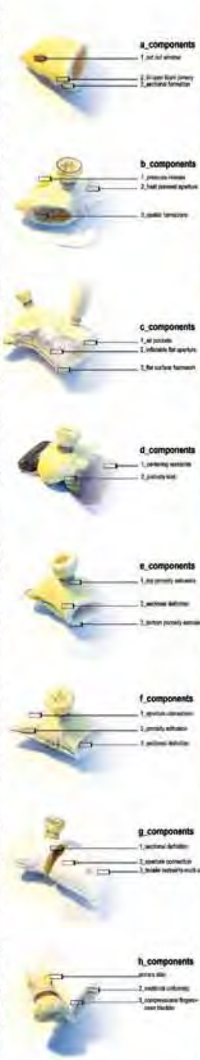
double inflatable with heat pressed aperture_

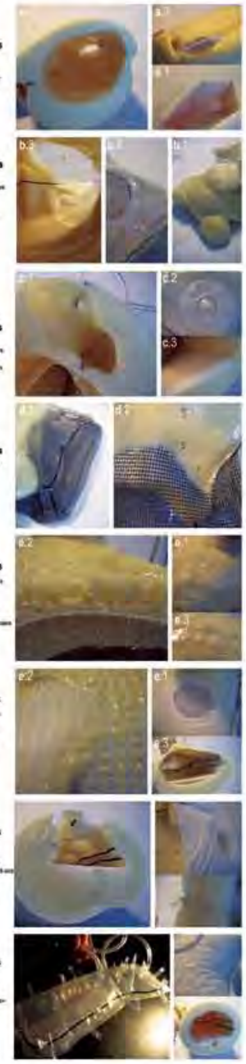
air permeable outer skin(1)+restrained inner bladder(1)_

air permeable outer skin(2)+restrained inner bladder(1)_

air permeable outer skin(3)+restrained inner bladder(1)_

air permeable outer skin(3)+restrained inner bladder(2)_

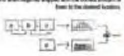




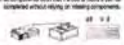
07
the scenario+ proposed response

application_

fabrication_

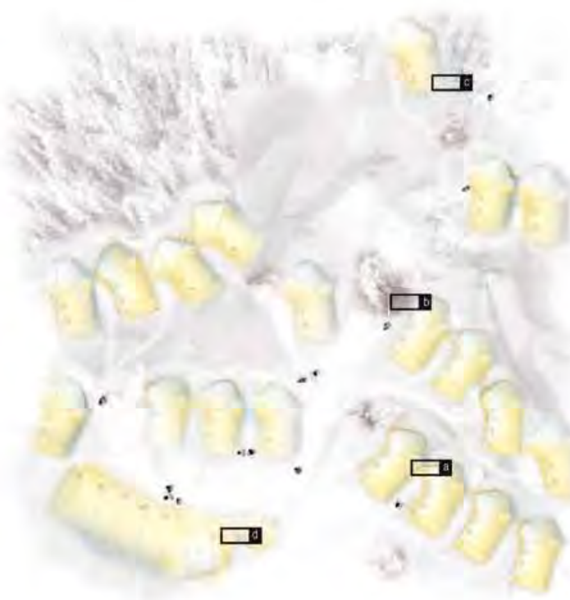


shipping_



construction_

08
positioning+formative base relationships



09
construction phasing + logics

1 unpacking+positioning
phase_a_time 00h00m00s

2 inflation
phase_b_time 00h10m00s

3 mixing+pouring
phase_c_time 00h15m00s

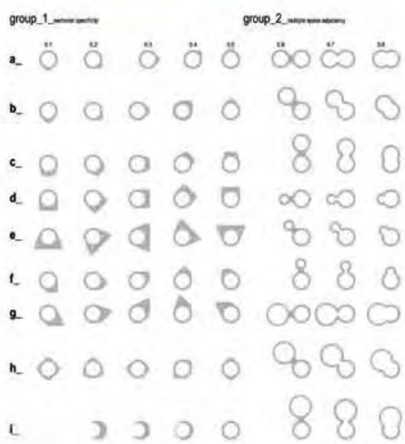
4 foaming+expansion
phase_d_time 00h17m00s

5 expansion+solidification
phase_e_time 00h18m00s

6 solidification+habitation
phase_f_time 01h00m00s

10

system potentials+
new derivative logics



spatial logics_

Now that a functioning system exists, it needs to be taken back through a new combinatory matrix such that new SYSTEM SPECIFIC spatial relationships can be derived and tested for potential application. The diagrams below are the start of what is to come in the systems development. Sectional specificity and the relationships between multiple adjacent spaces will be investigated to further the new enclosure system's response. Grouping units together to make spaces on sharing partitions makes more efficient use of material, and seems appropriate on some levels to apply to the intended cold climate response. The idea of a more specific section also seems to make sense with regards to the system. Sectional specificity is relatively easy to achieve simply by increasing the length of the tubes pressing on the inside of the air permeable layer, at specific points. Sectional specificity can begin biasing form towards more thermally active zones, and can also begin effecting the outside space where overhangs are now a possibility. Interior specificity is also now addressable. Inflatable interior forms seem appropriate to system logic, allowing one space to be actively configurable dependent on desired use. Additionally, flat panels are able to establish beneficial surfaces within the inflated bladder.

University of Arizona, College of Architecture - Tucson, United States

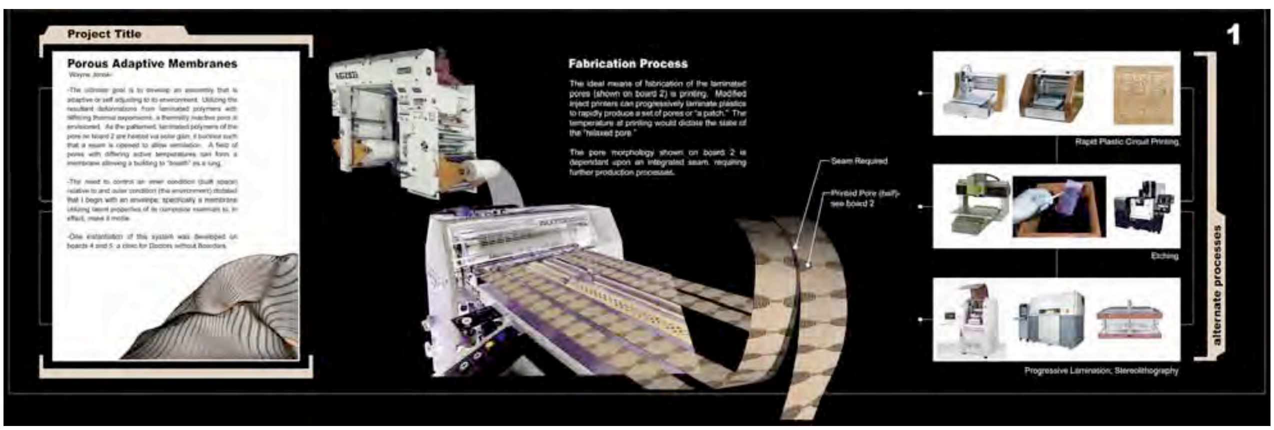
Project by: Wayne A. Jenski

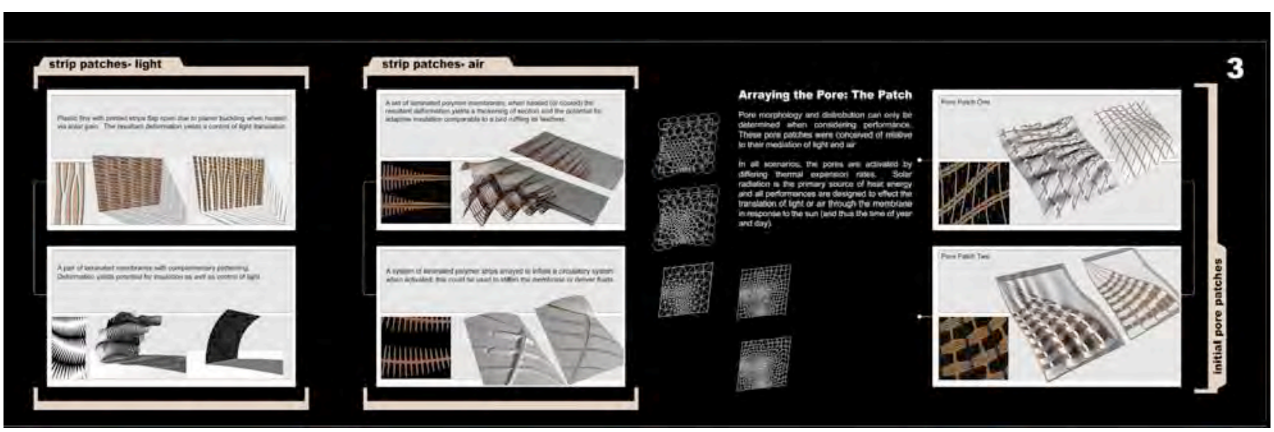
Tutors: Álvaro Malo, Peter Testa, Dale Clifford

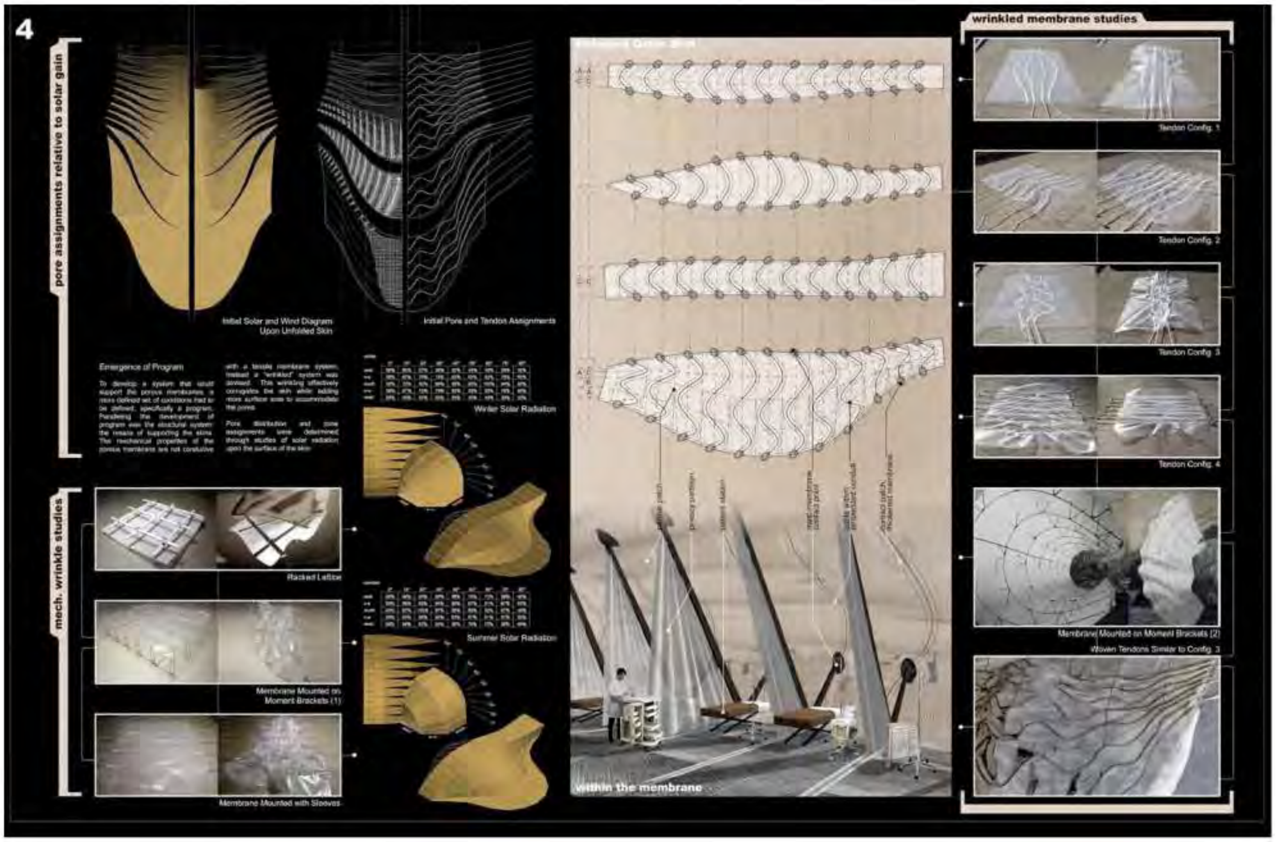
http://www.archiprix.org/2009/?project=2279

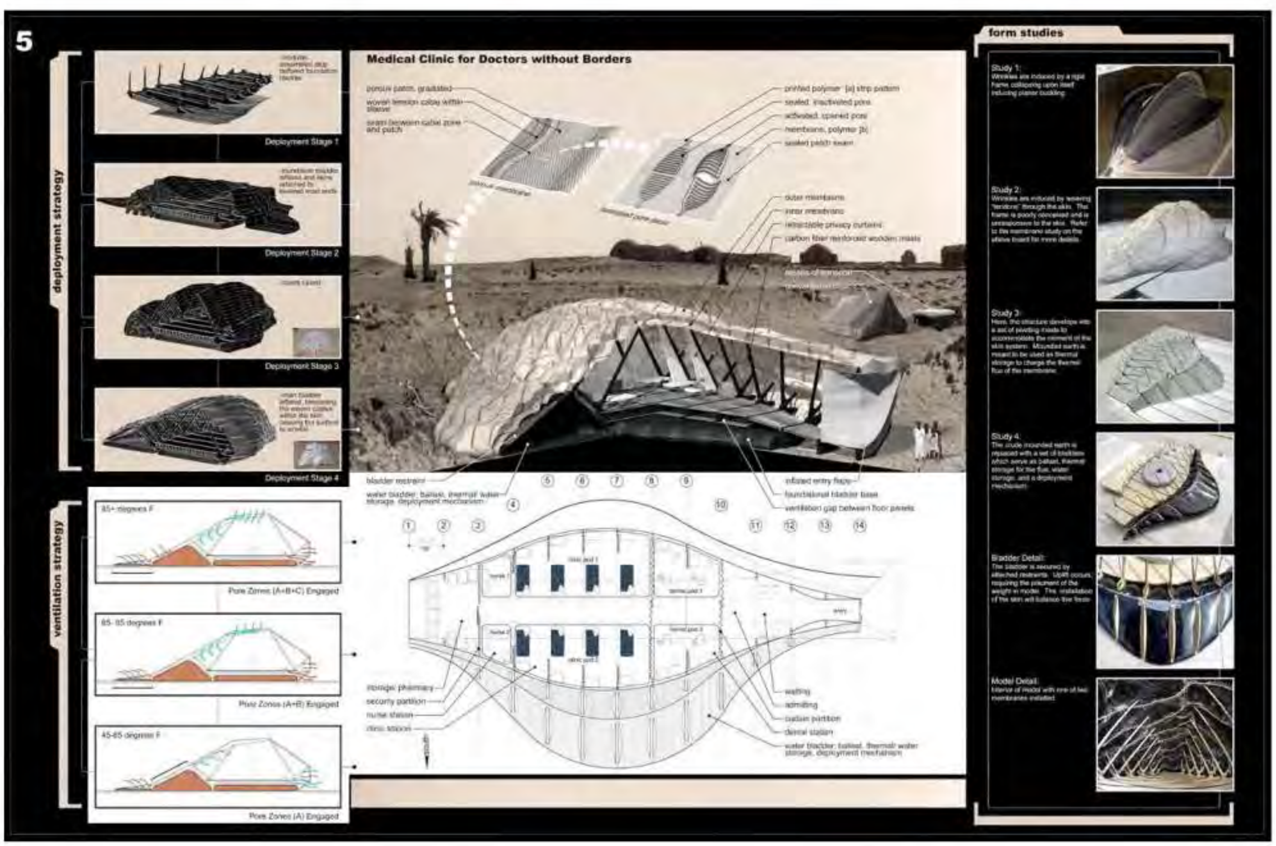
Porous Adaptive Membranes: A Clinic for Doctors Without Borders

The goal of the study was to design an 'adaptive system' with a higher degree of energy optimization in a built environment: a system that automatically ventilates responding to a changing thermal environment to maintain comfortable interior threshold. In an adaptive system it is reasonable to begin with a responsive detail. In exploring this detail, planar buckling that occurs due to differences in thermal expansion between two laminated materials was employed to effectively actuate small pores within a silicone membrane. The pores can be programmed through manipulation of morphology and constituent material properties, opening or closing in response to ambient temperature and solar gain. The system lends itself to lightness and portability which leads to the displayed manifestation of the adaptive membrane as a portable Clinic for Doctors without Borders. Clean water must be stored on site for sanitation and drinking; the foundational ballast bladder is used to filter and store local water. As the bladder is filled, it deploys the structural masts and tensions the membrane. The bladder is oriented to absorb solar energy, utilizing the water as a heat sink to further assist operation of the thermal flue.






4
pore assignments relative to solar gain
Initial Solar and Wind Diagram
Upon Unfolded Skin
Initial Pore and Tendon Assignments
Emergence of Program
Winter Solar Radiation
Summer Solar Radiation
mech. wrinkle studies
Racked Lattice
Membrane Mounted on
Moment Brackets (1)
Membrane Mounted with Sleeves
within the membrane
wrinkled membrane studies
Tendon Config. 1
Tendon Config. 2
Tendon Config. 3
Tendon Config. 4
Membrane Mounted on Moment Brackets (2)
Woven Tendons Similar to Config. 3


5
deployment strategy
Deployment Stage 1
Deployment Stage 2
Deployment Stage 3
Deployment Stage 4
Medical Clinic for Doctors without Borders
ventilation strategy
Pore Zones (A+B+C) Engaged
Pore Zones (A+B) Engaged
Pore Zones (A) Engaged
form studies
Study 1:
Study 2:
Study 3:
Study 4:
Bladder Detail:
Model Detail:

University of Arizona, College of Architecture - Tucson, United States

Project by: Jed Laver, Kelly Winn

Tutors: Jason Vollen, Dale Clifford, Álvaro Malo

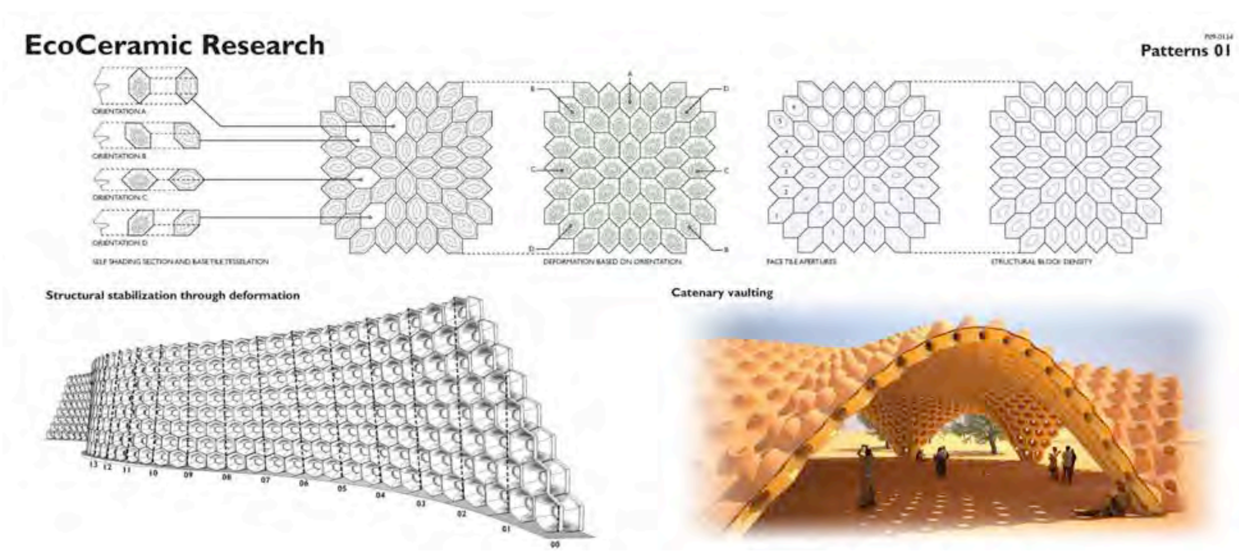
http://www.archiprix.org/2009/?project=2577

EcoCeramic Research

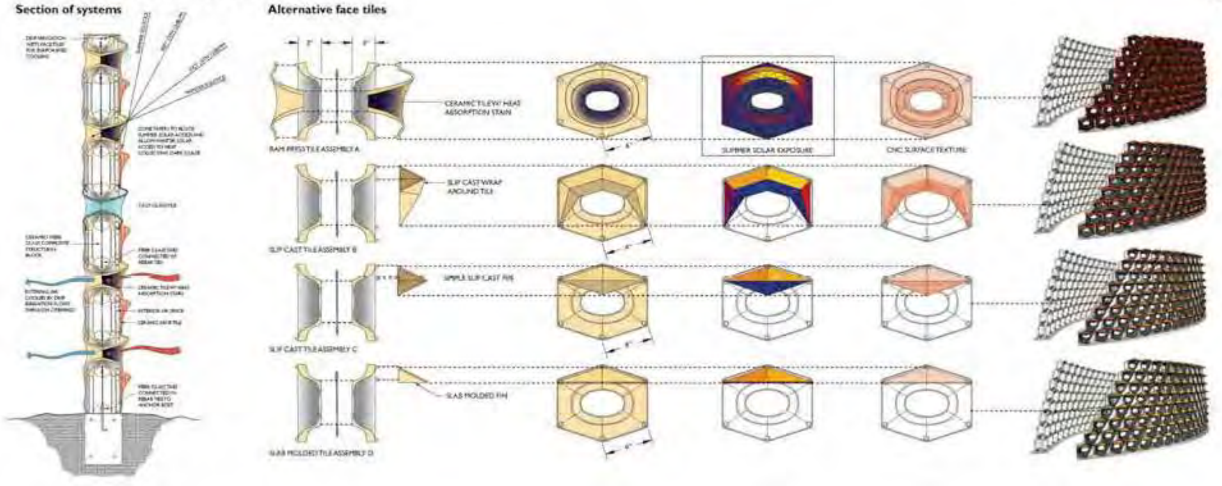
At the turn of the 20th century the height of building technology was hand-crafted ceramic tiles mounted on structural steel framing. There were more than 15 companies nationwide employing thousands of workers making each tile from custom-built molds interpreted from architects' drawings. Now only three such companies remain and two are primarily involved in the preservation of historic buildings. Yet the natural process of erosion of the Earth's surface produces clay five times faster than we could ever expect to use it. While terracotta has many desirable properties as a building material — vitrified glazed finishes (durability), thermal mass characteristics (energy efficiency), humidity controlling properties (environmental comfort), plasticity of form (structural stability) — modern building techniques require a resilient construction system with a streamlined design and manufacturing process: EcoCeramic.

The applied research, EcoCeramic, has been focused on innovative methods, integrating traditional ceramic materials with digital design and manufacturing processes. Using the extreme arid climate of Tucson, Arizona as an extension of the Emerging Material Technologies Ceramics Laboratory, building modules were developed with surface geometries that mitigate the environmental forces of the desert. The geometric development of a modular ceramic wall, as an active surface, creates a topologic environmentally positive relationship between the material and ourselves, resulting in a phenomenological awareness of the articulated surface and its compliance with the local ecology. Within this context, EcoCeramic Research seeks to redefine traditional ceramics as an ecosophical building material.

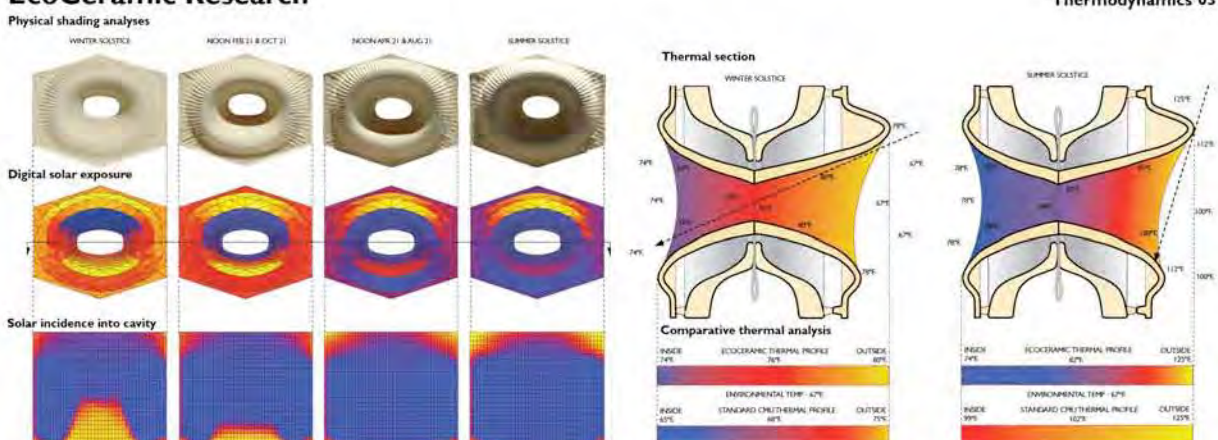
This research phase involved the fabrication, testing and optimization of materials as full-scale prototypical units, the correlation of the design data into a desired performance-profile, and the fabrication of ceramic composite building modules that are being assembled as a testing facility on The University of Arizona campus. Additionally, it included the design and fabrication of several molds for press forming multiple iterations of composite test modules with varying degrees of multidimensional complexity, and performing initial strength tests to gather data on design-performance criteria.



EcoCeramic Research



EcoCeramic Research



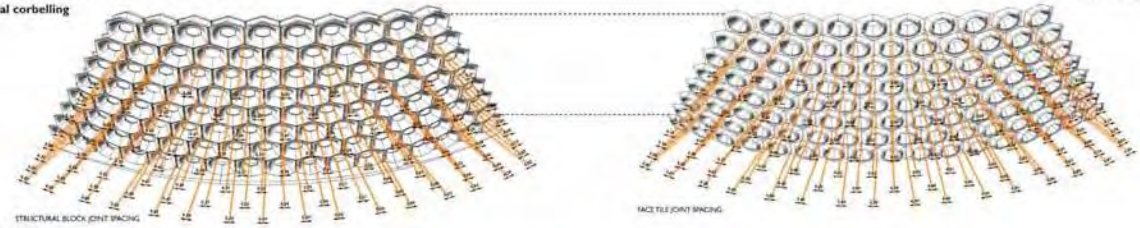
EcoCeramic Research

Pressurizing the plaster production mold

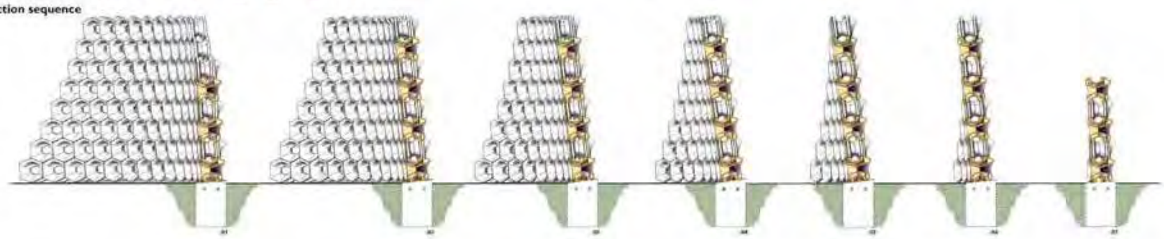
EcoCeramic Research

Construction 05

Digital corbelling



Section sequence



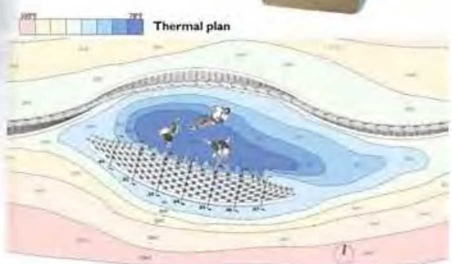
EcoCeramic Research

Ecology 06

In situ

Physical prototype

Thermal plan



EcoCeramic Research

Mass Production 08

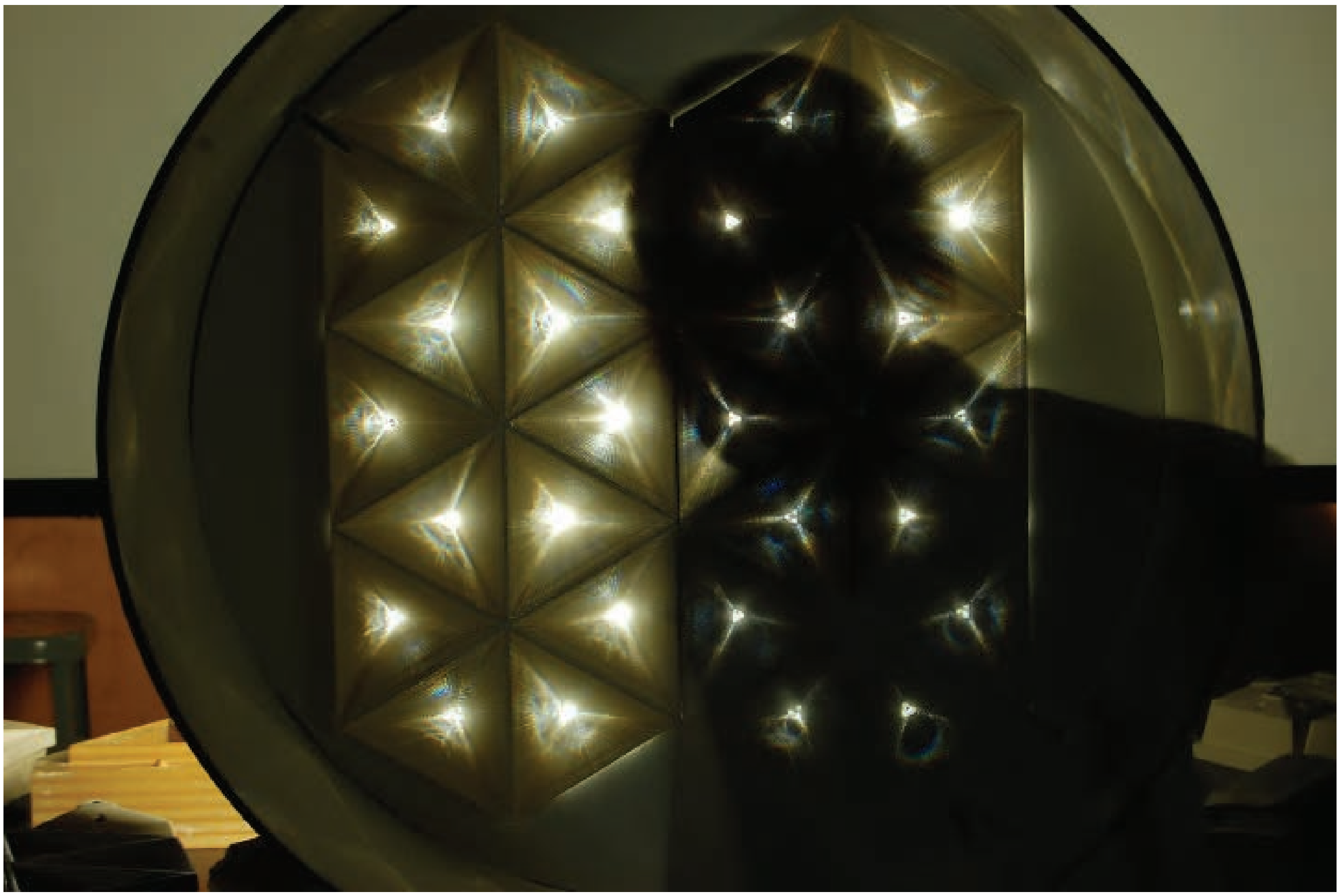
Ceramic face tiles w/ heat absorption stain

Ceramic tile production

Sensitive Apertures

By Ben Ari McDonald

A Master's Report Submitted to the Faculty of the Department of Architecture
In Partial Fulfillment of the Requirements For the Degree of Master of Architecture
in the Graduate College of The University of Arizona.



University of Arizona
School of Architecture
Spring 2008

Sensitive Apertures

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Approval by Master's Report Thesis Committee Members:

Alvaro Malo, Chair — Date
Professor of Architecture

Dr. Joseph Simmons — Date
Department Head and Professor of Material Science

Dr. William Bickel — Date
Professor Emeritus of Physics

University of Arizona
School of Architecture
Spring 2008

Hypothesis

Twice a day, at dawn and dusk, photoreceptive cells in our eyes reach a 'crossover' point of equal efficiency in response to ambient daylight. At these low light levels (around 1 cd/m^2), color and detail sensing cone cells share responsiveness with shape and contrast sensing rod cells. This perceptual phenomenon within the 'mesopic vision range' marks a potentially unique moment of visual awareness and the starting point a possible search for the 'right' kind of light.

This project proposes to discover a desirable light quality through observations at twilight and then set that condition up in the design of an architectural enclosure system. Most attention will be given to how the light is transmitted and presented within this enclosure. Rather than dimming daylight using large expanses of darkened translucent materials such as plastic or glass, this project aims for a solution using opaque material pierced with small, solar-oriented, refractive apertures to admit and redirect a limited amount of light onto the interior surfaces of the material. When the direction of the sun and the geometry of the light containers align, light will fill the aperture spaces uniformly. At all other times, the enclosure will admit light in a dynamic way that will, by the nature of the small apertures, reveal changing light and the passage of time.

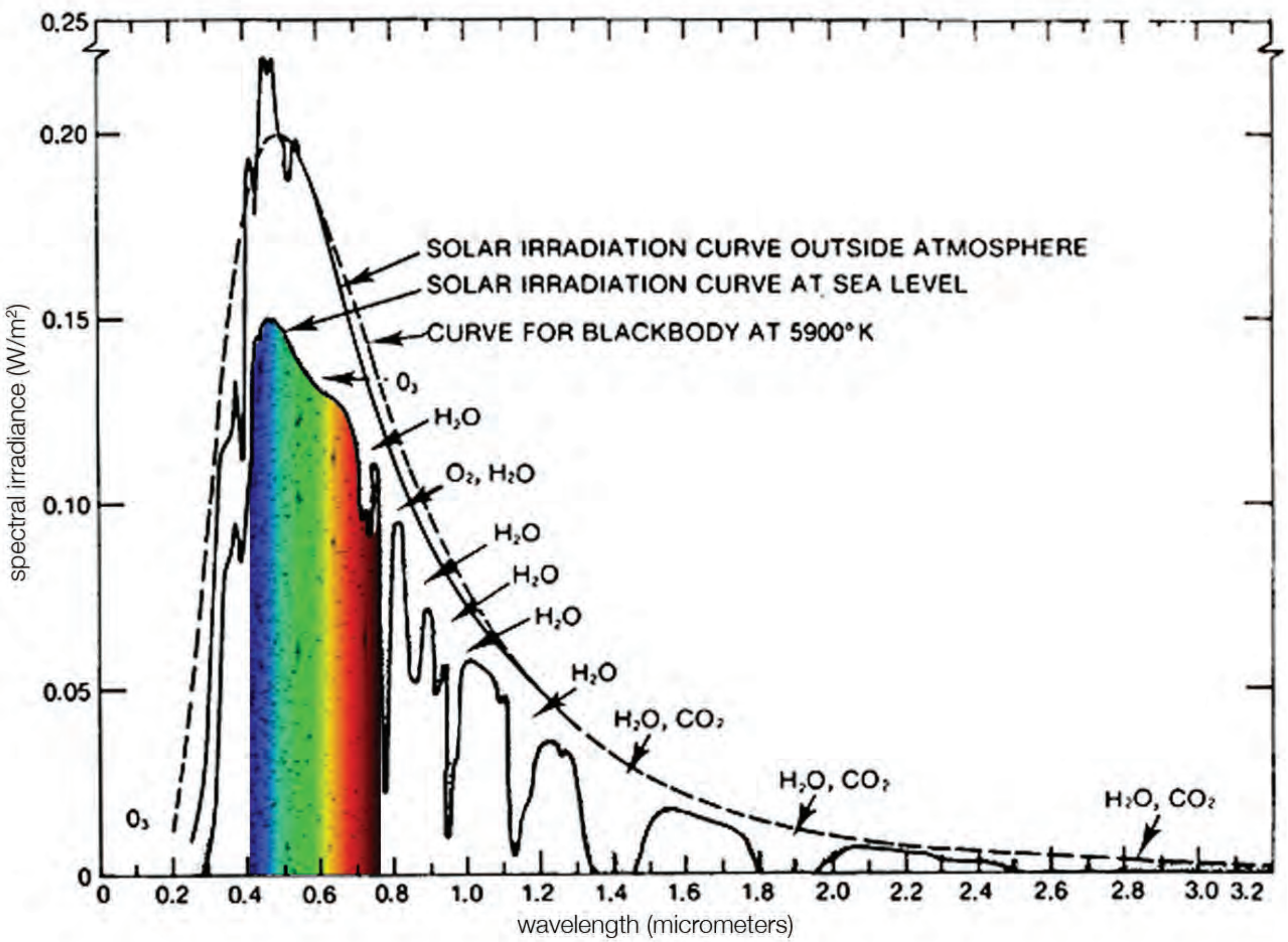
Structurally, this idea is imagined to be a cellular network of ceramic light containers shaped to receive light from the apertures. Together, these cells will form a field of roof or wall enclosure within an otherwise dark space. As vision in mesopic range primarily affects our ability to distinguish detailed shapes and color, the scale of the light containers and the presence of refracted color will be tuned to highlight this change in our perceptual capacity.

Solar Origin

It seems all life forms have evolved directly or indirectly as a response to the radiative power emitted by the sun. It comes as no surprise then that our visual perception is closely linked to the sun's spectral properties.

An overlay (Figure 1) of the spectral distribution of power from the sun and our range of vision demonstrates the evolutionary target of human visual sensitivity to light matches the range of most abundant wavelengths of the sun.

Radiative absorption by molecules in our atmosphere significantly impacts energy received at sea level. Note the drastic valleys of irradiance caused by absorption, especially in the longer wavelengths. Radiation within the visible range, however, remains relatively smooth.

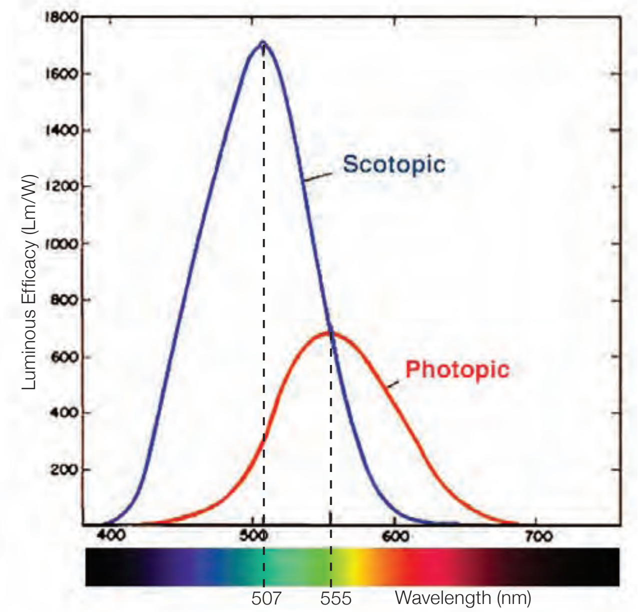


1. Solar Irradiation (Source: Handbook of Geophysics and Space Environments, S. Valley. 1965)

Within the range of detectable wavelengths (380nm - 780nm), so closely tied to the sun's energy, our vision has varying sensitivity. Generally speaking, sensation peaks in the middle of this range (around 555nm) and is very week toward the ultraviolet and infrared boundaries.

Spectral Sensitivity

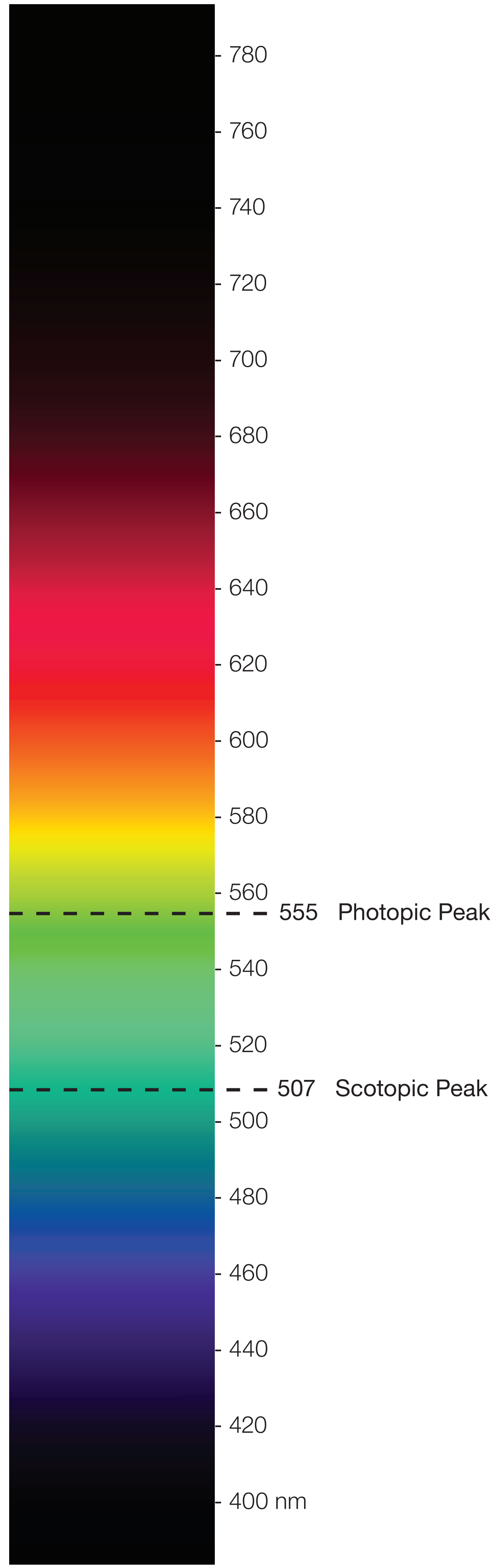
A more subtle fact is that this spectral sensitivity curve changes relative to the amount of light present in our visual field. Our vision goes through three major wavelength sensitivity changes. These are called the photopic, scotopic, and mesopic visual ranges.



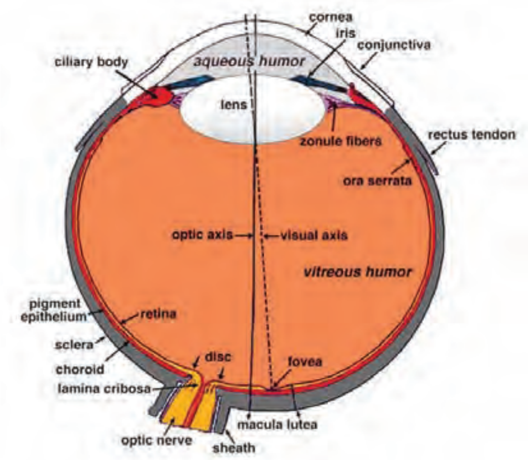
2. Luminous Efficacy Functions (Source: http://webvision.med.utah.edu/)

Most of our daily visual experience occurs within the photopic range (> 3 cd/m^2). This is our light-adapted vision. At these levels, cone cells are the most active. Strong signals from the three types of cone receptors allow us to maximize our color and detail sensing ability. The great majority of cone cells are packed in the fovea of the eye (Figures 6,7) which corresponds to the center of our vision.

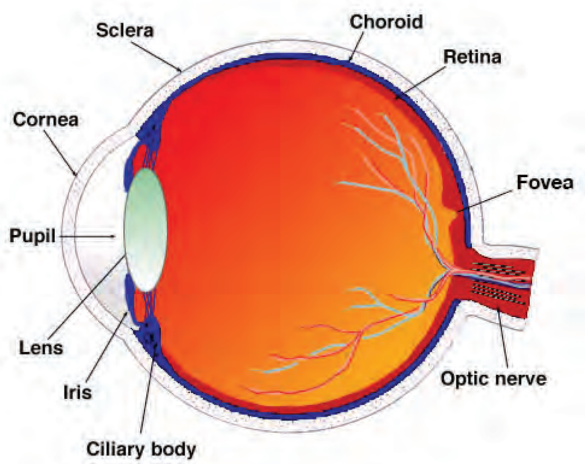
Vision in the scotopic (< .001 cd/m^2) range requires dark adaptation. At these light levels, rod cells are the dominant receptors and cone response is nearly non-existent. Because there is only one type of rod cell, scotopic vision is color blind. What rods lack in color detection, however, is made up for by an increased ability to sense peripheral vision, detect movement, and detect subtle changes in shape and contrast. A classic example of this is from stargazing when an object in the sky is invisible to the center of vision but is revealed when we avert our eyes slightly to allow more rod cells to pick up a response.



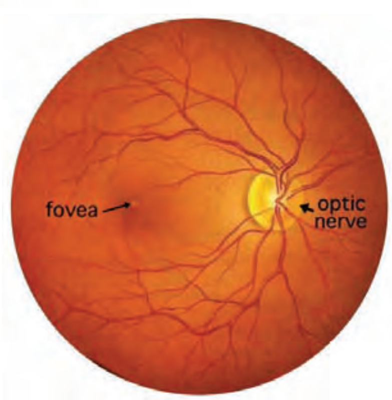
3. visible spectrum



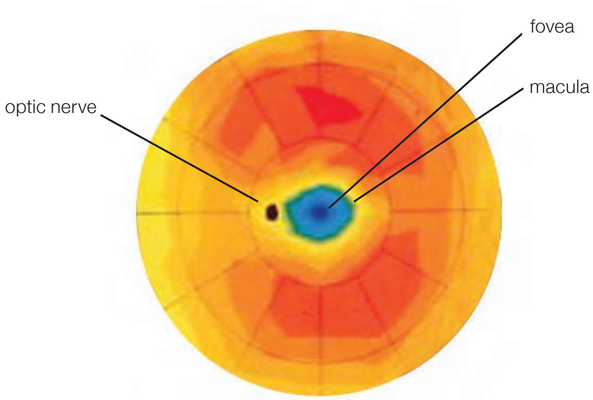
4. horizontal section of eye



5. vertical section of eye



6. ophthalmoscope view of human retina



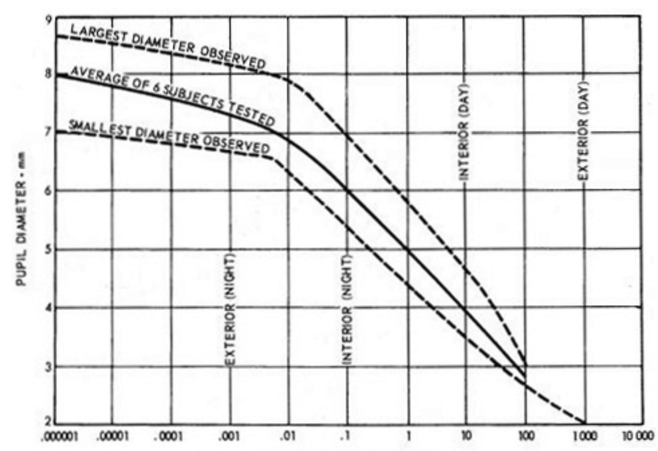
7. retina rod/cone distribution

Finally, mesopic vision range (.001cd/m^2 - 3 cd/m^2) occurs in between light and dark. Within this range, rod and cone response is shared. As of yet, there is no standard luminous efficacy function for mesopic vision. It appears that vision in this range undergoes rapid changes that are a result of a complex set of factors including illumination level, spectral content of the image, and adaptation time. Owing to a lack of scientific knowledge relating to the mesopic range, it might be best described experientially as a combination of photopic and scotopic vision. Color and detail are simultaneously detectable with peripheral vision, motion detection, and light sensitivity.

This thesis sets out to explore the perceptual intrigue of the mesopic range through observational studies which are then intended to be used as inspiration for creating an architectural enclosure.

Pupil Aperture

Adaptive pupil size helps the eye to accommodate the broad range of light levels spanning photopic and scotopic vision. Beyond the basic principle of letting more or less light into the eye, the size of the pupil (Figure 8) also determines the region of the retina that receives light and helps to explain the perceptual changes of dark versus bright environments. In bright light, the pupil contracts and limits incoming light to falling in the center of vision containing most of the cone cells. In the absence of light, muscles in the iris relax, resulting in an enlarged pupil that admits light to a much larger portion of the retina, thus allowing rod cells more opportunity for response.



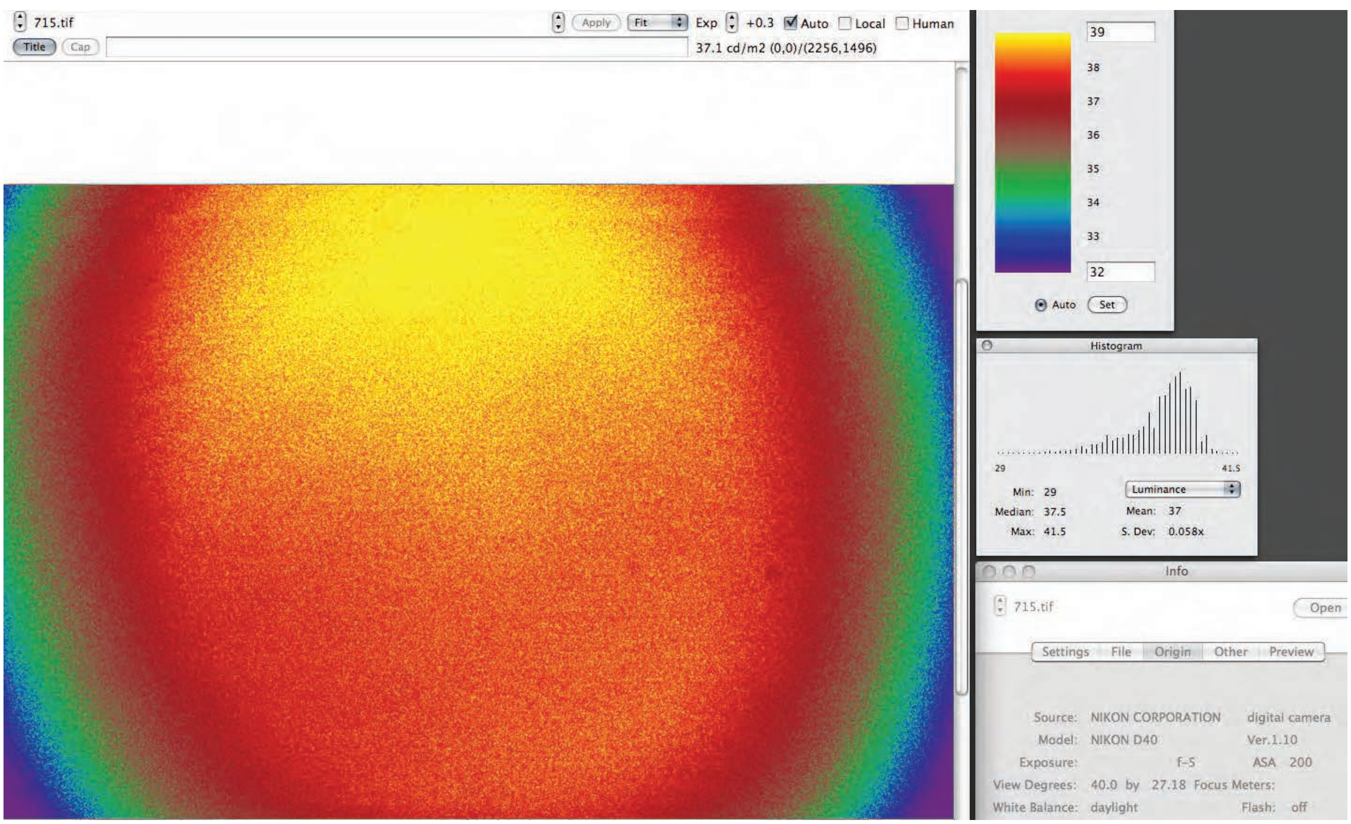
8. Pupil Luminance Response (Source: IESNA Lighting Handbook)


9. Pupil dilation (actual size)

Typical Image Luminance Analysis

Figure 4 shows a typical example of an HDR image displayed in Photosphere as a false color luminance map. This particular image is from the overhead sky at 7:35 on May 9th (West is up). Even though the brightness of the sky was relatively consistent across the image to the naked eye, the luminance map clearly shows more brightness, as it should, toward the western-setting sun. Because the range of luminance values is so narrow (32-39 cd/m^2), the luminance value recorded for this time is an average of the entire image.

Proceeding this way, average luminance values corresponding to observed areas of sky were recorded for each image. Figure 6 shows another way to visualize luminance values across an entire twilight session by setting a custom range for the false color map based on the brightest values from the early photo and darkest values from the latest photo.



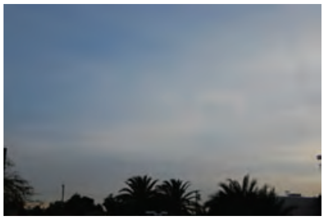
4. Photosphere false color luminance map of zenithal sky at twilight

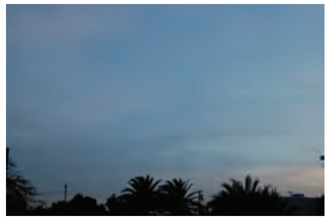

5:50 pm, 1440 cd/m²


5:55 pm, 901 cd/m²

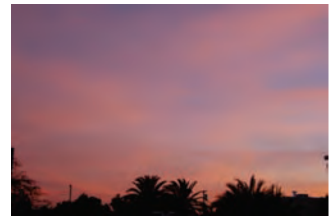

6:00 pm, 645 cd/m²


6:05 pm, 437 cd/m²

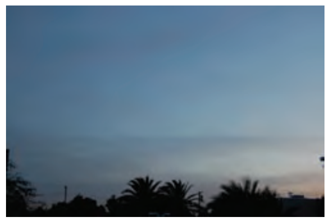

6:10 pm, 166 cd/m²


6:15 pm, 111 cd/m²


6:20 pm, 81.5 cd/m²


6:25 pm, 20.9 cd/m²


6:30 pm, 6.78 cd/m²


6:35 pm, 1.77 cd/m²

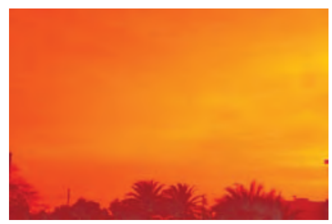

6:40 pm, .542 cd/m²


6:45 pm, .186 cd/m²

5. HDR twilight image sequence


5:50 pm, 1440 cd/m²


5:55 pm, 901 cd/m²


6:00 pm, 645 cd/m²

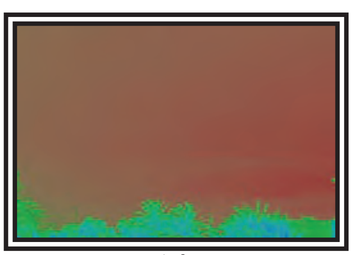

6:05 pm, 437 cd/m²


6:10 pm, 166 cd/m²


6:15 pm, 111 cd/m²

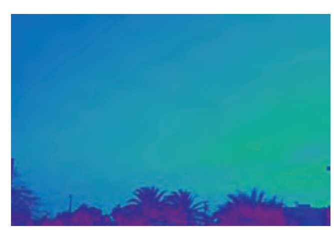

6:20 pm, 81.5 cd/m²


6:25 pm, 20.9 cd/m²


6:30 pm, 6.78 cd/m²


6:35 pm, 1.77 cd/m²


6:40 pm, .542 cd/m²

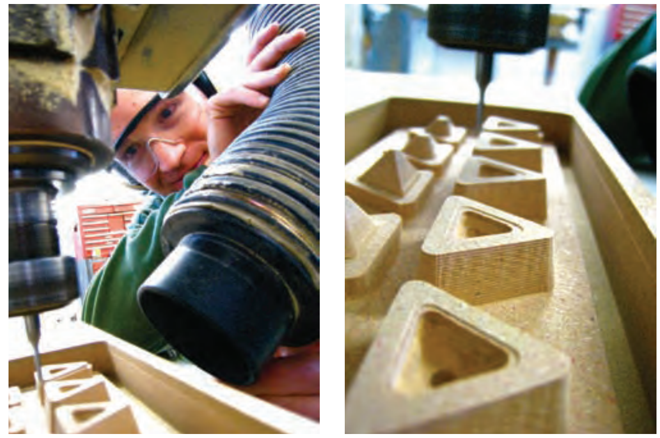

6:45 pm, .186 cd/m²

6. False color HDR twilight image sequence

Aperture Fabrication: Acrylic

Glass was chosen as the ideal material because of its durability and high index of refraction. However because the glass fabrication process took a long to time to begin, cast acrylic was also explored.

A series of ‘best guess’ aperture geometries were digitally designed so each could be tested empirically for best performance. At first, the CNC router was used to machine the geometries out of MDF (Figures 4-6). Liquid silicone was then cast into these as a final step before being able to cast acrylic. Because the apertures were so small, it was a challenge to get enough machining resolution to make the apertures as smooth and clear as possible. 3d printing was tested for precision but it too had more texture than desired. Finally, Dupont’s Corian countertop material was tested for its machinability with the router and the results were far better than the MDF or 3D print. (Figure 7)



4. CNC routing of MDF

5. Typical light container refraction analysis

6. Typical light container refraction analysis

7. Typical light container refraction analysis

Aperture Fabrication: Glass

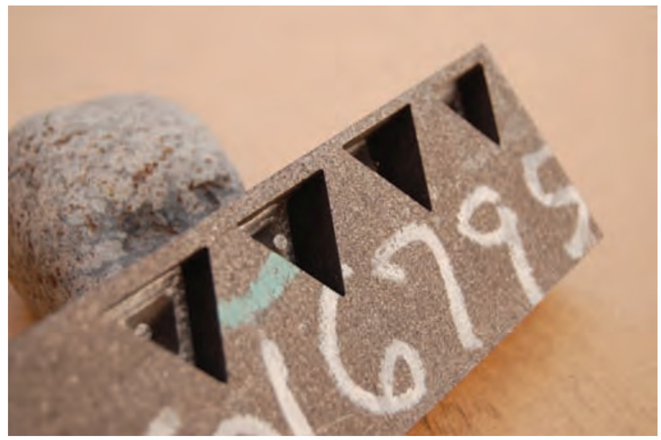
Casting the small glass apertures required a thorough process of seeking advice on and off campus, asking for material donations, and being able use lab space and furnaces in the Material Science Department.

A strict requirement of the apertures was that they had to be optically clear - the surface of the glass had to be smooth and specular. Any light scattering at the surface would have defeated the refractive intentions for the glass. After talking with glass fabricator Charly Amling, in the Chemistry Department, it became clear that graphite might be a perfect mold material for casting glass. Thankfully, a few blocks of graphite were generously donated for this research by Leon Good of Weaver Industries. The graphite block was then carefully machined using the CNC router (Figure 8). Special care needed to be taken for this machining because graphite, though relatively soft and easy to machine, also produces dangerous shavings which are both abrasive and conductive.

Even though graphite is an ideal material for casting glass into, it is prone to oxidation when exposed at temperatures above 480°C.

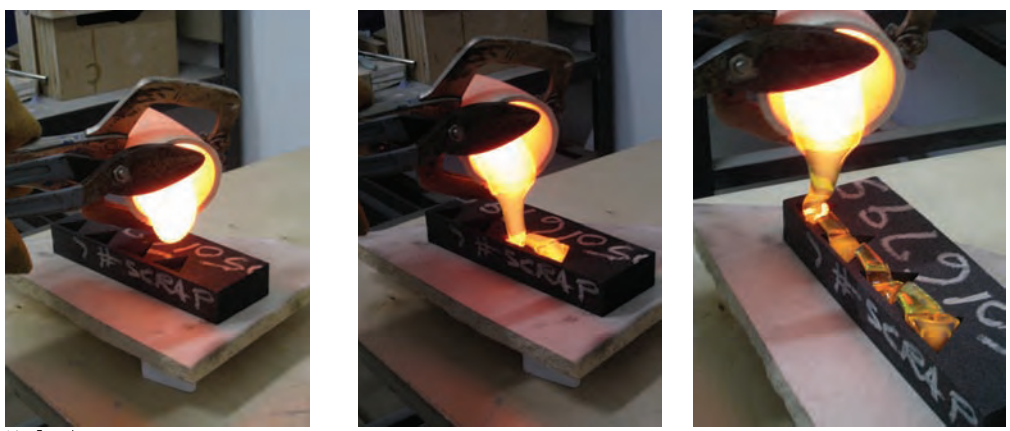
This required glass to be melted in a crucible first which could then be poured into the graphite which could then be placed in a separate oven for annealing. (Thankfully, graphite's oxidation threshold was also the annealing temperature of the lead crystal glass used for the casting)

The first casting experiment with graphite was done using two ovens in the Architecture materials laboratory. The glass product of this cumbersome procedure (Figures 9-12) was beautifully clear - but also deformed because the glass did not reach a high enough temperature to become liquid enough to fill the small shapes in the graphite.



8. Machined graphite mold block

9. 850°C furnace



10. Casting sequence

11. Heat reflective armor

12. Annealing oven

13. Material Science laboratory furnaces

14. Casting tools

15. 1000° C furnace

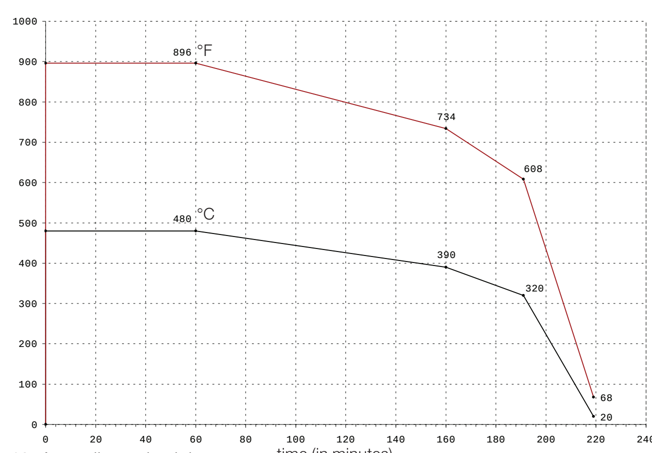
16. Casting

17. Graphite mold

18. Glass placed in oven for annealing

Glass: Casting

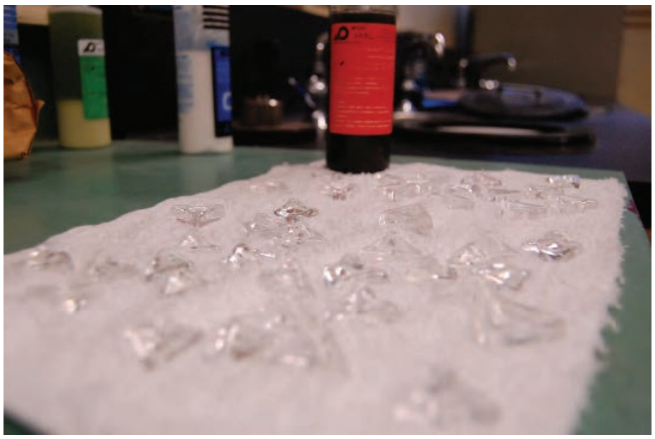
The second casting series was done using a pair of small furnaces in the Material Science laboratory. These furnaces were able to reach 1300° C, the true melting point of the glass. Once the glass castings were sufficiently cool in the graphite mold, they were removed and placed in the other oven for annealing (Figures 17-19). This process allowed new castings to be made back to back which greatly increased production efficiency.



19. Annealing schedule

20. Unfinished glass castings

21. Polishing wheel



22. Final polish with 9 micrometer polycrystalline diamond lubricant

23. Finished apertures

24. Finished apertures

25. Annealing oven

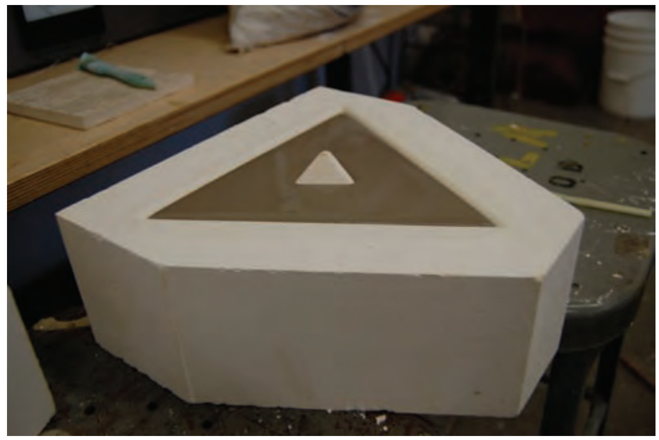
Glass: Finishing

After annealing, the glass apertures required grinding to remove the upper half. This was followed by wheel polishing (Figure 21) using water-lubricating abrasive pads decreasing in grit size from 240 to 400 to 800 to 1200. A final polish was made using a 9 micrometer polycrystalline diamond lubricant.

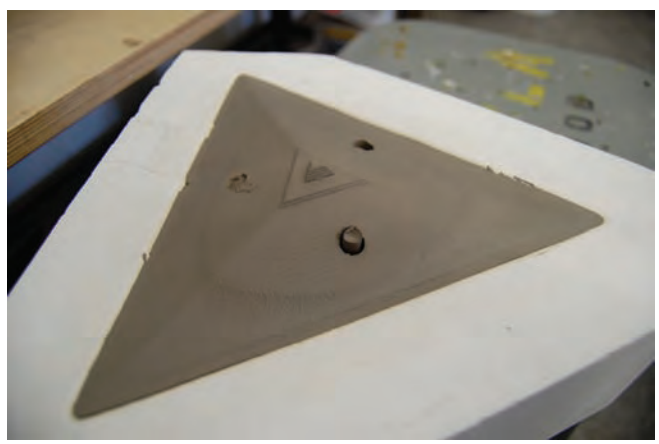
43. Slip casting setup

44. Slip casting production line

45. Pottery plaster molds for slip casting



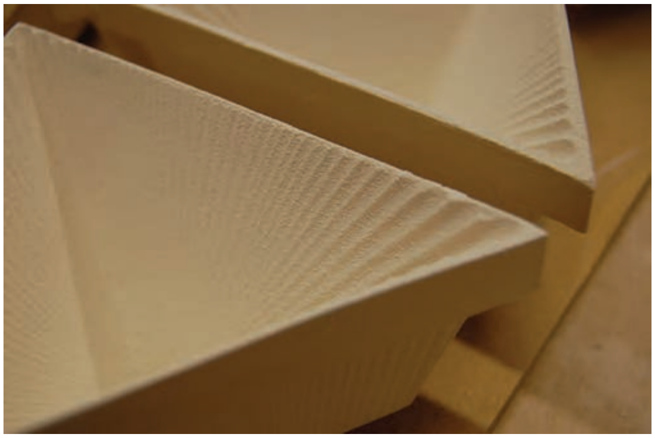
46. Slip



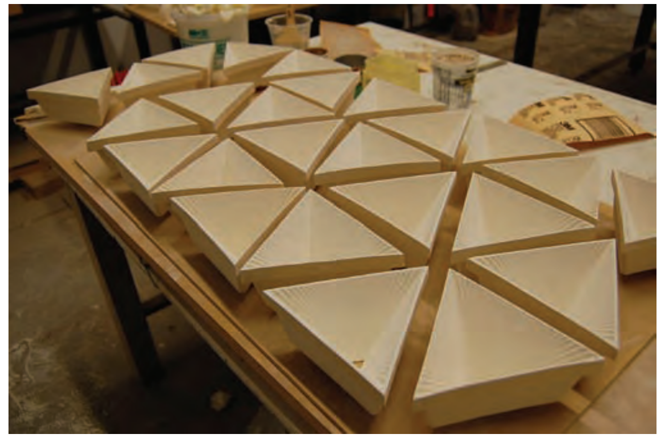
47. Greenware

Slip Casting

Two-part pottery plaster casts made from the machined Corian molds enclosed a cavity which was then be filled with the liquid slip. (Figures 45,46) The pottery plaster is highly absorbent and pulls moisture from the slip at all interfaces, causing the slip to harden. After a period of about 15 minutes, the thickness of the hardened slip was optimal and the remaining liquid was poured out, producing the hollow cavity for insulation as see in Figure 55. The clay body then remained undisturbed in the plaster for a period of at least 8 hours which gave them time to harden enough to be released from the molds to air dry. To increase production capacity, four sets of the plaster sets were made so that up to 12 pieces could be made daily. (Figure 44)



48. Glaze coating detail



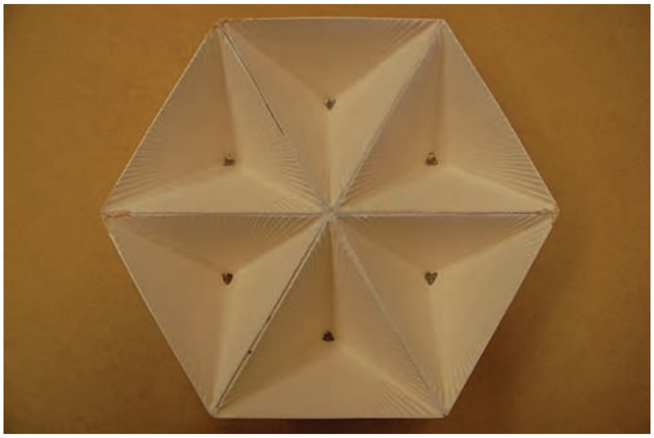
49. Glazing production

50. Ceramic kiln

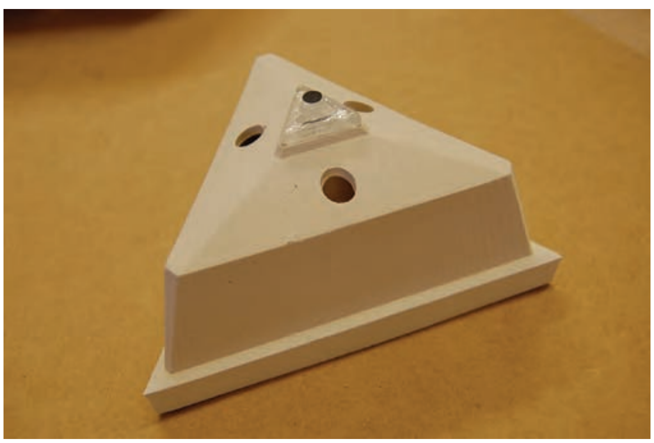
51. Glazing application

Glazing

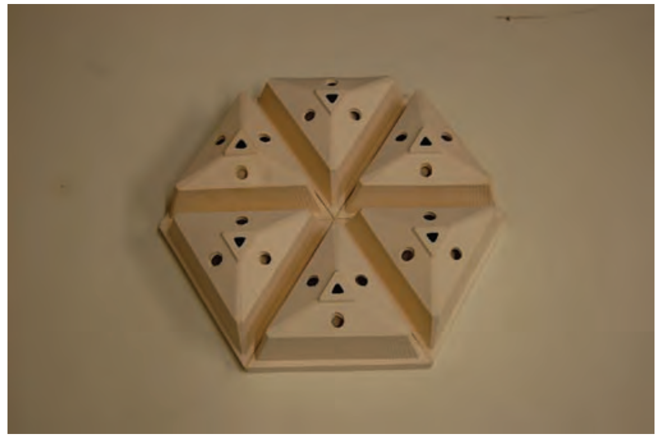
The finish surface of the light containers greatly affected the quality of light. To reinforce the intention of an evenly scattered interior light, a matte white glaze was chosen to minimize any specular behavior. After an initial bisque fire (Figure 50), the light containers were glazed using a spray applicator. (Figure 51)

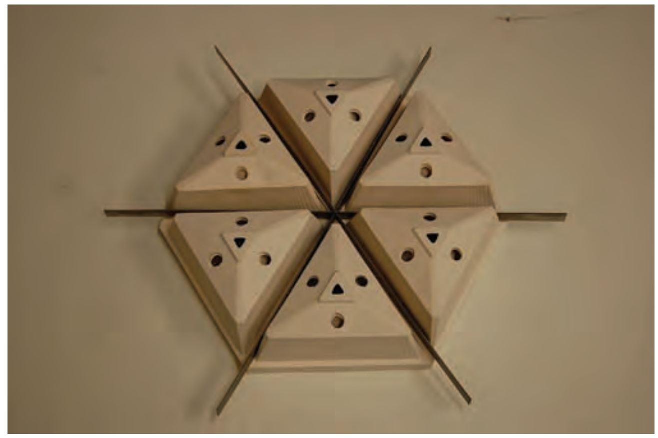

52. Hexagonal unit interior


53. Interior detail


54. Typical light container


55. Section through typical cell

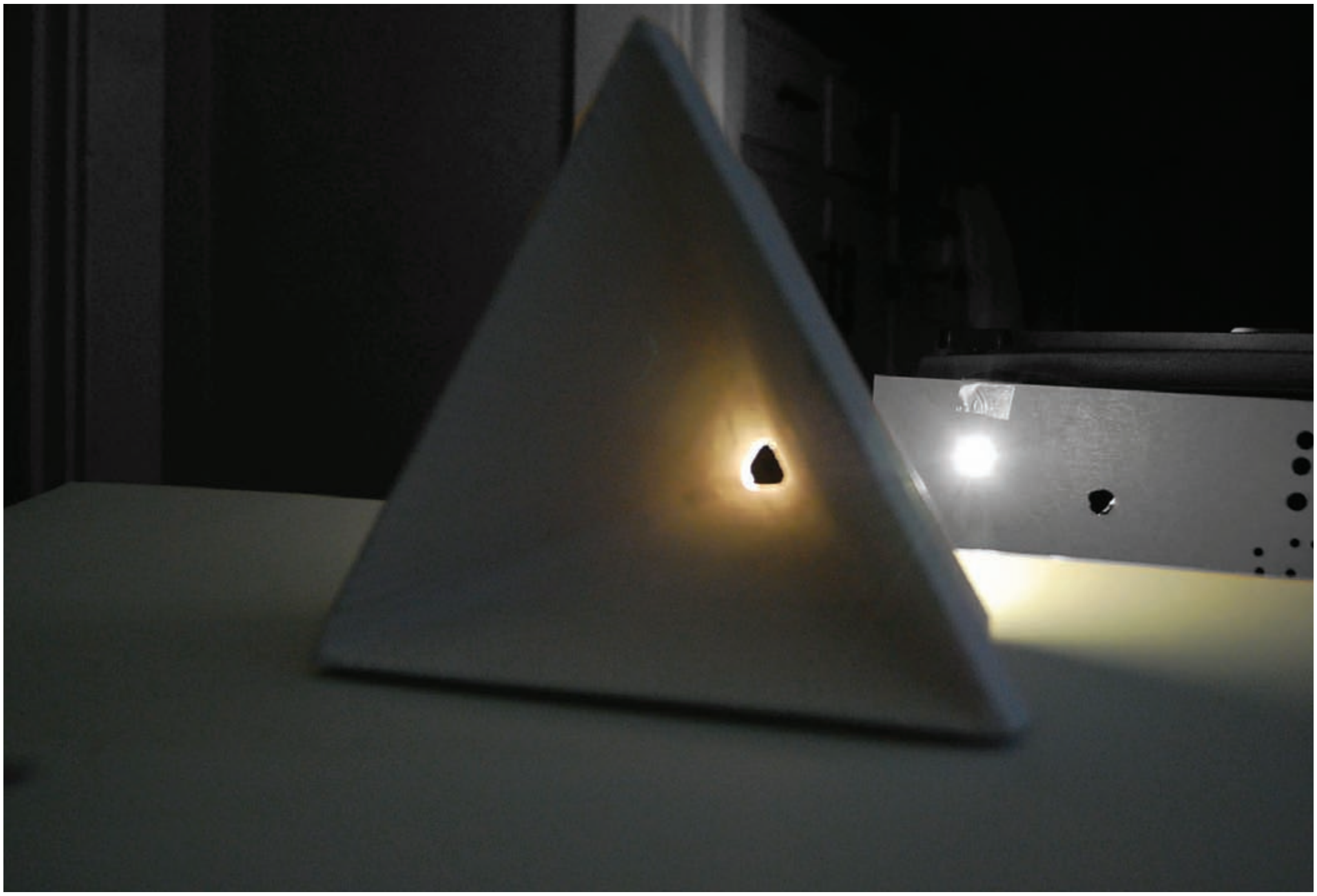

56. Hexagonal unit exterior

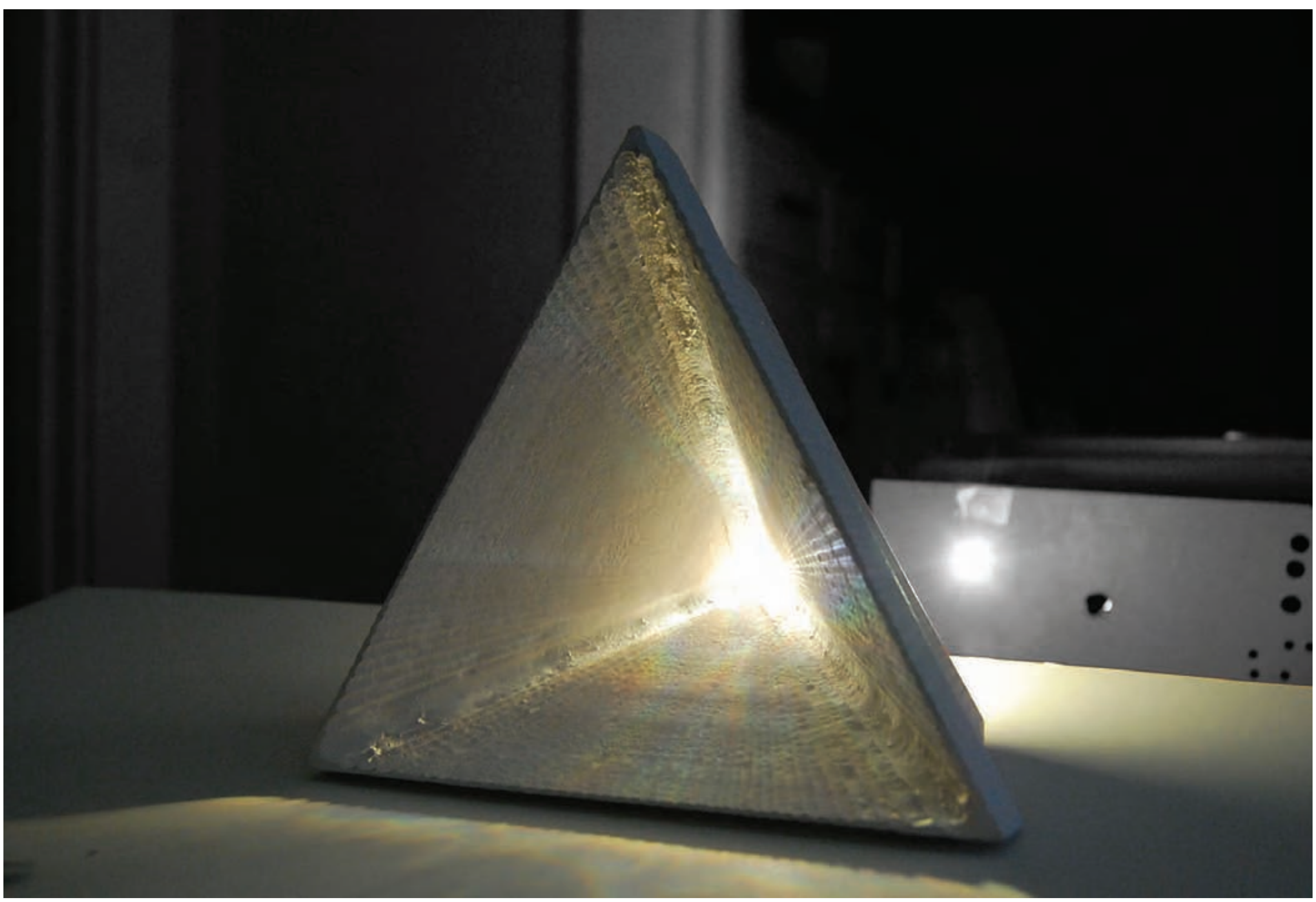

57. Potential reinforcement

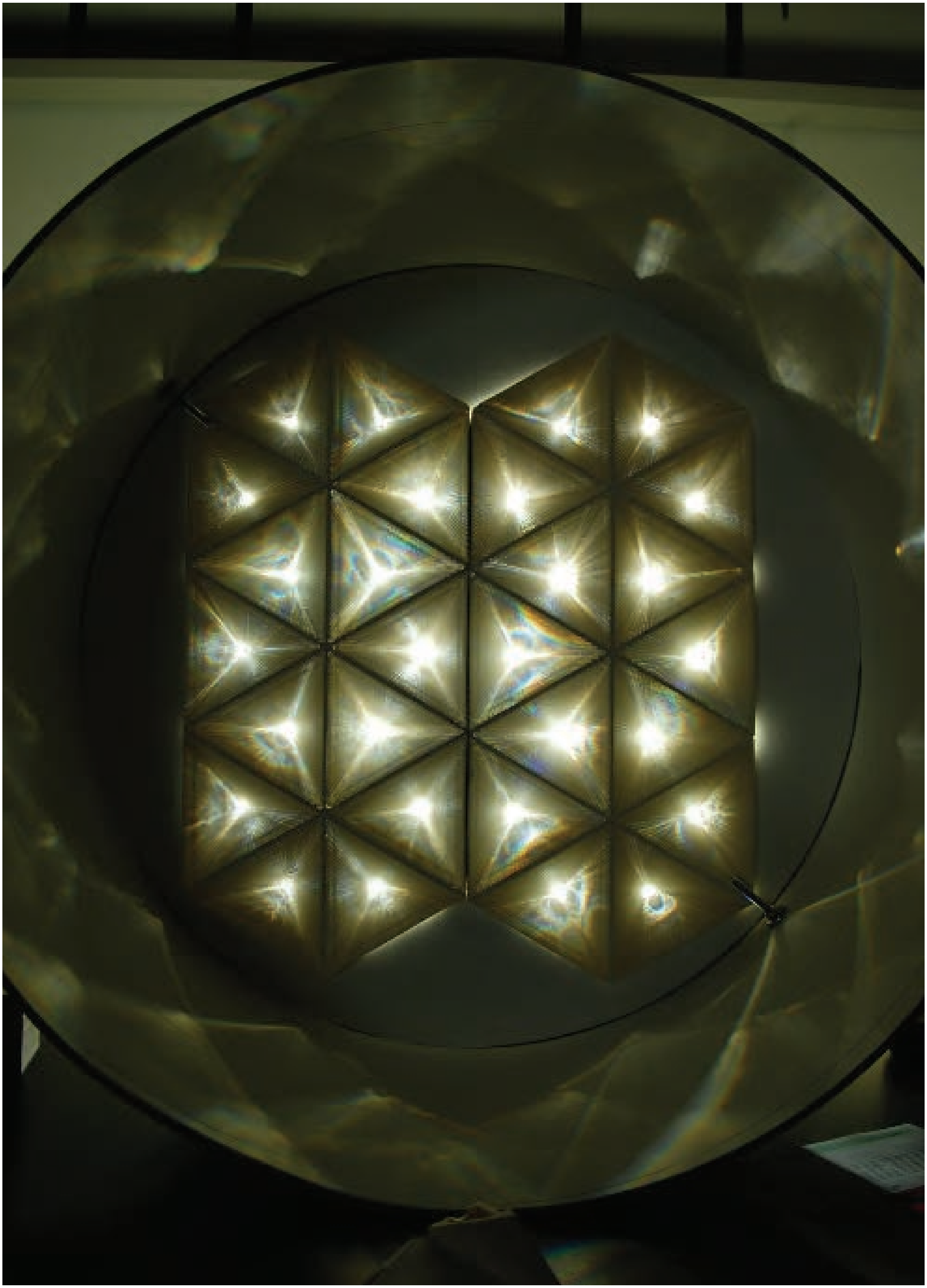
Assembly

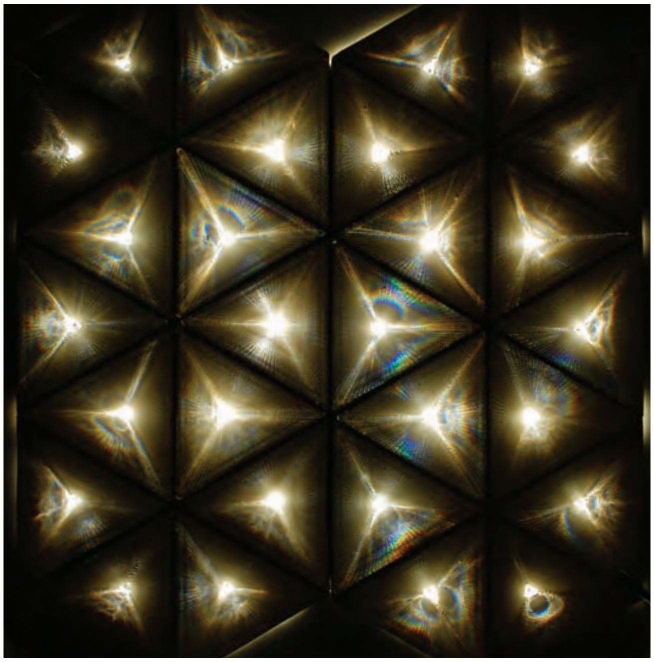
Individual light containers were bonded into larger cells using fiberglass and epoxy resin. The space between cells on the outside of the enclosure provided opportunity for reinforcement, weather sealing, and additional insulation.

Prior to the assembly of a large number of cells, a quick light study looked at the refractive performance of one container. Figures 58 and 59 demonstrated the performative difference between aperture and no aperture and provided some assurance that the cells were going to function as designed.

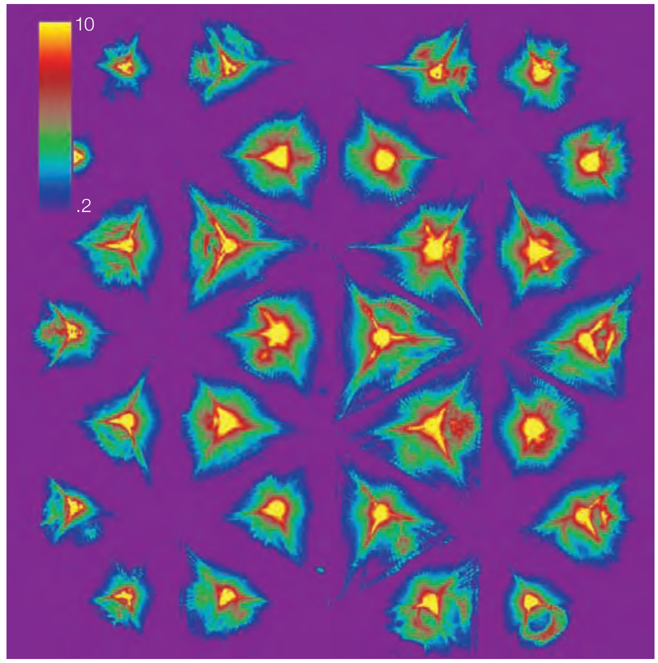

58. Light test - no aperture


59. Light test - with aperture


61. Light containers

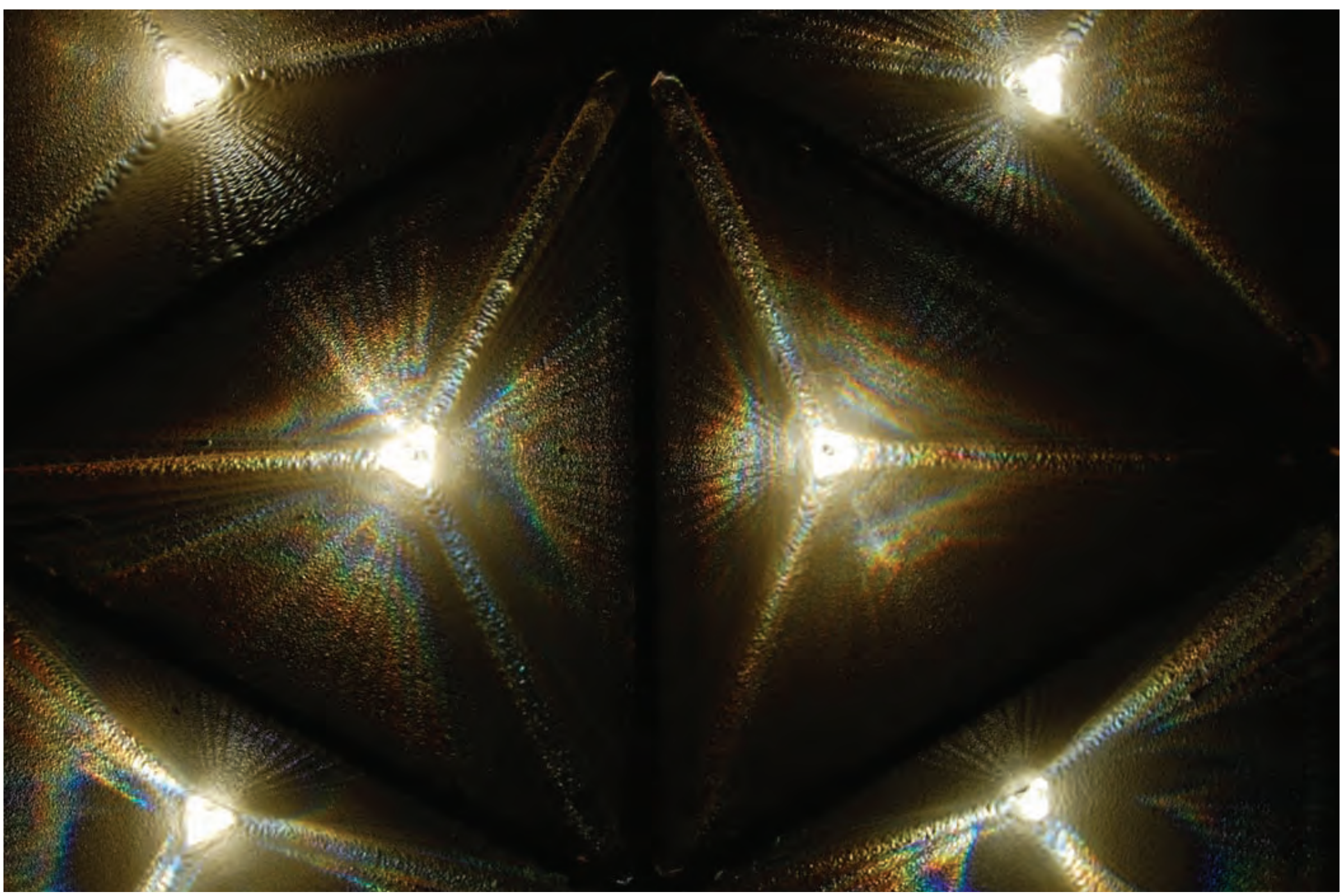


69. HDR composite photograph

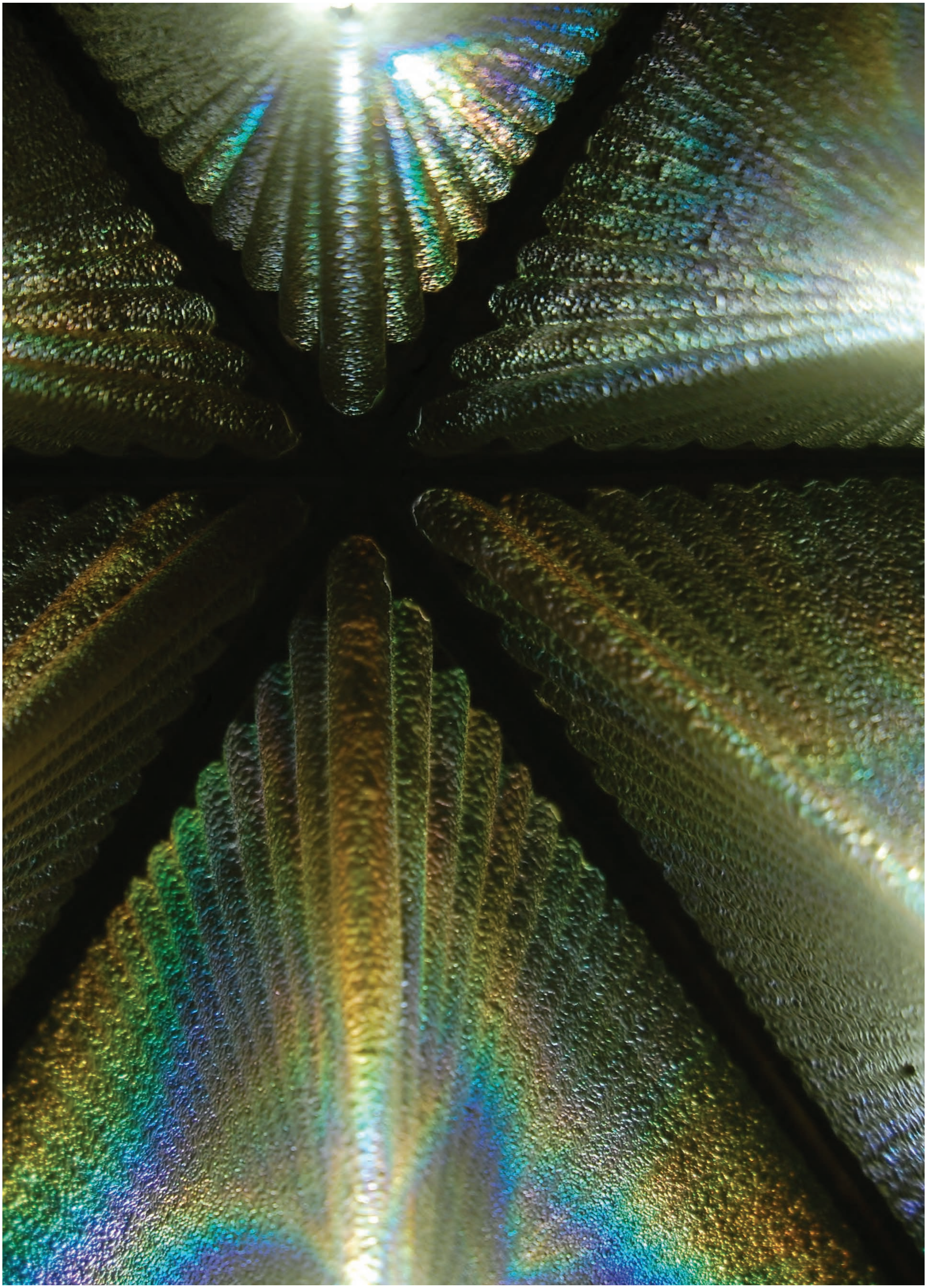


70. False color luminance image for values between 10 and .2 cd/m^2)

Finally, an HDR image of the enclosure was made to demonstrate the proposed method for analyzing the resultant luminance values. Despite the arbitrary luminous intensity of the projected light source, Figure 70 shows significant presence of light levels falling near the target luminance values at the upper boundary of the mesopic vision range.

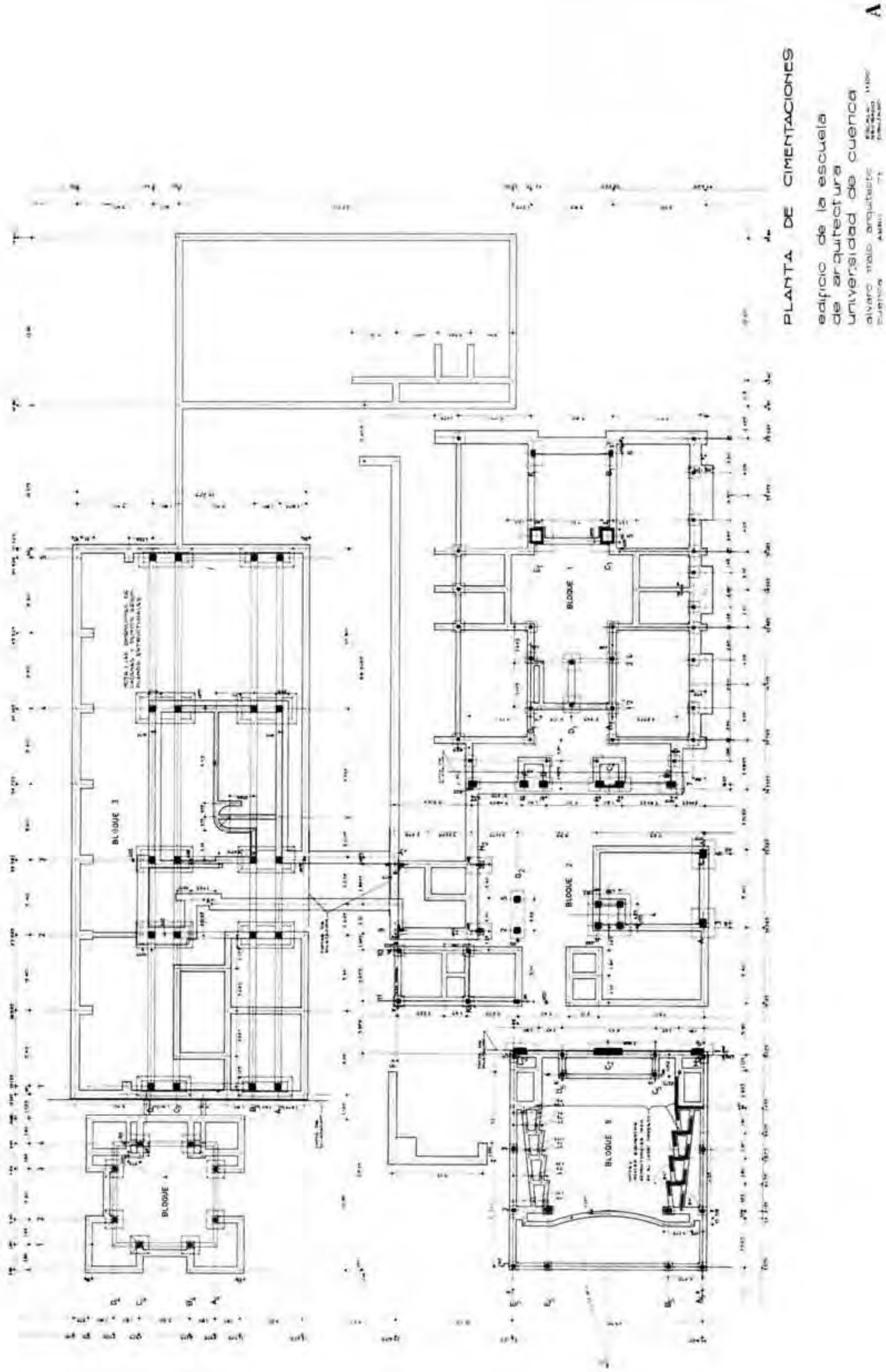


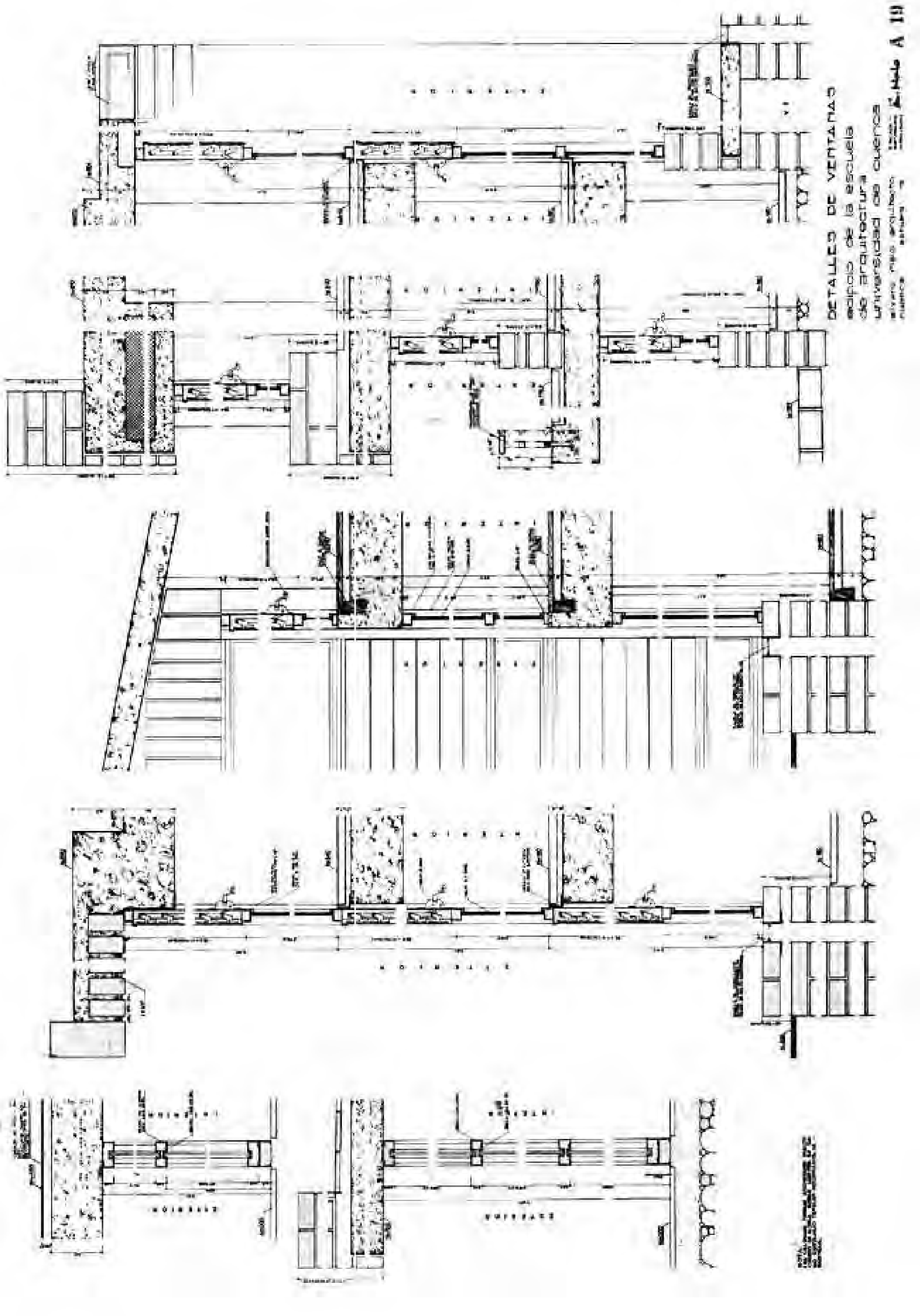
71. Light containers

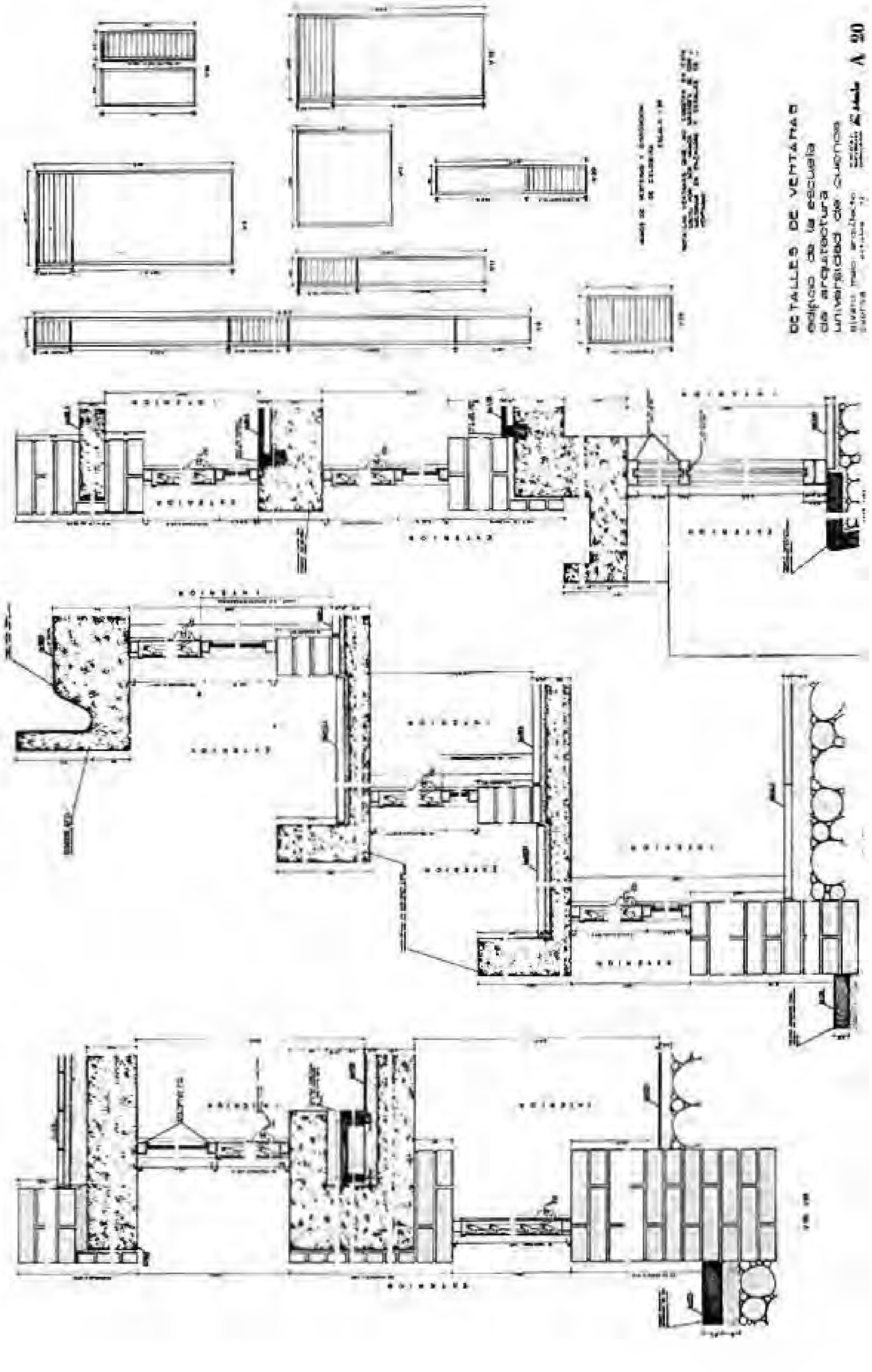


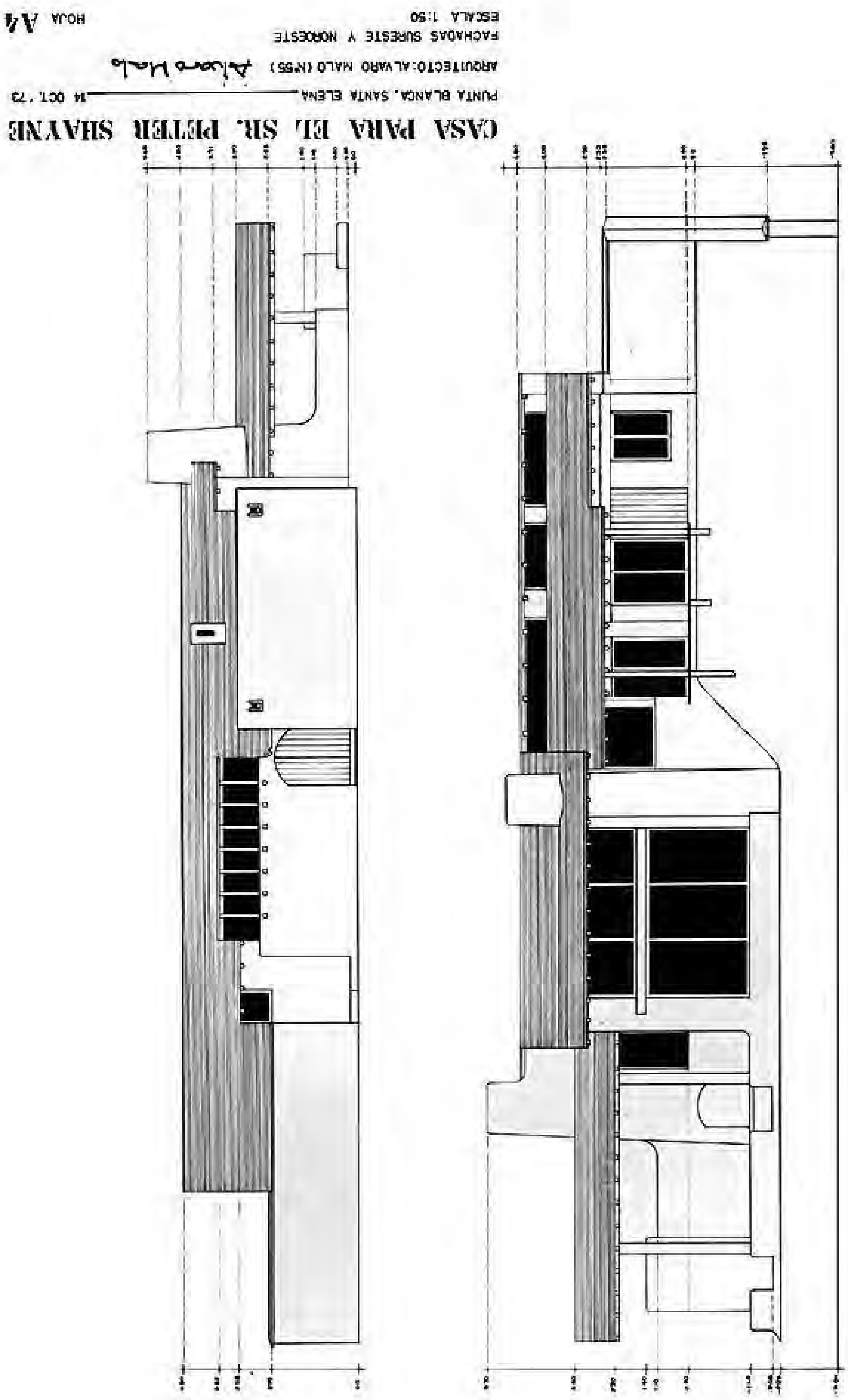
66. Light Container intersection

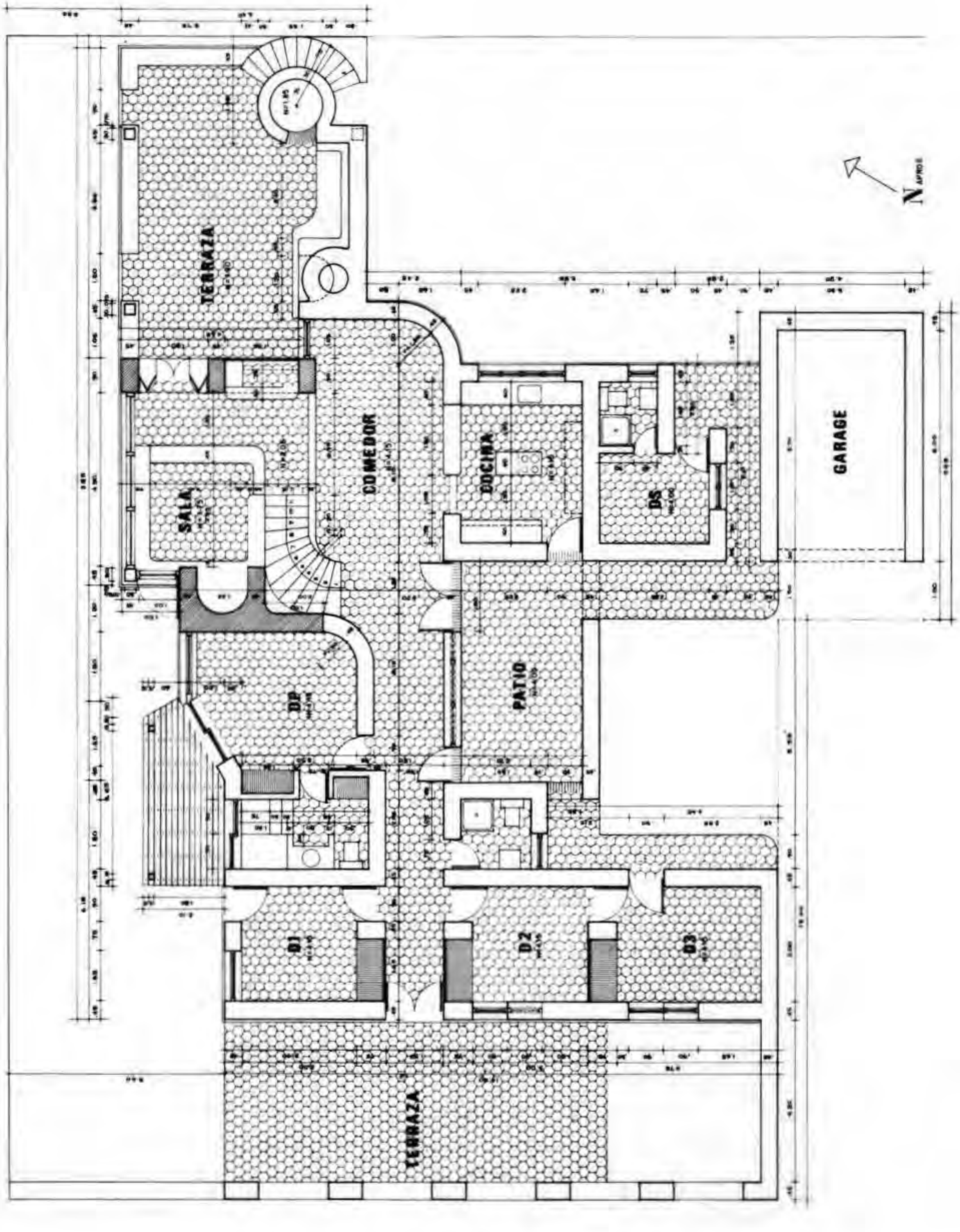
DESIGN PRACTICE


PLANTA DE CIMENTACIONES
edificio de la escuela
de arquitectura
universidad de cuenca
alvaro malo arquitecto
A1
BLOQUE 1
BLOQUE 2
BLOQUE 3
BLOQUE 4
BLOQUE 5


DETALLES DE VENTANAS
edificio de la escuela
de arquitectura
universidad de cuenca
A 19


DETALLES DE VENTANAS
edificio de la escuela
de arquitectura
universidad de cuenca
A 20


CASA PARA EL SR. PETER SHAYNE
PUNTA BLANCA, SANTA ELENA
14 OCT.'73
ARQUITECTO: ALVARO MALO (Nº55)
FACHADAS SURESTE Y NOROESTE
ESCALA 1:50
HOJA A4

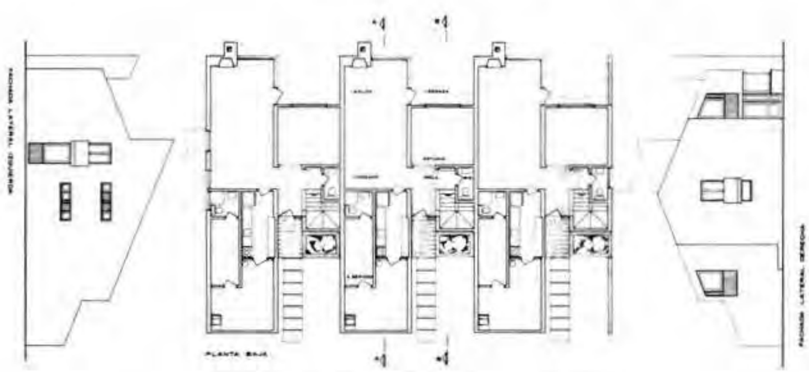

TERRAZA
SALA
COMEDOR
COCINA
DS
GARAGE
DP
PATIO
D1
D2
D3
TERRAZA
N

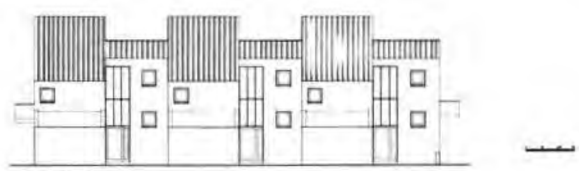
VIVIENDA DE SUBSIDIO
arq. alvaro malo

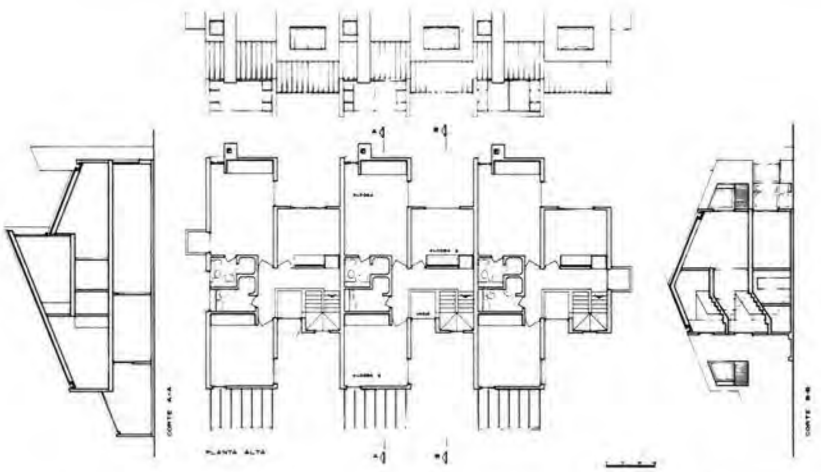
20 Unidades
Area del lote: 6.162.10 m2
Area construida:

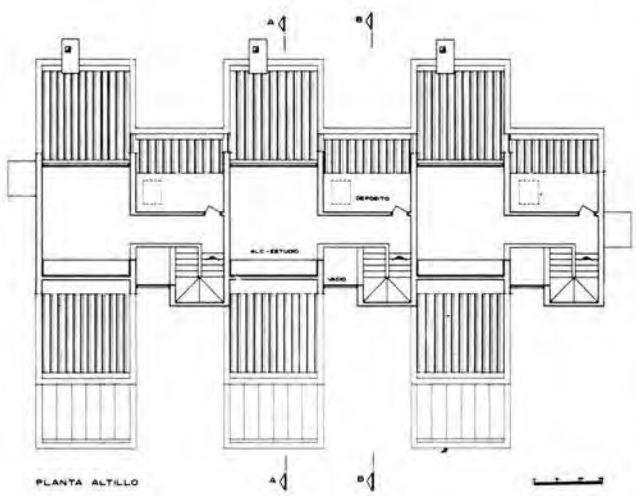
Primer piso	**1.710.20**
Segundo piso	**1.635.20**
Altillo	**456.60**

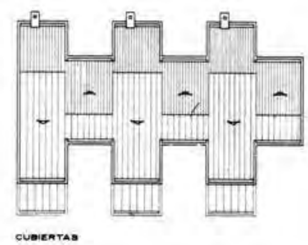
	Proyecto	**Regl. Dist.**
Indice de Ocupación:	**0.32%**	**0.40**
Indice de Construcción:	**0.55**	**0.80**
Estacionamientos	**40 U.**	**20 U.**






CORTE A-A
PLANTA ALTA
CORTE B-B


DEPOSITO
ALC.-ESTUDIO
VACIO
PLANTA ALTILLO


CUBIERTAS

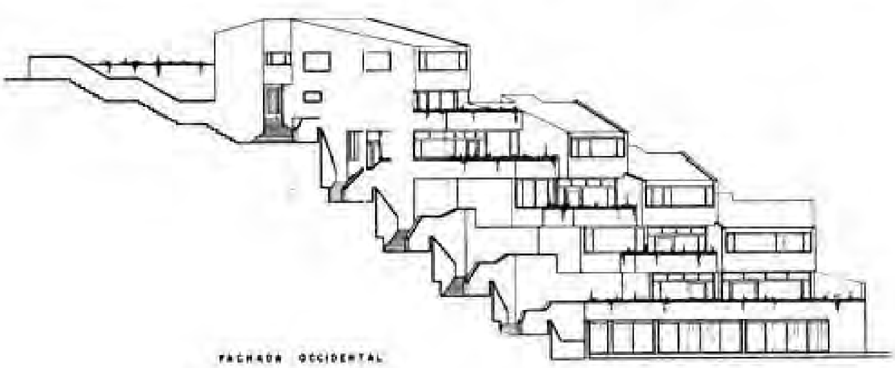
VIVIENDAS ESCALONADAS

arq. alvaro malo

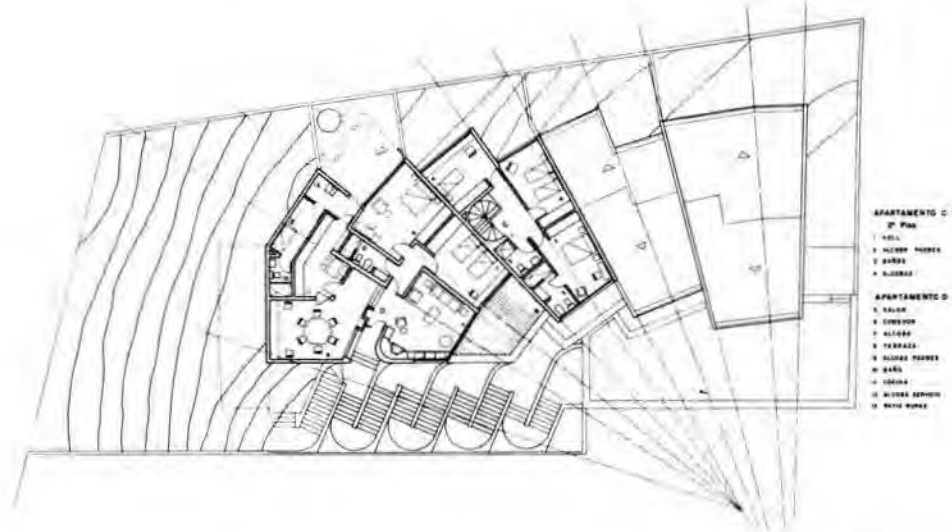
La disposición está dada por la pendiente del terreno y se accede a ellas por una serie de escaleras que las definen claramente. La óptima distribución y su ubicación dentro del lote, permite a cada una contar con una serie de terrazas que se integran a los diferentes espacios interiores y logran una excelente vista sobre la sabana.

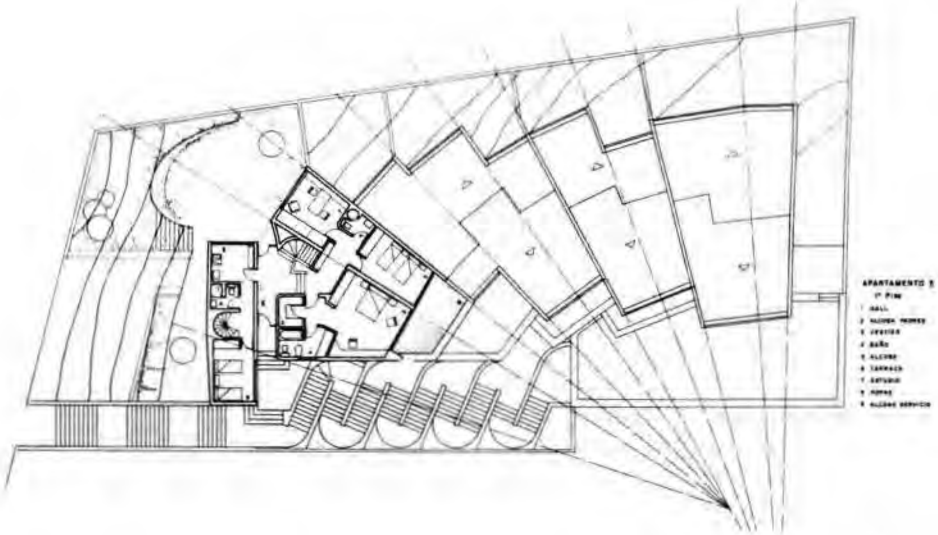
Las viviendas fueron tratadas en dos niveles y en su interior están resueltas con generosas áreas sociales, tres alcobas y un estudio convertible en cuarta alcoba.

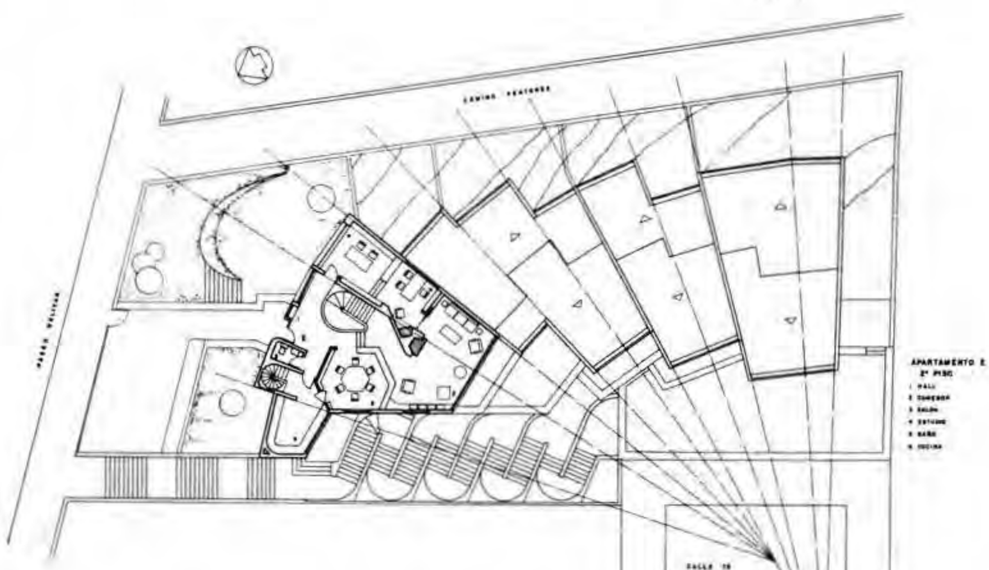
En la composición de fachadas se destaca el ladrillo a la vista.

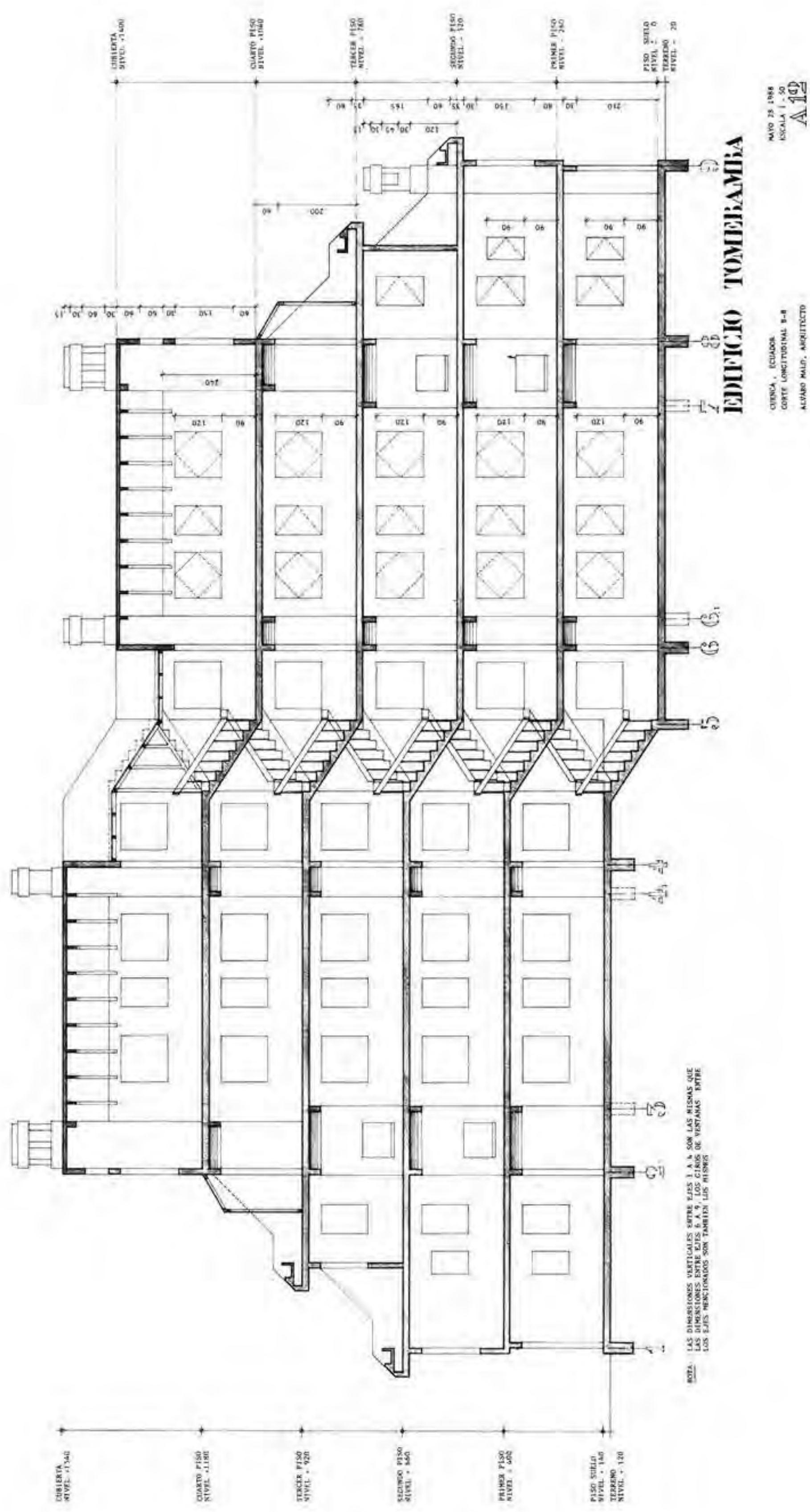


FACHADA OCCIDENTAL

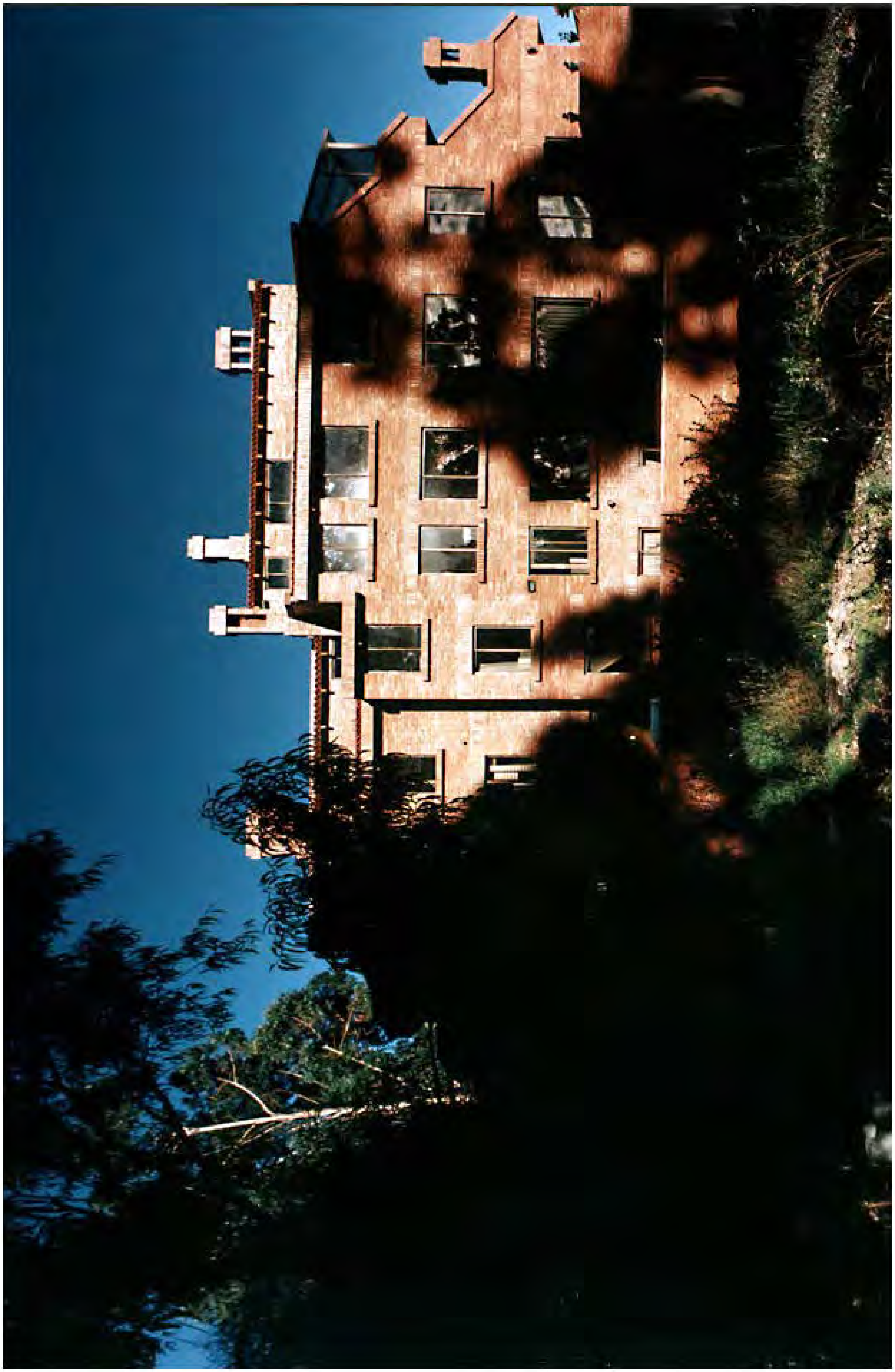

APARTAMENTO C
APARTAMENTO D

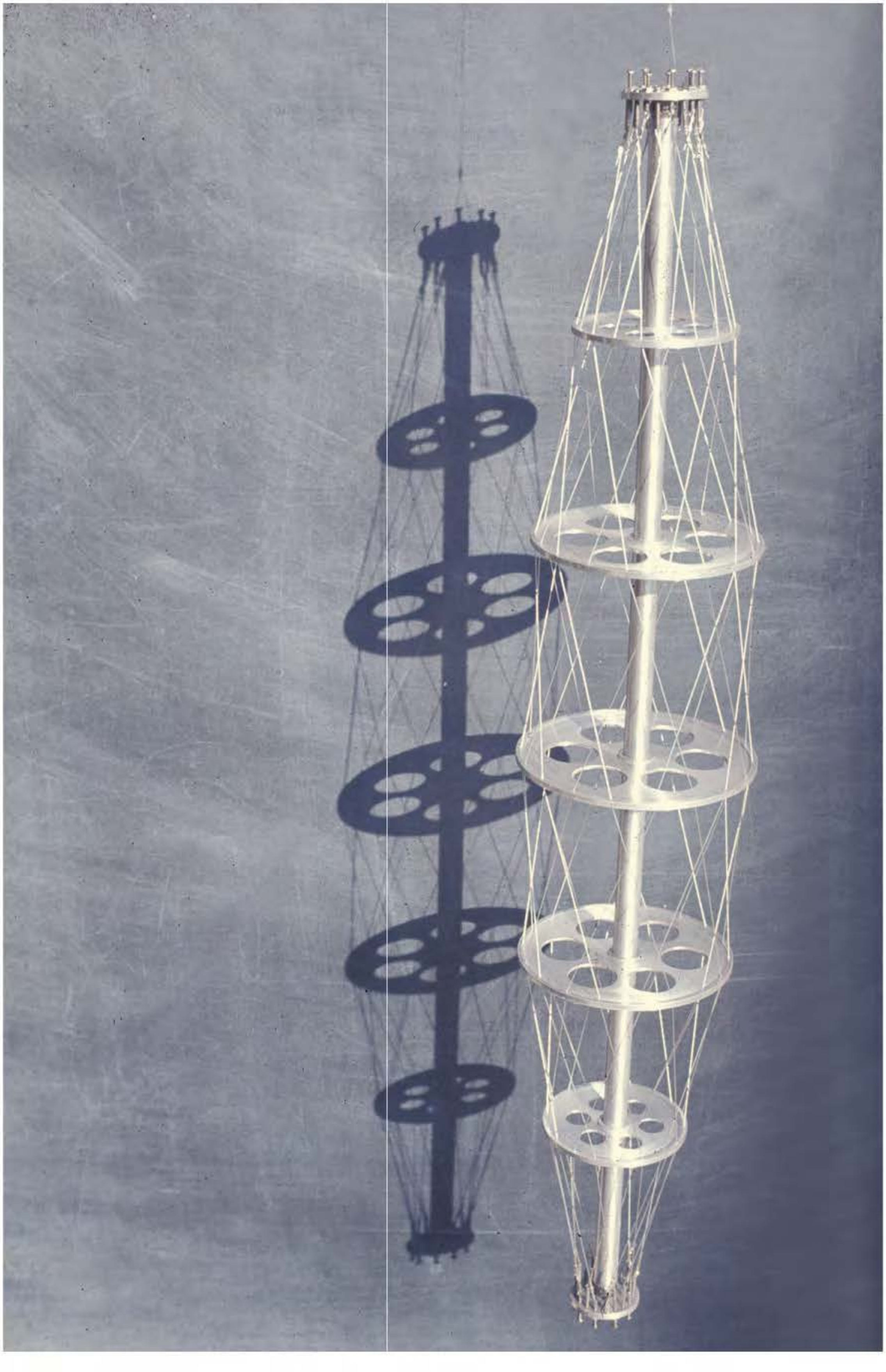

APARTAMENTO E


APARTAMENTO E



CUBIERTA NIVEL +1340
CUARTO PISO NIVEL +1180
TERCER PISO NIVEL + 920
SEGUNDO PISO NIVEL + 660
PRIMER PISO NIVEL + 400
PISO SUELO NIVEL + 140
TERRENO NIVEL + 120
CUBIERTA NIVEL +1400
CUARTO PISO NIVEL +1040
TERCER PISO NIVEL + 780
SEGUNDO PISO NIVEL + 520
PRIMER PISO NIVEL + 260
PISO SUELO NIVEL ± 0
TERRENO NIVEL - 20
NOTA: LAS DIMENSIONES VERTICALES ENTRE EJES 1 A 4 SON LAS MISMAS QUE LAS DIMENSIONES ENTRE EJES 6 A 9. LOS GIROS DE VENTANAS ENTRE LOS EJES MENCIONADOS SON TAMBIEN LOS MISMOS
EDIFICIO TOMEBAMBA
CUENCA , ECUADOR
CORTE LONGITUDINAL B-B
ALVARO MALO, ARQUITECTO
MAYO 25 1988
ESCALA 1 - 50
A12





WRITING

Models: Instrumental and Iconic

ÁLVARO MALO
University of Pennsylvania

> *"Through the years, a man peoples space with images of provinces, kingdoms, mountains, bays, ships, islands, fishes, rooms, tools, stars, horses, and people. Shortly before his death, he discovers that the patient labyrinth of lines traces the image of his own face."* JORGE LUIS BORGES

Modeling is an activity that makes propositions of a possible order of things, real or imaginary. An instrumental model is a reasoned proposition. In its constitution, it is aimed at giving empirical proof of the elements and forces that make up a possible physical reality. It explains the physical limits of the order as an object, fixing the number and kind of its parts and their relative positions, its permanence or change, and its capacity for internal and external movement. In the instrumental sense, when describing the everyday experience of a cosmological reality, I should not say that the sun rises but that the earth turns.

An iconic model is a proposition of a kind of reality that is ordered predominantly, if not exclusively, by the realm of sensations. It is a phenomenon of perception making a direct appeal to our affective consciousness, bypassing the filter of reason. As such, it may yield in consciousness a kind of 'blind affection'; an illusion that may not have a corresponding physical reality. Paradoxically, even though an iconic model may in such case fail to describe a comprehensive 'other reality', when it is given physical description as a stereometric body, or system of bodies, and even more, when materially constructed, it gives proof of at least its own physical reality. Words also allow the proposition of a kind of abstract reality: that is the reality of language, which wraps the physical body in a verbal body, articulating and extending its action upon the world.[1] The propositions in language may also yield simply to the seduction of sensations, bypassing the scrutiny of reason to create psychological illusions. It is inevitable that language, or the memory of language, produces in consciousness its own kind of reality. In the iconic sense, I may say that the sun [also] rises, as a description of psychological perception, which remains in the language as a remnant of a previous mode of knowledge.

Architecture, as a proposition for construction [or re-construction] of the world, oscillates in the gap between the instrumental and the iconic. For Roland Barthes, architecture is simultaneously function and dream: an instrument of convenience and an icon of cultural mythology.[2] When fully vested as a practice, it has a double character, it is a mode of feeling as well as a mode of cognition. As feeling (modus aestheticus), it turns upon the imagination, and as cognition (modus logicus) it is an appeal to judgment:

> Now, imagination rather entitles an art to be called an inspired (geistreiche) art then a fine art. It is only in respect of judgment that the name of fine art is deserved. Hence it follows that judgment, being the indispensable condition (conditio sine qua non), is at least what one must look to as of capital importance informing an estimate of art as fine art.[3]

When the practice, and the study, of architecture are addressed primarily to the fulfillment of the sensual appetite, in the name of beauty, it satisfies a particular aesthetic: that is, a disposition towards composition, production, and perception of buildings as beautiful things. Under the influence of this aesthetic, the iconic intention becomes dominant, probably turning the architect into what Northrop Frye may call: a beautician.

Without disregard for the beautiful [here I make an appeal to a thorough reading of Kant's "Analytic of the Beautiful"[4]], it is conceivable that I may direct my attention to the culture of an aesthetic based not on the idea of beauty but on that of force. Force, here, must be understood as the introduction of human sensibility and desire as an intentional energy that reforms the substance of matter-that makes what is artificial in counterpoint to what is natural. The driving force of this mode of action is human sensibility focalized as intelligence, and made efficient as scientific enquiry and technical production. The notion of the instrument is the focal point of this aesthetic: it is born out of an intention to measure and understand the world by rearrangement of materials and condensation of energy into discreet units of construction that intensify and magnify our senses. Requisites for the making of instruments are an intuitive understanding of the nature of materials in their capacity to bear and transmit energy, good judgment of their capacity to embody particular forms with more or less precise functional efficiency, and technical dexterity to bring their construction forth. Within this tectonic transformation, the human force spent in the act of construction is embodied in the work as a double index: as materialized ideas and idealized matter.

An instrument, in itself, may have a double potential: when used as a means of magnification of the senses, to help the acuity of perception of a given physical reality, its net effect is one of input in the cognitive process; but when used as an extension of the body, a kind of prosthesis that replaces a missing or defective part, or adds to the body as a whole, to help it in its project of fabrication, its net effect is one of output in the active process. In either case the instrument is a body, or body-double, of materials assembled in accordance with a specific diagram of intention or extension, of cognition or action. It is a point of condensation and passage between Bergson's two kinds of memory: the sensory-motor memory of the repetitive acts of the human body, and the imaginative memory of the mind's intuition and recognition of the world.[5]

If the practice and the study of architecture are to point towards a unity of consciousness in experience, it demands an instrumental aesthetic, that is a unification of cognition and action, a redoubling of matter and memory. In the end, instruments also have an iconic destiny, they have a physical body that may have a sensual appeal, and as such be the object of affection. But instead of blindness, this affection will bring clarity to the free and ordered play of the imagination, and will be an enticement to further the project of global construction. At that point the architect may be able to say, with Paul Valéry: "by dint of constructing, I have constructed myself."[6]

In The Critique of Judgment, Kant proposes that there are only three kinds of fine art: the art of speech, formative art, and the art of the play of sensations. The formative arts are subdivided into arts that are either of sensuous truth or of sensuous semblance. To the arts of sensuous truth, also called plastic arts, belong sculpture and architecture. Architecture is unique in that it:

> ...is the art of presenting concepts of things which are possible only through art, and the determining ground of whose form is not nature but an arbitrary end—and of presenting them both with a view to this purpose and yet, at the same time with aesthetic finality. In architecture the chief point is a certain use of the artistic object to which, as the condition, the aesthetic ideas are limited.[7]

The combination of both aesthetic ideas and rational ideas is a necessary condition in architecture. An aesthetic idea is an intuition of the imagination, which in exercise of its free play reaches a subjective accord with the understanding. A rational idea refers to a concept of the understanding, which is regulated by an objective principle of reason with the sole purpose of bringing reason into harmony with itself. Judgment is the faculty faced with the task of bringing imagination and understanding to a free and indeterminate agreement: "This agreement defines a properly aesthetic common sense..."[8]

The appeal of an aesthetic based not on the notion of beauty but rather on that of force is akin to Kant's idea of the sublime. In the judgment of the sublime there is initially an opposition rather than accord between imagination and reason:

> The mind feels itself set in motion in the representation of the sublime [in nature]; whereas in the aesthetic judgment of what is beautiful there it is in restful contemplation.[9]

The feeling of the sublime is experienced when, in the presence of force, one is faced with deformation and reformation. It is a dynamic experience that follows the tug of war between imagination and reason. It is as if the imagination were given unlimited power, and forced to strain to its utmost, "in its fruitless effort to extend this limit, recoils upon itself."[10] Even though it may appear that the limitless, the force that sets back the imagination, is a condition of the object, in reality it is a subjective experience. It is reason that pushes imagination to the limit of its power, "forcing it to admit that all its power is nothing in comparison with an Idea...which forces us to unite the immensity of the sensible world into a whole."[11] This is a dialectical judgment that is grounded in sensibility. It is a mental movement where reason must prevail in sensibility, by turning imagination itself into an instrument of reason. The aesthetic finality is an intellectual admiration, an astonishment that does not cease when the sensuous novelty wears off.

> ...poetry is music made with ideas and therefore with words. Imagine what your making music with ideas instead of with emotions would be like. With emotion you make only music. With emotion that tends toward ideas, that accumulates ideas in order to define themselves, you create song. With ideas alone, which contain only that part of emotion that is necessarily in all ideas, you make poetry...The cooler the poetry, the truer it is.[12]

The genuine problem of an aesthetic based on the idea of force, an instrumental aesthetic, is a paradox of seeking an accord by opposition. In this paradox, imagination and reason seek unity as positive contraries. This dialectical unity is the most profound relationship possible. "Paradox is the typical formula of Nature. That's why all truth has a paradoxical form."[13] If I agree with Kant that architecture is an art of sensuous truth, then I must keep its practice as a paradoxical form. For it is only this possible truth that gives me the grounding of final aesthetic judgment—other than as an expression of taste. But the truth to be found in art is different from the truth of science; it is neither determinable by principles nor verifiable by proof. There can never be an aesthetic science, but only aesthetic judgment.

> For, as to the element of science in every art—a matter which turns upon truth in the presentation of the Object of art—while this is, no doubt, the indispensable condition of fine art, it is not itself fine art. Fine art, therefore, has only got a manner (modus) and not a method of teaching (methodus).[14]

Finding a proper manner for the production of architecture—its study and practice—is the critical task for the teacher. To set up a mode of work at the beginning is, in most cases, a scheme that is immediately under suspicion: it may be seen as an attempt to subordinate the spirit of poetry to logic. It is consequent, however, to recognize that preconceptions, routine, and excessive familiarity may already be part of a mode of production, indeed one of reduction and impoverishment. In order to exorcise the demon of routine and mechanical repetition, of sensuous imitation, we may take advice from the work of Novalis, and have it as an aim "to make the familiar strange and to make the strange familiar". Or follow the suggestion of Erik Satie, that "every act is a virgin act, even the repeated one". The pedagogy must not operate by giving precepts, but by culture of sensibility: by making an appeal to the imagination and its transactions with reason, by eliciting aesthetic and rational judgment, and by giving to precise criticism the positive force that advances the sense of the proposition. It is advisable to avoid setting up examples as prototypes of excellence or models to be imitated without submission to the student's own critical judgment. All of this needs to be done while keeping in mind that (1) no definite rule for production can be given, since it would eliminate the necessary freedom of imagination; instead, the activity must be heuristic, that is, originate its own sense [or meta-logic] in the activity itself. (2) Paradoxically, while the products are not to be derived from imitation, they must in themselves be exemplary, i.e. models that serve as a standard or original meter for judgment. (3) While artistic production, similar to scientific knowledge, is founded on empirical observation and verification, the knowledge of art is eminently practical: it issues from the act of making—which is a mode of free play between mind and matter; in the aesthetic sense, it is the animating force which is set up in the material, and the given back to the imagination—this reciprocating force "sets the mental powers into a swing that is final, i.e. into a play that is self maintaining and which strengthens the powers for such activity."[15]

To enact the outline of a mode of teaching, as a kind of research, I am proposing a practical laboratory with the aim of reforming raw materials into architectural materials; thereby letting the play of forces involved and the resulting forms be the ground of an architectonic sensibility. The words of Novalis and Satie must be a fundamental credo for this laboratory, where the ideal state of mind should be one of critical innocence: that is to be intentionally ahistorical and atheoretical.[16] The radical proposition of this laboratory is to recognize that the most primitive architectural program, but also a thoroughly modern program, is the programming of materials. That is not being primitive in a chronological and historical sense, but being ontologically primitive:

> We learn to see what flows beneath, we learn the prehistory of the visible. We learn to dig deep and to lay bare. To explain, to analyze... We learn the very special kind of progress that leads towards a critical striving backward, towards the earlier on which the later grows.[17]

The words of Carlos Fuentes, "We must remember the future, and imagine the past," are the most compelling call for a modern program, that is: finding the sense of the present. They are a call for actuality, as well as a call for action—action being always a mode of definition of the present. The kind of action required for the practical programming of materials is that of making [material things]. I am selecting glass and metal as the materials for experimentation. I do this, simply, in order to refocus the attention: contrary to the habitual assumptions of the language, glass is a non-crystalline material, and metals are crystalline—in their molecular structure. The immediate task is to activate the materials by the introduction of force, and put the materials 'in tension', making a series of experimental probes. These probes should be taken as discreet units of fabrication that make the force, or forces, discernible from a double index: structural and optical.

The singular aim of each probe, and incremental aim of the series, is that of research and further definition of glass and metal, as building materials, in a threefold sense: first, structural, as that which recognizes the internal constitution and capacity of the materials in reference to internal or external forces. This is focused primarily on two topics: mechanical properties, such as the capacity to resist forces of tension, compression, and shear; and optical properties, which determine the peculiar behavior of materials in reference to light-reflection and absorption, refraction and coloration, transparency and opacity. As a great deal of information is contained in spectral analysis, one might say that matter communicates with us by means of the light that it emits and with which it interacts.

Second, factural, as that which examines the processes of technical production and elaboration of the materials, affecting the ability to work and give form to them by handling, tooling, and machining.

And third, tectonic, as that which represents the dynamic synthesis, or 'double entendre', of the forces employed in fabrication and the resulting forms. Forces and forms are encoded in the work as a transitive agreement between memory and matter. Heuristically, the laboratory must proceed along an experimental axis, being constantly 'on probation', on the look out for signs of artificial intelligence.

NOTES

1 Jean-Paul Sartre, *What is Literature?* Harvard University Press, Cambridge, 1988, p.30
2 Roland Barthes, *The Eiffel Tower*. Hill and Wang, New York, 1979, p.6
3 Immanuel Kant, *The Critique of Judgment*. Clarendon Press, Oxford, 1991, p.182
4 ibid. pp. 41-89
5 Henri Bergson, *Matter and Memory*. Zone Books, New York, 1988, pp.139-152
6 Paul Valéry, *Dialogues*. Princeton U. Press, Princeton, 1962, p.
7 Kant, *The Critique of Judgment*. p.186
8 Gilles Deleuze, *Kant's Critical Philosophy*. U. of Minnesota Press, Minneapolis, 1990, p.49
9 Kant, *The Critique of Judgment*. p.107
10 ibid. p.100
11 Deleuze, *Kant's Critical Philosophy*. pp. 50-51
12 Fernando Pessoa, *Always Astonished*, City Light Books, San Francisco, 1988, p.29
13 ibid. p.30
14 Kant, *The Critique of Judgment*. p.226
15 ibid, p.175
16 Paul Valéry, *The Outlook for Intelligence*. Princeton U. Press, Princeton, 1962, p.114
17 Paul Klee, *Notebooks Volume 1: The Thinking Eye*. Lund Humphries, London, 1961, p.69

A L V A R O   M A L O

The Hand: Organ of Knowledge

I start to write with hesitation. The doubt is provoked by the fact that the proclamation of the rights and virtues of the hand may not be done properly in language. I think that this advocacy must be done by presenting the evidence of the hand's own making. Yet, as the writing progresses, I sense the proof beginning to appear on the movement of the hands across the keyboard, the shape of the script, and the precise rectangle of whiteness of the paper. Still indecisive and seeking support, it is my hands that open a book and I read, "through his hands man establishes contact with the austerity of thought."[1] I close the book and set it on the table. I open another and I read:

> Thinking is too easy. The mind in its flight rarely meets with resistance. Hence the vital importance for the intellectual of touching concrete objects and of learning discipline in his intercourse with them. Bodies are the mentors of the spirit, as Chiron, the centaur, was the mentor of Greek heroes. [2]

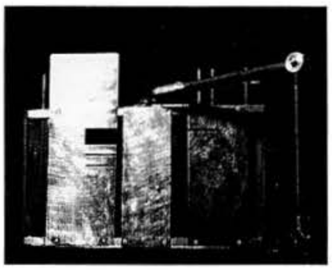
My project now is the pursuit of this paradox (and I will continue writing), that there are two kinds of knowledge: One is the knowledge of matter, which belongs to the notion of instinct, and is encoded as a system in the sensor-motor memory of the body; the other is the knowledge of form, which belongs to the notion of intelligence, and has a seat in the affective-imaginative memory of the mind. [3]

1. Henri Focillon, *The Life of Forms in Art*. Zone Books, New York, 1989, p.157.

2. Jose Ortega y Gasset, "Man the Technician." *History as a System*. W.W. Norton, New York, 1941, p.160.

3. Henri Bergson, *Matter and Memory*, Zone Books, New York, 1988, p.78-131.

The knowledge of matter is instinctive, it is part of the natural order. It is the awareness of the world by which every living organism, plant and animal, is in continuous exchange with its surroundings. It rises spontaneously out of physical necessity and has an effect on matter by integrating it into the body, or arranging it as a direct extension of it. In this order, time is not a separate category of awareness, but it is a mode of simultaneous coexistence of matter, a presence forever certain in the present. The knowledge of form is intelligent, operating within the datum of nature, deliberately rearranging matter to set up a new kind of order, the artificial order. Intelligence, which gains complete instrumentality in the human being, fabricates by abstraction, and is separable from the physical act of making. The sense of time as pure possibility, as a reversible category of representation, and as an abstract measure of virtual or real work, is the transcendental sign of intelligence. [4]



Intelligence and instinct, if highly specialized, may represent two divergent solutions of the same problem: the problem of being aware in the world. But in the human being they are necessarily cooperative capacities: "There are things that intelligence alone is able to seek, but which, by itself, it will never find. These things instinct alone could find; but it will never seek them." [5] The cooperation between intelligence and instinct is best represented not in *Homo sapiens*, but in *Homo faber*, who is the being in complete self-possession of his own instrumentality. The project of the *Homo faber* is the reform of nature by the construction of the artificial world, a supernature interposed between the human being and original nature. Because the human being is made of such paradox as to be natural and extranatural, his whole being is fulfilled only in the *Homo faber*, "a kind of ontological centaur, half immersed in nature, half transcending it." [6] Because he lacks all the necessary instruments to satisfy his extranatural being, to earn his life metaphysically, he fabricates them out of outlying matter in order to become a master of his own destiny. The dialectical project of the *Homo faber* is found in "the concept of nature as 'the inorganic body of man': the naturalization of man and the humanization of nature." [7]

When I consider the system of things which I call the natural world, my body is one of them. But the distinction is not so simple. My body is also the boundary, perhaps shifting, between what is interior and what is exterior to myself. It is the ever advancing boundary between the future and the past, the exact position of the present. It is the place of passage between intention and extension, "a hyphen, a connecting link between the things that act upon me and the things upon which I act." [8] In the *Homo faber*, the body has a tendency, a favorable disposition

4. Immanuel Kant, *Critique of Pure Reason*, St. Martin's Press, New York, 1965, p.74-91.

5. Henri Bergson, *Creative Evolution*, Henry Holt, New York, 1911, p.151.

6. Ortega y Gasset, p.111.

7. Jean Baudrillard, "The Mirror of Production." *Selected Writings*, Stanford University Press, Stanford, 1988, p.106.

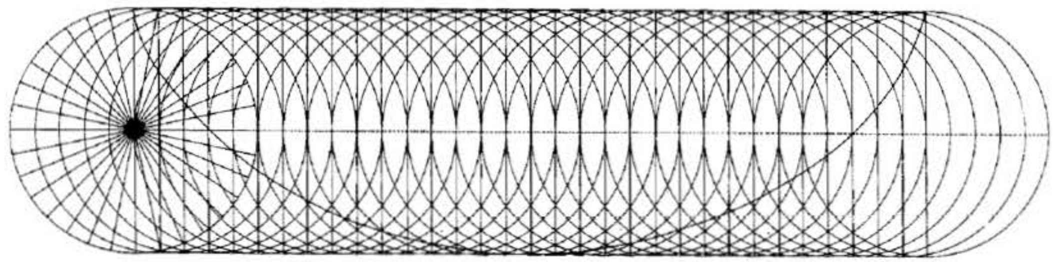
8. Bergson, *Matter and Memory*, p.151.

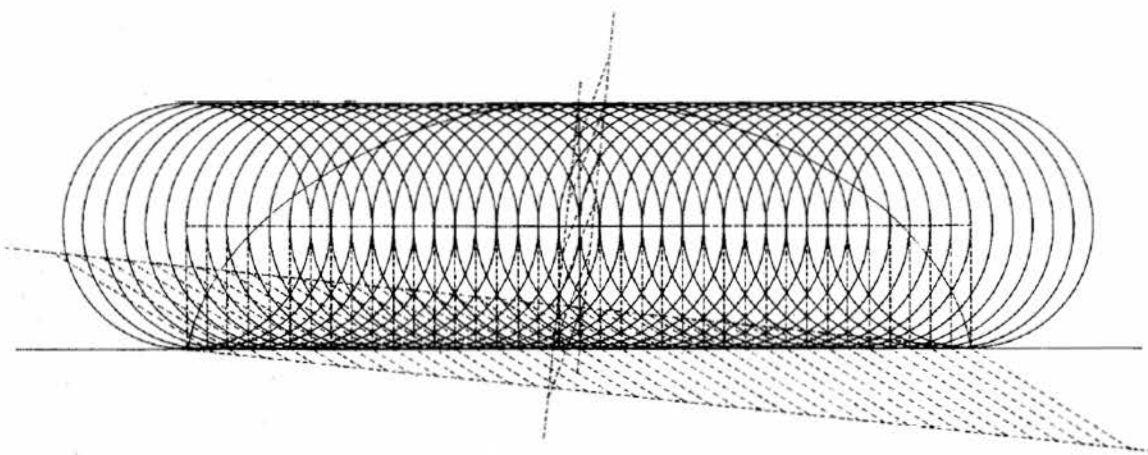
towards action. Already sensing the weight of earthly gravity, it must play its muscles and joints and direct its movements to the task of surmounting the resistance of materials, making them malleable, pliable, and carvable at will. It is most effectively in the hand where energy converges and leaves the body in the process of fabrication. All kinds of fabrication must be at the beginning, essentially, manufacture: that is, they must start with the intentionally directed movement of the hand. Initially, the hand may move across materials by direct contact, such may be the rudimentary movement that leaves on the sand the drawing of a circle, imprecise though it may be. If the movement must become more precisely measured, or if the hand is by itself insufficient for the task, the hand must then manufacture an artificial instrument to make its action more efficient. The manufactured instrument, the tool, multiplies the capacity and efficiency of the hand that constructs it. In one sense, the tool is the "congealed outline of an operation," and the objective memory of movements already executed. In another sense, it is a "finality without end," soliciting the free and ordered play of the mind in its project of fabrication. [9] Tools are occasions for further work of the hand; they are the precise locus of a dialectical experiment of knowledge that neither mind nor sight can conduct alone. The human being patiently creates his own hands by gradually freeing them from the animal world. "The hand that is in his mind is at work," liberating the human being from animal bondage and turning him into recognition of his own aspiration, his own project of life. Like the Centaur, he has transferred into reality the program that is his own transcendental self. Though my hands make other things, they can also make that 'thing' which is myself: "They are the instrument of creation, but even before that they are an organ of knowledge." [10]

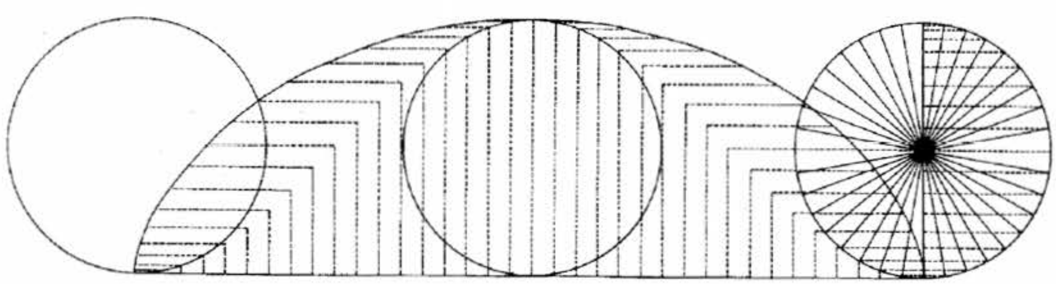
Holding a compass, and supported by it, the hand can bring its movement into greater control and draw the outline of a more precise circle. Here is the beginning of a systematic geometry, which records the abstract choreography of movements, as lines constructing the basic scaffolding of space. In this ordered space, subtending and reflecting the conceptual capacity of the mind, the hand may continue the production of measured work. In the act of drawing itself, we can establish a gradual passage from intention to extension, identifying at least three stages: first, conceptual drawing as a precise abstract of a form in space, without regard for material; second, pictorial drawing, displaying in light and shadows an object capable of embodying such form with articulation and detail; and third, construction drawing as a mode of transfer of the object into its material stereoscopic body, reciprocally measuring the object and a possible material, and their coherence, in anticipation of manufacture. Representation or imagination is the evoca-

9. Jean-Paul Sartre, *What Is Literature?* Harvard University Press, Cambridge, 1988., p.55.

10. Focillon, p.166.







tion of objects in their absence. Distinct from that, perception is the knowledge of objects resulting from direct contact with them, through the manifold of the senses. In the act of drawing, both intelligence and instinct are brought into a precise oscillation and correspondence, making the opening on a plane through which the perception-image going towards the mind, and the imagination-image launched into space, rebound from each other in proper synchrony. Writing is a peculiar kind of drawing that does not aspire to become a material object. It is rather the drawing of words, or calligraphy, which in themselves may be abstract representations of things. Yet, calligraphy itself has a particular kind of materiality that is lodged in the widening gap between words and things. In the calligram, where the arrangement of the script plays with the visible resemblance of the thing represented, the quasi-materiality of the writing is further enhanced, and the text becomes tautological, or redundant as words. [11]

While I remain intuitively skeptical of our tendency to use words to explain our understanding of things, for intuition is silence, and the name is inessential in the face of the thing which is essential, it is inevitable that we must speak. We are within language as within our body, and words are prolongations of our senses, which articulate the structure of the external world. The hand's action defines the cavity of space and the fullness of the objects that occupy it. For the poet, the movement of the hand, with the permanent mark of humanity on the inside and outside of all objects, has a metaphysical equivalence to a whole life of literary production:

> That is the kind of poetry we should be after, poetry worn away as if by acid by the labor of hands, impregnated with sweat and smoke, smelling of lilies and of urine, splashed by the variety of what we do, legally or illegally. [12]

I think that the poet would agree if I modify the proposition, and say, "I make, therefore I am." Now I am comforted and less apologetic of the fact that lately I have been frequenting hardware stores, and avoiding the local libraries.

11. Michel Foucault, *This is Not a Pipe*, University of California Press, Berkeley, 1983, p.19-31.

12. Lois Poirot, *Pablo Neruda : Absence and Presence*, W.W. Norton, New York, 1990, p.38.

Through the Looking Glass

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> You see, to me it seems as though the artists, the scientists, the philosophers were grinding lenses. It's all a grand preparation for something that never comes off. Someday the lens is going to be perfect and then we're all going to see clearly, see what a staggering, beautiful world it is…[1]
>
> - Henry Miller

The most primitive and traditional proposition of architecture, but also a truly radical and modern proposition is one of reformation of materials. To begin the reform one must have plans, or models, which show in advance the forms into which the material could be reformed. Plato called these models, or forms: "Ideas". For him, they were immutable matrices of perfect form, or eternal truths that reside beyond the imperfect physical world. The Platonic plan is not a plan for action, but for contemplation. It gives rise to the classical notion of pure metaphysics.[2] On his footsteps came Aristotle, not concerned with the recognition of forms as immutable entities but with formation as a gradual process found in experience. He called this process of unfolding of physical reality " "Energeia". The Aristotelian concept, with its concomitant research of the "dynamic principles" and the "four causes" —material, efficient, formal and final— laid out the foundations of western science and technology.[3] This is a plan for action; for making and doing. It grounds metaphysics in real everyday experience, providing, as it were, with a "center of gravity". And, it gives physics a fluency, a direction looking to the other side of reality, animating it with a "center of levitation".

My choice for a daily occupation is to experiment in the gap between materials and ideas, between the concrete and the abstract. And then, traverse that space, which I define as *work-space*, by approaching its two opposite ends as paradoxical coincidences: the "Idea of Materials" and the "Material of Ideas".

> There are clay ideas, and there are ideas forever carved of gold or of our precious glass. And in order to determine the material of which an idea is made, it is enough to pour into it a single drop of strong acid. One of these acids was known to the ancients too: "reductio ad finem".[4]

Reduction to the end! This is the concept of analysis: to take apart a compound into its simplest parts. In so doing, I am searching for an understanding of the substance out of which something is made, and also what is the thing made with that substance. In simple terms, the reciprocal influence of form and material. As a practical craftsman, it is only proper that I should be concerned with matters of form. But I should not forget that alongside the formal interest, before the first line is drawn, there lies a whole prehistory: the nature and capacity of materials. The aim is to work without preconception of either optimum form or optimum material. It is rather, to experiment critically, but freely, trying to determine the practical boundaries and coincidences between the two —looking for technical and aesthetic "common sense".[5]

I have selected glass as a material for experimentation. Out of technical and epistemological necessities, metals will also be part of the work. I do this simply in order to refocus my attention. Contrary to the habitual assumptions of the language, glass is a non-crystalline material and metals are crystalline —in their molecular structure.

It is necessary, for me, to rectify the notion that the structure of glass is that of crystal. Even more, that as a matter of physics, glass is unequivocally a solid. The study of solids is mainly a matter of geometry. The building blocks of a solid can be considered as arrays of atoms and clusters of molecules that have a precise distribution over the field of matter. Before a liquid can crystallize it must have in it a seed —a small crystal. A seed is often made of small groups of atoms attached to foreign particles or irregularities on the surface of the container holding the liquid. In the case of crystalline solids, almost all metals, atoms aggregate around the seed forming a perfectly repetitive structure: a closely packed spatial arrangement of regular and deformed polyhedrons.

Crystallization normally takes place when a liquid is cooled to a particular temperature, or freezing point. At this point the liquid is affected by a sudden heat loss to its surroundings. This burst of heat is the effect of a phenomenon by which atoms or molecules, initially in a state of randomness, move into the highly ordered geometrical field of crystalline structure. Some liquids become extremely viscous near the freezing point, impeding the formation of crystals. The more the temperature drops the more viscous the liquid becomes, turning rigid gradually, on an asymptotic curve to infinity. Glass is not a crystal but a supercool liquid of infinite viscosity.

The degree of molecular ordering in glass is dependent on the speed of cooling. In the practice of glassmaking close attention is paid to the techniques of quenching (rapid cooling) and annealing (slow cooling). The game plan of the glassmaker is that of checkmating the liquid between time and temperature.[6]

The geometry of glass structure is the geometry of disorder on the way to order. The art of the glassmaker can be explained in terms of thermodynamics, chemical bonding and molecular architecture.[7]

My immediate task is to activate materials. To make them work by the introduction of force. To put the materials "in tension" (or attention) by making a series of experimental probes. These probes should be taken as discrete units of fabrication that have no ulterior motive other a double index: than encode, and decode, one structural-optical and other aesthetic-visual.

The singular target of each probe, and the incremental aim of the series, is that of research and further definition of glass as a building material. The double index is an intrinsic necessity after the proposition that the act of building has a physical, as well a metaphysical effect. In the words of Valéry:

> By dint of constructing —he put it with a smile— I truly believe that I have constructed myself…Here I am, says the Constructor, I am the act.[8]

The first, structural-optical, is a physical index. Structurally, it deals primarily with mechanical properties, such as resistance to forces of tension, compression and shear. Optically, it refers to the behavior of glass in relation to the light: reflection and absorption, refraction and color, transparency and opacity. A great deal of information may be obtained by spectral analysis —one may say that matter communicates with us by means of the light that it emits, and with which it interacts. Indeed, one may go further and say, with Louis Kahn, "Material is spent light".

The second, visual-aesthetic, is a metaphysical index. Didn't Klee say: Art does not reproduce the visible but makes visible?[9] By the function of the optical, sensory eye, it communicates with the visual, the mind's eye. A close encounter between mind and matter, form and material. By means of sight we move to insight, Outward sight and inward vision, and vice-versa. Such experience enables the "I" to draw inferences about the inner object from the optical exterior. To look is to examine the structure of appearances:

> Not to say that behind appearances is the truth, the Platonic way. It is possible that visibility is the truth, and what lies outside visibility are only 'traces' of what has been or will become visible.[10]

What is the effect of visibility? It is a form of energy continually transforming itself: a solidarity between who is looking and what is being looked at. An exchange, a transitive agreement between the subject and the object. The effect of visibility is an "affection" of the body, and an "affect" of the mind (Spinoza).[11] The aesthetic index is a wake up call, prompting an intuitive movement of the "forms of internal sensibility" (Kant).[12]

A particular aesthetic is that, which in the name of beauty and the satisfaction of our sensual appetite, looks at buildings primarily as beautiful things. If dominant, it may turn the architect into what Northrop Frye may call: a beautician.

I think, with Fernando Pessoa, that we can formulate "an aesthetic based not on the idea of beauty but rather on that of force…constructing new kinds of works" that could not be foreseen or accepted by those subscribing univocally to the aesthetics of the beautiful.[13] Force not understood as brute uncritical violence, but as the introduction of human sensibility and desire into the substance of matter. This driving force is a kind of functional penetration of sensibility, made abstract as intelligence, and made effective as scientific inquiry and technical production. It is born out of a tectonic intuition of the nature of materials, their capacity to bear and transmit energy, and their ability to embody particular forms with greater or lesser efficiency. The human force spent in the act of construction is reflected twice: as "materialized ideas" and "idealized materials". Now, we may go further than Louis Kahn, and say that: material is spent desire.

MECHANICS

Mechanically, even though apparently at rest, glass in its rigid state is always at work. When molten glass cools, the outer surfaces become cooler and rigid sooner than the inner mass. As cooling continues, the inner mass will contract putting the outer layers, which are already rigid in compression. Inversely, the outer layers will, in opposition to further contraction, set tension in the inner layers. If only one side of a flat glass pane is heated, that side wants to expand. But is held back by the other side, which itself is being stretched. This tug of war of compressive forces on one side and tensile forces on the other side causes a deformation, or warping of the plane, eventually leading to fracture. Permanent strains are always present in glass due to the antimetrical forces acting between the outer surfaces and the inner layers. Temporary strains are due to differences in temperature from side to side. Theoretically, the tensile strength of flat glass is approximately 1000 kilograms per square millimeter; in practice it has only 1 percent of that value. The compressive strength is 10 times higher.[14] The working strength of glass can be increased manifold: tempering by heat, plate laminating, and by chemical treatment of the surface. To cut, or break glass it is sufficient to scratch its surface, breaking the continuity of the compressive layer. Microscopic flaws of the surface reduce its strength considerably. The strength may be regained with a bath in hydrofluoric acid, which gives the glass a smooth, virgin surface.

> The form, then, of any portion of matter…may in all cases be described as due to the action of forces. In short, the form of an object is a 'diagram of forces'.[15]

OPTICS

It is possible to make forces visible through polarization and reduce perception to a diagram of light. The development of optical theory and technology in the twentieth century has been astonishing. Corpuscular ideas of light, after having been forgotten for a century, reappeared when Einstein postulated the existence of "quanta" of light. As a result, Newton's *Optiks*, in its curious blend of corpuscular-theory with wave-theory, is now found to be inconsiderable agreement with modern views.[16]

Moved by the logical clarity of the "definitions" and "axioms", I ventured further to examine the "propositions" and the "proofs" by experimentation. Of immediate interest are the first five propositions of Book I, dealing with the composition of sunlight, the colors of the spectrum, refraction, and reflection. And the first seven propositions of Book II, regarding the permanent colors of natural bodies and their analogy to colors of thin transparent plates.

With this enticement and ammunition, I proceeded, with my students, to construct a number of probes made of glass, metal, water, and air. I resisted the temptation to add to the arsenal, at this point, the plethora of a new generation of sophisticated glasses: colored, filtered, multi-coated, dichroic, et cetera. There is sufficient challenge, at the beginning, in the work that one can do with clear sheet glass.

Only part of a beam of light striking a glass plane will pass through it. Some of the light is reflected at the front surface; the remainder passes through the glass, where part is absorbed as heat, and part reflected at the second surface. The percentage of light transmitted depends on the optical properties of the glass and on the wavelength of the incident light. Visible light extends from about 400 nanometers for violet light and 700 nanometers for red light —a nanometer is one millionth of a millimeter. The angle of refraction of a beam of light passing through a pane of glass is in inverse proportion to the wavelength: the shorter the wavelength the larger the angle, and vice versa. The dominant feature of sunlight, as seen through Newton's prism, is a color continuum extending over the entire visible spectrum, from red to violet.[17]

> Between the parts of opaque and color'd Bodies are many Spaces, either empty, or replenish'd with Mediums of other Densities; as Water between the tinging Corpuscles…Air between the aqueous Globules…and for the most part Spaces void of Air and Water, but yet perhaps not wholly void of all Substance…PROP.III, BOOK II.[18]

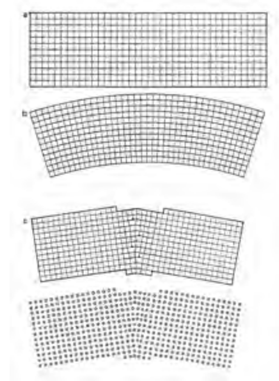

Fig.1 Diagrams of elastic and plastic deformations.

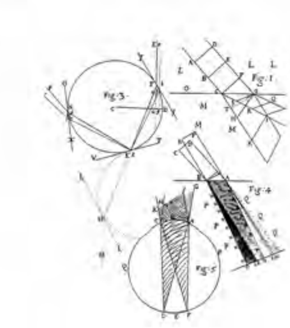

Fig.2 Diagrams of light paths in the eye and other media.

VISIBILITY

The diagram, being visible, is the symbolic representation of invisible processes, forces, structures. The totality is the surface, which is now the sum and origin of all that one sees. Seeing is a synthesis that allows the passage from the exterior to the interior, from spectroscopy to introspection. The phenomenon changes from extension to intention: the category from "quantity" to "quality".[19]

The synthesis achieved by our consciousness has a different sense of time from that of mere physical measure. Consider the example given by Bergson: in the space of a second, red light —which has the longest wavelength, and therefore the least frequent vibrations— realizes 400 billion successive vibrations. To form an idea of this number we would need to separate the vibrations sufficiently to account for each one. The smallest interval of time that we can detect, according to Exner, is 0.002 seconds. If we were to add these intervals, so that each of the 400 billion vibrations is accounted, and separated from the next by 0.002 of a second, 25,000 years would elapse at the end of the operation. The perception of red light, experienced by our consciousness in one second, would require 250 centuries for its empirical demonstration.[20]

Working with glass, we are working in the realm of light. We are diagramming space with light. Space is part of that realm, "part of the continuity of events within it…It is not a mere container." My interest lies in the position of glass, not as a fill-in material, but as a material of structure. Without a rigid bias against what you may call structure, let me say that, for me, it is what is sufficient and necessary for construction. And add, with Louis Kahn, that: "Structure is the giver of light."

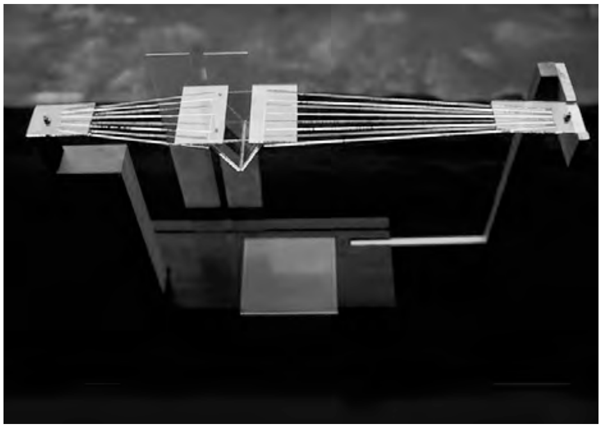

Fig.3 Holleman compression-tension probe.

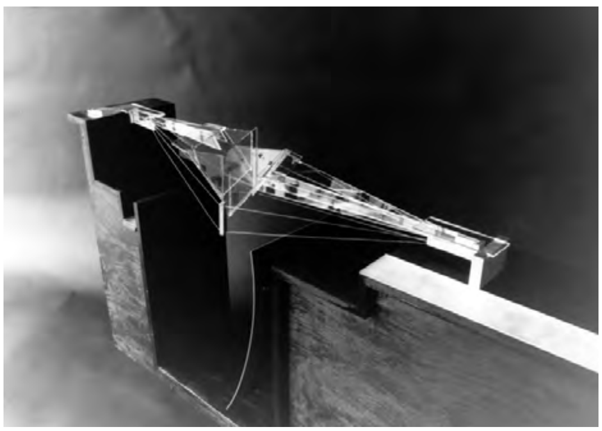

Fig.4 Holleman light "Spectrum Splitter".

Between the curtains and the window: a space like the lines on which music is written: but three-dimensional, and the notes of light, rather than sound.[21]

AESTHETICS

If we are moved by Kahn, we may move to Kant and speak of aesthetics as the condition of inner experience. Where, "Time is therefore to be regarded as real, not intended as object but as the mode of representation of myself as object."[22] I cannot search for empirical data her. To look here is to overflow the outline, the category, the name of what it is. I must abandon myself to my own devices of reflection and speculation: "looking for the autonomy of the inside". The surface becomes the site of a departure that works up the slope of tactile sensations, the optical model, and of geometry of perception, to arrive at an "architecture of vision". Paradoxically, the site of departure becomes the site of arrival, and the "status of the object is profoundly changed, so also is that of subject." The inside and the outside mark the limits of the infinite fold that separates or moves between matter and memory. The line of inflection is materialized in the mind but idealized in matter, "the search for a model of the fold goes directly through the choice of a material".[23]

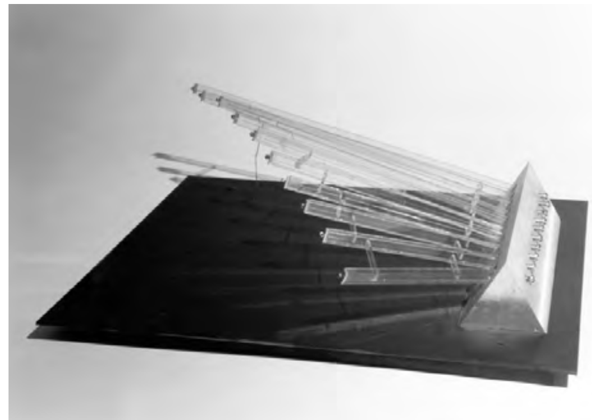

Fig.5 Gehrwig "Optigraph" structure.

Fig.6 Gehrwig "Optigraph" plane

Whether it is paper or glass, the aesthetic "affect" is ne of levitation from the "kingdom of nature" to the "kingdom of grace".

And from the inside, too, I'd duplicate
Myself, my lamp, an apple on a plate:
Uncurtaining the night, I'd let dark glass
Hang all the furniture above the grass
And how delightful when a fall of snow
Covered my glimpse of lawn and reached up so
As to make chair and bed exactly stand
Upon that snow, out in that crystal land![24]

NOTES

[1] Gilles Deleuze, *Spinoza: Practical Philosophy*, City Lights Books, San Francisco, 1998, p.14.
[2] Plato, *The Republic*, Bk. X, Penguin Classics, Hamondsworth, 1984
[3] Aristotle, *Physics*, Bk. II, Ch. 3-9, and *Metaphysics*, Bk. I, Ch. 3-10, J.A. Smith and W.D. Ross (ed), *The Works of Aristotle Translated into English*, Oxford U. Press, Oxford, 1952.

[4] Yevgeny Zamyatin, *WE*, translated by Mirra Ginsburg. Avon Books

[5] The notion of "common sense", is here derived from Immanuel Kant's *Critique of Judgement*, translated by J.C. Meredith, and further expounded in Gilles Deleuze, *Kant's Critical Philosophy*, U. of Minnesota, Minneapolis, 1983.

[6] Checkmating is here a reference to Primo Levi's "Time Checkmated", *The Mirror Maker*, Schocken Books, New York, 1989, p.71-76.

[7] R.J. Charles, "The Nature of Glasses", *Scientific America*, September 1979, p.127-136.

[8] Paul Valéry, "Eupalinos, or the Architect", *Dialogues*, Bollingen/Princeton U. Press, Princeton, 1989, p.81, 148.

[9] Paul Klee, *Notebook Volume I: The Thinking Eye*, Lund Humphries, London, 1978, p.76.

[10] John Berger, *The Sense of Sight*,

[11] Deleuze, *Spinoza: Practical Philosophy*, p.48-51.

[12] Immanuel Kant, *The Critique of Pure Reason*, translated by N.K. Smith, St. Martin Press, New York, 1965, p.66-91.

[13] Fernando Pessoa, *Always Astonished*, City Lights Books, San Francisco, 1988, p.70-73

[14] Rune Person, *Flat Glass Technology*, Plenum Press, New York, 1969, p.27.

[15] D'Arcy Thompson, *On Growth and Form*, Cambridge U. Press, Cambridge, 1977, p.11.

[16] Isaac Newton, *Optiks*, Dover, New York, 1979, p.lx-lxiv.

[17] Ali Javan, "Optical Properties of Materials", *Scientific America*, September 1979, p.239-248.

[18] Newton, *Optiks*, p.249.

[19] Kant, *The Critique of Pure Reason*, p.111-115.

[20] Henri Bergson, *Matter and Memory*, Zone Books, New York, 1989, p.205-206.

[21] Berger, *The Sense of Sight*, p.220.

[22] Kant, *The Critique of Pure Reason*, p.79.

[23] Gilles Deleuze, *The Fold: Leibniz and the Baroque*, U. of Minnesota Press, Minneapolis, 1993, p.19, 35-37.

[24] Vladimir Nabokov, *Pale Fire*, Vintage International, New York, 1989, p.33.

URBAN LANDSCAPES
Intermodalities of Miami: Public Transportation Projects

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INTERMODALITIES:
Water, Land, Air…

The geography of the South Florida metropolis is that of a long and narrow urbanized strip, 90 by 15 miles, stretching north to south from Palm Beach to Homestead. The natural physiognomy of the region is framed on the eastern front by a string of sand barrier islands on the Atlantic Ocean and the edge of the Everglades aquifer on the west — the Intracoastal Waterway, a navigable artificial canal connects a series of natural bays and lagoons that separate the barrier islands from the mainland. The Florida Keys, a row of limestone and coral reefs, thrust 125 miles further southwest into the Gulf of Mexico, reaching its southernmost point at the historical town of Key West — a refuge for a succession of buccaneers, political expatriates and American poets.

If it was only the dark voice of the sea
That rose, or even colored by many waves;
If it was only the outer voice of sky
And cloud, of the sunken coral water-walled,
However clear, it would have been deep air,
The heaving speech of air and summer sound
Repeated in a summer without end
And sound alone. [1]

By water: The Everglades, the Miami River, the Port of Miami…

The geology, archeology and mythology of the region prompt a question: where do you begin? Miami is an Indian word meaning *sweet water*… In the Miami River, a natural drain of the South Florida aquifer, the brownish water from the glades, infused with metabolic detritus, mix and dissolve intermittently with clear spring waters. Tidal action extended close to the headwaters, but the heavier brackish water was prevented from receding further by the rapids, or falls at the edge of the Everglades.

1. Towing cargo ships on the Miami River, with Metromover span on the background.

The miracle of the light pours over the green and brown expanse of sawgrass and of water, shining and slow moving below, the grass and water that is the meaning and central fact of the Everglades of Florida. It is a river of grass. [2]

Today, after dredging the riverbed and building of artificial canals to improve navigation and marine industry, the river still retains traces of its vector of natural flow cutting a diagonal swat across the orthogonal pattern of the city. Much of the eastern edge of the Everglades has disappeared after repeated channeling and draining to provide land for agriculture and westward expansion of the city. Salinity dams have replaced the natural function of the rapids. What remain now are incidental lagoons and ponds scattered among urban and industrial development.

The Miami River is a shallow draft seaport, doing business primarily with the Caribbean Basin. Contrasting with the luxury cruise liners that dock in Biscayne Bay at the Port of Miami, those who venture up river are battered freighters doing industrial hauling, fishing boats that unload their catch at the many fisheries located on the river's edges, and a plethora of small makeshift vessels flying Caribbean flags. The latter have become permanent fixtures lining the riverbanks, barely a flew blocks from downtown Miami. Overloaded with second hand appliances and surplus merchandise, they seem to be forever on the brink of departure — a nomadic urban colony, collecting the refuse of a wealthy society and suspended in time at the water's edge.

On land: drawbridges, highways, elevated trains…

An intense relationship between the city and the water occurs at the river crossings. Ten operating bascular drawbridges, each under the watch of a bridge tender, span the river stitching back the orthogonal fabric of the city. The exposed mechanism of the drawbridges reveals an almost archaic technology of gigantic gears, cantilevered girders and counterweights, resembling skeletons of prehistoric amphibians washed up at the riverbanks. But the fleeting resemblance is quickly dispelled when the enormous clockwork mechanism is set in its up-and-down motion.

Bridges are practical structures and powerful aesthetic objects. For impatient motorists, they are the only evidence that the river exists. For boaters, they are rhythmic visual gates that keep the beat of their river journey. And for pedestrians, they are points of passage where two elemental landscapes meet: water and land. A new practice of urbanity and civic architecture can be hammered out at the exact location of the bridges: a magnificent linear gallery and a theater of machines, a dispersed collection of large mechanical artifacts that animates the life of the city with the naïve mythology of efficient and playful monuments that sway between physics and fairy tale.

The overlap of the city map, based on an orthographic logic, and the meandering course of the river, responding to the dynamics of water flow, is a condensed version of the exchange between the *striated* and the *smooth* physiognomies of the landscape.[3] In this exchange, the drawbridges gravitate towards the striated by their stability and alignment with the city, but respond to the *smooth* by their mechanical movement and transformation yielding to the flow of the river. The bridges counterpoint is manifest in the *unsettled settlements* of the "Tent City" of Cuban refugees beneath I-95, in 1980, and today's "Haitian Boats", both apparently fixed in the pattern of the city, but inevitably shifting to nomadic fabric patchwork and scrap metal shantytowns (Figure 2).

Contrasting with the aquatic and the earthbound movements is the third dimension of the quasi-aerial choreography of regional highways (I-95 and SR-836) and elevated trains (Metrorail and Metromover) that responding to different speed and spatial geometry inflect their smooth and mathematically elegant parabolic vectors, at least 75 feet high, over the terse compressed surface of the water.

2. Cuban "Tent City" beneath I-95, refugees from the exodus of 1980. Historical Museum of South Florida, 1980.

The overlapping vision of the river and the city from the lofty overlook of the highways and elevated trains brings to mind a compression of history. The simultaneity of the past geological time immersed in the fluent memory of the river, a territory now haunted by forgotten Indian burial grounds; the present time of the city of Miami, barely reaching its first centennial in 1996; and, the cybernetic promise of a future time afloat in the air, sporadically materializing in technologies of movement and information — *tempus fugit.*

The effects of enormous transportation structures such as I-95 and Metrorail, which traverse downtown Miami at elevations between 55 and 75 feet, can be the exhilarating vision of a *brave new world* from above, but devastating at ground level. The radical task of integrating these large linear public work structures, normally associated with engineering and vectors of movement, rational efficiency and economy, into the heterogeneous fabric of the city demands new philosophies and practices of land use, adaptation of road alignments to local circumstances, and continuous structural and aesthetic innovation.

Of air: tropical storms, the Airport…

The cosmopolitan glamour and ethnic frenzy lush tropical vegetation and changing skies of Miami are haunted by the memory of devastating tropical storms. For centuries storms have wreaked havoc in the Caribbean region, punishing with natural neutrality the efforts and hegemony of power of the day: sinking Spanish gold galleons, blowing away the plantations of colonists and native settlements, and putting to severe test the ingenuity of modern structures.

Forty-seven thousand Miamians were left homeless by a hurricane, in 1926 that destroyed five thousand dwellings and killed 113 people. In 1992, Hurricane Andrew denied the naïveté that such natural disasters could not strike again. Eighty thousand homes were destroyed and 160,000 people left homeless. The normally ordered regimes of water and land were turned up side down: of the hundreds of boats in the harbor many ended on the streets, and the causeways were under water.

Natural forces and phenomena are inevitable ingredients of the region. An urban mythology of Miami may not be found in imported styles or depleted historical models — which raise the question of the image's truth — but must reflect its region in the dynamic interplay between natural forces, technology and a sensible aesthetic of construction.

For millions of visitors and immigrants, the first impression of the United States is a vision from the air of the barrier islands, the Florida Keys and the immense expanse of the *river of grass* of the Everglades. Located between the forks of the Miami River, the Miami International Airport is a major destination for domestic travel in the United States and connecting gateway for international travel from Europe, the Caribbean and South America (Figure 3).

One of the country's busiest airports, MIA handles 30 million passengers per year. Its projected growth forecasts 55 million passengers by 2010 and 70 million by 2020. It is unlikely that expansion of the airport functions could occur within the airport grounds.

To solve this problem and to ease east-west traffic congestion, the Florida Department of Transportation began, in 1993, studies for two major projects: 1) the Miami Intermodal Center, and 2) the East-West Multimodal Corridor (along S.R. 836) providing increased vehicular and train access between the Airport, downtown Miami and the Seaport.

3. Miami International Airport and SR 836 (right) going to the Seaport. FDOT, 1993.

INTERMODAL PROJECTS

Systematic requirements of these projects called for a proper understanding and adherence to existing or developing transportation technologies: either elevated tri-rail, high speed rail, surface light-rail, or automated people movers were primary functional parameters. Travel speeds, vertical and horizontal radiuses, and dimensional tolerances were determining factors in the spatial and structural organization of the buildings.

Other functional parameters required the integration of several modes of transportation on a case by case basis for each individual station: private and public land transit, water taxi and boat, helicopter and seaplane. The resultant programmatic hybrid in each case influenced the spatial arrangements.

Physiognomic requirements were derived from practical and aesthetic sensibility to each particular site. Boundaries are in most cases permeable technical and sensual envelopes and filters that establish a coherent dialogue between the regimes of air, water and land, whether at the edge of the Everglades or Biscayne Bay. Boundaries were addressed at a series of levels, resulting in *similar differences* and *different similarities*.[4] The perception of elevated trains over the river and adjacent to the lagoons, the high platforms at the edge of the harbor and within view of the cruise ships, the transparency of the slightly raised light-rail as it enters the beach, all these conditions refer back to the vectors and inflections of the respective modes of transportation: land to sea, air to sea, and land to air connections.

1. Miami Intermodal Center (MIC)…

The Miami Intermodal Center is to be considered as an *asymmetrical twin*, handling the landside expansion of the airport, and a *grand central station* collecting regional and local train circulation, including high-speed rail. The selected site is a triangle bounded by water on two sides and an elevated roadway to be designed and built concurrently on the third side.

To the east and north the Miami Canal and to the south the Tamiami Canal are water boundaries. Palmer Lake, an inlet of the Miami Canal, is an area designated for preservation as a green space and ecological haven for breeding of manatees and other native species. Water has its own definitive and dynamic character. The canals were created for the movement of water and to reclaim land for urban development and agriculture. They were designed to accommodate requirements of volume, depth, and navigation. The day to day movement and interaction of water with its edge constantly changes and redefines the edges and cross-sections of waterways.

To the west will be the proposed elevated Interconnector joining S.R. 836 and S.R.112. The elevated roadways have a curved geometry, which contrasts with the orthogonal grid of the city. This diversion from the grid, because of the specific curvatures related to mathematical calculations of speed and structural continuity give the roadways a unique language and aesthetic based on the dynamic and technology of movement.

The Airport is designed to accommodate the following functions: airplanes (landing, taxing and takeoff), passengers (arrivals, departure and waiting), baggage and cargo handling, and general ancillary functions of passenger service and transportation equipment and storage. This requires specific distances, clearances, and radii for the proper and safe operation of airplanes. The restrictions that apply for the Airport reach out and affect the built environment that surrounds it. The flight path has a set three-dimensional envelope that must remain free of physical interference. The same restrictions will influence the site planning of the MIC and joint development in the triangle.

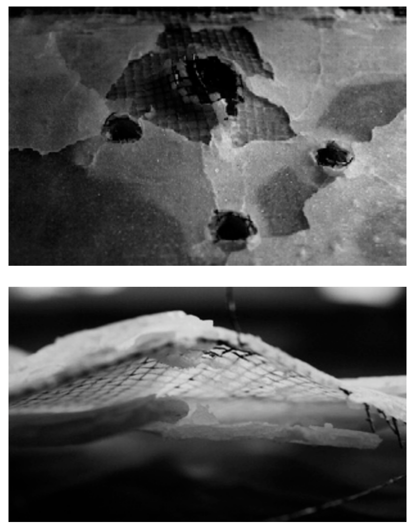
A series of *kinetic impact probes* initiated the design experiment: deforming metal meshes of different densities with a kinetic impact. The impact was achieved with the use of a sixty-pound draw bow and arrows with differently sized blunt tips. The meshes were dipped in wax to enhance the reading of the deformations and intuit conceptual possibilities of the same. The experiments yielded the following concept: using two layers as the elemental generator of the spatial envelope. Analogically, the different rail technologies would impact functionally and penetrate the station as a kinetic force. At the point of impact the station and rail would react with each other creating the resultant opening of the boundary along the vector of movement. The point of impact is the place where the rupture generates space and separation of the spatial envelope into two layers providing an interstitial space that can be used programmatically (Figures 4-5).

A computer generated *wire model*, was used to explore the fluidity and topological continuity of the envelope. The model explored the difference between the two layers. The outer layer displayed a tense and continuous surface in contrast to the interior layer, which showed greater dynamic deformation. The combination of the two layers reiterated the possibility of using interstitial voids, generated by the spatial and structural envelope deformation, for the primary functions of the program (Figures 7-8).

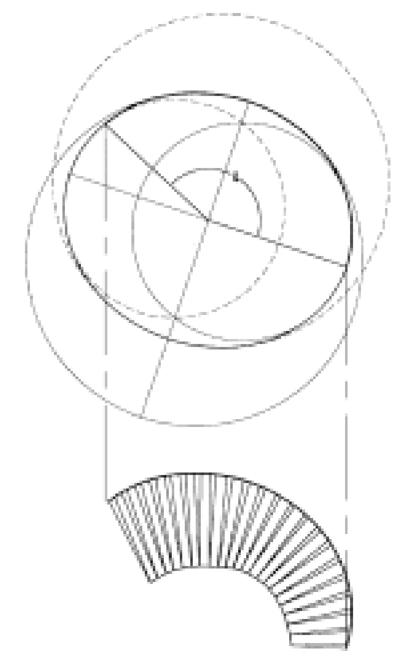
A *geometrical model* of construction and a rupture of the ellipse was an attempt to redefine mathematically the plan outline. The geometry of the plan is generated by vectors of movements and is a dynamic reconstruction of the geometry of the roadways. Geometry was also used as a method to simplify the regulating profile of the structural skeleton, in section, by means of a series of parabolic compression elements hinged at the ground (Figure 9).

The schematic program includes: rails and platforms, vertical circulation, parking, water-taxi docking and lagoon — water is given a larger presence to organize and clarify the site perceptually and for its potential environmental benefit. The sectional layering is paradoxical, in the sense that there is an inversion of the typical arrangement for train stations. Traditionally train stations either sit on the ground or are below ground, in this case the rail tracks and platforms are up in the air, because all guideways must be higher than 65 feet when crossing the Miami River. Out of necessity, this is an aerial station and its roofs are aesthetically and structurally dominant elements.

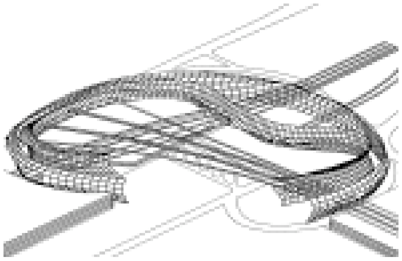
The station hall roof is parabolic in section and elliptical in plan; the roof over the platforms is shaped as a series of *airfoils*. A suspended tensile glass plane — a true *curtain wall* — between the two roofs separates the conditioned space of the hall from the open-air area of the platforms. Response to wind forces, airflow, sun shading, lightness and transparency were critical aspects of the design (Figure 10).

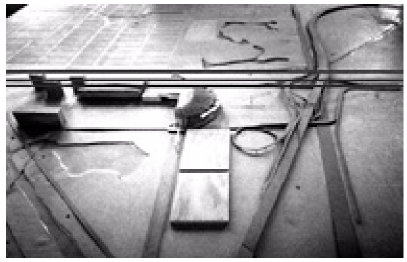


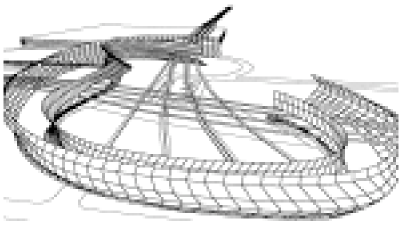
4-5. Kinetic impact modeling.



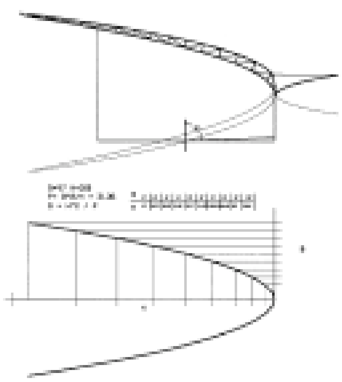
6. Geometric modeling, segmental ellipse generation by displacement of centers projected to plan outline.



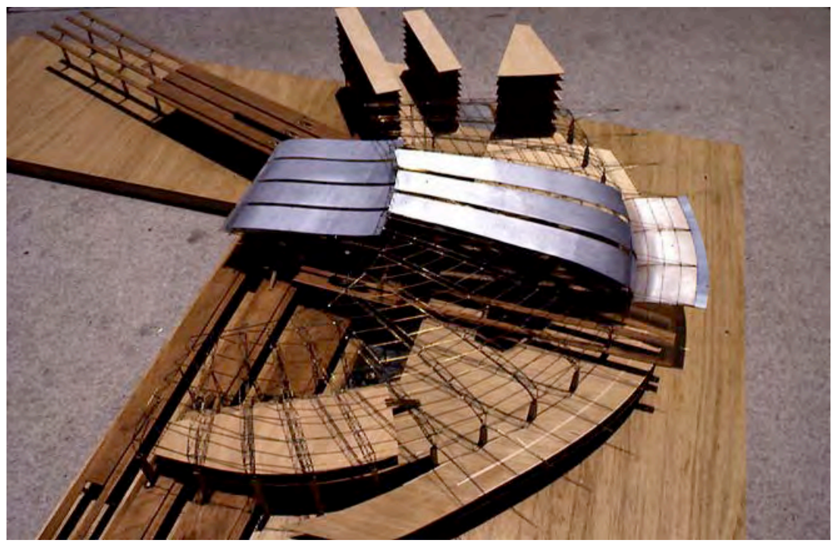




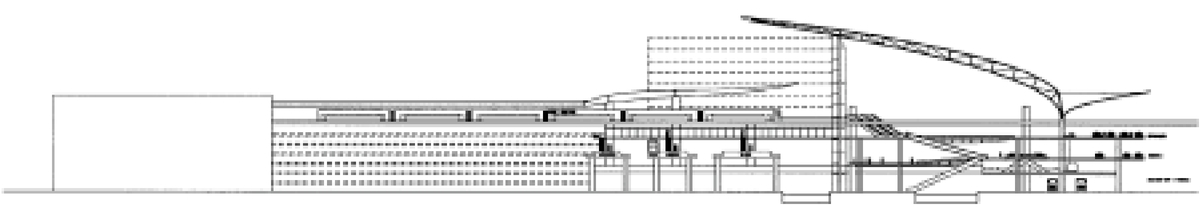
7-8. Computer wire modeling.



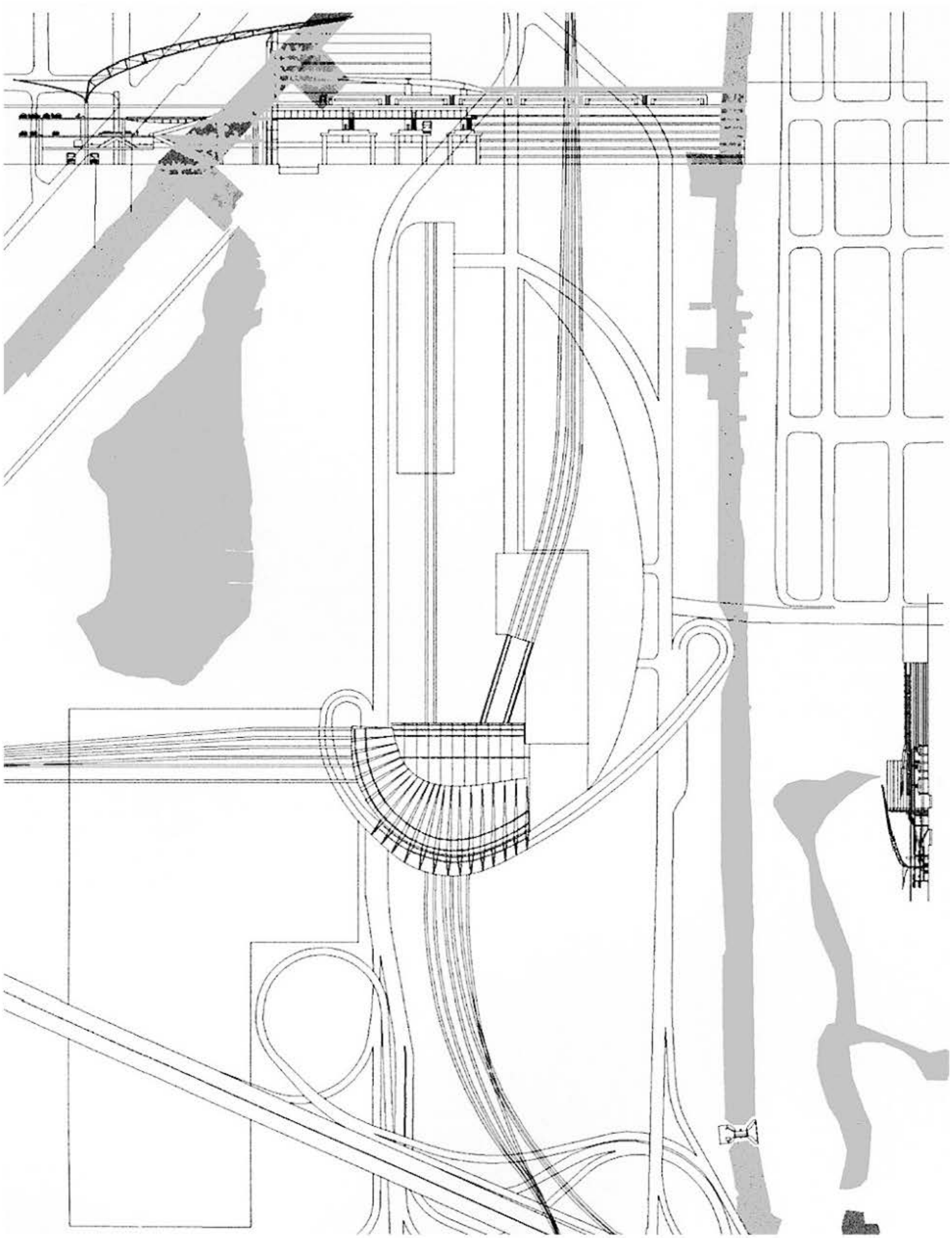
9. Geometric modeling, parabolic construction projected to sectional profile.



10-12. Miami Intermodal Center (MIC) models above.



13. Miami Intermodal Center transverse section.



14. Miami Intermodal Center (MIC) site plan.

2. Airport-Seaport Corridor: Bayside Station…

Bayside Station will be strategically located as a transportation hub connecting the Seaport, Airport, downtown Miami, and eventually Miami Beach. The station goals are:

- To provide efficient mobility between Seaport and Airport.
- To provide Metro Miami travelers with easy access to the airport and downtown activity centers.
- To contribute to increased mobility in the South Florida Region, supporting 21st century plans for regional transportation and sustainable growth.

The building is spatially interwoven with the elevated East-West train guideway. The design explores possibilities of creating dynamic facilities structurally and functionally integrated to transportation, using the land beneath mass transit system as efficient programmatic space linking and promoting transportation systems of the future as civic structures.

Conceptually, the plan yields to the movement of the trains above and vehicular traffic below. The water edge amplifies the possibilities of movement on water or hybrid systems: water-to-land and water-to-air.

The roof canopy has been shaped as a permeable airfoil that plays with air movement, promotes thermal comfort, and eventually reacts positively to strong hurricane wind forces

In this project, the 640-foot long rail platform at 61 feet above sea level determines the footprint of the building. The platform and concourse below form a spine linking the building's programmatic functions:

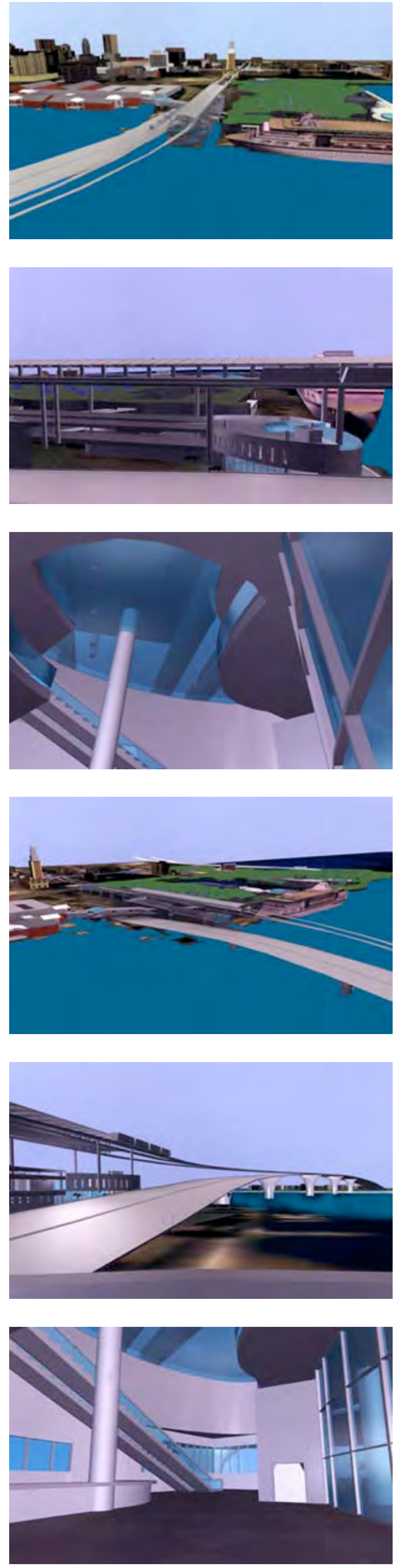
Level 1: The station hall on the ground floor is a three-story atrium, encircled by passenger services linking the different transportation modes. A glass curtain-wall facing the water frames views of the cruise ships docked close by, the cargo port and derricks further away on Dodge Island, and Miami Beach across the surface of Biscayne Bay

Level 2: Maritime offices and the train control and communications room. Two pedestrian bridges, one connecting to Bayside Marketplace, and the other connecting to the proposed Maritime Park and a parking garage

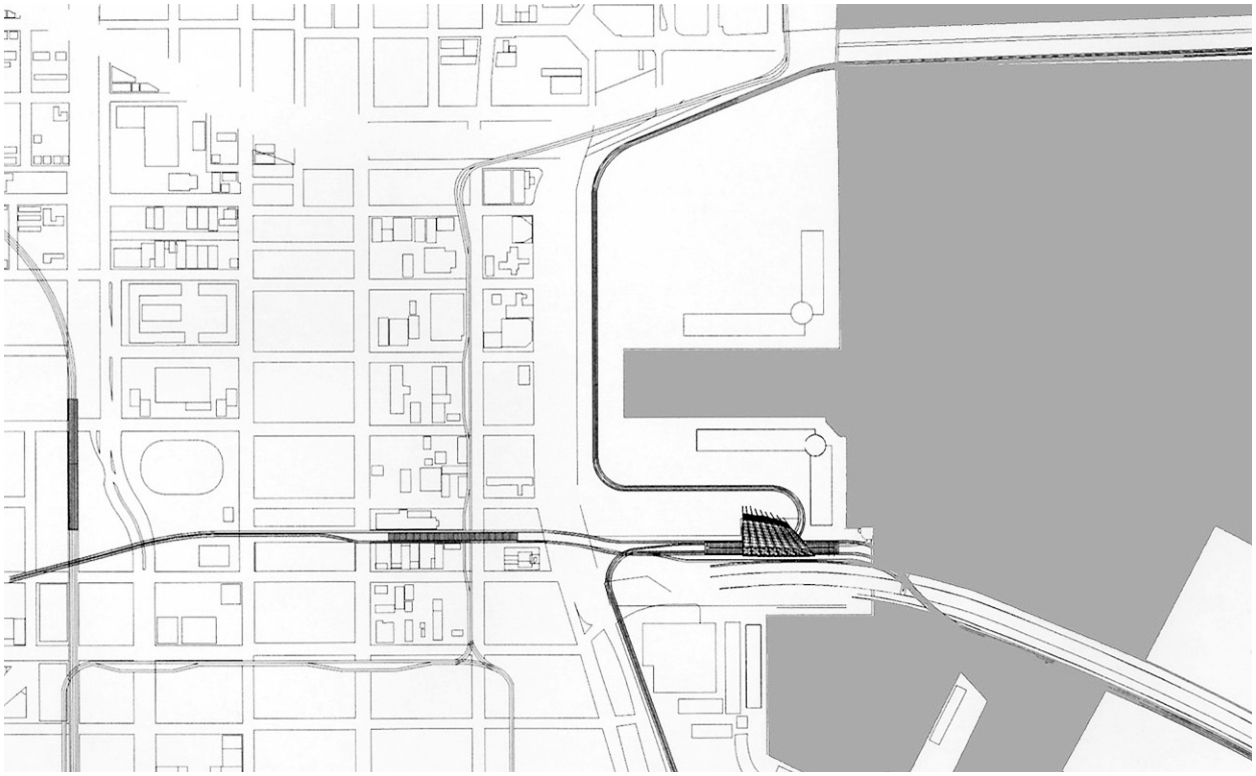
Level 3: Miami Beach light-rail transfer platform, travel offices, an observation deck and maritime gallery with mural photo documentation of the historic evolution of the Port of Miami.

Level 4: Main platform area, open to the air but covered and shielded from the sun and the rain, providing 360 degree panoramic views of the seaport and the downtown skyline.

A computer generated spatial simulation (3D Studio) was used to explore visual qualities of the station. Exterior views examine the alignments of the infrastructural systems and the urban macro-textural qualities of the site. Internal spaces are intended to amplify the dynamic of external movement by inflection of similar spatial geometries and tuning vectors of circulation that refer visual orientation back to the open air and water. The three dimensional simulation exploring the application of materials, light, and textures to a wire frame model is a useful step at the beginning of the spatial modeling of the building. Although this is a rudimentary study that lacks the sophistication of measured lighting models, it offers a useful method to incorporate and study visual qualities that directly affect the spatial experience (Figures 15-20).

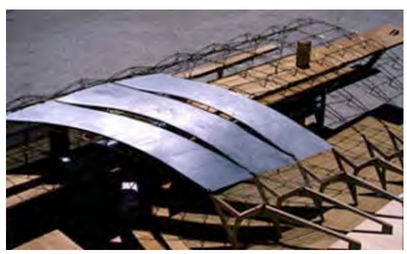


15-20. 3D Studio computer modeling of exterior-interior spatial sequences.



21. Bayside Station and Port of Miami expansion at Bicentennial Park, at the edge of Biscayne Bay, site plan.

22. Port of Miami Bridge. MB3D, 1995.



23. Bayside Station model.

24. Downtown Miami. Gleason, 1995.

25. Bayside Station model.

3. Miami Beach Gateway Station…

The station site was selected based on the following criteria:

- The existing geometry of transportation infrastructure: causeways, bridges, arterial and local collector roads — specially, MacArthur Causeway and its merging into the 5th Street and Alton Road intersection.
- The natural geography of the site, at a critical confluence of land and water, that will permit a true 'intermodal' connection of light train, public and private ground vehicles (buses, cars, electric shuttle, and bicycles), and water transportation (water taxis and small craft).
- The site's urban geography, at the edge of the internationally known Art Deco District, a prime tourism destination, and South Pointe, a fast growing medium to high density residential district with public access to an extraordinary waterfront.

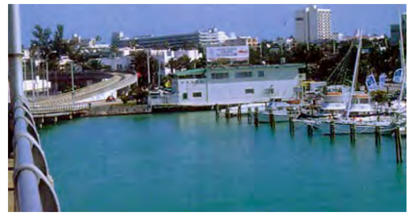
To resolve public transportation and environmental problems, many large cities in North America and Europe have returned to light rail systems in the past 20 years. Light rail offers an environmentally clean, economically efficient, and aesthetically pleasant mode of public transportation. Siemens Duewag, with headquarters and manufacturing facilities in Sacramento, California, has supplied light rail vehicles and installations in seven major cities in the U.S. and two in Canada. In this study, particular attention has been paid to those systems currently operating in Portland and Sacramento. These cities have comparable ridership projections and a manifest concern for the impact of track alignments and stations on urban aesthetic.

The urban design program includes the following components: a small intermodal center, providing connection with other modes of land and water transportation; a visitor information center and gallery (being an entry point to Miami Beach and serving a large number of tourists, the station is the desirable location for introduction to the culture of the city); a waterfront promenade lined by ancillary services and entertainment; a 180 room hotel, with adjacent meeting and exhibition rooms; and a low profile 500 car parking garage.

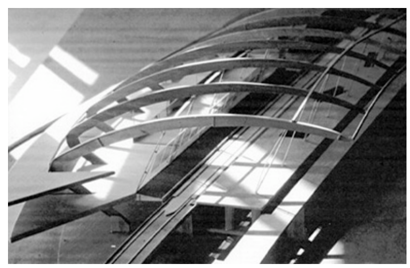
The public value of this waterfront site derives from its open edge exposed to extraordinary views and the cooling effect sea breezes — which sporadically may turn to tropical storms. The platform and canopy are sited hovering over the water and connected to the landside by a spatial wedge at grade level, with escalators going up to the light rail the platform and down to the water taxi dock. The visitor center and gallery, located at a mid-level mezzanine can be accessed from the station or directly from the exterior by a bridge ramp.

Access from the waterfront promenade and parking garage to the station is provided by a transparent weather canopy beneath the light rail track, which in the northern half of the site remains elevated, at 16 feet, to allow vehicular access and service to the waterfront, sloping down gradually to reach grade at the southern limit of the site. This linear canopy also serves as waiting area for transfer to the electric shuttle and city buses.

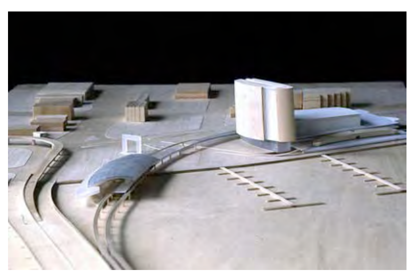
The spatial structure is defined by a metallic airfoil sheathed over a series parabolic rib-trusses hinged at the foundation and fixed on their cantilevered side by compression-tension struts. The struts would act on either mode in response to the changing wind directions and the dynamic effect of wind loads.




26-27. Miami Beach Station site.

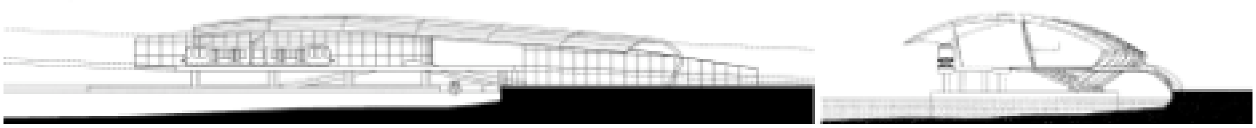



28-29. Canopy study models.

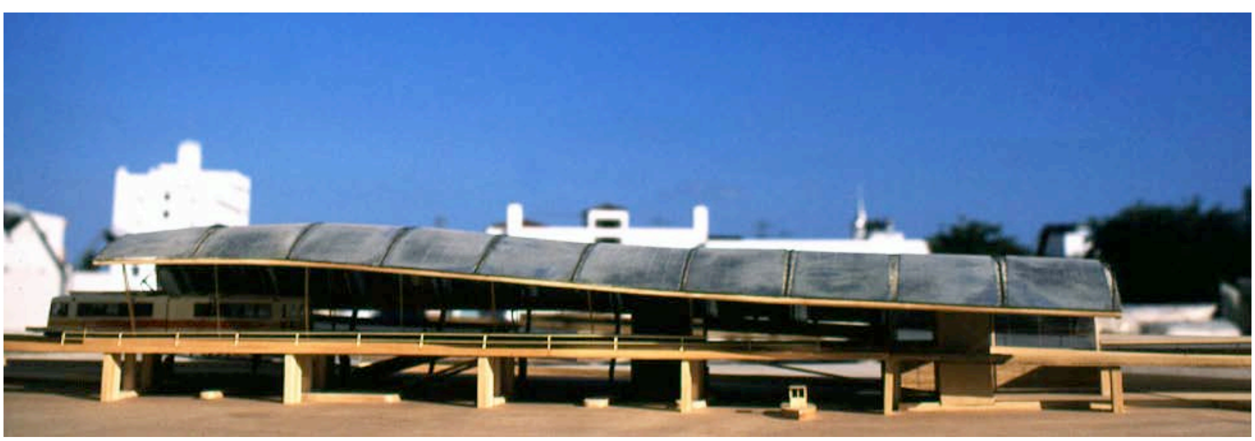



30-31. Site models.

32. Miami Beach Gateway Station and City Marina, at the eastern edge of Biscayne Bay, site plan.



33-34. Elevation and section.



35. Miami Beach Gateway Station, model.

4. SW 2nd Avenue Bascular Bridge…

This is a proposal for the replacement of the existing bascule bridge at the intersection of S.W. 2nd Avenue and the Miami River. It is aimed at creating a structure that has an integral functional relationship with the *working river* in which the river and the bridge have a physical interaction that is advantageous to both. The architectonic aspect of the structure is expanded by the proposal of a *civic program* of uses within, and adjacent to realm of the bridge's operational system.

The proposed bascule bridge is a simple 'trunnion', or hinge, also known as the 'Chicago' type, where the moveable portion made of the leaf and the counterweight, is carried by the trunnion when the bridge is in motion or open. The bascule is in dynamic equilibrium through its whole range of motion; the gravitational forces on both sides of the trunnion are always equal. The force required to move the leaf is minimal, needing only to overcome the inertia and the mechanical friction of the system.

A variation, proposed for this bridge, is based on 'Archimedes principle of displacement of water' — a submerged body becomes lighter by an amount equal to the weight of the volume of water it displaces. This is accomplished by increasing the counterweight, thus taking the leaf out of equilibrium and restoring equilibrium by placing the weight into water. Using this principle, the movement of the leaf will be aided by controlling the movement of water within the pier.

At the present, there is a significant amount of hydraulic turbulence at the site, caused by the geometry of the river bend and magnified by the existing bridge piers which project several feet from the edge into the water — turbulence hampers the navigation of vessels. The new bridge should lessen the turbulence by providing smoother edges and recessed piers allowing a more uniform flow of the river.

Because the proposed hydraulic operational system requires significant volumes of water to be taken from and released into the river, it is necessary to develop a system that accomplishes this task without introducing additional hydraulic turbulence to the site. This will be done through the manipulation of the rivers' edge, taking and releasing of water in a gradual manner. The northeastern edge will be developed as a reservoir providing storage for sufficient amounts of water to aid the bridge opening throughout several cycles. The reservoir will also act as a storm water catch basin in the northern portion of the site and will become an aeration and filtration device to remove pollutants from the river water and storm water run off.

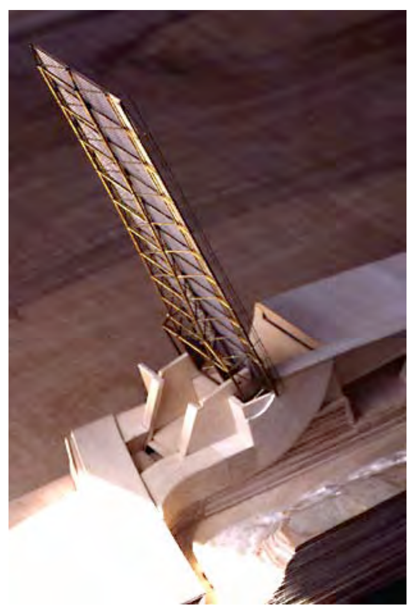
This is interdependency between the bridge and the river, in which the river serves the movement of the bridge and the bridge serves as a valve in a system that will improve the *ecology* of the river.

In addition, the new edge will be developed as a series of hydraulic events acting as an urban educational playground within the program of a *hydric park*: a hydraulic riverwalk which establishes a working relationship between the city and the river and provokes in the mind's eye an awareness of that relationship.

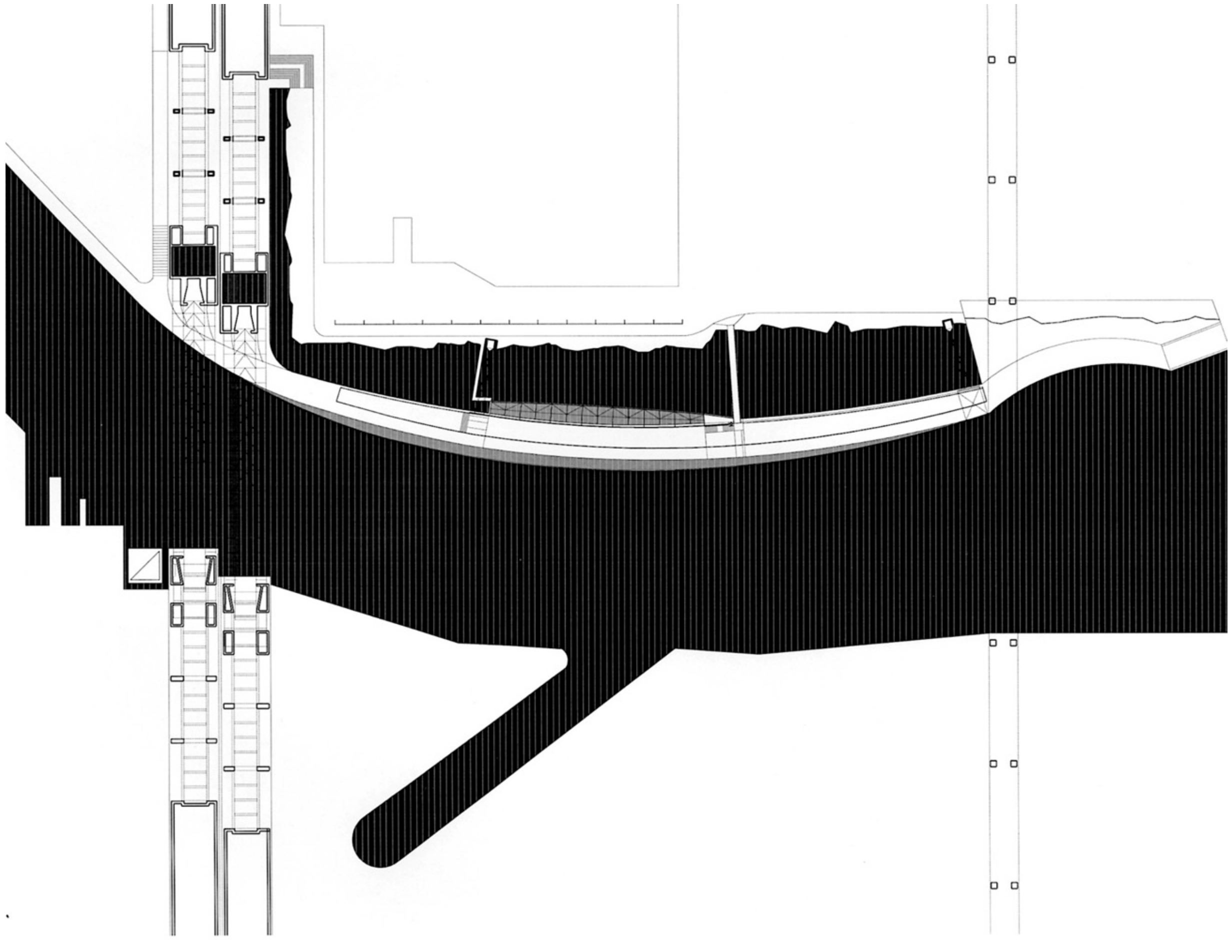
The Miami River lies within the realm of what Gilles Deleuze defines as *The Smooth* and the *Striated*. Deleuze defines the smooth as "a space constructed by local operations involving changes in direction . . . it is filled by events, or *hacceities*, far more than perceived things. It is a space of effects, more than one of properties. It is of haptic rather than optical perception. Whereas in the striated forms organize matter, in the smooth materials serve as symptoms for them…In striated space, lines or trajectories tend to be subordinated to points . . . In the smooth, points are subordinated to the trajectory."[5]

This project defines the river as *smooth* space: a space constructed of a hydraulic-navigational trajectory and of specific haptic uses of those trajectories — it is a space that does not give in easily to perceived forms. The adjacent land lies within the realm of the *striated*: it has been spatially organized in such ways that points formed by the intersection of trajectories are of utmost importance. The river's *edge* is the boundary between the smooth and the striated. The intent of the project is to define the bridge, the condition that lies between the smooth and the striated, as a woven condition. The bridge is intended to be an event in which the river and the adjacent land are hydraulically woven together.

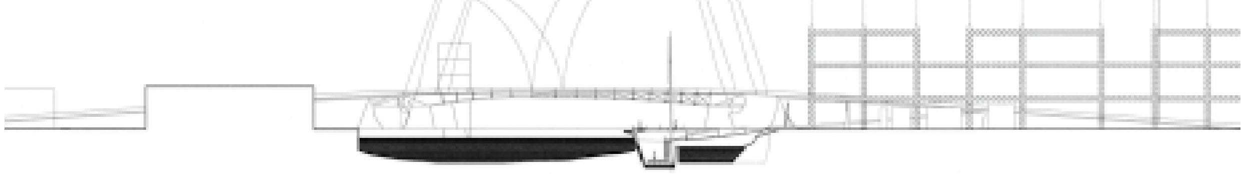
36. Miami River through Downtown Miami, model.



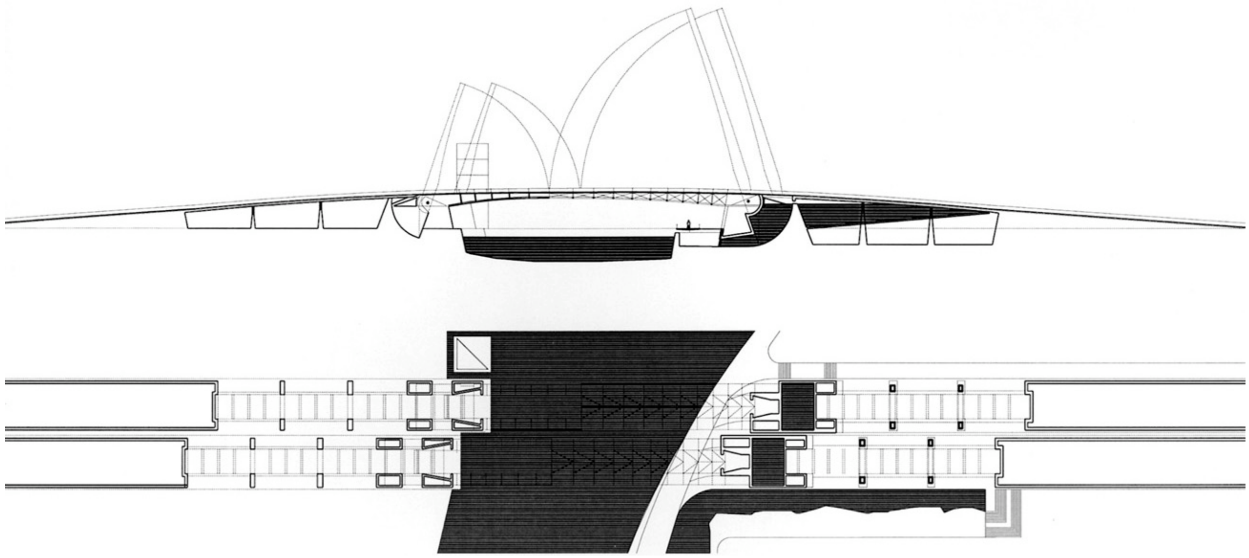
37. Bascular leaf, structural model.



38. SW 2nd Avenue Bridge (left), hydraulic reservoir and hydric park (right), site plan.



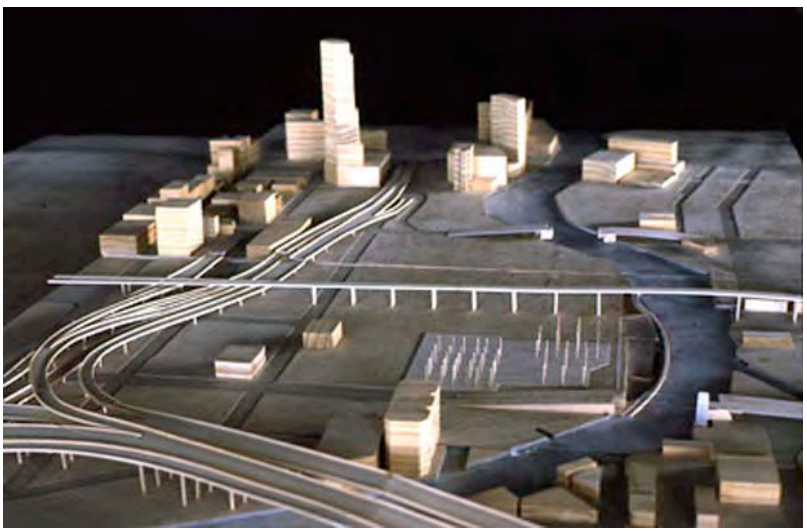
39. Section-elevation looking west.



40-41. SW 2nd Avenue Bridge, section looking west (above, plan (below).

42. Existing SW 2nd Avenue Bridge over the Miami River (foreground), and elevated Metrorail span (background).

43. SW 2nd Avenue Bridge model.



44. Miami River through downtown Miami, site model.

Credits

Miami Intermodal Projects
Álvaro Malo, Architect
Carlos Zapata, Architect

Miami Intermodal Center
Juan Linares

Bayside Station
Eric Blumberg

Miami Beach Station
Hamed Rodriguez

SW 2nd Avenue Bridge
Trent Baughn

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Marcus Binney, *The Architecture of Rail: The Way Ahead* (London: Academy Editions, 1995).

Notes

[1] Wallace Stevens, "The Idea of Order at Key West", *The Collected Poems* (New York: Vintage Books, 1982) p 128

[2] Marjory Stoneman Douglas, *The Everglades: River of Grass* (Marietta: Mocking Bird Books, 1974) p.1

[3] Gilles Deleuze and Félix Guattari, "The Smooth and the Striated", *A Thousand Plateaus* (Minneapolis: University of Minnesota Press, 1991) p 474

[4] David Bohm, "On Creativity", *VIA Vol.2, Structures: Implicit and Explicit,* Publication of the Graduate School of Fine Arts, University of Pennsylvania *(*Philadelphia: Falcon Press, 1973) p 69

[5] Gilles Deleuze and Félix Guattari, ibid.

Matter and Memory

The true effect of repetition is to decompose and then to recompose, and thus appeal to the intelligence of the body…In this sense, a movement is learned when the body has been made to understand it…Now the logic of the body admits of no tacit implications. It demands that all constituent parts of the required movement shall be set forth one by one, and the put together again.[1]

Henri Bergson

Instructions for climbing a stair

A stair may be considered as a body-double, extended beyond our own natural body. The body of a stair bearing a double index: one iconic, as the material outline of movements already executed in its fabrication; another instrumental, as a further appeal to the body in anticipation of renewed movement. But the work of manufacture and assembly of a stair is in one sense the same and in another not the same as climbing a stair.

> *It shouldn't have escaped anyone's attention that often the floor folds in such a way that part of it climbs at a straight angle to the plane of the floor, and the next part is positioned parallel to this plane, giving way to a new perpendicular, a behavior that is repeated in a spiral or a broken line, reaching heights that are extremely variable.*[2]

The project of construction of a stair is a concrete example of work executed not on the basis of immediate need, but according to a desire, a will of production, and expenditure of time. That is, when constructing a stair I am not yet using it, but rather I am using my body. The sensor-motor mechanism of my body is spending its energy by moving, shaping and allocating outlying materials according to a spatial diagram.

> *Bending down and putting the left hand on one of the vertical parts, and the right on the corresponding horizontal, one is in brief possession of a step.*[3]

The diagram is an attempt to reconstruct in space the memory already encoded in the body corresponding to the experience normally associated with the name: *stair*. It bids the body to discriminate and classify; it defines what is sufficient and necessary; it traces, within the total movement, the lines that generate its internal structure. It has no further intention.

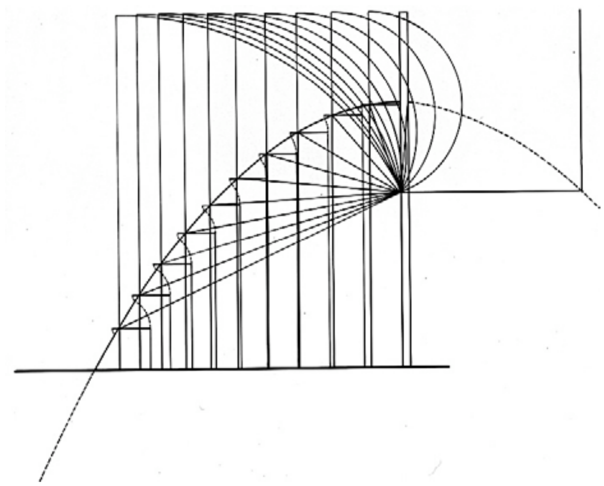

Fig. 1. Stair: motion diagram.

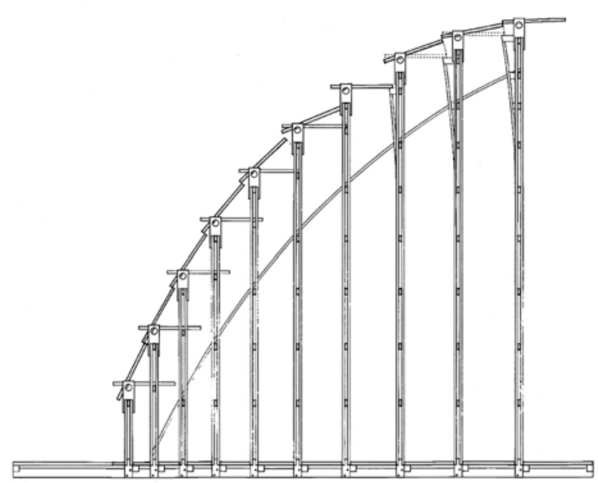

Fig. 2. Stair: elevation

Each one of these steps, formed as is evident by the two elements, is placed a little higher and in front of the previous one, a principle that gives its sense to the stair, since any other combination will produce forms perhaps more beautiful or picturesque, but incapable of transferring from the ground level to the first floor.[4]

It is true, that during the assembly the body is transporting itself, climbing as it were by the effect of its own work. The work acting as a temporary scaffolding which moves the body up for no other purpose than reaching its proper completion.[5] Once complete, the construction must be released to a condition of uselessness, having reached its own material autonomy. In its positive sense the finished work is no longer a proposition of work, but one of play—or perhaps use.

Steps must be climbed head on, since backwards or aslant they become particularly uncomfortable.[6]

The movements of the body during the act of construction do not correspond necessarily to the act of climbing. They are most likely superabundant and not directed towards comfort but technical efficiency. The body of a stair, as a material synthesis, conceals within its mass most of the redundant movements and releases to perception a clarified visual diagram. This diagram resembles the dynamic of climbing, revealing to the body the instrumental capacity of the stair: it bids the body an invitation to climb. The perception of the external object provokes in our part a dynamic attitude, prompting the memory encoded in the body to retrace its movements. It is simply a one-to-one exchange, without an ulterior motive, issuing instructions for climbing.

The natural attitude is that of staying on your feet, the arms dangling without effort, the head erect but not so that the eyes cannot see the steps immediately above the one you are stepping on, and breathing slowly and regularly.[7]

To begin construction of a stair one needs to have the proper attitude, which is to remain attentive to the purpose of the project. Step by step, attention is realized as an adaptation of the body and the mind, realizing in this attitude of consciousness the consciousness of an attitude.[8] The 'true utility' of a stair is, first and foremost, that of being useless for any purpose other than that of agreeing with the movements of the body, and supporting its power of action.[9]

When climbing a stair one must, begin by lifting that lower right part of the body, almost always wrapped in leather or suede, which save few exceptions fits exactly on the step.[10]

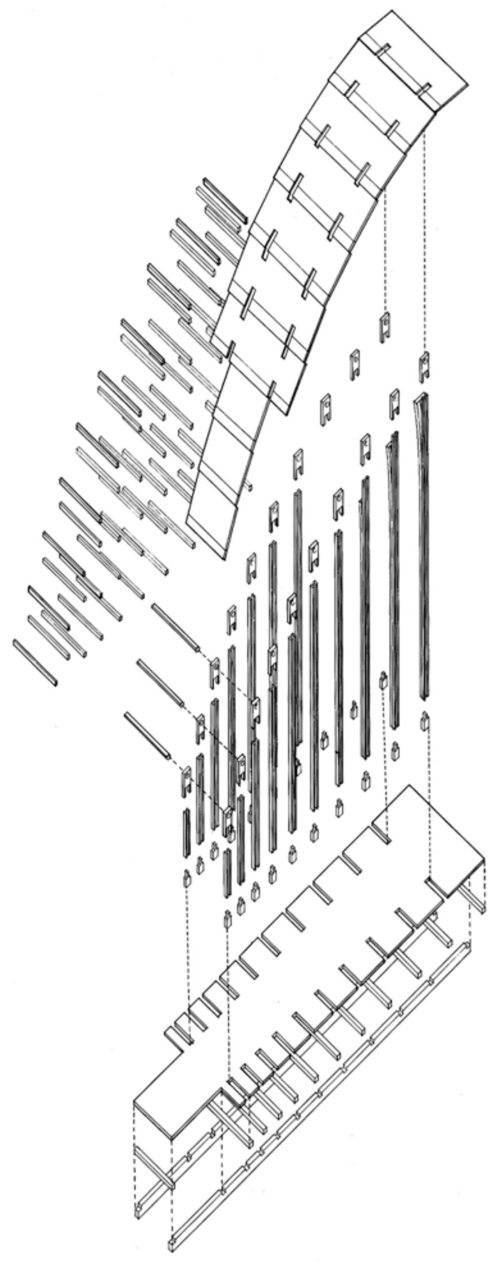

Fig. 3. Stair: exploded axonometric.

The dimensional ratio between a tread (horizontal) and a riser (vertical) determines the slope of a stair. Usually this ratio remains constant throughout the body of a stair. A possible effect of this constancy may be the uniform speed of movement of the body as it surmounts the slope, or inclined plane of the stair. A greater inclination slows down the movement and demands more expenditure of energy; conversely, a lesser inclination speeds up the movement and requires less effort from the body. To become sensitive to the nuances of speed (space over time), to the quality of the actual event of climbing, one may play with variations of slope in the contour of a stair. This would require a certain degree of "refinement in the perception of small differences."[11] To take this attitude even further, one needs to train oneself in the art of self-forgetfulness, and return to childlike playfulness. The secret of such innocence lies in the acceptance that "every act is a virgin act, even the repeated one." (Erik Satie)

> *Placing such part, which for the sake of brevity we will call foot, on the first step, one must then lift the equivalent part on the left (also called foot, but not to be mistaken with the aforementioned foot) and bring it to the height of the foot, making it to go forward and up, until it stands on the second step, upon which the foot will rest, and on the first step the foot will rest.*[12]

The ratio between tread (level) and riser (plumb) is variable: the greater the ratio, the lesser the slope; and vice-versa. Usually the tread is made deep enough to accommodate the foot, more or less thirty centimeters. And, as a rule of thumb, the sum of two risers and one tread is sixty-four centimeters. This makes the height of the riser approximately seventeen centimeters. For no specific reason, other than habit, a stair leading to the attic, or cellar, is frequently made steeper than other stairs of a house. Forgetting the excuse, or pretext, that such a stair is "used less often," or is "less important," or the lack of space, one will find the body experience of climbing such stair more difficult, or just different.

> *The first steps are always the most difficult, until the necessary coordination is acquired. The coincidence of name between foot and foot makes the explanation difficult. Be especially careful of not lifting at the same time the foot and the foot.*[13]

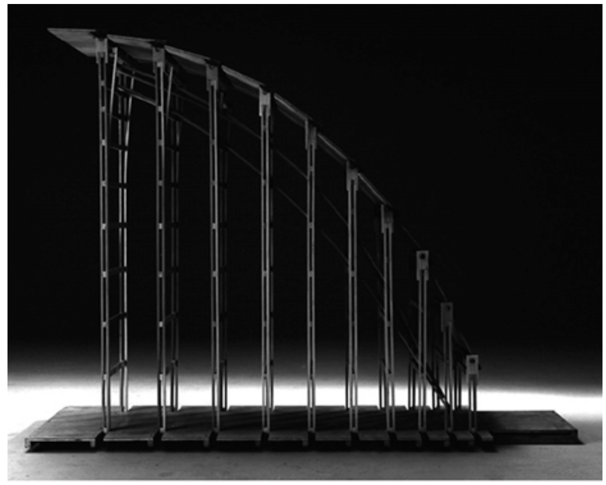

Fig. 4. Stair: side elevation.

Fig. 5. Stair: front angle view.

There are events that come to us concealed under the appearance of everyday occurrences. In order to become sensitive to their quality as actual events we need to fine-tune our body—our sensual manifold—heightening the intensity of perception. A true perception requires contact and coincidence between the mind and the thing perceived. The most immediate thing perceived is our body; among other things, it is our center of affection and our center of action. To be more precise, "…our body, with the sensations that it receives…and the movements that it is capable of executing…is then, that which fixes our mind, and gives it ballast and poise."[14] Climbing a stair is an act of defiance of gravity, as well as a balancing act. Step by step, it is a limited form of flight, abandoning the security of the ground to find it again relocated at a higher level. In its upward trajectory, the body performs a repetitive series of back and forth rotating movements: of the foot joints (metatarsal), ankles, knees, and hip joints as a function of load bearing; and, lateral sway of the torso, pendular movement of the arm at the shoulder, and slight flexion of the elbow as a function of balancing.

> *Arriving this way to the second step, it is sufficient to repeat the movements alternately until the end of the stair is found.*[15]

The body carries forward and up, within itself, a volume of movements. The total sum of the movements produces a corresponding volume of space with an ever advancing boundary between the future and the past—the body itself being the point of passage, the exact position of the present. The act of climbing is the diachronic unfolding and penetration of two volumes of space: the transitive space of my body and the passive space of the stair. These two have in common "similar differences" and "different similarities," [16] arousing the notion of interiority and exteriority, which is merely the distinction between my body and other bodies.[17] The difference shown in a stair between tread and riser (level and plumb) is similar to the difference found in the sensory-motor mechanism of my body (inner ear) that allows upright dynamic equilibrium. The similarity between the steps of a stair, which exist all at once (coexistence), is different from the similarity between the steps taken by my body, not all at once but in different time (succession). Yet each new step to be taken depends on the existence of the steps previous to it (paradox of coexistence with the past). This involves the adaptation of the past to the present, the utilization of the past in terms of the present—what Bergson calls "attention to life." Thus the notion of time is introduced as a form of "internal sensibility" (Kant). Here, a pure being of the past, or imaginative memory of the mind (ontological memory), coincides with the immediate present, or memory encoded in the body (sensory-motor memory). Thus, the present is a point of animation when, during the act of climbing, my body attributes movement to the body of a stair.[18]

> *Exiting from it is made easy by a light tap of the heel that fixes it on its place, where it will remain until the moment of descent.*[19]

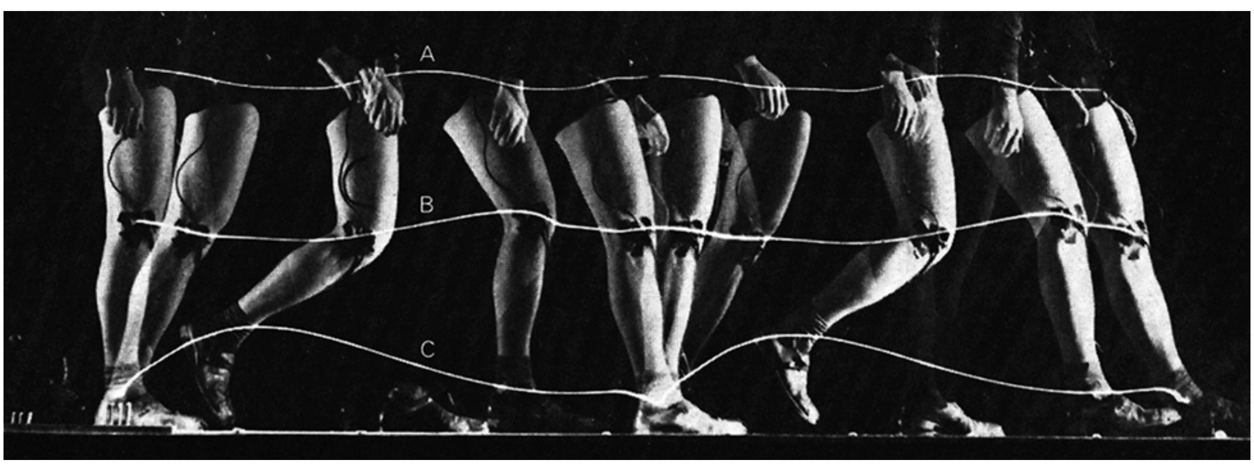

Fig. 6. Walking cycle extends from the heel strike of one leg to the next heel strike of the same leg. The photographs by Gjon Mili trace the progress of the right leg in the course of two strides. (Source: *Scientific America,* April 1967, 58)

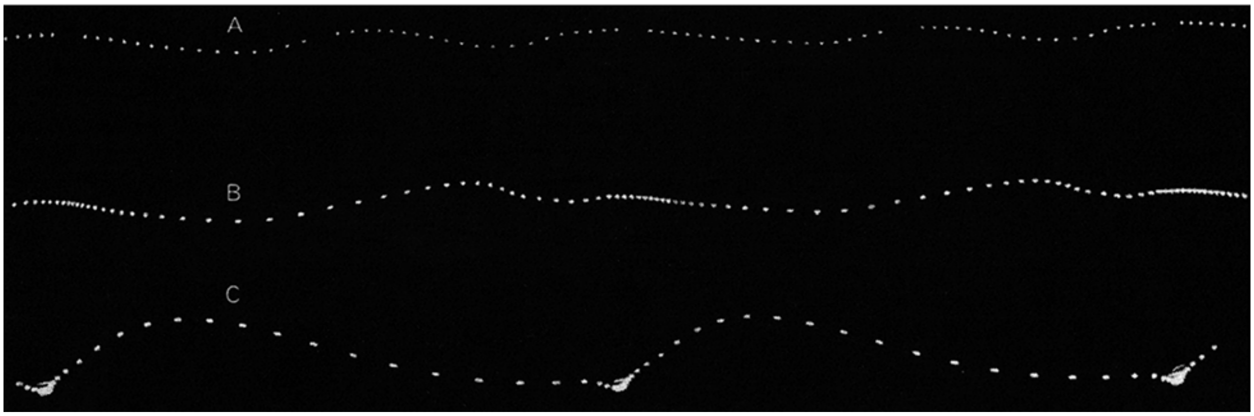

Fig. 7. Sine curves described by the hip (A), knee (B) or ankle (C) of a walking human body. The speed is determined by measuring between dots. (Source: ibid, 58)

As a function of gravity, the ball of my foot on the tread makes the main contact of my body with the body of a stair. But as a function of dynamic equilibrium, of upright body posture, my hand may seek to touch again the stair and reaffirm its flow on the *handrail*. It is there that I bring the diagram of movement into close reciprocity and bring the memory of the body to the hand: the quintessential haptic organ and original organ of manufacture.

Manufacturing instructions

In order to construct a stair, the following steps are required:

1. Two-dimensional kinesthetic diagrams, which may be produced by rendering, photomontage, etc., showing up and down movement of the body.

2. Geometric drawings, which give precise outlines and measurements to the motor diagrams and approximate boundary of the body-double, i.e., stair.

3. Construction drawings, which determine the possibility of technical execution of the stair-body in a given material, i.e., metal or wood.

4. Full size construction of a step in the chosen material. And, reproduction of a sufficient number of steps to be assembled as a stair, reciprocating the motor diagram of the human body as a three-dimensional artifact.

5. Assembly and testing of the stair as a functional artifact, animating the experiment in its present sense, and giving to it a practical verdict.

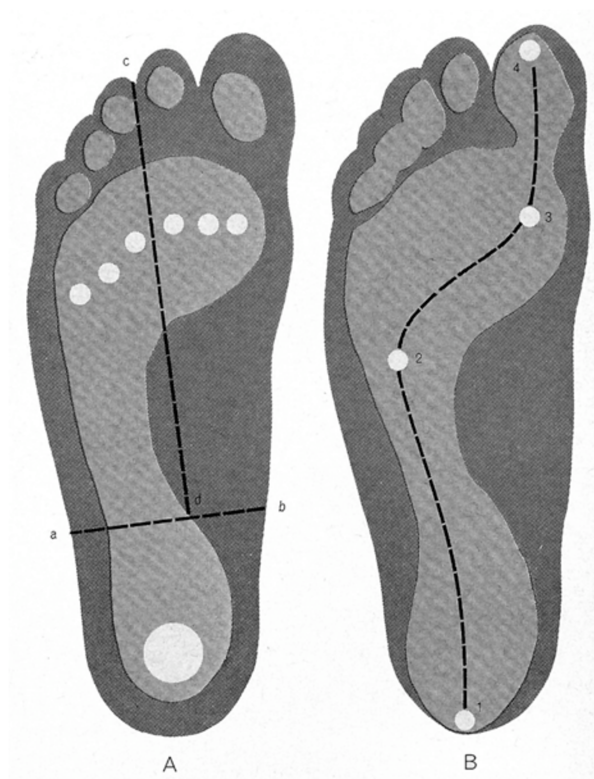

Fig. 8. Distribution of weight alters radically as movement takes place. Static load at rest (A); dynamic redistribution when striding (B). (Source: *Scientific America,* April 1967, 59).

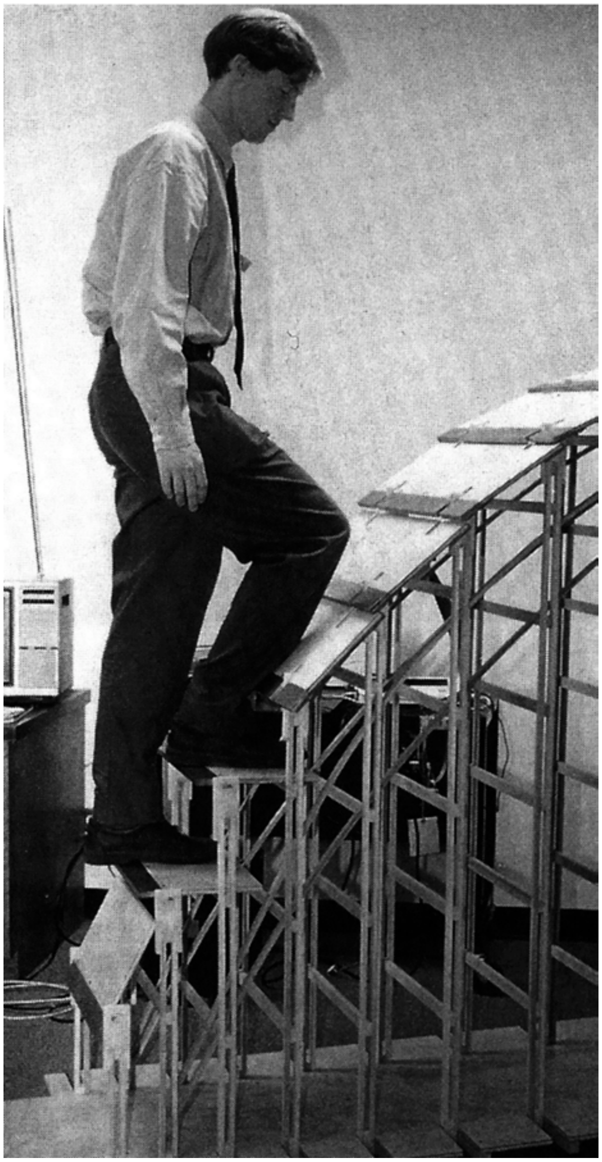

Fig. 9. Stair: being tested by a member of the design team.

Notes

1. Henri Bergson, *Matter and Memory* (New York: Zone Books, 1988) 111-112.
2. Julio Cortázar, *Historia de cronopios y de famas*, "Instrucciones para subir una escalera" (Barcelona: Edhasa, 1992) 21-22. (Translated from Spanish original, Álvaro Malo).
3. Ibid
4. Ibid
5. Entelechy (Aristotle) (Gk., *entelecheia,* "being complete"). In Aristotle's philosophy, "entelechies" are regarded as the regulators of orderly activity causing things to do that which is natural to them and to seek their specific natural ends or completion.
6. Julio Cortázar, *Historia de cronopios y de famas*, 21-22.
7. Ibid
8. Henri Bergson, *Matter and Memory*, 100.
9. Gilles Deleuze, *Spinoza: Practical Philosophy* (San Francisco: City Lights Books, 1988) 21.
10. Julio Cortázar, *Historia de cronopios y de famas*, 21-22.
11. Jean François Lyotard, *Peregrinations: Law, Form, Event.* (New York: Columbia U. Press, 1988) 18.
12. Julio Cortázar, *Historia de cronopios y de famas*, 21-22
13. Ibid
14. Henri Bergson, *Matter and Memory*, 173
15. Julio Cortázar, *Historia de cronopios y de famas*, 21-22
16. David Bohm, *On Creativity* (London: Routledge, 1998) 7.
17. Henri Bergson, *Matter and Memory*, 47
18. Gilles Deleuze, *Bergsonism.* Zone Books, New York, 1991, 59-70
19. Julio Cortázar, *Historia de cronopios y de famas*, 21-22

ARQ 57
Zonas áridas Arid zones

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Colaboradores ARQ 57 / ARQ 57 Collaborators

Portada Sol radiante, imagen de arte rupestre encontrada en Concho County, Texas, EE.UU. Tomado de *Native American Rock Art, A petroglyph stamp kit for all ages*, de Judith Dupré, Chronicle Books, San Francisco, 1997. **Max Aguirre** Arquitecto, Universidad de Chile, 1978. Candidato a Doctor por la Universidad Politécnica de Madrid. Desde 1983 ha ejercido la docencia en varias universidades chilenas, en el área de teoría e historia de la arquitectura. **Carlos Aldunate** Licenciado en Ciencias Jurídicas y Sociales y en Prehistoria y Arqueología de la Universidad de Chile. Abogado, Universidad de Chile, 1965, y arqueólogo, Universidad de Chile, 1982. Actualmente es director del Museo Chileno de Arte Precolombino y de la Academia Chilena de la Historia. **Alejandro Aravena** Arquitecto, Universidad Católica de Chile, 1992. Estudios de Postgrado en Teoría e Historia en el Istituto Universitario di Architettura di Venezia, 1992-1993. Desde 1992 es profesor de Teoría y de Taller de Proyectos en la Escuela de Arquitectura de la U.C.; ha sido profesor invitado en la A.A. de Londres y en la G.S.D. de la Harvard University. Su trabajo profesional ha sido expuesto y publicado ampliamente, recibiendo diversos premios. Actualmente trabaja de manera independiente. **Ricardo Astaburuaga** Ingeniero Civil Hidráulico, Universidad de Chile, 1969. Actualmente se desempeña como consultor. **Victoria Castro** Profesora de Estado en Filosofía, Universidad de Chile, 1978; licenciada en Prehistoria y Arqueología, y arqueóloga, Universidad de Chile, 1982. Magister en Etnohistoria, Universidad de Chile. Actualmente es profesora titular de la Universidad de Chile, ejerciendo la docencia en el Departamento de Antropología de la Facultad de Ciencias Sociales. **Tomás Cortese** Licenciado en Arquitectura, Universidad Católica de Chile, 2002, y alumno del programa de Magister en Arquitectura de la U.C. Actualmente colabora en el proyecto de Vivienda Social Quinta Monroy en Iquique, junto con los arquitectos Alejandro Aravena y Alfonso Montero, además de llevar a cabo un programa de asistencia técnica para las familias de la Quinta Monroy. **José Cruz Ovalle** Arquitecto, Escuela Técnica Superior de Arquitectura de Barcelona, 1973. Estudios de postgrado y de filosofía en esa misma ciudad. Estudios de arquitectura en la Universidad Católica de Chile (1968-1970). Ha sido profesor asociado de la Escuela de Arquitectura de la U.C.; su obra ha sido expuesta en Europa y Sudamérica. Actualmente ejerce de manera independiente. **Paulo Dam** Arquitecto, Universidad Ricardo Palma, Lima, 1990. Desde 1991 se ha dedicado a la docencia del diseño en arquitectura. En 2000 abre su propio estudio, concentrado en la práctica crítica del diseño en proyectos privados y concursos. Actualmente es profesor de diseño de la Facultad de Arquitectura de la Pontificia Universidad Católica del Perú. **Emilio De la Cerda** Licenciado en Arquitectura, Universidad Católica de Chile, 2002, y alumno del programa de Magister en Arquitectura de la U.C. Entre 2002 y 2003 ha colaborado en el proyecto de Vivienda Social Dinámica sin Deuda, de la Quinta Monroy en Iquique, y en el Edificio Tecnológico San Joaquín de la U.C. a cargo del arquitecto Alejandro Aravena. **Germán Del Sol** Arquitecto, Escuela Técnica Superior de Arquitectura de Barcelona, 1973. Ha ejercido en España, EE.UU. y Chile; su obra ha sido extensamente publicada en Chile y el extranjero. Ha sido profesor de Taller de Proyectos de 4º año en la Escuela de Arquitectura de la Universidad de Chile, donde actualmente es profesor de Taller de Titulación. **Bonifacio Fernández** Ingeniero Civil, Universidad Católica de Chile, 1973; MSc, 1982, y PhD en Ingeniería Civil, 1984, Colorado State University. Desde 1991 es profesor titular de Ingeniería Hidráulica en la U.C. y desde 2002 Affiliatte Faculty of Civil Engineering en Colorado State University. Entre 1995 y 1998 fue presidente de la Sociedad Chilena de Ingeniería Hidráulica, de la que es Director Honorario desde 1999. **Teodoro Fernández** Arquitecto, Universidad Católica de Chile, 1972, y Postítulo en Arquitectura y Manejo del Paisaje, Universidad Católica de Chile, 1992. Desde 1984 es profesor de Taller de Proyectos de la Escuela de Arquitectura de la misma universidad. Autor de los proyectos para el Parque Inés de Suárez en Providencia y el Parque Bicentenario para la comuna de Vitacura. Actualmente desarrolla trabajo profesional en forma independiente. **Soledad Hoces de la Guardia** Diseñadora, Universidad Católica de Chile, 1979. Miembro del Directorio del Comité Nacional de Conservación Textil. Actualmente es docente de la Escuela de Diseño de la U.C. e investigadora alterna del Museo Chileno de Arte Precolombino en Santiago. **Rick Joy** Arquitecto, University of Arizona, Tucson, 1990, y estudios independientes de música. Entre 1990 y 1993 colaboró con William Bruder en el diseño de la Biblioteca Central de Phoenix. Su oficina en Tucson ha producido un extenso conjunto de obras, ampliamente expuesto y recientemente publicado por Princeton Architectural Press. Ha sido profesor invitado en las universidades de Arizona, Harvard y Rice. **Alexia León** Arquitecta, Universidad Ricardo Palma, Lima, 1993. Entre 1993 y 1995 trabajó junto al profesor Juvenal Baracco en la Facultad de Arquitectura en Lima. Su proyecto de la casa en Playa Bonita ha sido finalista en la I Bienal Iberoamericana, Madrid, 1998, y finalista en el segundo premio Mies van der Rohe de Arquitectura Latinoamericana, 2001. Desde 1996 ejerce de manera independiente. **Wiley Ludeña Urquizo** Arquitecto, Universidad Ricardo Palma, 1978; Master en Diseño Arquitectónico, Universidad Nacional de Ingeniería, Lima, 1987, y Doctor en Urbanismo, Technische Universität Hamburg-Harburg, 1996. Profesor en la Universidad Nacional de Ingeniería, Universidad Ricardo Palma y en la Escuela Nacional de Bellas Artes. Director de las maestrías en Historia y Crítica y en Renovación Urbana en la Facultad de Arquitectura, Urbanismo y Artes de la Universidad Nacional de Ingeniería. Actualmente dirige la revista peruana *ur[b]es*, sobre ciudad, urbanismo y paisaje. **Fernando Maldonado** Arquitecto, Universidad de Chile, 1969. Actualmente trabaja como arquitecto y fotógrafo, participando en investigaciones y registros del Museo Chileno de Arte Precolombino. **Álvaro Malo** Arquitecto, Universidad de Cuenca, Ecuador, 1967; Diploma en Diseño, Bouwcentrum, Rotterdam, 1969, y Master en Arquitectura, Louis I. Kahn' masters studio, University of Pennsylvania, 1970. Colaborador en el estudio de Kahn en Filadelfia, 1970. Entre 1986 y 1994 ha ejercido la docencia en Norte y Sudamérica, principalmente en las universidades de Columbia y Pennsylvania. Desde 1998 es director de la Escuela de Arquitectura de la University of Arizona en Tucson. **Alfonso Montero** Arquitecto, Universidad Católica de Chile, 1992. Entre 1999 y 2001 se traslada a Los Angeles, EE.UU. para ejercer como arquitecto en la oficina de Zecchetto Architecs y posteriormente en Steinberg Group Architects. Actualmente comparte su tiempo como jefe de proyectos del equipo Elemental en la Universidad Católica y su oficina particular. **Paola Moreno** Diseñadora, Universidad Católica de Chile, 1990. Miembro del Directorio del Comité Nacional de Conservación Textil. 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Su obra profesional incluye la coautoría de la recuperación de la Estación Mapocho y la remodelación de la Plaza de Armas de Santiago. **Milva Pesce** Arquitecta, Universidad Católica de Chile, 1999. Alumna de último semestre del Postítulo en Arquitectura y Manejo del Paisaje de la Universidad Católica de Chile, actualmente trabaja como arquitecta en la oficina de Teodoro Fernández. **Ignacio San Martín** Master en Arquitectura del Paisaje, 1978, Master en Planeamiento Urbano y Regional, 1980, y Master en Diseño Urbano, 1981, University of California, Berkeley. Entre 1994 y 2001 fue director del Programa de Graduados en Planeamiento Urbano y Regional de la Arizona State University en Phoenix. Actualmente es profesor de arquitectura y coordinador del Programa de Graduados en Diseño Urbano de la University of Arizona en Tucson. **Varinia Varela** Licenciada en Arqueología y Prehistoria, y arqueóloga, Universidad de Chile, 1992. Actualmente es investigadora del Museo Chileno de Arte Precolombino y profesora de la Escuela de Artes del Fuego en Santiago.

Editorial

Entre las noticias que nos llegan, hay dos que pasan casi sin tocar nuestra imaginación. Es lo que nos ocurriría –o nos está ocurriendo– con el agua, y que es contradictorio: su escasez y también su aumento. Abundancia por el derretimiento de los hielos en el mar (hay estadísticas espeluznantes a futuro, que harían a un astuto director de cine –como Mel Gibson– centuplicar sus ganancias). Pero que los hielos se derriten, es cosa de mirarlos. La desertificación, en cambio, disimula más; y la escasez de agua para tomar y regar que ocurre, por ejemplo, en África, no es noticia para los medios.

Creo que el Seminario que se realizó en nuestra Facultad en noviembre de 2003, aparte de convocar a profesionales y expertos de buen nivel, chilenos y de la Universidad de Arizona, logró fijar nuestra imaginación en el tema del agua y del desierto. Las imágenes, cifras y técnicas expuestas nos hicieron apreciar estos climas, como el de Santiago: una zona árida de siempre que, sin proponérnoslo racionalmente, hemos ido acercando a un oasis. A través de los años, hemos conseguido veredas sombreadas y espacios intermedios que nos protegen del sol brillante de nuestros largos veranos, pero no logramos desarrollarlos con nuevos recursos de la arquitectura y del jardín urbano para la ciudad que estamos construyendo ahora, precipitadamente.

Este número retoma algunos temas del Seminario de 2003, ampliándolos con, por ejemplo, el artículo de Wiley Ludeña sobre Lima, una gran ciudad en el desierto; un artículo del ingeniero hidráulico Bonifacio Fernández sobre parques inundables, o una invitación a reinventar la ciudad jardín, de Rodrigo Pérez de Arce.

Obras de arquitectura y paisajismo que se adecuan a este clima seco y caluroso demuestran –tanto en Arizona como en Perú y en el norte de Chile– que podemos intercambiar ideas y empezar a afrontar con inteligencia y sensibilidad la transformación de una serie de “inconvenientes” como el calor, la falta de agua y la aridez, en características positivas para nuestra arquitectura y nuestras ciudades.

In the daily news, two items hardly register in our imagination: What could happen, or is already happening to us, in relation to water. We are warned, contradictorily, about its scarcity, and its increase. There is an abundance from melting sea ice. The scary forecasts could make millions for an astute filmmaker like Mel Gibson, but in fact the phenomenon is visible to the naked eye. Desertification, on the other hand, is not so obvious, and the shortage of drinking and irrigation water in Africa, for example, simply does not make the news.

I believe the seminar held by our faculty in November 2003, with top professionals and experts from Chile and the University of Arizona, helped focus our imagination on the issue of water and the desert. The images, figures and techniques presented prompted us to reflect on climates like Santiago’s, historically an arid zone that, with no rational plan, we are transforming into an oasis. Over the years we have created shady sidewalks and intermediate spaces to protect us from the bright sun of our long summers, but we have not developed them with the new resources of architecture and urban landscape for the city we are constructing now so hastily.

This issue takes up some of the themes from the 2003 seminar and develops them in articles like Willy Ludeña’s on Lima, a great city in the desert, or hydraulic engineer Bonifacio Fernandez’s piece on “drainage parks” or Rodrigo Pérez de Arce’s invitation to reinvent the garden city.

Works of architecture and landscaping adapted to hot, dry climates show how in Arizona, Peru or northern Chile we can exchange ideas and begin tackling with intelligence and sensitivity the transformation of a series of obstacles like heat, lack of water and aridity into positive features of our architecture and our cities.

Montserrat Palmer Trias

Álvaro Malo

Una ética del desierto: investigación estética

En el paisaje del valle de Tucson diversas formaciones rocosas, cursos de agua, colinas y cañones definen un espacio que es el hábitat de un silencioso ecosistema. La incorporación del hombre y ciertos hábitos ciudadanos ajenos a la realidad del territorio señalan una serie de preguntas por la adaptación, que están todavía por responder.
Palabras clave: Paisajismo – EE.UU., Arquitectura – EE.UU., Arizona, Tucson.

In the Tucson valley landscape, rock formation, watercourses, hills and canyons define a space that is the habitat for a silent ecosystem. The presence of people and certain human behavior patterns foreign to the reality of the local territory raise a series of questions about adaptation that are yet to be answered.
Key words: Lanscaping - U.S.A., Architecture - U.S.A., Arizona, Tucson.

La vida del desierto vive de adaptarse a las condiciones del desierto.
…Y así sucede que aquello que es capaz de sobrevivir en el desierto, con el tiempo adquiere un peculiar carácter desértico… La lucha parece desarrollar en estos seres características especiales, que sin hacerlos distintos de los de su especie, los vuelve más positivos, más insistentes.
John C. Van Dyke, 1999

Geología del desierto de Sonora

Me levanto muy temprano desde que llegué a Arizona, apremiado por la luminosidad del cielo de la mañana. Y lo que hago al amanecer es caminar por mi jardín al pie de las montañas de Santa Catalina –si bien la noción de jardín aquí es distinta; en general un cerco o una pared levantada para apoderarse de una porción de desierto tal cual es. La vegetación es escasa, siendo el perímetro de la estructura de la raíz el que determina el derecho a agua de cada planta. Pero es la cualidad de la superficie la que, bajo los rayos rasantes del sol de la mañana, seduce al ojo particularmente.

Material de acarreo proveniente de las montañas desborda a través de quebradas o cañones, y cubre gran parte de la superficie del desierto de Sonora. Varía mucho en color y textura: arenosos y porosos, cristalinos y duros como roca, blanco opalino a negro intenso y basáltico, y con sus matices intermedios. La presencia de rocas ígneas y metamórficas evidencia un activo pasado volcánico.

La geología desafía la razón y la imaginación. La noción de tiempo relativa a los ciclos biológicos parece fugaz comparada con los ciclos geológicos, que duran millones de años. La noción de espacio geológico es igualmente provocadora. Nos preguntamos qué causó que la Tierra tomara su actual forma y qué será de ella en el futuro. (fig. 1)

La cuenca de Tucson es un vasto valle a 2.400 pies (aprox. 924 m) de altura media, circunscrito por las montañas de Santa Catalina (al norte), de Tucson (al este), de Santa Rita (al sur) y las montañas Rincón (al este). El intenso calor proveniente del centro de la Tierra derritió la corteza, convirtiéndola en un fluido viscoso; esta zona recalentada de Arizona formó un área enorme de fallas geológicas como respuesta al movimiento (hacia el noroeste) de la placa tectónica del Océano Pacífico: el alejamiento de las montañas de Santa Catalina se debe a una de estas fallas, prácticamente lisa. Una vez liberadas por la falla, estas montañas se elevaron y arquearon aún más, debido a la alta temperatura y a la flotación. Los separados bordes de la *gneiss*


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(roca metamórfica) se movieron una considerable distancia, 10 millas (16 km aprox.) o más hacia cada lado, formando los valles de San Pedro y Tucson, en un proceso que duró unos cuantos millones de años (Phillips y Wentworth, 2000). (fig. 2)

Hay una definición que he decidido atesorar en mi memoria: *tectónica*. Lo relativo a la deformación de la corteza terrestre, las fuerzas involucradas y las formas resultantes. La lección del día, en mi jardín de las Catalinas, deriva de la noción de *fuerza*. Me olvido intencionalmente de los cánones de belleza, que podrían convertirme en un "esteticista", y sigo la sugerencia del poeta portugués Fernando Pessoa: uno puede formular una estética basada no en la noción de belleza sino en aquella de la fuerza (Pessoa, 1988). Fuerza entendida no como violencia, sino como el evento de transición entre mi cuerpo y el material. La búsqueda de la expresión pasa directamente por la elección del material. Sea el material traccionado o comprimido, el punto es que el trabajo debe revelar la fuerza prefiriéndose el sentido Aristotélico de *energeia* por sobre la noción Platónica de *idea*.

"*Creo que al menos una vez en la vida el hombre debería concentrar su mente en el recuerdo de la tierra. Debería entregarse a un paisaje de su vida. En particular, mirarlo desde tantos ángulos como pueda, preguntarse acerca de éste, morar en él… Me interesa la manera en que un hombre mira un determinado paisaje y toma posesión de éste en su cuerpo y en su mente*" (Momaday, 1998).

Agua

La palabra *Tucson* deriva de la original *Cuk Son*, que en el lenguaje de los nativos *tohono O'odham*, también llamados *papago* o "gente del desierto", significa "a los pies de la montaña negra" (Zepeda, 1997). La montaña negra, ahora llamada Montaña "A", es un cono volcánico de lava que se sumerge profundamente y se encuentra con la cuenca del río Santa Cruz en la ubicación geográfica exacta del actual centro de Tucson. Menos de diez millas (16 km aprox.) río arriba, a lo largo de la autopista I-19, hay otro cono de lava llamado Wa:k (que significa "el manantial") ubicado en el distrito de San Xavier de la nación *tohono O'odham* –donde el misionero jesuita Eusebio Kino construyó la reconocida Misión de San Xavier del Bac. Estas incursiones rocosas desviaron el flujo de agua subterránea hacia arriba, forzándola a manar; los manantiales hicieron de Bac y Tucson los sitios donde prosperaron, antes de la llegada de los conquistadores españoles, los asentamientos de los nativos *tohono O'odham* y, miles de años antes que ellos, los *hohokam*.

La discusión acerca de la etimología y el significado del nombre *Arizona* aún no está resuelta. Puede haber surgido de dos palabras piman, *ali* y *shonak*, que significan "pequeños manantiales". O de los vascos asentados en la región, descendientes de Anza el Mayor –fundador de Alta California– quienes podrían haber denominado el área *arritz onac*, o "lugares rocosos" (Sheridan, 1995). Cualquiera fuera el origen lingüístico del nombre, la coincidencia fonética de los distintos idiomas parece calzar con los atributos del territorio. Hoy en día la gente piensa intuitivamente que significa "zona árida" –y también tienen algo de razón. Las lluvias en el desierto de Sonora alcanzan un promedio anual de 76,2 mm en Yuma, Arizona, y 381 mm en las tierras altas de Arizona. El valle de Tucson, ubicado en esta última, recibe 305 mm de precipitaciones al año, distribuidas principalmente en dos estaciones lluviosas: una invernal, en diciembre y enero; y una veraniega, desde julio hasta principios de septiembre. Las lluvias de invierno suelen ser constantes y suaves; en contraste, las de verano pueden ser abruptas y torrenciales, pudiendo registrarse varios milímetros en unas pocas horas. Se producen tras los monzones, vientos de verano que soplan desde la tierra hacia el mar para llenar el vacío originado al subir el aire caliente (Phillips y Wentworth, 2000).


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1 Acantilados del Eco, en el borde de la meseta Kaibeto, cerca de Tuba City, reserva Navajo, Arizona (© Adriel Heisey)

2 Interior del cañón de Chelly, nación Navajo, Arizona (© Adriel Heisey)

3 Acueducto Granite Reef, Central Arizona Project, en el desierto Tonopah, Arizona (© Adriel Heisey)

El agua es la sangre vital del desierto de Sonora. La lluvia que cae en las montañas y en las colinas fluye por los cañones hacia los valles aluviales y los acuíferos, sosteniendo las zonas ribereñas del desierto de Sonora. El patrón de drenaje de la cuenca de Tucson es un sistema infinitamente variado de geometrías: profundos cañones de montaña, arroyos superficiales de pie de monte y amplios sistemas de flujos en los valles se agregan a los típicos patrones de meandros que serpentean horizontalmente, cascadas y estanques. (fig. 3)

El bombeo excesivo de agua desde las napas subterráneas, requerida para labores agrícolas, la industria y consumo humano en áreas urbanas, aumentó la profundidad de estas fuentes, no alcanzando el nivel de las raíces de las plantas nativas. Los *cottonwood* (árbol norteamericano con una fibra similar al algodón) y sauces que una vez poblaron los corredores fluviales del desierto de Sonora, incluyendo los cajones de los ríos Salt, Gila, Santa Cruz y Rillito se han perdido o están desapareciendo. La reserva de agua que yace bajo Tucson central ha descendido más de 70 m en los últimos 50 años; para suplir esta deficiencia se ha desviado agua desde la cuenca del río Colorado, ubicada varios cientos de kilómetros al norte, a través del enorme acueducto del proyecto *Central Arizona*. (fig. 4)

El bombeo de agua subterránea y la importación del elemento desde otras regiones han demorado el proceso inevitable de moderación en el consumo de agua que deben enfrentar los habitantes llegados al desierto; en general siguen reproduciendo los modos de vida que abandonaron. La lección ética que estoy aprendiendo del desierto es el establecimiento de un nexo entre mis decisiones y las de la Naturaleza. Es una lección bien inscrita en la experiencia de Joseph Wood Krutch "*…el desierto es conservador, no radical*", pues alienta "*…el heroísmo de la resistencia, no el de la conquista*". El desierto es la última frontera, "*…una frontera que no puede ser cruzada. Enfrenta al hombre con sus propias limitaciones*" (Wood, 1954).

"*…Agua, agua, agua… No hay escasez de agua en el desierto, sino la cantidad exacta: la razón perfecta de agua por roca, de agua por arena, asegurando ese amplio y generoso espacio libre entre plantas y animales, hogares, pueblos y ciudades, lo que hace que el árido Oeste sea tan distinto de cualquier otra parte de la nación. Aquí no falta el agua, salvo que se intente establecer una ciudad donde no debe haberla*" (Abbey, 1990).

Aire y luz

Mi casa se asienta en una pendiente del diez por ciento hacia el sur, en las montañas de Santa Catalina. Es muy simple: un rectángulo espacial con vidrio de piso a cielo, sombreado por un pórtico abierto de madera de 18,3 x 4,3 m a lo largo de toda la fachada sur. Desde este mirador, con las montañas de Santa Catalina a mis espaldas, puedo ver claramente la amplitud de la cuenca de Tucson, enmarcada por montañas en todos sus costados: las de Tucson a mi derecha, las de Rincón a mi izquierda, y las de Santa Rita al frente –e imagino la frontera mexicana no demasiado lejos, y el resto de América, siempre hacia el sur hasta Tierra del Fuego. (fig. 5)

El azul profundo suspendido sobre el desierto está en su tono más intenso en la mañana antes del amanecer; un azul oscuro que linda con el morado. Hacia la tarde ha cruzado el espectro completo pasando por azul pálido, amarillento y lila. Al atardecer ha pasado nuevamente por el magenta, rosa y naranja. Luego del crepúsculo un cálido velo morado ha regresado para envolverlo todo, lo visible y lo invisible.

El aire seco y relativamente puro del desierto, las rocas volcánicas cercanas, los árboles palo verde en flor, los saguaros (cactus gigantes del desierto) y las verbenas de duna muestran una sobresaliente variedad de matices –rojo, naranja, amarillo, verde. Pero en la distancia, cuanto más


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4 Casa Malo, laderas de las montañas de Santa Catalina, Tucson, Arizona

5 Cañon del río Little Colorado, vista al oeste hacia el Gran Cañón, Arizona (© Adriel Heisey)

6 Chollas e incienso, desierto de Sonora, Arizona

7 Casa Ramada, laderas de las montañas de Santa Catalina, Tucson, Arizona. (fotografía de Judith Chafee, arquitecta)

interviene el aire, todo aquí parece tener un brillo azulado. Cielos azules, montañas azules y pájaros azules: todo parece comprimir la perspectiva aérea a un delgado y trémulo velo. (fig. 6)

Ética de la tierra / investigación estética

Vittorio Gregotti aconseja a los arquitectos que comiencen su trabajo a una escala geográfica, para asegurarse que el marco construido instituya una red de conexiones que estructure o modifique la "forma del territorio". La geografía no es solamente un territorio esperando ser proyectado y subdividido –un recurso a ser desarrollado. Es también un campo de fuerzas cuyos vectores esperan ser vivenciados –una fuente de sensibilidad. El filósofo noruego Arne Naess nos abre, a través de su concepto de ecosofía (Naess, 1989), a la noción de que podemos tomar parte en la naturaleza de la piedra en el torrente, del incienso que crece en las mesetas, del halcón que cruza las masas de aire. Habiendo experimentado sucesivos traslados, desde las tierras altas andinas en América del Sur, a las llanuras de los Everglades en Florida, a las tierras altas del desierto de Sonora en Arizona, estoy preparado para decir que el vector de inflexión que vincula geografía y geometría penetra la superficie de la tierra; o siguiendo a Spinoza en *Ética*, extiende la superficie de nuestro cuerpo hacia el paisaje, ofreciendo una continuidad que prolonga la naturaleza misma de las cosas. (fig. 7)

Siguiendo a Spinoza, y tomando prestados los términos de la geografía, definiríamos un cuerpo no por su forma, tampoco por sus órganos y funciones, sino más bien por longitud y latitud. En este esquema, longitud es el conjunto de relaciones mecánicas de extensión y orientación en el espacio, y latitud es el conjunto de motivos o fuerzas emotivas y estados intensivos en el tiempo. Así, podemos construir un mapa del cuerpo, "formando una geometría natural, que nos permita comprender la unidad de la composición de toda la Naturaleza, y los modos de variación de esa unidad" (Deleuze, 1988).

Sin ser distinta del papel de las fuerzas tectónicas en la corteza terrestre, la relación primaria de mi cuerpo con el suelo es la transacción con la gravedad. El reconocimiento de la gravedad prepara el acto geométrico de poner a tierra, preparando el suelo para levantar pantallas para otras fuerzas: luz, viento y lluvia. Mi experiencia es que esto usualmente comienza, y en la mayoría de los casos termina, con la excavación. (fig. 8)

"…*Pero, ¿dónde está la superficie de un agujero? Antes creía que la superficie de un agujero estaba a nivel con la superficie del suelo a su alrededor. Observando, me he dado cuenta que esto no es cierto… Un agujero tiene sólo lados y un fondo desde donde se extiende infinitamente hacia arriba, como un rayo de luz: y cuando la tierra gira, éste se mueve con gran cuidado y precisión entre las estrellas*" (Shelton, 1987). ARQ

Bibliografía: Abbey, Edward; *Desert Solitaire*. Touchstone/Simon & Schuster, New York, 1990, p. 126. / Deleuze, Gilles; *Spinoza: Practical Philosophy*. City Light Books, San Francisco, 1988, pp. 125-128. / Momaday, N. Scott; "An American Land Ethic", en *The Man Made of Words*. St. Martin's Griffin, Nueva York, 1998, p. 45. /Naess, Arne; *Ecology, community and lifestyle*. Cambridge University Press, Cambridge, 1989. / Pessoa, Fernando; *Always Astonished*. City Lights Books, San Francisco, 1988, p. 70. /Phillips, Steven J. y Wentworth Comus, Patricia; *A Natural History of the Sonoran Desert*. Arizona-Sonora Desert Museum y University of California Press, Tucson, 2000, pp. 75-85. /Shelton, Richard; *The Other Side of the Story*. Confluence Press, Lewiston, 1987, p. 22. / Sheridan, Thomas E.; *Arizona: A History*. University of Arizona Press, Tucson, 1995, p. 31. / Van Dyke, John C.; *The Desert: Further Studies in Natural Appearances*. Johns Hopkins University Press, Baltimore, 1999, p. 150. / Wood Krutch, Joseph; *The Voice of the Desert*. William Morrow & Co, New York, 1954, p. 221. / Zepeda, Ofelia; *A Papago Grammar*. University of Arizona Press, Tucson, 1997


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FERNÁNDEZ ALBA + DEL PINO 09

casa tucson

[2004]

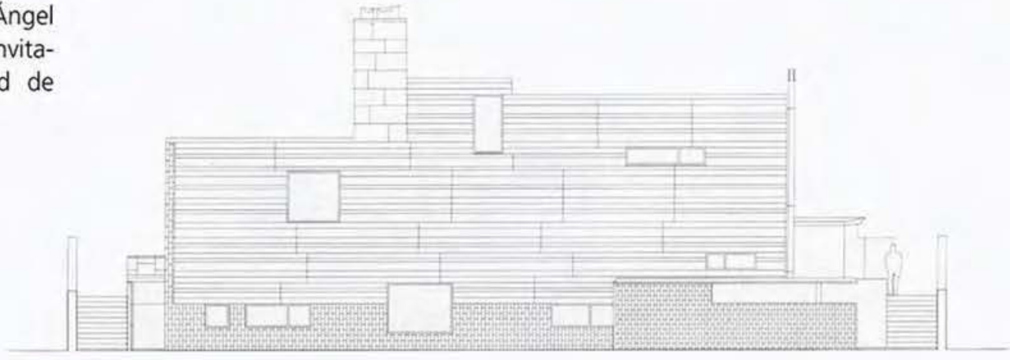
ARQUITECTOS:
Ángel Fernández Alba
Soledad del Pino

COLABORADORES:
Kiani Wamsteker, Ben Busche
Arquitecto técnico: José Luis Benavides
Estructuras: Alfonso Gómez Gaite

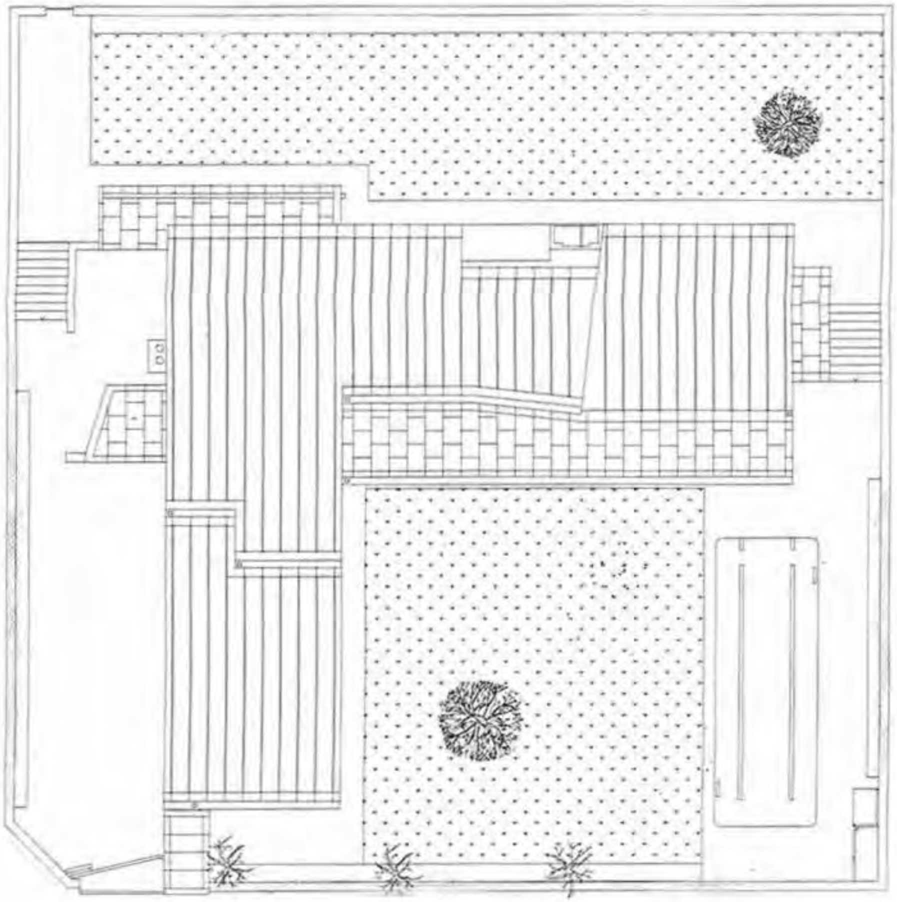
FOTOGRAFÍAS:
Åke Lindman

La construcción de la Casa Tucson concluyó en el otoño de 2004 en Zaragoza, la capital de la provincia de Aragón, a una longitud de 0'89° oeste, latitud 41'65° norte y una altitud de 660 pies (unos 200 metros) sobre el nivel del mar. Fue concebida y diseñada en Tucson, Arizona, EEUU, a una longitud de 110'89° oeste, latitud 32'3° norte y una altitud de 2.500 pies (unos 770 metros), en la primavera de 1999. El arquitecto, Ángel Fernández Alba ejercía como profesor invitado de arquitectura en la Universidad de Arizona.

Álvaro Malo (sigue en la página 84)



ALZADO A CALLE



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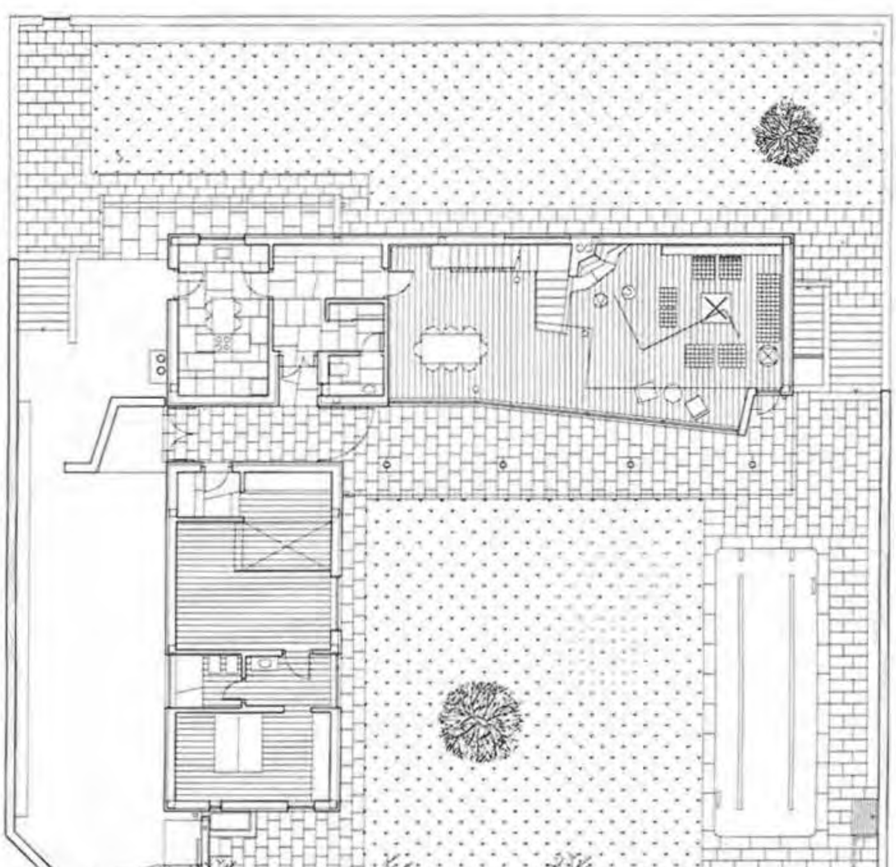

PLANTA BAJA

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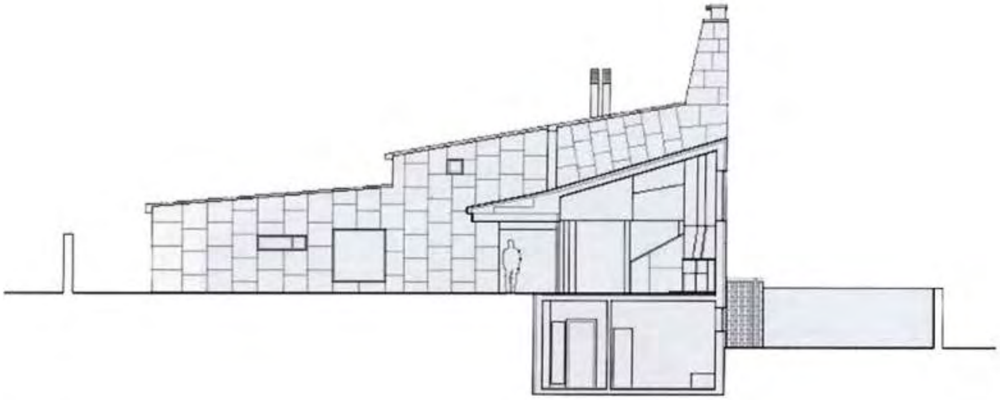
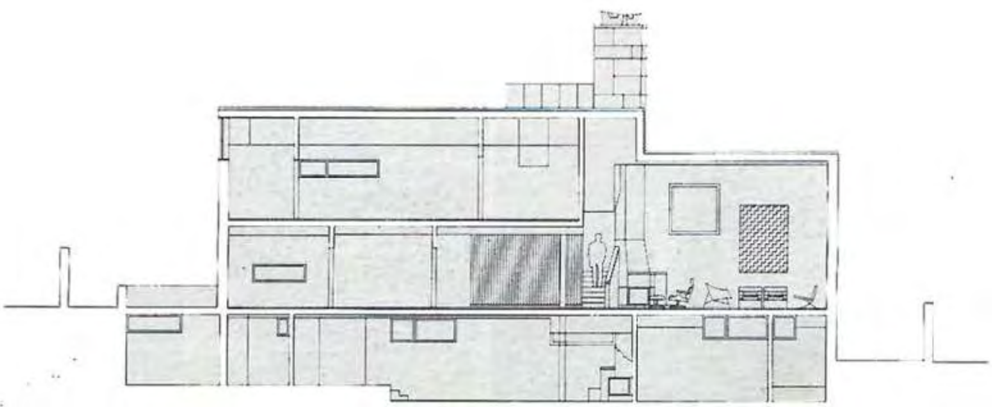


SECCIÓN TRANSVERSAL



SECCIÓN LONGITUDINAL

Casa Tucson en Zaragoza, España

Álvaro Malo, nacido en el Ecuador, en la ciudad de Cuenca, realizó el Master de Arquitectura en Louis I. Kahn's Master's Studio en la Universidad de Pensilvania en 1970. Ha enseñado Arquitectura en America del Norte y del Sur, recientemente en la Universidad de Columbia y la Universidad de Pensilvania, y ahora es Director de la Escuela de Arquitectura en la Universidad de Arizona, en Tucson.

Zaragoza, una de las ciudades monumentales de Espana, fué fundada hace unos 2.000 años en las margenes del rio Ebro. Antiguos iberos, romanos, godos y árabes han dejado huella de su herencia arquitectónica en esta ciudad, que también posee edificios importantes del periodo barroco español. Tucson, originalmente Cuk-Son en la lengua de los nativos Tohono O'odham, sería uno de los asentamientos más antiguos de Norte America según recientes hallazgos arqueológicos verificados por el Smithsonian. Fué fundada por antepasados de los Hohokam approximadamente hace 8.000 años en las tierras bañadas por el río Santa Cruz. También tiene muestras históricas importantes de arquitectura misionera española en el suroeste de America del Norte: la Misión de San Xavier del Bac, la "paloma blanca del desierto".

¿Cual es el significado, si lo tuviera, del hecho de que un trabajo arquitectónico puede concebirse, o imaginarse, en un lugar y construirse en otro separados por 110° de latitud, 9.135 kilometros y 9 husos horarios? Se podría argumentar que la imaginación es extraordinariamente móvil y no importa en donde estás, que opera en un espacio abstracto utilitario igualmente divisible, lo cual es probablemente cierto en los estudios de arquitectura "globales" que proyectan en Norte America y Europa, subcontratan los planos de construcción en la India, y construyen en China. O se podría reconocer que el espíritu del lugar, or *genius loci*, afecta a la imaginación intuitiva en maneras que podrían ser profundamente relevantes para el proyecto — y este puede ser el caso propio de Ángel Fernández Alba.

Segun la *Ética* del filósofo Spinoza, el vector de inflexión que une la geografía a la geometría, o arquitectura, interioriza la superficie del terreno, o más bien, extiende la superficie del cuerpo sobre el paisaje. Aquí, el cuerpo se convierte en un límite, una superficie selective de intercambio de percepciones, acciones y reacciones que ligan al individuo con la tierra. De acuerdo con los términos geográficos, Spinoza no definiría el cuerpo por su forma o por sus órganos, sino por *longitud* y *latitud*. En este esquema, longitud es el conjunto de relaciones mecánicas de extensión y orientación en el espacio, y latitud es el conjunto de fuerzas motivas, o emotivas, y estados intensivos en el tiempo.

Vittorio Gregotti aconseja a los arquitectos que empiecen el trabajo en una escala geográfica para asegurar que el marco de construcción instituya una red de conexiones que estructuran o modifican la "forma del territorio". La geografía no es solo un terreno en espera de planificación y subdivision, un *recurso* para ser explotado. Más aún es un campo de fuerzas cuyos vectores esperan ser experimentados, una *fuente* de sensibilidad. En el ensayo "Etica de la Tierra Americana", el poeta nativo Scott Momaday propone:

> *Yo creo que una vez en su vida el hombre debería concentrar la mente en la tierra evocada. Debería entregarse a si mismo a un paisaje concreto en su experiencia, mirarlo desde todos los ángulos que sea capaz y maravillarse de ello, detenerse en ello…Me interesa la forma en que un hombre mira un paisaje dado y lo apropia en su sangre y su cerebro.*

Ángel Fernández Alba habia encargado unas fotografías extraordinarias de la casa tomadas por el fotografo sueco Ake Lindman poco después de ser acabada y antes de que el dueño y su familia se hubieran mudado. Ver esas fotografias fué profundamente conmovedor y nostálgico como el poema de Wallace Stevens "La Casa Estaba Tranquila y el Mundo en Calma". Pero me he tornado suspicaz sobre la fidelidad de las fotografías como prueba estética y, mucho menos, evidencia tangible de la realidad constructiva de la arquitectura. Así, insistí que para escribir algo deberíamos visitar la casa en persona.

Un dia a finales de noviembre tomamos el AVE a las site de la mañana en Madrid con dirección al norte hacia Zaragoza, cruzando lo que desde la comodidad del vagón parecian los quiméricos campos deshabitados de Castilla-La Mancha y las imponentes tierras de Aragón, ambas reminiscentess del cuento caballerezco del *Don Quijote* de Cervantes o del gran poema épico medieval *El Cid Campeador* de Diaz de Vivar. Después se me ocurrió que aquellos eran los mismos españoles idealistas y aventureros que vinieron a America. En las palabras de Charles Bowden, un mordaz escritor del suroeste norteamericano, Alvar Nuñez Cabeza de Vaca "sería el primer europeo que pudo ser o fué americano — o más bien fué el último. Y hubiese explorado el territorio que mucho más tarde llamaríamos el Desierto de Sonora".

The construction of Casa Tucson was finished in Zaragoza, capital of the province of Aragón, Spain, at longitude 0°89' W, latitude 41°65' N, and altitude 660 feet above sea level, in the fall of 2004. It was conceived and designed in Tucson, Arizona, USA, at longitude 110°58' W, latitude 32°13' N, and altitude 2,500 feet, in the spring of 1999—the architect Ángel Fernández Alba was at the time a visiting professor of Architecture at the University of Arizona.

Zaragoza, one of the great monumental towns in Spain, was founded some 2000 years ago on the banks of the river Ebro. Old-Iberians, Romans, Goths and Arabians have left traces of their architectural heritage in this city, which also includes important buildings of the Spanish baroque period. Tucson, originally 'Cuk-Son' in the language of the native Tohono O'odham, is one of the oldest settlements in North America according to recent archeological findings verified by the Smithsonian; it was founded by the Hohokam's ancestors approximately 8000 years ago on the flood plains of the Santa Cruz River. It also has one of the most important historical examples of Spanish missionary architecture in the North American Southwest: the Mission of San Xavier del Bac, the "white dove of the desert."

What is the significance, if any, of the fact that a work of architecture may be imagined, or conceived, in one place and built in another separated by 110° of latitude, 9,135 kilometers and 9 time zones? One may argue that imagination is highly portable and that it does not matter where you are; that you are operating in an equally divisible utilitarian abstract space—which is probably true of 'global' architectural practices that design in North America or Europe, outsource construction drawings to India, and build them in China. Or, one may profess that the place where you are, or genius loci, affects the intuitive imagination in ways that may be profoundly relevant to the project—this may be the case with Ángel Fernández Alba.

According to the philosopher Spinoza's Ethic, the vector of inflexion linking geography to geometry, or architecture, internalizes the surface of the land; or, rather extends the surface of the body onto the landscape. Here, the body becomes a boundary, a selective surface of exchange of perceptions, actions and reactions linking together the individual and the world. Adopting the terms of geography, Spinoza would define a body, neither by its form nor by its organs and functions, but rather by longitude and latitude. In this schema, longitude is the set of mechanical relations of extension and orientation in space, and latitude is the set of motive, or emotive, forces and intensive states in time.

Vittorio Gregotti advises architects to begin their work on a geographical scale, to ensure that the built frame institutes a network of connections that structure or modify the "shape of the territory." Geography is not just a land that awaits mapping and subdivision—a resource to be developed. It is also, even more so, a field of forces whose vectors await experiencing—a source of sensibility. In his essay "An American Land Ethic," the Native American poet Scott Momaday proposes that,

> *Once in his life a man ought to concentrate his mind upon the remembered earth, I believe. He ought to give himself to a particular landscape in his experience, to look at it from as many angles as he can, to wonder about it, to dwell upon it…I am interested in the way that a man looks at a given landscape and takes possession of it in his blood and brain.*

Ángel Fernández Alba had commissioned some extraordinary photographs of the Tucson House by Swedish photographer Ake Lindman, taken shortly after completion and before the owner and his family had moved in. Looking at those photographs was deeply moving and reminiscent of Wallace Stevens' poem "The House Was Quiet and the World Was Calm." Yet, I have grown suspicious of the fidelity of photographs as proof of the aesthetic and, much less, of the tangible constructive reality of architecture. So, I insisted that in order to write something we must go to visit the house.

Al acercarnos a la casa tuvimos que pasar a través de la fantasia surrealista de portones de seguridad electrónica de una urbanización en las afueras de Zaragoza. La urbanización en sí misma tenia el aspecto insípido del endemico crecimiento mercantilista, ni urbano ni rural, que se esta convirtiendo en lo típico de todos los sitios, o de ningun sitio. Alli la casa se erguía solitaria en su actitud quijotesca idealista; la única atalaya distante de esperanza era una torre de aguas, prima lejana de los molinos de viento.

Ni la casa estaba tranquila, ni el mundo estaba en calma. Así como la urbanización exterior era inquietante, el interior era ruidoso con los muebles eclécticos de sus habitantes, quienes se habian mudado que todas sus posesiones acumuladas y descriptivas de sus biografías e historias de gusto, como era su legítimo derecho. Esto comfirma que el idealismo del arquitecto es muy vulnerable a las peripecias del exterior como del interior. Tuve que abandonar estas relexiones y comportarme como un experto forense, buscando las pruebas materiales de lo que fué la casa antes, cuando estaba vacía, como aparecia en las fotografías de Lindman.

En la parte norte que mira a la calle, la elevación de la casa tiene un aspecto defensivo de corte vertical que se ajusta al perfil topográfico del terreno. Excavando el nivel subterraneo, los muros de apuntalamiento y cimentacion, hechos de hormigón fundido *in situ*, se elevan desde la profundidad del subsuelo mostrando en su textura sedimentaria las líneas horizontales del encofrado de madera. El plano de cubiertas, fabricado de cobre chileno, se cuelga y envuelve el volumen en tersas franjas horizontales; la continuidad de su armadura vertical metálica, que cubre gran parte de la fachada hasta el alto de la cintura, está esporádicamente interrumpida por los intervalos de la fenestración. En el alzado sur, que mira hacia un patio interior, los planos de la cubierta de cobre moderan su pendiente y levitan abiertamente revelando el espacio interno a través de un corte de L, forrado en travertino romano y cristaleria de techo a suelo. El interior se desdobla en el contrapunto tectónico entre techo y suelo, ofreciendo una posición de refugio y perspectiva. Los pisos estan cubiertos con la madera africana "Mervau" (*Argelia Bijuda*) y granito español de las canteras de Quintana, en la comunidad de Extremadura. Las habitacionea son diáfanas y translúcidas, la mayoría vestidas en blanco semimate, que a través de sus sutiles matices de luz reflejada son quizás evocativas del cielo de Sonora.

La planta tiene forma de L y esta dividida en tres niveles. Al sótano solo se accede desde el exterior, con aberturas mínimas hacia el norte que permiten una mirada razante de un suelo cubierto de gravilla verde; contiene una bodega, una pequena colección de pinturas y esculturas, y el equipo instalaciones mecánicas. La planta baja, que se abre a través de un gran portico a un patio paisajista con piscina, acoge el comedor, el salón y la cocina en el ala larga de la L, y el dormitorio principal en el ala corta. La planta elevada, o primer piso, contiene dos habitaciones y una sala de juegos que mira al sur a través de ventanas de linterna. Las escaleras abiertas y la chimenea articulan el interior y amarran el desnivel entre el suelo y el cielo raso.

En la pelicula *Solaris*, Andrei Tarkovsky presenta una meditación rigurosamente poética sobre los viajes espaciales y sus ramificaciones físicas y existenciales. El científico Chris Kelvin viaja al misterioso planeta Solaris para investigar el fracaso de una misión anterior. Cuando su esposa, que lleva mucho tiempo muerta, aparece en la estación espacial se da cuenta de que el planeta tiene el poder de percibir los deseos humanos y hacerlos realidad. El interés de la Casa Tucson podría estar en los materiales y métodos de construcción, o también en su actitud en relación con la gravedad y la luz, pero además esta en la transposición de longitud y latitud, las diferencias similares y las diferentes similitudes entre Tucson y Zaragoza, y la realización de aquellos deseos humanos inciertos que habitualmente llamamos programa de necesidades — lo que los griegos llamaban la *causa final*, o teleología.

¿Como transforman los arquitectos los deseos humanos en realidad física? He visto la casa levantantandose solitaria en una zona residencial amurallada en el frío invierno de Zaragoza, y he sentido su nostalgia — o quizás la reminiscencia proustiana del propio Ángel Fernández Alba — por el *élan vital* del Desierto de Sonora. Este deseo de comunicarse con cosas inanimadas podría ser al final una forma de análisis poetico, similar en su futilidad al mito de Sísifo, que el filósofo Guiles Deleuze define como la aventura "de escalar desde la profundidad del cuerpo a la superficie de las palabras". Quizás futil, pero para el escritor Maurice Blanchot es un signo del impulso fundamental para "hacer que la oscuridad de la lengua responda a la claridad de las cosas".

We took the 7:00 am AVE rapid train one late November morning, going north from Madrid to Zaragoza, crossing what, from the comfort of the train's heated cabin, looked like uninhabited idealized fields of Castilla-La Mancha and the forbidding fields of Aragón, both reminiscent of either Cervantes chivalrous legend of *Don Quixote* or Diáz de Vivar great medieval epic poem, *El Cid Campeador*. Later, I thought these were the same idealistic or tempered heart Spaniards that came to America. In the words of Charles Bowden, an acerbic writer on the American Southwest, Alvar Nuñez Cabeza de Vaca (Head of the Cow) "will be the first European to have ever been an American or be an American. Or he may well have been the last. An he will have looked into the country that long, long afterward we will come to call the Sonoran Desert."

As we got close to the house, we had to clear through the surreal phantom of electronic security gates in a suburban development of Zaragoza. The development itself had the insipid quality of market driven endemic growth, neither urban nor rural, that is becoming typical of everywhere—and nowhere. The house stood there apart, alone in its idealistic quixotic attitude; the only distant beacon of hope visible from its site was a water tower—a distant cousin of Quixote's windmills.

Neither the house was quiet, nor the world was calm. As much as the exterior development was disturbing, the interior was made noisy by the eclectic furnishings of its inhabitants, which had moved in with their entire material biographies and individual histories of taste—as it was their legitimate right. This confirmed that the idealism of the architect is highly vulnerable to exterior as well as to interior forces. I had to put these reflections aside and behave like a forensic expert, searching for the material traces of what had been there before, when the house was empty—as depicted in the early photographs.

On the north side facing the street, the elevation of the house has a defensive position of vertical shear that takes topographical advantage of the ground profile. By further excavation below grade the shoring and foundation walls, made of cast in-situ concrete, rise from the depth of the ground showing a vertical narrow striated texture of the wood formwork. The plane of the roof, made of Chilean copper, drapes vertically as a horizontally banded shield; the continuity of this metallic armor, which covers most of the façade, up from waist height, is relieved sporadically at strategic fenestration intervals. On the south side facing an internal courtyard, the copper roof planes slope gently and are held up in an open inviting mode that reveals the interior through an L-shaped intersection of light Roman travertine and floor-to-ceiling glass panes. The interior is developed in the tectonic slippage between the roof and the ground, offering a position of refuge and lookout; the floor planes are lined with African 'Mervau' wood or Spanish granite from the quarries of Quintana, in the province of Extremadura. The rooms are diaphanous and translucent, mostly dressed in eggshell white, and through their subtle nuance of reflected light perhaps evocative of the Sonoran sky.

The house is L-shaped and divided in three levels. The basement is accessible only from the exterior, with minimal openings to the north providing level view of a green gravel covered ground plane; it contains a wine cellar, a small painting and sculpture collection, and the mechanical equipment. The ground floor is open through an extensive portico and accessible to a landscaped courtyard with a swimming pool on the south; it houses the living and dining rooms, and kitchen in the long side of the 'L', and the master bedroom in the short side. The raised, or second floor contains two bedrooms and a playroom that open to the south through clearstory windows. The open staircase and the chimney articulate the interior and lock the spatial slippage between ground and ceiling.

In the film *Solaris*, Andrei Tarkovsky presents an uncompromisingly unique poetic meditation on space travel and its physical and existential ramifications. Scientist Kris Kelvin travels to the mysterious planet Solaris to investigate the failure of an earlier mission. When his long-dead wife appears on the space station, he realizes that the planet has the power to perceive human desires and make them a reality. The interest of the Tucson house may be in its materials and methods of construction, or also in its attitude regarding gravity and light, but even more so in its transposition of longitude and latitude, the similar differences and different similarities between Tucson and Zaragoza, and the grasping of the elusive attributes of what we may call program, or human desires — what the Greek called *final cause*, or teleology.

How do architects turn human desires into physical reality? I have seen the house standing alone in a gated suburban community in the cold of the winter in Zaragoza, and I sensed its nostalgia—or perhaps Ángel Fernández Alba's own Proustean reminiscence—of the *élan vital* of the Sonoran Desert. This desire to communicate with inanimate things may be at the end a form of poetic analysis, similar in its futility to the myth of Sisyphus, which the philosopher Guiles Deleuze defines as the adventure "of climbing from out of the depth of the body to the surface of words." Perhaps futile, but for the writer Maurice Blanchot it is a sign of the fundamental impulse to "make the obscurity of language respond to the clarity of things."

Architecture and Engineering: asymptotic paths

There are things that intelligence alone is able to seek, but which, by itself, it will never find. These things instinct alone could find; but it will never seek them.

Henri Bergson[1]

My acquaintance with Peter McCleary dates back to 1969, when I came to the University of Pennsylvania to attend Louis I. Kahn's "Masters Studio." The last stirrings and social ferment of the 60's were still part of the campus drama in the warm humid days of a lingering Philadelphia summer. I remember clearly my first studio session: it was one o'clock in the afternoon, up the stairs I went to the penthouse of the Furness Library, Kahn's bastion and overlook — he refused to meet with his class in Meyerson Hall, the Architecture building, which unlike the Furness he considered to be a building without merit.

After twelve years of rehearsal, the ritual of the Master's Studio was well established. There was a group of three, Kahn, Robert le Ricolais, and Norman Rice, sitting at the ubiquitous oak table at the west end of the long room, opposite the east end's rotunda. Rice attended to administrative aspects of the class and occasionally engaged in distracting platitudes. Le Ricolais was taciturn, yet when he spoke he was precise, poetic, and even in silence his presence was positive and had a sense of scrutiny. Although the studio had three afternoons in the school's calendar, Kahn only came on Mondays and Fridays.

[1] Bergson, Henri, *Creative Evolution*. New York: Holt, 1911.

There were three kinds of events, and we (the twenty-four odd students) spontaneously learned the order and rhythm of things as time elapsed and our work progressed. One was what can be best described as Kahn's soliloquies on architecture, which with minor distractions and a short break at mid-afternoon normally lasted until the early evening. Of a different sort were the meetings that had the group still congregated around the table, and those students who wished, voluntarily brought their work forward to be examined in quorum, seeking comments — and perhaps the blessing — of the master. The third kind was that when all students put their work on vertical boards, along the perimeter of the room, a few feet away from the walls and windows, and a procession began with Kahn bearing the standard. A peculiar ceremony was enacted in front of each board, with the student in one side, the work in the middle open to the view of the group, and Kahn with his two colleagues on the other side, sitting on high stools, speaking of the work as if it was common property. Even when his observations were particular and focusing on detail, their precision hit the target of everybody's mind. In all three kinds of meetings, an omnipresent chalkboard was by Kahn's side, waiting for his mark.

I sensed that his validity as a teacher was even more persuasive when, after belaboring for days, you put your work up on the board in spite of the intellectual discomfort, which comes about from the act that the Russian writer of fairy tales Alexander Afanasyev calls "burning the frogskin." Kahn and the procession stopped at your board, an with what appeared to be effortless facility and unexpected revelation, he would uncover the cause of your discomfort with the precision of a surgeon and bring your mind back to the state that Aristotle called "wonder" — back to the fold of architecture.

It was customary that most of the students in Kahn's Master's Studio also enrolled in Robert le Ricolais "Laboratory of Experimental Structures" — it was in the grape-vine's explicit knowledge that it was the best thing to do. Perhaps less preoccupied with the quality of the building, Le Ricolais was satisfied to set up quarters in the top floor of Meyerson Hall. The room was approximately 30 by 40 feet and had plenty of natural light coming down from a roof monitor. On the north end was a long table with a select display of structural models, mostly made out of steel, which had been built and tested by students in-house during a period of fifteen years. On the south end was the stationary heavy equipment: a Bridgeport milling machine, a six-foot lathe, a bench top drill presses, a band saw, and a wet metal saw for cutting heavy stock. There was also acetylene and arc welding equipment, an air compressor, a complete array of portable power and hand tools, and a more than sufficient supply of raw stock — assorted gauges of rods, tubes, cables and plate metals. Everything was kept in good order under the vigilant eye and stern hand of "Blackie," a no non-sense master mechanic that promptly instilled in us the ethic of shop equipment maintenance, by hail or brimstone.

My affection for machines and equipment was aroused in my high-school days when during the summers I became the self-appointed mechanic who kept things running in a sugar cane plantation and rum distillery that my father owned in South America. But the experience at le Ricolais' laboratory was an induction into a higher order of workmanship, putting manual dexterity on an equal footing with logical precision. The laboratory was scheduled on Tuesday and Thursday mornings, but as we became engrossed in model fabrication, we began to log in hours well in excess, perhaps five-fold the time allotted in the calendar.

The funicular polygon of revolution

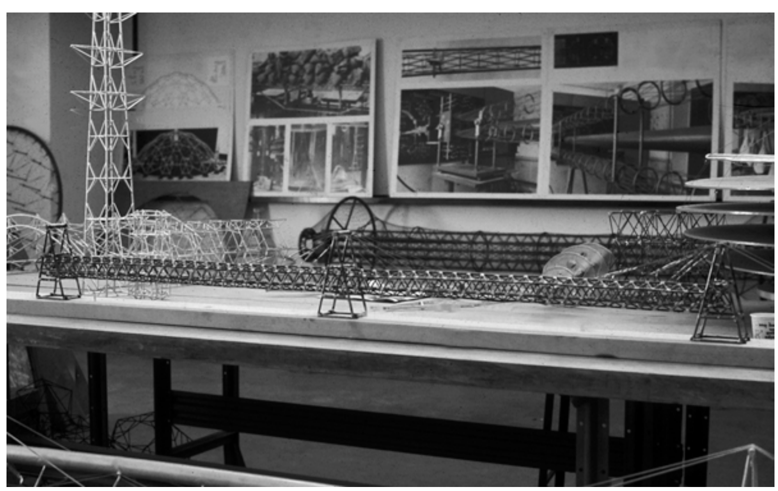
After working for three weeks in minor variations of a couple of models, which I chose from the existing repertoire of structural concepts, I felt confident with the fine points of operation and calibration of the machines, particularly the Bridgeport mill, which was new in my experience and induced the greatest appeal in my imagination as an instrument of three-dimensional metal milling. So I began work on a new variant of the lemniscate, or funicular polygon of revolution. Having no current access to the physical object or to my shop log, which I have searched for in vain, I will reconstruct the model from memory. The stock materials used in fabrication were: 3/4 inch diameter aluminum tubing for the central compression post, 3/16 inch thick aluminum plate for the circular diaphragms, 1/32 inch stainless steel aircraft cable for the funicular tensile strands, and 3/4 diameter stainless steel ball bearings for the ends.

With sporadic assistance from Blackie, I managed to finish the model in six weeks — it was by all accounts a well-run laboratory, balancing tacit and explicit knowledge.[2] The contour of the spatial volume was the revolution of a parabolic segment, intentionally adjusted by

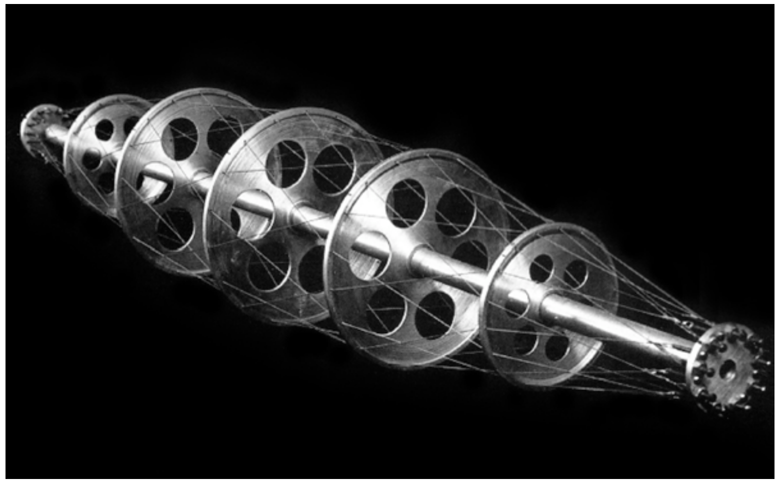
[2] Sennett, Richard, *The Craftsman*. New Haven: Yale U. Press, 2008.

the diameter and spacing of the five diaphragms. The diaphragms were milled to 1/16 inch thickness and perforated by six proportionately sized portholes — inadvertently heeding to le Ricolais' maxim, *The art of structure is where to put the holes* — to lighten their physical and visual weight, remaining thicker at the outer perimeter, as compression rings, and the inner circumference touching the center tube. The ball bearings, whose function was to eliminate torsion and to allow self-adjustment, were installed at both ends, over bushings that protected the tube walls from crushing. Two small diameter plates were installed over the ball bearings to allow the array of the tension strands, which were eighteen in total and rotated one full revolution from end-to-end, alternately clockwise and counterclockwise.

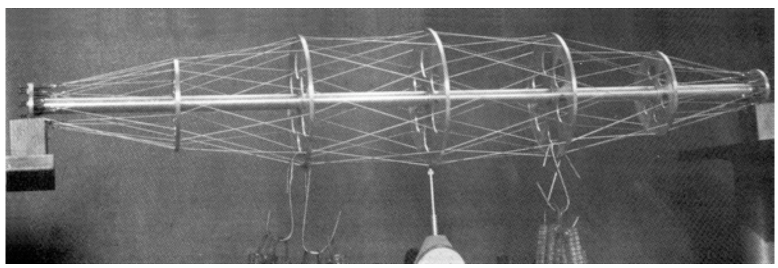
On judgment day, the mechanical performance of the model was more than satisfactory: its weight to span ratio was very economical, and the deflection under load was minimal, maximizing its dependence on the tensile network (funicular polygon) of revolution. Le Ricolais was quite pleased with the results — I remember his sober smile clearly. He made an intuitive assessment and jotted some numbers, which he probably knew by heart, on a piece of paper, and the test was finished. This model was still far from his dictum, *zero weight, infinite span*, nevertheless, it has stayed in my cerebral cortex as an example of what the Greek called "entelecheia" — or, entelechy: the actualization of form-giving cause and an inherent regulating and directing force in the development and functioning of a system.



1. Robert le Ricolais "Laboratory of Experimental Structures."
Philadelphia, 1969.



2. Lemniscate, funicular polygon of revolution (FPR), manufactured by Álvaro Malo. Philadelphia, 1969.



3. FPR, load test. Philadelphia, 1969.

The general run of inventions conforms to the following pattern: a series of progressive, almost continuous deformations of the raw material, and then — a step over a threshold — a sudden perception of the future of one of these states. "Future" here means a value that can be utilized; one that is significant and singular.[3]

The testing of the model also brings forth the recollection of my first formal encounter with Peter McCleary. He was present at the event and made some observations, which I probably disregarded, for I thought he was only an assistant to the master, better listen to the master himself. But, soon I found that he was also teaching some of the required courses in structures, from which I was exempt in Kahn's "Masters Studio" — I had already satisfied this requirement in my diploma studies in South America. Nevertheless, a

[3] Valéry, Paul, *Analects*. Princeton: Bollingen Series, Princeton U. Press, 1970.

conversation began that has lasted almost forty years, perhaps our own version of Maurice Blanchot's *The Infinite Conversation*. Peter introduced me to two books: D'Arcy Thompson's *On Growth and Form* and Kenneth Boulding's *The Image: knowledge in life and society*. I suspect that he remembers well being the source of the first, but perhaps not of the latter. Thompson's work has been a font of inspiration and a model of precision in the geometric and poetic analysis of natural morphologies and specimens, providing clear methods of reference through analogy — similarity of function — and homology — similarity of structure. I have continuously brought it to light in my own teaching and have worn out several copies that have come apart at the spine. Once, when visiting the Rhode Island School of Design, I found that its "Foundation Program" had the "Nature Resource Room" in the heart of the building, better than a library I thought, there was Thompson's opus in full regalia.

Boulding's work has come back to my attention, after a long hiatus, particularly chapter 2, "The Image in the Theory of Organization," where he identifies seven levels of complexity: the jig-saw puzzle, the clockwork, the thermostat, the cell, the plant, the animal, and the human being. In my current research in "emerging material technologies," I find it necessary to challenge the exaggerated claims of "biomimetism" and "intelligent buildings." For thousands of years buildings have been designed to function as jig-saw puzzles, even some of exquisite intricacy, such as the Alhambra. One may find clockwork attributes in the building methods of Brunelleschi, one of the foremost architects and engineers of the Italian Renaissance — considering that his construction machines are fundamental to his architecture. Later, the thermostat as a device has been part of the mechanical equipment of buildings, as the governor is a regulating part of the operation of an engine; but buildings as whole thermodynamic systems are still experimental and rare. All claims above this level, even if well intentioned, are theoretical self-indulgence.

The cycloid

After graduation in 1970, I went to work in Kahn's office. There were two active projects on the boards: the Kimbell Art Museum, in Forth Worth, Texas, and the Yale Center for British Art, in New Haven, Connecticut. Construction of the Kimbell had begun in 1969, but there were still construction documents and shop drawings being prepared. The Yale

Center was at the preliminary design stages, in its truly archaic beginnings. My affection for the Yale Center notwithstanding, it is the Kimbell and the lessons that issued from its conception, design, and construction that are more persuasive within the framework of this recollection.

The curator Richard F. Brown was entrusted in the mid 1960's with the task of developing the collection of the Kimbell Art Foundation and building a new public museum for what until then had been the private possession of the local entrepreneur Kay Kimbell, which was displayed in his home as a rotating exhibit. The story of Kahn's selection as the architect for the Kimbell is well recounted elsewhere in the museum's literature.[4] Of central concern to Brown was the desire to refine the quality of natural light as a condition of both visual perception and the potentially detrimental effects of direct sunlight on art objects. He stated this in an explicit note, "The creation of the ideal total visual situation, of course, involves the physics, physiology and psychology of it: i.e., all levels of perception."

This dealt the cards directly into Kahn's hand. I do not know whether his pronouncements concerning light, material, and structure — *Light is spent material* and *Structure is the giver of light* — predate, are contemporaneous, or came after the crafting of the Kimbell — I will leave the detective's work to historians. The transformation of the Kimbell's roof geometry from a folded plate, to a semi-circular vault, to a quasi-elliptical section, and finally to a half-cycloidal shell is also well documented on Kahn's own notebooks.[5] The technical work of refining, calculating, and making possible the construction of the structure as a post-tensioned thin-shell, working longitudinally as a beam, fell to the engineer August Komendant. Kahn and Komendant's collaboration, which lasted eighteen years, can be best described as a difficult love affair. During my time at the office, a young Swiss architect, who spoke German, was often sent out ahead of Kahn to speak with Komendant and smooth out the terms of their meetings.

Speculating on the pertinence of the Aristotelian "four causes" to the making of the structure of the Kimbell, I would say that the *formal* cause belongs mostly to Kahn, he shares the *material* cause with Komendant, the *efficient* cause, or technical implementation, belongs mostly to the latter, and the *final* cause is shared with Brown.

[4] Loud, Patricia C., *In Pursuit of Quality: The Kimbell Art Museum*. Fort Worth: Kimbell Art Museum, 1987.
[5] Ronner, Heinz and Jhaveri, Sharad, *Louis I Kahn: Complete Work 1935-1974*. Basel: Birkhäuser, 1987.

However, the remaining question is, Why the cycloid? And here, I must relate the cycloid's own history and definition. The cycloid is the locus of a point on the rim of a circle rolling along a straight line. The cycloid was first studied by Nicholas of Cusa and later by Mersenne. It was named by Galileo in 1599. In 1634 G.P. de Roberval showed that the area under a cycloid is three times the area of its generating circle. In 1658 Christopher Wren showed that the length of a cycloid is four times the diameter of its generating circle.

The cycloid has been called "The Helen of Geometers" as it caused frequent quarrels among 17th century mathematicians.[6] In 1696, Johann Bernoulli challenged other mathematicians to find the curve that solves the "brachistochrone problem" (Greek: "brachistos" shortest, "chronos" time), knowing the solution to be a cycloid. Leibniz, Newton, Jakob Bernoulli and L'Hospital all solved Bernoulli's challenge. The cycloid also solves the "tautochrone problem," as alluded to in the following passage from *Moby Dick*: "The try-pot is also a place for profound mathematical meditation. It was in the left-hand try-pot of the *Pequod*, with the soapstone diligently circling round me, that I was first indirectly struck by the remarkable fact, that in geometry all bodies gliding along a cycloid, my soapstone, for example, will descend from any point in precisely the same time" (Melville 1851).

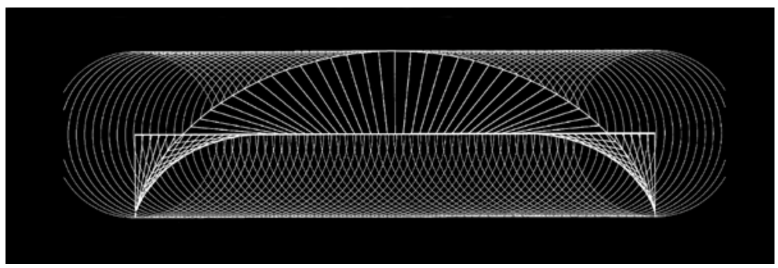
The brachistochrone problem asks for the shape of the curve down which a bead, starting from rest and accelerated by gravity, will slide (without friction) from one point to another in the least time. Fermat's principle states that light takes the path that requires the shortest time. Therefore, there is an analogy between the path taken by a particle under gravity and the path taken by a light ray, and the problem can be modeled by a set of media bounded by parallel planes, each with a different index of refraction (leading to a different speed of light). Consequently, the path taken by a light ray in these media where light propagates at variable speeds is the answer to the problem — the path taken by light approaches the cycloid, *quod erat demonstrandum*.

This comes back full cycle —better yet, full cycloid — to Brown's instructions regarding light, and Kahn's geometrical choice, which I think was not guided by analysis but rather by intuition — perhaps using intuition, in the Bergsonian sense, as a "method of precision."

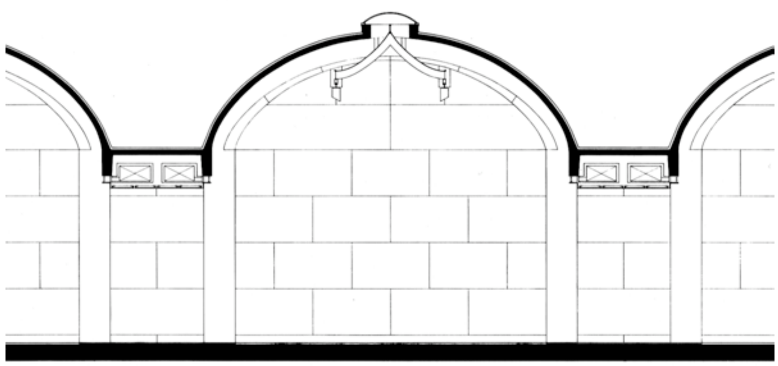
[6] Boyer, C. B. and Merzbach, U. C. *A History of Mathematics, 2nd ed.* New York: Wiley, 1991

This is yet another example of "entelecheia," a regulator of orderly activity causing things to do that which is natural to them when seeking their specific natural ends or completion — *a materialized idea* and *an idealized material*. In Kahn's words,

Order is
Design is form making in order
Form emerges out of a system of construction
Growth is a construction
In order is creative force[7]



6. Cycloid, student drawing at Á. Malo's seminar at Columbia University. New York City, 1987.



4. Kimbell Art Museum, section through cycloid shells. Philadelphia, 1968.

[7] Scully, Vincent J., *Louis I. Kahn*. New York: G. Braziller, 1962.

5. Carpenters preparing formwork for cycloid shells. Forth Worth, 1969.

…matter is slow space and space is fast matter…matter and spirit are the same, they follow the same direction…Could spirit be such infinitely fast matter that to our eyes it disappears as matter?[8]

This desire to communicate with inanimate things may be at the end a form of poetic analysis, similar in its futility to the myth of Sisyphus, which the philosopher Guiles Deleuze defines as the adventure "of climbing from out of the depth of the body to the surface of words." Perhaps futile, but for the writer Maurice Blanchot it is a sign of the fundamental impulse to "make the obscurity of language respond to the clarity of things."

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[8] Ugarte, Luxio, *Chillida: dudas y preguntas*. Donostia: Erein, 2000.

CENTER 15

DIVINITY CREATIVITY COMPLEXITY

A DESERT LAND ETHIC: AESTHETIC RESEARCH

Álvaro Malo

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INTRODUCTION

Michael Benedikt

With rare exception, architecture schools belong to universities within which religious education is offered only in Religious Studies programs. There, the gods are always *their* gods, while religious rituals are seen as "serving social purposes."[1]

Inside architecture schools, where studios will sometimes take on the design of a church, a mosque, a synagogue, or a Buddhist retreat, it is the putative client's faith that is the subject of the program, not the student's (or the teacher's), which are off-limits to discuss except over pizza some blocks away. Temples and cathedrals comprise a substantial part of architectural history courses, but as the slides roll by, they become seen as demonstrations of the lengths to which master builders once went to please princes, popes, and power generally, rather than as "engines of divinity" or "receptions of the spirit." As in Religious Studies, keeping distance is essential, even if it undermines understanding.

For its part, today's architectural design discourse provides few ideas that would guide designers anywhere near the gates of Mystery in contemporary terms, this even though the field, especially of late, has become rife with mystifications of how form is generated, with "systems" and "processes" whose explanations are as dependent upon authority and intuition, on getting the language right (and the software to cooperate), as religious explanations ever were. In result, to reflect seriously, gropingly, upon God or the cosmos today in the halls of an architecture school, or to say out loud that one is searching for something deeply true, or ethical, or aesthetic in the free act (or result) of design, would be to betray a serious absence of "cool."

Now, secular universities should not offer training in any faith, granted. Nor should they offer in(tro)ductions to the mystical experience.[2] But one wonders whether the idea of God—or at any rate, of "the divine"—in all its historical richness and contemporary problematics could ever again inspire creative work in architecture, as it did for centuries in painting, music, and, yes, science as well. After all, our understanding of what "God" means has not been, and need not be, frozen in ancient doctrine. The idea of divinity varies from religion to religion, and it has already changed over historical time even within the Western tradition.[3]

For example, post-Enlightenment figures like Jefferson, Franklin, Newton, Kant, Emerson, Thoreau, James (William), and Einstein, to name a prominent few, proposed that God can be a/the stupendously intelligent and powerful creator of the universe that tradition tells us God is, but without day-to-day involvement in human history. This is *deism*. Here, God is not a person in any sense; nor is God addressible or caring, as "He" is in *theism*. For deists, it suffices that the universe be of God's design and marvelous beyond compare.[4] Deists can even accept evolution: it's the way God works. Evolution or no, it follows that the natural world is God's Book as much as the Bible is, and that we are free to read both "texts" using our full rational and interpretive powers. But (says deism), because we are a part of nature too and not our own creators, we may act upon nature only in reverence and with an understanding of God's purpose, which is to "hear" and "see" His name glorified in and by works of beauty, goodness, and harmony with all creation...whatever—or whoever—God *really* is.

Nowhere was deism more literally adopted than in Freemasonry, that secretive religious movement that, by its own account, originated in the stone-cutting guilds of medieval Europe and ancient Egypt. (It was officially founded in the early 1700s.) In Freemasonry, one image dominates: God as the *Architect* of the Universe, God as geometer-supreme. Polymath and architect Sir Christopher Wren was a Freemason, as were the architects Benjamin Latrobe, Pierre Charles L'Enfante, and possibly Le Corbusier.[5] So too was the poet and artist William Blake and a number of American presidents.

Among the great modern architects, Louis Sullivan, Frank Lloyd Wright, and Louis Kahn were arguably deists (but not, we think, Freemasons). And so too, perhaps, was Mies van der Rohe when he famously pronounced that "God is in the details."[6] Scientists and philosophers today who call themselves "spiritual but not religious" are frequently deists too, as are many artists, nature-lovers, and ordinary people who are tired of conventional religious dogma. And as we shall see, deism (together with pantheism, the idea that God and Nature are one) lends passion to many a contemporary environmentalist.

But deism is not the only alternative to atheism (i.e., the belief that there is no God in any sense) or to (mono)theism, i.e., the belief that there is one creator God—omnipotent, omniscient, and omnibenevolent—who is involved in human history and answers prayer. Nor is deism necessarily the best alternative for our time, even though it appeals nicely to the scientific temperament. One could equally well pay attention to what John Calvin called *sensus divinitatis*—our innate sense of the divine—and then explore that intuition's involvement not with Calvinism per se, nor with awe at God's once-and-for-all design (which yields up deism once more), but with a deeper than usual appreciation of the *process of human ethical creativity*—a process that is itself, as some of the papers in this book will argue, "divine enough," even when seen in a naturalistic, evolutionary context.

This interpretation of *sensus divinitatis*, anyway, yields up a different conception of God to the Biblical/Qur'anic one as well as to the deist one. And it brings us to a new understanding of the nature and meaning of human creative acts.

This fifteenth volume of *CENTER: A Journal for Architecture in America* was long—too long—in the making. Its origin lay in the conference held at The University of Texas at Austin in November of 2003, called "Divinity, Creativity, Complexity," which attempted to fuse these ideas to the phenomenon of architecture.

Four papers were presented then, and they appear here in edited form: "Strange, Hidden, Holy: Religious Experience in Recent Secular Architecture," by William Saunders, editor of *Harvard Design Magazine*, "Science and the Quest for Cosmic Purpose," by John Haught, Senior Fellow in Science and Religion at the Woodstock Theological Center of Georgetown University, "God, the Architect of the Universe—Universe, the Architect of God" by Charles Jencks, independent author, historian, designer, and theorist extraordinaire, and "The Argument from Design(ers)" by yours truly of the University of Texas at Austin. Thereafter, several papers were invited specifically for this volume. Harvard theologian Gordon Kaufman's "In the Beginning...Creativity," is a by-permission reprint of a chapter in a book of the same name. Florida State University philosopher of biology Michael Ruse's "Form and Function: On Biology and Buildings," Tom Fisher, Dean of the College of Design at the University of Minnesota's "Perennial Way of Design," and Chicago architect Stanley Tigerman's "Creativity, Melancholy, and the Divine" are original papers and were invited. The remainder of the articles in this volume were the result of an open Call For Papers published in the ACSA Newsletter and in other venues. Submissions from some thirty respondents were reviewed and six selected for publication by our Editorial Board.

I want to thank all of these authors, invited and selected, for the immense patience they have shown as this volume of *CENTER* was oh-so-slowly pulled together, edited, and financed. If it's any consolation, dear authors, remember that our subject is timeless and that your contribution is unique: there's no book quite like this in the annals of architectural publishing.

I shall try now to provide a coherent overview of our fourteen authors' disparate "takes" on the divine aspects of architecture (or is it the architectural aspects of the divine?). As intended, evolution is a recurrent theme: how it works, how it generates complexity, how creativity is evolutionary and evolution creative; and how human creativity, if not exactly proof that we are made "in the image of God," is nonetheless radically dependent on grace of a sort, on a Way found, on serendipity seized and put to ethical, life-promoting advantage.

The latter idea is largely the subject of the article by Gordon Kaufman, for whom God and creativity are all but identical. "The metaphor of creativity," he writes, "is appropriate for naming God because (1) it preserves and indeed emphasizes the ultimacy of the *mystery* that God is, even while (2) it connects God directly with the coming into being—in time—of the new and the novel." In Kaufman's view, human creativity is but a subspecies—a late manifestation—of eternal cosmic creativity, and *that* creativity, built upon and out of chaos, is Godly, or, cutting to the chase, God. Kaufman is not writing about architecture. He is a theologian. But his views lend permission, it seems to me, to welcoming aleatory and serendipitous design processes into architecture, both formally and socially. They suggest a limit to rationality. They put a circle around CAD (computer-aided-drafting) and BIM (Building Information Management) systems, around all performance checklists, and around all bloodless, volume-clumping, color coding "programming stages," which masquerade as design. No: *air* must be let in: *neshama*, spirit, serendipity, excess, love. And all these represent an embrace of complexity.

If Kaufman is indebted to the "process" view of divinity that goes back to Alfred North Whitehead and Charles Hartshorne, William Saunders seems more under the influence of Paul Tillich, for whom God was the Invisible Ground of Being and thus to be found everywhere "embodied" in/as a vast and charged stillness, or potential, which, like the Tao, underlies reality. Like balancing rocks seen against star-filling skies, "there are buildings and places," Saunders writes, "that put us in mind of the divine, and many (if not most) of them are not religious buildings." These are buildings and places that help you feel how large the world is—how infinite, unknowable, and little interested in you personally—and that, at the same time, deliver you to joy, to gratitude, that you can hear, see, and have this very thought. Such buildings and places make you feel fortunate to be at least *capable* of the same rationality and ingenuity that made them possible and yet feel humbled at the greater "work" that is the cosmos—"strange, hidden, and holy." Using a wide range of examples, Saunders lauds the elusive combination he sees in the best of contemporary architecture: human labor taken to perfection on the one hand, devotion to the unseen—both intimate and grand—on the other. Common to the best in architecture, he argues, is the suppression of the individual ego (architect's or observer's), a disinterest in comfort, and a willingness to take on the difficult whole and fail. Refreshing, too, is Saunders' critical take on the feeling of "spirituality" that is all but automatically produced by Minimalist architecture that plays coy with light. Ando pretentious? It's a thought.

Prominent as an explicator of science to religious thinkers and of religion to scientists, theologian John Haught offers a view of how evolution itself can be seen as "strange, hidden, holy," to use Saunders' words. The God known to the Western tradition is nothing if not purposeful; while biological evolution is nothing if not purpose*less*. Both would explain Everything. How can they be reconciled? First, Haught indicates, we can and should be skeptical of scientific reductionism: the world is not "nothing but" atoms or quanta and thus "flat;"

rather, it is intrinsically and "informationally" hierarchical. Evolution generates complexity, and complexity creates levels upon levels of phenomena with sharp ontological discontinuities. Second, we have to marvel at how the universe seems custom-made to have humans eventually poking about in it. Given how many constants in physics *had* to be exactly what we find them to be, more than luck is involved. It would seem that "(M)ind has been woven into the fabric of the universe from its earliest beginnings." Third, following Pierre Teilhard de Chardin, Haught sees not only *directionality* in cosmic evolution (to which any cosmologist might agree, given that the universe seems to be expanding and, on the whole, increasing in entropy), but *purpose*, which is directionality toward something of undeniable value. And what is that something of undeniable value? It is *consciousness*, human to be sure, but perhaps also, some day, supra-human consciousness. Fourthly, and finally, Haught deploys a version of the "Argument From Design" for the existence of God. Citing process philosopher Alfred North Whitehead (who appears more than once in this book), Haught casts evolution itself as a possibly divine process whose aim is "*more intense configurations of beauty*." (Here the architect-reader will surely rush to read Whitehead.) "The long view," Haught concludes, "...would consider all the puzzling features of the cosmos revealed by modern science to be consistent with the notion that the cosmos is grounded in and sustained by an *ultimate reality* [his emphasis] whose creative will is that of maximizing cosmic beauty."

This reader finds this last view somewhat terrifying, in as much as exploding stars, not to mention fireballs filmed from helicopters, are beautiful too. From this possibility, Haught covers himself, as it were, by offering as "possibly correct" a Christian article of faith: that the ultimate reality is *infinite love*. Some readers might sigh, "if only." But no matter. Haught here (and more so in his major writings, of course) comes close to making the science-religion divide leapable.

In "God, the Architect of the Universe—Universe, the Architect of God," Charles Jencks makes that leap on every page, back and forth, buoyed not only by the updraught of poetic insight (or is it license?), but also by contemporary cosmogony and complexity science. Appreciation of the architects' religious impulse, he says, begins in appreciation of architecture's claims to show/manifest "purposeful design" and "beautiful organization." Shades of Freemasonry: Who else but God/Architect can say "Let there be light"? Who else but God/Architect would judge that what He/he had made was *good* at the end of every day of a six-day "construction" sequence, and then walk away forever...except for rare-but-important visits? Look at nature's beauty and (fine) architecture's. Are they not of the same H/hand? Jencks does not *subscribe* to these views as much as delight in them. His own are more modern, and derived from the science of complexity and the process of evolution, which process Jencks—like Haught, Whitehead, and Darwin himself—finds mysterious and impressive enough. Complexity generates value, not from without, but from within as it were: a sort of welling up, a boiling, a burgeoning, into higher and higher levels of organization: matter into life, energy into intelligence. And "this is precisely what architects do. They take nature's basic language and idealize it, dramatize, or at least, edit it. They turn nature into the idea of Nature with a capital N, a kind of Godly act." Which is to say: Humans are involved in the evolutionary drama, moving it forward by their very agency (which could not have been said, say, fifty thousand years ago). Complexity is maximized when it is neither under- nor over-organized, the first (under-) yielding chaos, the second (over-) yielding rigidity. In making a building or work of art, this complexity "comes into being as the result of imaginative power" steering the middle course...this "imaginative power" being nothing other than *cosmogenesis* re-manifest in the human mind. Illustrations abound in Jencks's article as he explicates these ideas, but he concludes with annotations of his own design work—a remarkable landscape in Scotland in honor of his late wife, Maggie Keswick, called *The Garden of Cosmic Speculation*—and the suggestion that God "himself," "herself," or "itself" may be the superorganismic *product* rather than generator of nature, evolution, and ourselves: Universe, the Architect of God indeed.

Philosopher Michael Ruse takes a more measured approach. Expert in the rise of Darwinism and the debates that swirl around its finer points, Ruse looks more carefully at the process of natural selection than does Jencks or Haught (or anyone else in this volume for that matter). To this day, Ruse reports, it is not settled which is more important: the logic of *form,* or the logic of *function*. Both have a channeling effect on the course of a species' evolution: there are constraints and opportunities that derive from the patterns of self-assembly to which the species has already committed; there are constraints and opportunities that derive from the changes in the environment that affect every organism's chances for reproduction in/of its current form. If the argument between biologists consists in disagreeing as to which is the more powerful effect (Ruse confesses himself a functionalist), architectural readers will find the controversy familiar, even as the Modernist credo "form follows function" (usually ascribed to Louis Sullivan) holds sway and is challenged by the postmodern, computer-driven reversal, "function follows form." As Ruse observes however, the true divide between biological evolution and architectural (or cultural) evolution is *intentionality*. One cannot and should not ascribe intentionality to the bulk of living organisms he notes, much less long-term intentionality of the sort that could guide evolution to fixed ends across several generations. But this is precisely what human designers (and breeders) succeed in doing. Nor do buildings reproduce themselves by themselves. One realizes that to apply evolutionary narratives to architecture's technological or stylistic history (or to music's, or art's, or even science's) requires much squinting of the eyes. But not all rigor is lost: together with landscapes and urban conditions, buildings differentially support human life by their form and material, and so participate in human biological evolution quite literally: which families and traits will multiply and which will not (or not so fast).

Ruse opens a world of subtle considerations to the average reader, considerations that go not only into recent biological research but to the roots of philosophy, where, needless to say, there are further tendrils to follow and further assumptions to question. Every nodal word in the modern lexicon of evolution—"adaptation," "constraint," "function," "fitness"— is fraught with ambiguity or energized by buried teleology (as with "compensating," and "favoring," which are rarely prefaced with "as though…"). Indeed, one begins to wonder whether evolution could be described *at all* were its language stripped of living metaphors—were it left with only force, mass, time, and distance.

Then again, what *can* be spoken about without metaphors? Not much. Our most meaningful words are but metaphors compressed by time and usage into apparent solidity, into apparent objectivity. Life-soaked judgments of strength, weakness, resistance, progress, success, justice, and beauty suffuse almost all thought, even thoughts about numbers, inanimate objects, and "processes."

Ah, but in matters religious as well as scientific we seek the truth that lies beyond petty desire—beyond, even, relevance to life. We are looking for Truth eternal, which might not be expressible in words. How shall we experience it? And what should we learn from trying to? Getting the whole enterprise off to a bad start, Tom Fisher suggests, is positing that humans, nature, and God occupy separate and incommensurable realms. As he points out, it is abundantly clear now that humans and nature (to take two of the three) form one tightly bound system. And when it comes to design, or to explaining *why* things are the way they are, it is clear that whether or not to "bring God in" depends as much on what we mean by "design" as what we mean by "God." For, "as every working designer knows," Fisher observes, "'transcendent form giving' is not how design actually occurs. Most designers spend their time in unpredictable, trial-and-error processes, engaged in a project at all levels of detail." Sounds like evolution. Implication: if this is not how God works, then God is not a designer; if it *is* how God works, then God is a designer who works through—or perhaps simply is—evolution, especially if it's the case (as I suggest in my own contribution to this volume) that "design" *is* evolution and "evolution" design, distinguished from each other only by speed (fast vs. slow) and point of view (outside vs. inside). Fisher finds what he is looking for in Aldous Huxley's 1944 book *The Perennial Philosophy*. "(D)esign and evolution are not contradictory, but part of the same 'Divine Ground,'" writes Fisher, citing Huxley, and then turns our attention to the implications of all this for contemporary architectural design. "The doctrine that God is in the world, has an important practical corollary—the sacredness of Nature, and the sinfulness and folly of man's overweening efforts to be her master rather than her intelligently docile collaborator." That was Huxley. Follows Fisher: "A perennial architecture would be one that demands less space, requires fewer resources, and exhibits less hubris." It would be practiced by architects who "perceive everyone and everything as sacred…cherish all, …waste nothing, …and live simply." From the unity of God, humans, and nature, Fisher draws radical conclusions. Sustainability (or environmentalism), which for most architects passes as a simple responsibility, for Fisher reaches the level of moral imperative, a spiritual necessity, a total orientation, a path to planetary salvation. One could not ask for a more direct route from religious thinking to professional practice.

Fisher would not be the first person to see the road to God passing through Nature, or indeed, to see divinity in/as *natura naturans*, nature naturing. At the dawn of the modern era, Spinoza's heresy was to speak of "*Deu*s sive Natura," God-or-Nature, as a single entity. Now it is a fairly common view, akin to deism, or a sort of pantheism.

In his piece "Feminist Architecture, Meet Feminist Ethics," architect Tom Spector marks out another approach, another whole theology, although he does not say so. This approach comes out of Emmanuel Levinas, Martin Buber, and G.W.V. Hegel. In it, the connection between divinity and humanity is forged in the phenomenon of *ethical development* (largely between humans, but also other forms of life); and it privileges real-time encounters between sentient beings over hierarchical rule-making or rule-play. Care, love, genuineness, community, benevolence, and justice, are expressions of God in—and perhaps of God *as*—modes of human, moral, living-in-relationship. Politics matter, and actual life matters, "religiously." Spector's essay starts by exploring the gender differences delineated by Ancient Greek city life: life in the *agora* (public square, men) and in the *oikos* (home or hearth, women). Sustained by architecture, he remarks, "the walls of domesticity (that) mark an abrupt boundary between public and private, the moral and beyond-moral, (may be) nothing more than a convenient fiction for those who want to exclude women and the lessons of domestic life from their theorizing." Spector's main sources are not the three philosophers I mentioned, but contemporary feminist moral philosophers like Carol Gilligan, Margaret Urban Walker, Beatriz Colomina, Joan Tronto, and Brenda Vale. Were feminist ethics allowed into the *agora*, workplaces would be more nurturing in design and operation. They would evenly offer personalized interiors, zones of intimacy, access to outdoors, child care facilities, paternal and maternal leave, conflict resolution that was negotiated and interpersonal rather than authoritarian or contract-waving. Gone would be glass houses and office buildings (both male ideas). Welcome would be repair over new construction. And so on. If this threatens to devolve into a parlor game, Spector stays well away, and goes deeper: The general perception, he observes, that "the best designers are concerned with such presumably masculine things as formal perfection and aesthetic ingenuity, and that there is (for them) something second best, or merely compensatory about connecting people in caring ways with their environment" (i.e. femininely), "finds its…opponent in traditional moral philosophy, in which artistic matters are considered to be of lesser consequence than moral concerns." Feminists, he suggests, ride upon this traditional prejudice, but do so at some risk. "Catering to needs" should be neither a weakness nor a strength when it comes to the "serious pursuit of form." Architecture is equally a collaborative ("feminine") and heroic ("masculine") discipline. Spector takes the next logical step: perhaps "gender itself is constructed, and heretofore fashioned primarily to serve the interests of…men." "If this is true," he goes on, "then the unquestioned embrace of a care-ethic may be a refusal to explore creatively the more interesting boundaries of what it means 'to be a woman'." Or a homosexual. Is there really "queer space" for example? Looking at the Lesbian-Gay-Bisexual-Transgender Community Center in San Francisco, Spector says no, not in form or aesthetic, and he doubts that either "gender construction" theory or "the woman's voice" will make a difference to that aspect of architecture. Where would it, then? Drawing on his own locale, Spector suggests we look to process/practice, specifically to the caring practice of such pioneers as Martha Berry (1866–1942), architectural patron in Georgia responsible for Berry College's campus being among the most beautiful in the country, and Anna Colquitt Hunter (1892–1985), Savannah preservationist extraordinaire. The Historic Savannah Foundation that Hunter founded, and which is mostly run by women, has now directly saved over 350 historic buildings and sparked the rehabilitation of 1000 more. "(W)illing to take substantial personal risk to protect the objects of their affection," these women acted out the ethics of care in a way that one could call "religious" (see Note 2). No traditional theology is committed to here except perhaps the conviction that God is good, or that *our* doing good—caring for others, preserving them, honoring them, without thought for reward—is God's will obeyed. Some non-traditional theologies however, *are* implied if not committed to; again, coming out of Hegel, Buber, and Levinas: the idea that divinity is seen through, embodied in, and perhaps even generated by, personal virtue in the encounter with other living beings.[7]

William Richards looks at the late 20th-century architect who most clearly personified the ethical attitude to architecture, Louis I. Kahn. Of course, Kahn is well known for such metaphysical pronouncements as "I asked brick what it wanted to be, and it said, 'an arch,'" and "All material in nature, the mountains and the streams and the air and we, are made of Light which has been spent, and this crumpled mass called material casts a shadow, and the shadow belongs to Light." He spoke of the Treasury of Light, of the Immeasurable from which Form comes and returns, of the Desire to Express and to Be, and so on. Less emphasized, however, is Kahn's commitment to human community and to human institutions, and his firm belief that buildings—architecture—should *dignify* individuals from the scale of the city to the scale of rooms. ("A plan is a society of rooms" he would say, with all that implies for the inherent "rights" of every room to have its own front and back, source of daylight, and structure.) These are ethical concerns, and they explain his buildings as much as, if not more than, his metaphysics do. If Kahn's metaphysics were not any recognizable religion but rather a Romantic NeoPlatonism, Kahn's *practice* might be called religious humanism. Indeed, as Richards writes, "Kahn's shift from *Modern* architect to *modern* architect…is about his changed conception of community." Rather than the Modernist notion of "the collective containing the individual," Kahn posits instead "that the collective is an extension of the individual." The hinge point of his oeuvre in this regard lies between his unbuilt Adath Jeshurun Synagogue and his First Unitarian Church, the first being interested in technological prowess and universalizing symbolic form, the second in the actual working of an actual community. Kahn's work before and after these projects was not the same. "For Kahn," Richards concludes, "a combination of Renaissance principles and Bueax-Arts organization filled the chasm between the relentlessly systematizing heroics of Modernism and the archaic timelessness of 'community'—community not as a simple coming together physically (which makes only crowds), but as an existential concept applicable to individuals and working as a concrete genesis of programmatic, functional form…"

Though much has been written about Louis Kahn, a definitive account of his "religion" has yet to be written. The same could be said of the faith-life of most architects about whom essays are worthy of being written. Strongly influenced by Kahn, and almost as well known for his philosophical if briefer, more Zen-like pronouncements, is the Japanese architect Tadao Ando. (Ando—an ex-boxer—underwent Zen-influenced martial arts training.) Our author, Jin Baek, focuses his attention on one of Ando's best-known and, as it happens, explicitly religious buildings: his Christian "Church of Light" in Osaka, of 1989.[8] Baek traces Christianity's interest in "emptiness"—otherwise a distinctly Buddhist or Taoist ideal—to Protestantism's rejection of the Catholic Church's fondness for religious representations, that rejection based in turn not only on the Church's corruption at the time, but on the Biblical proscription of idolatry and on the monastic ideal of simplicity. The theme of emptiness, Baek tells us, was further reinforced by theologian Paul Tillich's belief that after the horrors of the 20th century, the only authentic representation of (Christian) faith was "sacred emptiness," which (in Tillich's words) is possible in architecture "only if the architecture shapes the empty space in such a way that the numinous character of the building is manifest." *Numen*, from the Latin, means "divine power," and that, for architects, is suggested by structural magic, plain surfaces, and pure *light*—light unexpected, mysterious, and content-free. Room must be left for the Word, which is borne by sound and voice, not vision. The cross is simply a cross, unoccupied (Christ risen?) not a crucifix (Christ crucified); and the cross that appears and at the same time disappears at the Church of Light (is it structural, just window, or a geometrical/formal consequence of squareness?) raises its abstraction to new heights. Baek looks back to the history of Christianity in Japan to explain how it is that the cross became seen as "the symbol of cruelty or of inhumanity" not of transcendence or pathos. "The Buddhist idea of death is rest and peace, not agony" he reports, while the Buddha's sitting or horizontal posture is "a great contrast to Christ on the cross." (Baek is here quoting scholars Daisetz Suzuki and Shinichi Hisamatsu.) One can see why Ando would try to draw the central sign of Christianity away from Western and towards Eastern sensibility. Otherwise bathed in darkness, Ando's signature, polished concrete gleams like lacquer-ware from the light of the cross, like gold on the skin of the Buddha…

Readers of Baek's analysis will find themselves either exhausted or elated, either confounded or enlightened, by its poststructuralist thoroughness. Sheryl Tucker de Vázquez provides a counterpoint: a no less thorough, but surprisingly straightforward, discussion of a single moment in the work of Mexican (and Catholic) architect Luís Barrágan, a contemporary and friend of Louis Kahn's, also prone to making materially simple, empty, and powerful spaces (if with much more color). While de Vázquez intrigues us with her description of the debates in art-history that would conflate (and then deconflate) the movements known as "magical realism" on the one hand, and "surrealism" on the other, her focus soon descends upon a single moment in Barrágan's oeuvre: a small interior pool of water at the back of La Casa Gilardi in Mexico City that, by virtue of its color and lighting, both hints at and transcends baptism, both hints at and transcends the lucky occurrence of water in a rocky cleft of wilderness, that is wade-able but isn't—that is useless really, but pregnant with significance. One looks at the composition with the expectation…of what? One is not sure: perhaps the appearance in some accidental reflection of Our Lady of Guadalupe. De Vázquez's excerpts of Gabriel Garcia de Marquez's *Strange Pilgrims* help us accept Barrágan's religio-magical ambition. De Marquez and Barrágan were friends. But one is reminded too of the work of minimalist Donald Judd, hinting at—or is it hunting for?—fullness in emptiness, the divine in the ordinary, the rich in the simple, heightened perception and speeded thought, including the thought that God cannot be seen except in passing, or, having always already passed by, in a momentary breeze.

Not for Richard Becherer such light and magical moments. Not for him the "miracle" of sun-slice upon water, but long and complicated human memory, the ghosts of the past haunting the banal post-industrial landscapes of old downtowns. Becherer's lengthy meditation-cum-history of an abandoned section of downtown Sioux City, Iowa, is a rare find in the literature of architecture's "spiritual dimension." Becherer and his students researched it in libraries and map rooms, to be sure, but more importantly, they recovered its complex and layered human history of service and struggle as the meat-packing district of a once thriving town, and turned it into an exhibit emplaced in the same space. Why call this exercise—surely a humanistic one—"spiritual"? One need not, except that Becherer's voice raises images of transience and loss, inevitability and freedom that go beyond the recitation of circumstances. He tells, for example, of how "the *uncanny* shows its face in the insurance map" of Sioux City; how the random variation of the built-out grid "owes its visibility to unseen and unforeseeable forces," which is to say, to the 'acts of God' that work differently upon wooden and brick structures. His narrative wanders like the Missouri River ("Old Misery") through Sioux City's history, revealing complexity upon complexity: nature and humankind struggling over livelihood as though one wanted to take it away from the other; of fortunes won and lost. He tells of the people, mainly African-American, who lived and worked and died in the South Bottoms and Stockyards, as the rest of the city spread itself over river and hills energized primarily by real-estate boosterism. It could be the story of many a mid-American city. Becherer conjures the soul of Sioux City out of its brothels and feedlots. In his hands, the city gains a sort of consciousness of its own, a will, a fate. If Italo Calvino enchanted us with tales of imaginary cities, Becherer does so with a real one.

INTERLUDE

Becherer's essay and Baek's lead me to wonder about *words*, about how they seem both necessary and superfluous to conjuring up the gods of Architecture (to speak loosely). The stones of Architecture's are silent, yes. To stand in their presence with only the sun and the wind and a few small birds flitting through the columns…is to experience eternity; or if not eternity, time becalmed; or if eternity again, not the eternity that the "never-ending waves" or "wheeling stars" remind us of, but the kind that has human beings *in* it, able, somehow, to participate in Olympian foreverness because they had achieved perfection in design and construction and had thus earned a place in the Universe.

But here again, see, I have applied words. It seems that one steps willingly into Silence only when prepared to do so…by words. Do Zen masters not put us in the palms of their hands with images of unblemished mirrors, departing geese, single hands clapping, and then laugh at how, with the intention of ridding ourselves of thought, these images make us think? I inhale the vaults of the Kimbell Art Museum and wonder if it is the building or my vocabulary that seduces me into lauding this building's supreme indifference *and* supreme compassion, a combination that is surely a version of divine love.

Of course, divinity—or God—as described in the Bible will have none of this. There God is nothing if not "proactive," confronting the ready-to-meet-Him and the unready-to-meet-Him with the same disregard for their plans. Abraham's God is not the Tao experienced in meditative bliss. He is not in the tinkling of bells or in the space between words (or columns). Abraham's God speaks in the imperative. He churns with us and wars with us, bargains with us and makes covenants with us, even sacrifices what is dearest to Him and shares our tears. Throughout the Bible, our Father (who art you-know-where) *wants* things from us.

What are people of rational mind today to make of all this personification? For that is what the Bible's theology uses: personification, not as a mere literary trope, but to speak of something unspeakable. The Bible is a collection of human dramas based on historical events and written in the language of relationship: of fathers and mothers, brothers and sisters, sons and daughters, husbands and wives, kings and subjects, masters and servants. It is a morality play, a book of allegories held to be true, in which much of the wisdom *found* reflects the wisdom *brought* to it: the word of God, yes, but heard and spoken by humans retelling, rewriting, and reinterpreting its stories for three thousand years or more, tracking an evolving intuition of what is truly Good. Why can the "Word of God' not be a *process* too?

Where a modern religious sensibility sees "God" as giving voice to our conscience and an address for our gratitude, a committed atheist must find, within the narrative sweep and undoubted truth of evolution, alone sufficient reason to pick up where our mostly-believing ancestors left off, and do good. For surely *good* is in our hands to do, which makes it a matter of will and imagination, not just true knowledge of nature. Indeed, as Steven Pinker, Robert Wright, Daniel Dennett, and many other evolutionists have pointed out since, and including, Darwin: what is good and right in our eyes often runs *counter* to what we know is true of nature, counter to what evolutionary dynamics (not to say instinct) would advise us to do in order to survive and reproduce. Care for the ill, the aged, or the handicapped? Please. Love your enemies? Pshhh. Refrain from killing? Get real. These things will only slow you and/or your tribe down in the struggle to out-survive and out-reproduce your neighbors.

INTERLUDE OVER

While reading Álvaro Malo's often-technical descriptions of the Sonoran desert landscape, I found myself wondering again about the need for poetry to prepare us to see that place in the right way. "(A)s I dig in the foothills of the Catalinas," Malo begins, "…I forget the canons of beauty…and go along instead with the Portuguese poet Fernando Pessoa's suggestion that one may formulate an aesthetic based not on the notion of beauty, but on that of force—force not understood as violence, but as the transitive event between my body and the material I move…the line of inflection…actualized in the mind but realized in matter." Throughout, Malo intersperses his disquisition on the geology and hydrology of Arizona with reveries that could have been cited by Gaston Bachelard in *The Poetics of Space*:

> How silently, even swiftly, the days glide by out in the desert…How 'the morning and the evening make up the first day' and the purple shadow slips in between with a midnight all stars!
>
> With the dawn we face the sunrise./We face it with all our humility./We are mere beings./All we can do is extend our hands toward the first light… We take it and cleanse ourselves./We touch our eyes with it…[9]

Malo's is a plea for architects to find the spiritual dimension of their art in the land to which their buildings belong, in landscape not as the object of view but as the play and result of forces: here, the forces of heat, wind, water, and time upon rock. No paper and scissors in this picture, but plenty of poetic sensibility: "Geography is not the surrounding of the building, but rather the impossibility of its closure…Geography is not the field next door, nor even the neighboring district, but a line that passes through our objects, from the city to the teaspoon, along which there is an absolute outside."[10] Malo: "Geography is not just a territory that awaits mapping and subdivision… It is also a field of forces whose vectors await experiencing—a *source* of sensibility." That's where beauty comes from. That's where truth comes from, aided not by philosophy so much as "ecosophy." Malo makes no theological claims except the implicit deistic and perhaps pantheistic ones: that the true and eternal come from appreciating our temporality in the face of geographic time and our weakness in the face of geological forces, forces whose ability to punish and sustain and produce complex beauty is inexhaustible. These words point to the near-religion that environmentalism has become in this day. And yet it would be wrong not to remark upon how the desert Southwest recalls the landscape of the Hebrew Bible: impassive, magnificent, harsh in the day but forgiving at dusk, parched for miles but watered in grateful clefts by passing thunder. Forty days and nights alone in this land would surely purge the soul. Malo would have us bypass talk of meeting God or the devil, however, and bypass even First Nations narratives that saw spirit-entities everywhere in this gorgeous and terrible landscape. It would be enough, Malo suggests, to become One with the desert by having the map of our very bodies coincide metaphorically with the Earth's. With "[l]ongitude [as] the set of mechanical relations of extension and orientation in space," he writes, "and latitude [as] the set of motive, or emotive, forces and intensive states in time…we may construct the map of a body and [with it] 'form…a natural geometry that allows us to comprehend the unity of composition of all of Nature and the modes of variation of that unity.'" Ecstatic union with divinity is the model. It is a model that goes back to medieval Sufi, Jewish, and Christian mysticism.

Architect, educator, and writer Stanley Tigerman takes us to the theme he first explored in *The Architecture of Exile*: that architecture begins in human beings finding themselves where they do not belong, where they did not grow up as a species, which is Eden (or East Africa a hundred or more thousand years ago). Architecture is thus suffused with our longing to return to seventy-five-degree temperatures, fruited plains, and animals to name; which is why we roof, and blow air, and garden. Tigerman begins this article, however, with a discussion of the melancholy of architects today who, afraid of "playing God" also cut themselves off from cultivating any poetic-ethical sensitivity, a sensitivity which, Tigerman argues, is itself "informed by a sense of the divine." Like the wandering Israelites of Exodus, many in architecture are caught between hope and nostalgia, carrying around with them a spark, a lamp, against the darkness of developer culture and philistinism. "Once it is posited," he goes on, "that creativity has greater authority when it relates to a sense of the divine, the question as to *which* kind of divinity this applies to, or derives from, becomes worth scrutinizing." He sees two kinds: those that derive from and idealize constant reinterpretation and updating of what "God" and "good" mean, and those that "emanate from an unwavering faith in fixed ideals." The second is where architecture has for too long placed it bets, as it were, which is to say, in the Hellenic, Roman, and (Roman) Christian ideal of eternal truth wedded to power, which is the reward for "being right with" God almighty. Tigerman makes a case for the first, however, and its post-exilic, Hebraic (and he does not mention, but might have, early Christian) roots. It is time that architecture turned its attention to the powerless and homeless, the disabled and the disenfranchised, the lost and lonely; not to posit new structures "out of the blue," but to interpret old ones: those from history as well as those aging buildings right nearby, and then accept the "impure" and complex results. Like Spector, Becherer, and Richards in this volume, Tigerman taps into the ethical roots of religious sensibility, rather than the aesthetic ones, to find architecture's path.

My own contribution to this volume is one about which I can be brief. Like Tigerman, I start with a discussion of how and why architects are sometimes accused of "playing God."

Noting that film directors, surgeons, and playwrights often face the same accusation, I try to show how it does not hold up and is not fair, if only because the God they sometimes think they "are" is not the God of the Bible, but something/someone/some-process more gentle by far. I then look into the so-called "Argument From Design" for the existence of God, which goes back to the 19th century, and note Darwin's view of it. I consider what *evolution* consists in by contrast to *design*, only to find structural parallels—parallels so deep that it can fairly be asserted that evolution and design *are one and the same process*. All that is different is the spatial scale, the temporal speed, and point of view of the namer of the process. "Designing is evolution speeded up and seen from outside the system; evolving is design slowed down and seen from inside the system." More often than not, too, evolution increases life's complexity, and it is from that complexity reaching higher and higher levels over millions of years that life-forms such as ourselves come eventually to have the power to sway large parts of the process of evolution. The very notion of *ethicality* emerges at this point too, and with it, a profusion of allegories, stories, rules, and theories that "explain" its arrival on the scene, allegories and rules that, being held to be true, work to have ethicality survive and reproduce as a way of life. Designing, which we recognize as *designing*, reflects the taking-over of biological evolution by ethical intention and its speeding up in neuronal processes. Where is the divinity in all this? In the very process of ethical creativity and/or in its result: the good. What has this to do with architecture? A great deal, just as it does with all the activities of daily life that allow creativity to take place. My paper concludes with short studies of Michelangelo, Le Corbusier, Frank Lloyd Wright, and Louis Kahn, all of whom, I try to show, had distinctly theological understandings of the source and purpose of their creativity, and all of whom (excepting Michelangelo, although he had a distinctly cosmic/developmental cast to his thinking) understood and accepted evolution as the way of nature.

To my knowledge, the Argument From Design has never had actual designers address it directly. Symmetrically, it would seem that no theologian has visited a designer's office or themselves picked up a pencil to sketch something not in front of them, but in their heads, that might just work... But many fine architects and designers over the centuries (and too few of them having been mentioned in this book) have had profound things to say about the nature of their calling and the stars that they follow, and thus about the Argument From Design by implication. No one has mentioned Philippe Starck, for example, who is eloquent on the subject of design's cosmic and ethical purpose. Christopher Alexander has spent a lifetime reconciling "the quality that has no name" to the evolution, order, and complexity of the universe, and he too remains under-cited in this book, including by yours truly. Actual designers have long felt the triple process of reproduction, variation, and selection move through them as they labored.

But times have changed. Religion counts again, even as the voices of atheism grew more strident in the early 2000s and the faith vs. science debate heated up again. Computers have opened up our appreciation of the power of micro complexity to generate macro order. Evolution has received a boost in the public mind, with books about it proliferating everywhere and explaining everything. In result, where faith is in resurgence, it is at a higher, more self-aware and scientifically informed faith. In result too, we can expect more books about the spiritual aspects of architecture to appear, fusing poetic and practical sensibilities. Yale University hosted two conferences on the topic in 2007. Attendance was excellent (I am told, I was not there), and a book of collected papers called *Constructing the Ineffable* is forthcoming from Yale University Press, edited by Karla Britton. The Architecture Culture and Spirituality Forum held its first symposium in Oregon in March of 2009. Membership is growing (visit http://

faculty.arch.utah.edu/acs/). Renata Hejduk and Jim Williamson of Arizona State University have a volume in press with Routledge, titled *Saved! The Religious Imagination in Modern and Contemporary Architecture.* And then there are the several symposia and publishing efforts of the Center for American Architecture and Design at the University of Texas at Austin over the last ten years or so, focusing on architecture's values at a fundamental level, from psychology to economics.

In all, these are good times for architects to re-evaluate what they know about their art. "Sustainability" does not begin to exhaust the ways in which architecture is able to contribute to the quality of life today. Nor, without a guiding notion of what makes places great and abiding, does the computer open doors to anything but antic technophilia in certain architects' hands, and ruthless efficiency in others'. In presenting this fifteenth volume of *CENTER: A Journal for Architecture in America,* my hope is that talk of God and goodness, of design and evolution, of complexity and its causes, of truth and beauty and "spirituality" and all the things that matter to us beyond cleverness and money, will enter the mainstream of architectural conversation refreshed. ✻

ENDNOTES

1 Consider this statement: "From the viewpoint of religious stud(ies), a religious ritual is a ritual precisely because it is human behavior that accomplishes nothing except the construction of concepts about its own legitimacy." Or this: "In sum, the religion researcher is related to the theologian as the biologist is related to the frog in her lab." From K. L. Knoll "The Ethics of Being a Theologian," *The Chronicle of Higher Education*, 7 July 2009.

2 Some say that architecture is rather too much like a religion already (at least in the academy), with design studio being precisely the place of in(tro)duction to the mystical experience, at around 2 am. On John Dewey's definition of "the religious," they have a point. To wit: "Any activity pursued on behalf of an ideal end against obstacles and in spite of threats of personal loss because of conviction of its general and enduring value is religious in quality." John Dewey, *A Common Faith* (New Haven: Yale University Press, 1934) 31.

3 See Jack Miles, *God: A Biography* (New York: Knopf, 1995), Karen Armstrong, *A History of God* (London: Random House, 1997), or Frederick W. Schmidt, ed., *The Changing Face of God* (Harrisburg, PA: Morehouse Press, 2000).

4 One can trace deism itself to Spinoza, Descartes, and before that Aristotle and his idea of the Prime Mover.

5 See J.K. Birksted, *Le Corbusier and the Occult* (Cambridge: MIT Press, 2009).

6 Mies's pronouncement actually comes from Gustave Flaubert, who got it from Thomas Aquinas. Michelangelo is quoted as saying something very similar: "Trifles make perfection, but there is nothing trivial about perfection." "Whoever is striving for perfection is striving for something divine." And "Beauty is the purgation of superfluity." I imagine Mies van der Rohe having these sayings in a bedside reader.

7 My own efforts to describe this last option can be found in *God Is the Good We Do: Theology of Theopraxy* (New York, Bottino Books, 2007).

8 I say "as it happens" because many of Ando's secular buildings have the same serenity, physicality, and capacity to throw one into contemplation of beyondness (for lack of a better word).

9 The first sequence is by John Van Dyke, the second by Ofelia Zepeda; see Malo's article in this volume.

10 The words are Bernard Cache's.

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A DESERT LAND ETHIC: AESTHETIC RESEARCH

Álvaro Malo

> The life of the desert lives by adapting itself to the conditions of the desert...
>
> And so it happens that those things that can live in the desert become stamped after a time with a peculiar desert character...The struggle seems to develop in them special characteristics and make them, not different from their kind; but more positive, more insistent.
>
> – John C. Van Dyke[1]

SONORAN GEOLOGY

PRECEDING PAGE: Catalina Highway in the Santa Catalina Mountains.

Since I arrived in Arizona, the brightness of the morning sky prompts me to get up early. At sunrise, I walk around my "garden" in the Catalina Mountains foothills—the notion of a garden here is different: mostly a fence or a wall erected to claim a portion of the desert as it is. Vegetation is sparse but evenly distributed, as the perimeter of the root structure establishes the water rights of each and every native plant. Yet under the low incident rays of the morning sun, it is the quality of the surface that is seductive to the eye.

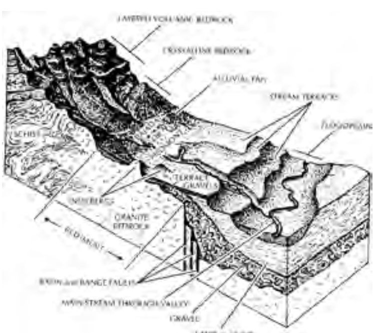
Gravelly or stony *alluvial fans* spill out of the surrounding mountains through drainages or *canyons* and cover much of the surface of the Sonoran Desert. They vary greatly in color and texture, from sandy and porous, to rock hard and crystalline, from white and opalescent, to jet black and basaltic, with all the hues in-between. The frequency of mica and pyrite incrustations, mineral silicates, and sulfides common in igneous and metamorphic rocks, gives evidence of an active volcanic past, painting the surface with a shimmering quality, a silvery to golden glitter. Fool's gold.

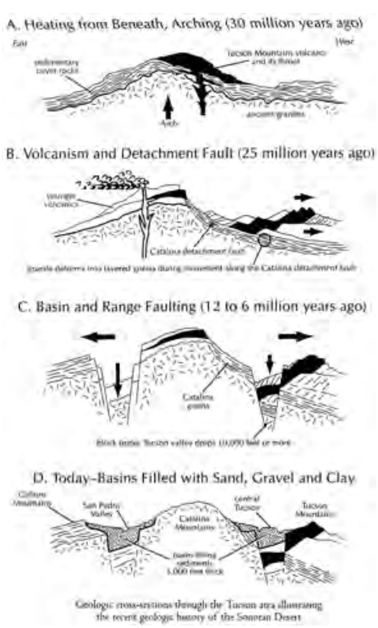
Geology challenges both reason and imagination. Biological cycles and life spans are fleeting when compared to geological cycles, which span millions of years. Hardly less provocative is the notion of geological space, as we wonder what caused mountains and plains to take their present form and what might become of them in the future. Although geological time and space may have little bearing on the utilitarian dimensions of our present undertakings, there are lessons to be learned from the geological processes. One definition I have consigned to hard memory: *tectonics*—the deformation of the earth's crust, the forces involved in that deformation, and the resulting forms.

LAND

The land of the Sonoran Desert is configured as a broad shallow bowl surrounded by considerably high mountains. It displays nearly two miles of vertical relief, from sea level to 9500-foot high mountaintops covered with Evergreen forests. On the northeast, it is encircled by the Mogollon Rim, a mile-high escarpment of sedimentary rocks (from 30 million to 1200 years old) that cuts diagonally across Arizona and is fully exposed to view in the immense stratified walls of the Grand Canyon. On the north, it joins the Mojave Desert through a saddleback depression on the rim. On the west, it is bounded by the Sierra Nevada, the coastal Laguna Mountains in southern California and the Sierra San Pedro Mártir in Baja California composed mostly of cretaceous granites (140 to 80 million years old). On the southwest and south, the rim flattens out to the bottom on the Mexican Baja Peninsula and then is cut diagonally by the Gulf of California. The southeastern edge is defined by Mexico's Sierra Madre Occidental, a massive accumulation of volcanic rocks (30 million years old) exposed to view in the Barranca del Cobre (Copper Canyon) in the Mexican states of Sonora-Chihuahua. On the eastern edge, the rim consists of a series of high valleys and parallel ranges, including the Chiricahua and Pinaleño Mountains in southeastern Arizona.[2]

RIGHT: Sonoran Desert Region, courtesy of the Arizona-Sonora Desert Museum.





LEFT: Sonoran Desert Landforms, courtesy of the Sonora Desert Museum Press, 2000.

Tuscon and San Pedro Basin formation, courtesy of the Sonora Desert Museum Press, 2000.

The Tucson basin is a broad valley at 2400 feet of median altitude, circumscribed by the Catalinas (north), Tucson (west), Santa Ritas (south) and Rincon Mountains (east). Long, long ago, intense heat rising from the earth's core melted the crust into a viscous fluid. This heated zone across Arizona responded to the pull-apart northwest movement of the adjacent Pacific Ocean tectonic plate by forming a huge fault zone. The Catalina detachment was one of several nearly flat faults. Once released by the faulting, these mountains rose and arched further due to heat and buoyancy. The detached edges of the Catalina *gneiss* (foliated metamorphic rock) then moved a considerable distance, ten miles or farther on either side, forming the San Pedro and the Tucson valleys, in a process that lasted a few million years.[3]

The lesson for today, as I dig in the foothills of the Catalinas, is derived from this picture of *force*. Intentionally, I forget the canons of beauty (which may turn me into 'a beautician') and go along instead with the Portuguese poet Fernando Pessoa's suggestion that one may formulate an aesthetic based not on the notion of beauty, but on that of force[4]—force not understood as violence, but as the transitive event between my body and the material I move. The search for expression goes directly through the choice of a material. Whether the material is tensile or compressive, the point is that your work must reveal the force—the line of inflection is actualized in the mind but realized in matter—paradoxically preferring of the Aristotelian notion of *energeia* over the Platonic notion of *idea*.

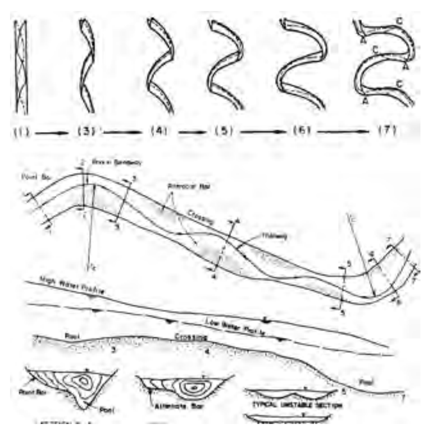
> Once in his life a man ought to concentrate his mind upon the remembered earth, I believe. He ought to give himself to a particular landscape in his experience, to look at it from as many angles as he can, to wonder about it, to dwell upon it...I am interested in the way that a man looks at a given landscape and takes possession of it in his blood and brain.
>
> – N. Scott Momaday[5]

WATER

The word "Tucson" is derived from the original *Cuk Son* that in the language of the native Tohono O'odham (also called Papago or "Desert People") means "at the foot of the black mountain." The black mountain, now called "A" Mountain, is a volcanic lava cone that submerges deep below the surface and intersects the flood plain of the Santa Cruz River at the precise geographical location of modern downtown Tucson. Less than ten miles upstream alongside Interstate 19 is another lava cone called *Wa:k*, which means "the spring" and is located in the Tohono O'odham Nation San Xavier District, where the Jesuit missionary Eusebio Kino built the renowned Mission of San Xavier del Bac.[6] These rocky plugs inflected upwards the vector of underground water flow forcing it to spring to the surface, making of both Bac and Tucson the two places where Tohono O'odham native settlements, and the Hohokam for thousands of years ahead of them, prospered before the arrival of the Spanish conquistadors.

There is an unsettled discussion of the etymology and meaning of the name "Arizona." It may have come from two Piman words, *ali* and *shonak*, which mean "small springs." Or the Basque settlers of the region, descendants of Anza the Elder who founded Alta California, may have called the area *arritz onac*, or "rocky places."[7] Whatever the linguistic origin that bequeathed the name, the phonetic coincidence of many languages seems to fit well most of the attributes of the territory. Today, people think intuitively that the name means "arid zone"—they are also right.

Arid zones, or deserts, are better understood in terms of the basic patterns of global climate and atmospheric thermodynamics. First, hot air rises, and cool air sinks; second, rising air expands and cools, while sinking air compresses and gets warmer; and, third, warmer air can hold more water vapor than cooler air. Hot equatorial air rises and spreads horizontally at high elevations. Air cools at high altitude and then sinks, flowing along the surface to replace the rising equatorial air and forming a circulation loop. The sinking occurs normally at 30° of latitude, north and south.



RIGHT: Normal annual precipitation in the Santa Cruz-San Pedro River Basins. Meander formation, from Luna Leopold, Fluvial Processes in Geomorphology (San Francisco, W.H.Freeman, 1964).

Rainfall in the Sonoran Desert averages three inches in Yuma, Arizona, to fifteen inches a year in the Arizona Uplands. The Tucson Valley, located in the latter, gets approximately twelve inches distributed primarily in two rainy seasons: a winter one in December and January, and a summer one in July through early September. Winter rains are typically gentle and steady. In contrast, summer rains can be torrential and abrupt, dumping several inches in a few hours. They arrive on the back of the summer winds called *monsoons*, which flow inland from the sea to fill in the vacuum created by rising air that has been heated by the summer sun.[8]

Water is the lifeblood of the Sonoran Desert. The rain that falls in the mountains and foothills and washes down the canyons to the alluvial valleys and aquifers sustains the riparian areas of the Sonoran Desert. The drainage pattern of the Tucson Basin is an infinitely diverse system of hydraulic geometries: deep mountain canyons, shallower foothill arroyos and broad valley washes, each exhibiting the typical wave patterns of horizontal meanders and braids and vertical riffles and ponds. The drainage basin, as delineated on a planimetric map

> ...provides a limited unit of the earth's surface within which basic climatic quantities can be measured and characteristic landforms described, and a system within which a balance can be struck in terms of inflow and outflow of energy.
>
> – Luna Leopold[9]

Excessive pumping of water for agriculture, industry and human consumption in urban areas has lowered the water table well below the native plants' root zone.

Cottonwood and willow forests that once lined the riparian corridors of the Sonoran Desert, including the Salt, Gila, Santa Cruz, and Rillito rivers are now lost or disappearing. The aquifer underlying central Tucson has fallen more than 200 feet in the last fifty years. To supplement the deficiency, water from the Colorado River basin, several hundred miles north, has been diverted south by the enormous water transportation infrastructure of the Central Arizona Project.

Pumping fossil groundwater and importing water from other regions has delayed the inevitable need that people migrating into the desert have to moderate their habits of limitless consumption, this as they continue to reproduce the world that they have fled. The lesson that I am learning from the desert is that my mind is beginning to turn, to share nature's intentions. It is a lesson well inscribed by Joseph Wood Krutch: "...the desert is conservative, not radical." It encourages "...the heroism of endurance, not that of conquest." The desert is the last frontier, "...a frontier that cannot be crossed. It brings man up against his limitations."[10]

> Water, water, water...There is no shortage of water in the desert but exactly the right amount, a perfect ratio of water to rock, of water to sand, insuring that wide free open generous spacing among plants and animals, homes and towns and cities, which makes the arid West so different from any other parts of the nation. There is no lack of water here, unless you try to establish a city where no city should be.
>
> - Edward Abbey[11]

AIR AND LIGHT

My house sits on a ten percent southward incline on the Catalina foothills. It is a one-story affair of great simplicity: a spatial rectangle with floor-to-ceiling glass shaded by a 60-foot by 14-foot open, wood portico running lengthwise the entire southern façade. From this aerie, with my back to the Catalinas, I can see clearly the amplitude of the Tucson Basin framed by mountains on all sides: the Tucsons to my right, the Rincons to my left and the Santa Ritas straight ahead—and I imagine, not far beyond them the Mexican border and the rest of the Americas, all the way south to Tierra del Fuego.

> How silently, even swiftly, the days glide by out in the desert…How "the morning and the evening make up the day" and the purple shadow slips in between with a midnight all stars!…And how day by day the interest grows in the long overlooked commonplace things of nature!…In a few weeks we are studying bushes, boulders, stones, sand drifts…And after a time we begin to take mental notes on the changes of light, air, clouds and blue sky.
>
> - John Van Dyke[12]

The "deep blue" that overhangs the desert is most intense in the morning before sunrise, when it is a dark blue bordering on purple. By noon, it has crossed the spectrum through pale blue, yellowish, and lilac. By sunset, it has passed again through magenta, rose, and orange. After twilight, a warm purple veil has returned to envelope all things, seen and unseen.

Sunlight passes through the atmosphere relatively undisturbed, but occasionally a light particle, a *photon*, collides with an air molecule and bounces off it, a process called "scattering." Colors, or more precisely light wavelengths, influence this process. Visible light is a mixture of all the colors of the spectrum, from red through violet. The blue-violet end of the spectrum scatters more than the orange-red, and as a result, to our eyes, the sky appears to be blue. In humid climates, water vapor condenses in microscopic airborne droplets that equally scatter light of all colors, diluting the blue. In the dry and relatively pure desert air, nearby volcanic rocks, blossoming Palo Verde trees, Saguaros, and Sand Verbenas show a remarkable variety of vibrant hues—red, orange, yellow, green; but in the distance, the more the air intervenes, the more everything here seems to have a bluish glow. Blue skies, blue mountains, and blue birds, all seem to compress the aerial perspective into a thin shimmering veil.

RIGHT: Giant Saguaro Cactus, photo by Greg Fink, printed with permission.

Sky Islands from the Catalina Mountains.

On the mountain ranges, the cooler and more humid regions of the upper elevations are ecologically as well as optically separated from one another. As they seem to float on seas of hot air, uplifted by conjured up "lakes," or arid habitats in the open desert. They are called "sky islands"—both the product of distinct ecological communities and aesthetic reveries. As the night falls, I see the city lights below through the southern glass wall and the image doubled on the northern glass across the room, creating the illusion of a mountain saddle or a sky island of my own.

> With the dawn we face the sunrise.
> We face it with all our humility.
> We are mere beings.
> All we can do is extend our hands toward the first light.
> In our hands we capture the first light.
> We take it and cleanse ourselves.
> We touch our eyes with it.
> We touch our faces with it.

A DESERT LAND ETHIC: AESTHETIC RESEARCH MALO

We touch our hair with it.
We touch our limbs.
We rub our hands together, we want to keep this light with us.
We are complete with this light.
This is the way we begin and end things.

– Ofelia Zepeda [13]

LAND ETHIC—AESTHETIC RESEARCH

The Spanish architect Juan Navarro Baldeweg, who is also a painter and begins his projects through painting, has reminded us that the analysis of energies, turbulence, hot air, the sun, light, or the wind in landscapes also appears in architecture. They are things that he calls "the coordinates within which we move." The different variables that intervene in the physical situation that surrounds us have a form of expression that through different combinations makes up the order of reality—a reality of which we inevitably become a part.

Vittorio Gregotti advises architects to begin their work on a geographical scale, to ensure that the built frame institutes a network of connections that structure or modify the "shape of the territory."

> Beyond the built frame there is the site, but beyond that still, there is the outside. Geography is not the surrounding of the building, but rather the impossibility of its closure...Geography is not the field next door, nor even the neighboring district, but a line that passes through our objects, from the city to the teaspoon, along which there is an absolute outside.
>
> – Bernard Cache[14]

Geography is not just a territory that awaits mapping and subdivision—a *resource* to be developed. It is also a field of forces whose vectors await experiencing—a *source* of sensibility. The Norwegian philosopher Arne Naes opens us up, through his concept of *ecosophy*, to the notion that we may partake of the nature of the stone in the wash, the brittlebush in the mesas and the falcon that soars in the air currents. Having undergone successive migrations from the Andean highlands of South America, to the lowlands of the Everglades of Florida, to the uplands of the Sonoran Desert in Arizona, I am prepared to say that the vector of inflexion linking geography to geometry internalizes the surface of the land, or rather, that it extends the surface of our body onto the landscape, offering a continuity that prolongs the very nature of things.

The experience that recognizes natural things, including inanimate and animate bodies, by the effects that they induce on each other is the foundation of what is today called *ethology*. Here, the body is a boundary, a selective surface of exchange of perceptions, actions, and reactions linking together the individual and the world, "The interior is only a selected exterior, and the exterior, a projected interior."[15]

The 'natural composition' between things is defined by the capacities for affecting and being affected that characterize each thing. It is a question of "whether relations can compound directly to form a new more *extensive* relation, or whether capacities can compound directly to constitute a more *intensive* capacity or power." Borrowing the terms from geography we would define a body neither by its form, nor by its organs and functions, but rather by *longitude* and *latitude*. In this schema, longitude is the set of mechanical relations of extension and orientation in space, and latitude is the set of motive, or emotive, forces and intensive states in time. Thus, we may construct the map of a body, "forming a natural geometry that allows us to comprehend the unity of composition of all of Nature and the modes of variation of that unity."[16]

Not unlike the play of tectonic forces on the earth's crust, the primary relationship of my body to the ground is the transaction with gravity. Standing up, walking, climbing, leaping, and all other countless movements may be defined as geometrical diagrams traced on the datum of the ground against the force of gravity.

The recognition of gravity prepares the geometrical act of grounding, making the ground ready to raise screens to other forces: light, wind, and rain. My experience is that this usually begins, and in most cases ends, with excavation:

> But where is the surface of a hole? I once believed that the surface of a hole is level with the surface of the ground around it. From observation I have come to realize that this is not true...A hole has only sides and a bottom from which it extends infinitely upward, like a shaft of light: and as the earth revolves, it moves with great care and precision between the stars. ✲
>
> – Richard Shelton[17]

ENDNOTES

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17 Richard Shelton, *The Other Side of the Story* (Lewiston: Confluence Press, 1987) 22.

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Álvaro Malo is Professor/Director of the Emerging Material Technologies Graduate Program and the School of Architecture at the University of Arizona. He has also taught at the University of Pennsylvania, the University of Florida, SUNY, Buffalo and the University of Colorado at Denver, where he was also Architectural Director of the Community Design Center. His focus is in architectural design and emerging material technologies and their ecological prospects.

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CERTIFICATION PAGE

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By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-29). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

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In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

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Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

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EFRI-SEED Preliminary proposal: ***Adaptive Autonomous Performance in a Sensitive and Integrative System (AAPSIS) for a Telemedicine Unit***

PI, Pierre A. Deymier, (Engineering) U. of Arizona. Co-PIs (all from U. of Arizona): Eniko T. Enikov (Engineering), Ana M. López (Medicine), Álvaro Malo (Architecture), Mary A. Peterson (Psychology).

Native American populations have urgent need and limited access to health care. The University of Arizona's Telemedicine program is an efficient means of delivering clinical, diagnostic and continuing education for the Indian Health Services system. However, the current telemedicine systems lack facilities that can adapt to variable physiographical settings and functional needs, that are culturally sensitive and user-friendly, and that have sufficient autonomy in off-grid remote locations. The goals and challenges of the proposed research will focus on the integrative design and realization of an efficient and competent Telemedicine Unit that will require the following attributes: (1) Adaptive to variable programmatic needs, climatic conditions, and cultural settings; (2) Autonomous, self-sufficient of energy and resources in off-grid remote locations; (3) Sensitive to human physiology, material propensities, and environmental factors; (4) Integrative of aesthetic socio-cultural, and ecological systems; and, (5) Sustainable prospect of use and regeneration of natural resources — air, water, light, energy and land. The Telemedicine Unit will be located in Sells, Pima County, AZ., The research and design process will be carried out with the integral participation of the Tohono O'odham Nation and the Tucson Area Indian Health Services (IHS).

The objective of the proposed research is therefore to develop the fundamental scientific, engineering, technical, aesthetic, social and cultural principles required to initiate a paradigm shift in the design, development and operation of energy/resource efficient and sensitive sustainable buildings. We propose the development of advanced and innovative concepts, which using interactive modeling and simulation, apply fundamental scientific and technical principles in the architectural design, engineering, testing, and construction of a Telemedicine Unit. This transformative paradigm is based on an efficient and graceful interface between buildings as operating "hardware" and human beings as sensible, sensitive, and culturally evolving "software." Cultural sensitivity toward users (patients) of this facility requires that special attention be paid to both the performance of clinical functions as well as to integrative aesthetic perceptual feedback loops. Integrative aesthetics includes measurable human sensory responses related to the buildings environmental conditions, which affect human comfort and well being and provide the common sense of an immanent aesthetic.

Intellectual merit:

The proposed research introduces a new paradigm in built environments: autonomous, sustainable, adaptive and sensitive building. The research on pneumatic envelopes with automorphic and phototropic properties will provide key insights into the engineering, technical and materials aspects of adaptive building. Insight gained from the study of energy production and energy storage by integrating flexible photovoltaic cells and compressed air storage within the building envelope will help establish the principle of *autonomy*. Thus, we will explore the application of high efficiency dual use compressor/motor systems in enabling operation of the unit as well as for energy storage and recovery. The integration of new micro and macro sensor technologies into the building that can respond to environmental, structural and human factors will enable the design of *sensitive* building. The development of model-based *multi-paradigm simulations* for real-time management of the complex interactions between flow of resources and human occupant establishes the foundation for *integrative modeling* of architectural design, engineering systems, operational building needs, human physiological and psychological comfort, and cultural sensitivity.

Broad impact:

The Arizona Telemedicine Program was founded by the Arizona legislature in 1996. To date, over 1,000,000 teleconsultations have been conducted resulting in enhanced clinical care for Arizona's population. The initial 8 vanguard sites have expanded to over 100 sites statewide. The principles derived from this research in model-based multiparadigm simulation will be transferable to numerous IHS renovation projects and other medical facilities. Teleconsultations enhance the readily accessible clinical services. Services provided in group settings would benefit from an *adaptive* structure. Nonclinical benefits would include enhancing the technical, business and sustainability expertise of the community. The *integrative aesthetics* and "feel" for the structure will be developed with guidance of and in response to community needs and priorities. Ideally, the structure itself should be able to *sense* and *respond* to human needs. For example, the smart building may sense the rapid heart rate of an individual who is nervous and fine-tune the lights and sound to create a more comforting atmosphere — a place where people will feel "at home" and welcome. The multidisciplinary research team that will conduct the research will provide a unique goal-oriented educational environment for graduate and undergraduate students.

1. Vision and Goals : We propose the development of advanced and innovative concepts, which using modeling and simulation interactive environments, apply fundamental scientific and technical principles in the architectural design, engineering, testing, and construction of a Telemedicine Unit. This transformative paradigm must be based on an efficient and graceful interface between buildings as operating "hardware" and human beings as sensible, sensitive, and culturally evolving "software." Cultural sensitivity toward users (patients) of this facility requires that special attention be paid to both the performance of clinical functions as well as to integrative aesthetic perceptual feedback loops. Integrative aesthetics includes measurable human sensory responses related to the buildings environmental conditions that affect human comfort and well-being and that provide the common sense of an immanent aesthetic.

More specifically, we envision a building-environment system that possesses the following attributes:

- Adaptive to variable programmatic needs, climatic conditions, and cultural settings
- Autonomous, self-sufficient of energy and resources in off-grid remote locations
- Performative efficiency regarding daylight, acoustics, energy balance and building physics
- Sensitive to human physiology, material propensities, and environmental factors
- Integrative of aesthetic (i.e. visual, acoustic, thermal, haptic, ergonomic, etc.), socio-cultural, and ecological systems
- Systematic thermodynamic prospect of use and regeneration of natural resources (i.e. air, water, light, energy, land, etc.)

We therefore propose research that will establish the foundations of a broader spectrum of ecological understanding of scientific, technical, architectural, engineering, social and cultural principles that are required to initiate a paradigm shift in the design, construction, operation and recycling of efficient, sensitive and sustainable buildings.

Specific research goals will include:

1. Discovery of a science and technology of adaptive sustainable buildings with dynamic morphing properties (e.g. automorphic structure, phototropic envelope, ergonomic adaptation).
2. Integration of new sensor technologies responsive to environmental factors, structural adaptation, and human physiology and behavior.
3. Creation of virtual environments for modeling and simulation of human responses to sensory stimuli in adaptive spatial environments.
4. Development of a model-based computational control system for real-time management of the complex interactions between flow of renewable resources and human occupant needs in adaptive structures
5. Establishment of architectural design and engineering principles derived from a scientific understanding of the operational energy needs of the building and the thermodynamic thresholds of human physiological comfort
6. Fine tuning of adaptive material spatial morphologies responsive to perceptual well-being.

These goals will be attained by conducting research within a philosophical framework emphasizing the exchange of ideas and expertise through experiential interaction with many disciplines including engineering, architecture, psychology, medicine. This project will serve as a vehicle to promote scientific, technical, social and cultural multi-linguism to enhance community's understanding of the role of knowledge integration, transfer and creation in the field of sustainable energy efficient and environmentally and culturally competent buildings.

2. Approach and Methodology: The proposed research program, inclusive of all relevant thrusts, approaches and methodologies, is described schematically in the flow chart shown below (fig. 1):

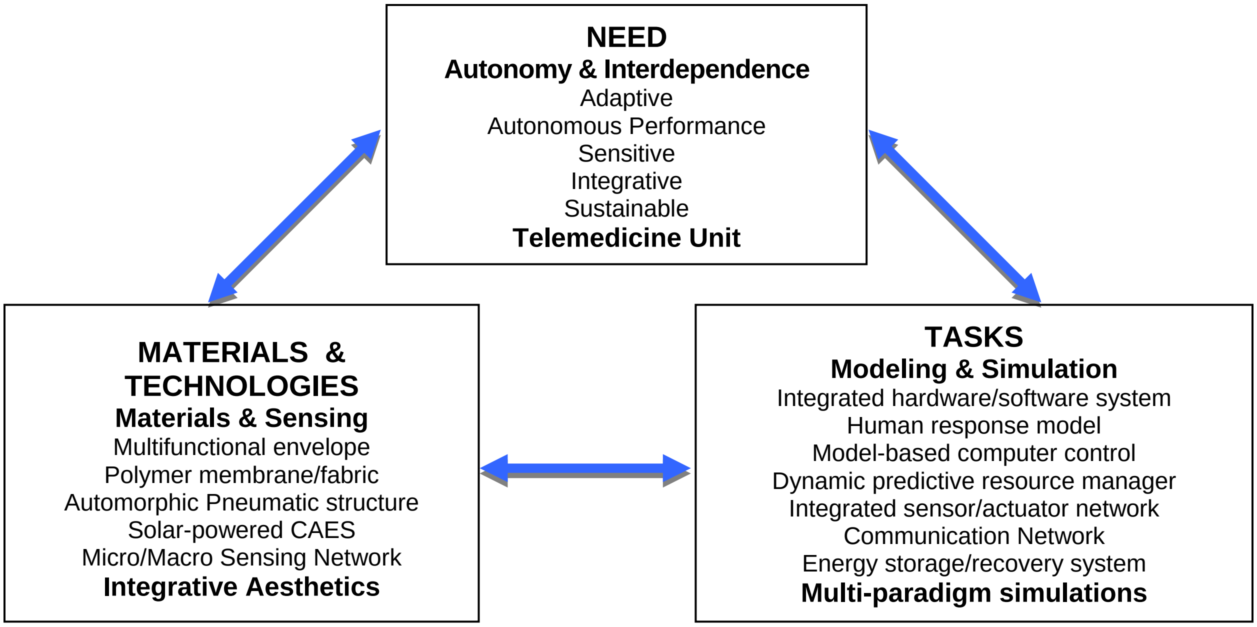

Figure 1: Flow chart illustrating interrelated thrusts for new paradigm in adaptive, autonomous, performative and sensitive building.

To meet the goals of this project we will take an approach in the design of the building envelope that addresses several integrated functionalities. The multifunctional envelope will provide efficient energy harvesting, energy and water storage capacity, thermal storage and insulation as well as light transmission. This envelope will be endowed with automorphic and phototropic properties to optimize its functions by adapting to environmental cyclic changes and human needs. To achieve theses functionalities, we will take advantage of technological progresses in new synthetic materials, pneumatic envelop design and microsensor technologies. We will investigate pneumatic phototropic envelope composed of three-layered cushion partitioned membrane system to meet daylight, acoustics, energy balance and building physics requirements.

The materials that will be considered for the envelope are three-layer membrane: (a) outer skin, PTFE coated glass fabric (polytetrafluoroethylene)—high tensile strength; abrasion, atmospheric aging, corrosion and fire resistant; chemically inert; (b) middle layer, transparent sound-insulating thermoplastic (polycarbonate); and, (c) inner layer, sound absorbing (70%NRC), low-E (infrared) coated fabric with defined light transmission. The partitioning of the envelope into individually inflatable pillows will enable it to morph (eventually automorphing via intelligent control software) and function in response to local conditions through sensing of light, pressure, and temperature. To that effect the envelope and supporting structure will incorporate materials with energetic and structural attributes, such as: (1) Photovoltaic PV-Flex film encapsulated in PTFE-coated glass fabric; (2) Flexible FRP tubing for air circulation system; (3) Flexible shielded FRP tubing for power supply system; (4) High modulus FRP for compressed air storage; and (5) Recyclable thermoplastics for water storage and circulation system.

The envelope will be partitioned into pillows to provide a high level of stability and fault tolerance. Each pillow will contain a low-cost pressure sensor/actuator pair and a simple communication mechanism responsible for assessing the state of its neighbors [Enikov and Lazarov, 2003]. The response of each pillow will be controlled by a low-cost sensor/actuator printed or woven into the fabric. The principle of emergent behavior will be utilized to control the shape and function of the inflatable surface. Resultant effects include minimizing or maximizing the solar gain by local regulation of pressure in the inflated pillow leading to change in the shape of the building envelope. Similarly, regulation of light intensity inside the building will be controlled by the response of an array of autonomous apertures integrated into each pillow of the fabric. Communication between neighboring cells could be wired or wireless. Commercial solutions include using a 1-wire interface circuit as a means to serially transfer data between multiple slave nodes (sensors) and a data-logging device (master). The protocol allows a large number of sensing nodes to be attached to a single wire, which is also used to provide power to them. An alternative solution is the use of low-frequency wireless communication akin to the RFID tag technology that allows passive operation, i.e. the transponding sensor is powered by the electromagnetic field of the transmitter/receiver. Since selecting the size and power of the two coils can control the range of transmission, it is possible to fabricate transmitter/transponder pairs that operate locally between two adjacent cells, thus avoiding collision between multiple sensors. Finally, interior retractable layered partitioning will be endowed with thermal, acoustic and haptic functions using porous, air and water filled composite acoustic metamaterials.

The proposed envelope will self-regulate and morph through a solar energy-compressed air cycle. Thus, we propose to employ solar-power driven, energy-efficient (>75%), small-scale, air compressor modules that can be specifically tailored to power the envelope's functions and provide additional compressed air energy storage to power some of the telemedicine unit appliances that can run solely on compressed air — such as water circulating system, air conditioning units (other appliances will be driven by excess photovoltaic power during daylight and recycled lithium-ion batteries). The compressor module is readily scalable to operate and power the telemedicine units by association of several modules in parallel or in series. The compressor prototype will be designed to operate as an open compression cycle system under isothermal conditions, carried out in a slow quasi-static fashion, thereby greatly reducing power consumption during compression — as compared to standard industrial air-compressors that function under adiabatic conditions [Lemofouet-Gatsi, 2006]. This low-cost, environmentally benign, compressor unit, which can be used in conjunction with off-grid stand-alone photovoltaic cells, has been built and tested. The compression module is specifically designed to, (1) be operational under isothermal conditions (stroke speed ~ 60 rpm), (2) be mechanically robust, and (3) minimize energy losses due to friction. The system uses a unique chemically inert, high thermal conduction fluid piston [Muralidharan and Deymier, 2009]. An equally important objective of the proposed research is to examine efficient energy recovery from the small-scale CAES systems. We will examine the viability of the prototype to function as a single-stage compressor/motor hybrid unit. A prime advantage of such a hybrid unit would be the reduction of energy losses, due to less moving parts/components required for the multi-stage conversion of solar-energy to compressed-air, to air-powering of the telemedicine unit.

The solar-energy driven compressor modules will also serve several functions, they will: (1) permit the deployment of the pneumatic telemedicine unit, (2) maintain air pressure in the pneumatic structure during operation, (3) store excess solar energy into additional high pressure compressed air storage tanks, and (4) power compressed-air driven appliances and systems (e.g. water circulation system, refrigeration unit). The proposed units are capable of compressing air at pressures raging from 10Atm (to inflate the envelope of the telemedicine unit) up to 40Atm (for high density compressed air energy storage). The low-pressure compressed air stored in the pneumatic building envelope will serve as a storage backup system, as well as a buffer pressure reservoir for a second stage compression at significantly higher pressure into commercially available solid storage tanks. The two-stage approach enables higher efficiency in the conversion of solar energy into compressed air in the event of loss of isothermal compression conditions.

Hardware-software feedback monitoring disjunctions and/or synergies between human activity and building mimesis will be accomplished via multi-paradigm simulation methodologies (system dynamic, agent-based model, dynamic system). These methodologies will be employed to develop simulation models of the key components of the proposed sustainable building, namely the environment, the power generating pressure-driven envelope, energy storage modules, water storage and circulation system, ventilation, sensor network, telemedicine appliances and facilities and human occupants. In particular, a system dynamic model will be developed to represent an environment (solar irradiance, cloud pattern, pressure, temperature, humidity, among others). Agent-based models will be developed to represent culture-specific human responses (involving synthetic cognitive model) as well as the proposed automorphic partitioned building envelope. Dynamic system models will be developed to represent energy flow, air pressure and airflow, and water in the building. An interoperable computational platform will be developed based on web service technology for integration of hybrid and distributed models. This platform will enable integration of heterogeneous simulation models, optimization engine, hardware, and autonomous systems [Rathore et al., 2005; Lee et al., 2008]. The components of the proposed platform include: 1) individual model (e.g. simulation, optimization program) federates, 2) corresponding client proxies and 3) the transaction coordinator. Each federate communicates with each other using XML-based messages via services provided by the transaction coordinator. A client proxy provides the interface that can be used by a federate to communicate with the transaction coordinator. The transaction coordinator is responsible for performing time and data management required for distributed computation. In this work, the transaction coordinator has been developed using web services technology (state-of-the-art distributed computing technology) to overcome the barrier of standard way of communication between heterogeneous distributed systems via W3C (http://www.w3c.org) standard protocols including XML, WSDL, and SOAP.

From a human occupant point of view, the purpose of telemedicine units serves three functions: (1) bringing health care to people in remote communities, specifically those living on reservation land in Arizona; (2) teaching native people to serve as technical staff, thereby bringing technical knowledge and jobs to those in remote communities; and (3) interacting with those in remote communities to determine how best to maintain their long term health. Prior research reveals that these health environments must be seen as in-group defining (as consistent with Native practices and beliefs) before Native people will engage with health promotion activities (Oyserman, Fryberg, & Yoder, 2007). Thus, comfort because of integrative aesthetics is important, but part of the comfort will come from alleviating identity threats—that we are asking them to do and engage in health promotion behaviors that are consistent with what it means to be Native. We expect that the comfort levels of the patient users will be affected by (1) physical features of the buildings exterior and interior spaces (e.g., dimensions and furnishings of spaces, temperatures, light, and sound levels maintained in various parts of the building); (2) familiarity with people who staff the unit; and (3) understanding of the technical information they receive, and their acceptance of its validity.

We will incorporate these critical social and psychological aspects into the design and function of the telemedicine building by: (1) Using community discussion in the planning process to determine the ideal size of the spaces to be used for medical examinations, for consultation with physicians, and for health education; (2) Assessing how levels of stress and anxiety are affected by ambient sensory stimulation (temperature, light, and sound levels) and setting those levels to minimize stress. These assessments will be made by using wearable monitors that provide a physiological index of stress, such as galvanic skin response (GSR); and heart rate variability (HRV) [Phukan 2009, Teller and Crossly 2009, Bhiwapurkar et al. 2009]. Wearable monitors can also be used to assess how patient stress is affected by interacting with other community members versus outsiders regarding their problems and diagnoses. These monitors can be used in advance in the laboratory to decide how to set these levels. They can also be used online in examination rooms in the telemedicine unit itself to adjust these levels for personal comfort; and (3) Conducting human-in-the-loop experiments in an immersive CAVE environment, which will allow us to collect quasi-real human response data in a practical way [Lee and Son, 2008; Shendarkar et al., 2008]. A Bayesian belief network (BBN) will be employed to represent the perception of an individual [Lee and Son, 2008]. By using a BBN, we can capture the probabilistic relationship as well as historical information between variables by containing prior and conditional probabilities that can be used to infer the posterior probability. In this project, we will leverage our expertise to develop models of the culture-specific human responses in the proposed sustainable building.

Building information models (BIM) will enable us to actualize a more robust paradigm, an integrated and holistic approach, based on collaboration and transparency. The sharing of increased amounts of information, at various levels, allows effective communication of information to a large design team (traditionally architects, engineers and consultants), but also incorporates manufacturers, contractors and sub-contractors into the process to create more integration with the final output. Part of this process will involve generative, parametric and algorithmic design models, which can be optimized through various analyses software with real time monitoring. The models will provide the ability to analyze a building according to its systems: climate, structure, skin, services and monitoring devices as well as analyze the building's occupants and relationship to it. Time based techniques will also facilitate assembly techniques. The ecologically sensitive design will be focused on making sure that performance is optimized technically, but also providing a positive balance between the user's personal levels of comfort and the overall energy use of the building's systems. Iterative models can be budgeted accordingly: recognizing the importance of addressing maintenance and repair costs, thermal insulation properties, life expectancy, appearance and the possible effect on value arising from the choices which are available.

The BIM model will become a 'living' model during construction and post-occupancy where any changes will be updated accordingly to help further measure and track key environmental performance indicator data, such as energy use, water consumption, air conditions, and CO2 emissions. This building management system will become an integral part of the energy conservation strategy. Feedback loops will provide information on energy usage and overall comfort giving key advances in changes in future life-cycle costs: where generally energy usage makes up the largest component.

3. Impact: This project will have scientific and technical impact, impact on community and education.

3.1. Scientific and technical impact: The proposed research introduces a new paradigm in built environments and will serve as a catalyst for initiating a transformation in the way engineers and architects will design and operate future sustainable buildings. The advances that will result from the proposed research on autonomous, performance, adaptive and sensitive structures will not only impact the development of telemedicine buildings but also the broader field of engineered sustainable buildings. The research on pneumatic envelopes with automorphic and phototropic properties will provide key insights into the engineering, technical and materials aspects of adaptive building. Insight gained from the study of energy production and energy storage by integrating flexible photovoltaic cells and compressed air storage within the building envelope will help establish the principle of *autonomy*. The integration of new micro and macro sensor technologies into the building that can respond to environmental, structural and human factors will enable the design of *sensitive* building. The development of model-based *multi-paradigm simulations* for real-time management of the complex interactions between flow of resources and human occupant establishes the foundation for *integrative modeling* of architectural design, engineering systems, operational building needs, human physiological and psychological comfort, and cultural sensitivity.

3.2. Impact on community: The focus of the proposed research on telemedicine building will have a significant impact on the Native American communities as well as on its health service provider (Indian Health Service (IHS)). IHS is an agency within the Department of Health and Human Services responsible for providing federal health services to 1.9 million American Indians and Alaska Natives (AI/AN) who are members of 562 federally recognized tribes throughout the United States. The IHS is the principal federal health care provider and health advocate for Indian people and its goal is to raise their health status to the highest possible level. The proposed project will serve as a flagship in demonstrating commitment in the development of state-of-the-art sustainable energy efficient building for Native American health care. The impact of the proposed research on the IHS employees and populations served will be significant. IHS services are administered through a system of 12 Area offices and 161 IHS and tribally managed service units. 71% of the IHS' 15,676 employees are Native American. As of 2008, the distribution of those employees, among the health professions categories is approximately: 836 physicians, 2,356 nurses, 302 dentists, 533 pharmacists, 429 engineers and 299 sanitarians. The Arizona Telemedicine Program was founded by the Arizona legislature in 1996. To date, over 1,000,000 teleconsultations have been conducted resulting in enhanced clinical care for Arizona's population. The initial 8 vanguard sites have expanded to over 100 sites statewide.

In addition to its proposed programmatic use as a Telemedicine Unit, the autonomous adaptive sustainable structure could also serve as a prototype light-weight portable building for use by federal agencies dealing with disaster mitigation, preparedness, response and recovery planning in cases of national and international emergencies and natural disasters. Its technological and ecological innovations could also be effectively transferred to the prefabricated and mobile home building industry segments.

3.3. Educational Impact: Management of the EFRI team will be conducted within a philosophical framework emphasizing the exchange of ideas and expertise through experiential interaction with many disciplines. This project will serve as a vehicle to promote scientific and technical multi-linguism and to enhance graduate student's understanding of the role of knowledge integration, transfer and creation. This philosophy requires that graduate students work jointly with faculty from different disciplines to form task-oriented teams reflecting the multidisciplinary nature of the challenge. This EFRI team will create a "virtual education and research unit" without departmental or individual faculty boundaries in order to better accomplish its educational and research objectives. Intervention of EFRI team members in Undergraduate/Graduate level courses such as ARC 461i/561i "Materials: properties and testing" will disseminate new knowledge gained through the proposed project to a wider audience of students. We also recognize that undergraduates are the scientists, engineers, and business executives of the future, the proposed project will support the involvement of undergraduate students. Students participating in this program will be heavily recruited from under-represented groups with emphasis on individuals from the ethnically diverse population of the Tucson community. Recruiting efforts will be facilitated by the University of Arizona's strong commitment to recruitment of minority students. Towards this end, we will be assisted by and we will work closely with the Director of the Multicultural Engineering Program in the College of Engineering, the Associate Dean of the Graduate College, the Coordinator of the Multicultural Programs and the Director of the American Indian Graduate Center.

Supplementary Docs

1. List of key Personnel and Synergies

Table 1: List of key personnel in alphabetical order

Name	Department	Expertise
E. Brody	Medicine	Clinical Services/Native American Cardiology
P.A. Deymier	Material Sciences Engineering	Materials, Energy Storage, Sustainability
S. Dickinson	Architecture	Building Information Modeling (BIM)
E. Enikov	Aero. Mechanical Engineering	Sensors and sensor networks
S. Fryberg	Psychology	Cultural and Social Psychology
A.M. López	Medicine	Telemedicine
Á. Malo	Architecture	Emerging Materials Technologies in Architecture
M. A. Peterson	Psychology, Cognitive Science	Cognition and Neural Systems
Y.J. Son	Systems Industrial Engineering	Model-based multiparadigm simulations

The proposed project will be conducted by an interactive multidisciplinary team of senior and junior faculty members and graduate students from the fields of architecture, engineering (materials science, aerospace & mechanical, systems & industrial), psychology & cognitive sciences, and medicine (Telemedicine). To bring this project to a successful completion, we will integrate senior and junior faculty into task oriented subteams, namely

(a) subteam of architecture faculty (A. Malo (senior faculty), S. Dickinson (Junior faculty)) jointly supervising an architecture graduate student,

(b) subteam of psychology and cognitive science faculty (M. Peterson (senior faculty), S. Fryberg (junior faculty)) supervising a psychology graduate student,

(c) subteam of engineering faculty (P. Deymier (senior faculty), E. Enikov (mid career faculty) and Y.J. Son (mid career faculty)) supervising three graduate students.

(d) Telemedicine needs are represented by a senior faculty member of the College of Medicine and Director of the Arizona Telemedicine program, A.M. Lopez and E. Brody (mid career faculty).

The project will be conducted through horizontal integration of experience (student, junior and senior faculty) but also vertical integration of expertise to address individual aspect of the project and attribute of the proposed telemedicine building, namely

1. Research on pneumatic envelopes with automorphic and phototropic properties for *adaptive* building (Malo, Enikov, Deymier, Lopez)
2. Energy production and energy storage to establish the principle of *autonomy* (Deymier, Enikov, Malo, Dickinson)
3. Integration of new micro and macro sensor technologies as components of the design of *sensitive* building. (Enikov, Peterson, Son)
4. Model-based multi-paradigm simulations for building control for *integrative modeling* (Son, Peterson, Fryberg, Dickinson, Lopez)
5. Participatory community design (Malo, Brody, Fryberg and designated Indian Health Services liaison)

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Enikov, E.T. and Lazarov, K. V.: PCB-integrated metallic thermal micro-actuators, Sensors and Actuators A: Physical vol.105, no.1, pp.76 -82, 2003.

Lee, S., X. Zhao, A. Shendarkar, K. Vasudevan and Y. Son (2008). "Fully Dynamic Epoch (FDE) Time Synchronization Method for Distributed Supply Chain Simulation." International Journal of Computer Applications in Technology 31(3-4): 249-262.

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Lemofouet-Gatsi S., These N 3628 (2006), Ecole Polytechnique Fédérale de Lauzane

Muralidharan M., P.A. Deymier, et al., « High efficiency solar powered isothermal compressed air energy storage module”, UA invention disclosure to be submitted (2009)

Oyserman, D., Fryberg, S. A., & Yoder, N. (2007). “Identity-based motivation and health. Journal of Personality and Social Psychology, 93, 1011-1027.

Phukan, A. (2009). Measuring Usability via Biometricc. In A.A. Ozok and P. Zaphiris (Eds.): Online Communities, LNCS 5621, pp. 101–107.

Rathore, A., B. Balaraman, X. Zhao, J. Venkateswaran, Y. Son and R. Wysk (2005). "Development and Benchmarking of an Epoch Time Synchronization Method for Distributed Simulation." Journal of Manufacturing Systems 24(2).

Shendarkar, A., K. Vasudevan, S. Lee and Y. Son (2008). "Crowd Simulation for Emergency Response using BDI Agents Based on Immersive Virtual Reality." Simulation Modelling Practice and Theory 16: 1415-1429.

Teller, A., & Crossley, M. (2009). Ambient and Wearable computing. (Manuscript).

Budget Justification:

The proposed research is labor intensive and will be conducted by an interactive multidisciplinary team of senior and junior faculty members and graduate students from the fields of architecture, engineering (materials science, aerospace & mechanical, systems & industrial), psychology & cognitive sciences, and medicine (Telemedicine). To bring this project to a successful completion, we will integrate senior and junior faculty into task oriented subteams, namely (a) a subteam of architecture faculty (A. Malo (senior faculty), S. Dickinson (Junior faculty)) jointly supervising an architecture graduate student, (b) a subteam of psychology and cognitive science faculty (M. Peterson (senior faculty), S. Fryberg (junior faculty)) supervising a psychology graduate student, (c) a subteam of engineering faculty (P.Deymier (senior faculty), E. Enikov (mid career faculty) and Y.J. Son (mid career faculty)) supervision three graduate students. Telemedicine needs are represented by a senior faculty member of the College of Medicine A.M. Lopez and a Eric Brody (mid career faculty). The budget for senior personnel reflects the commitment of the faculty to this project.
Support for the five graduate students is requested. These students will work specifically on (a) architectural principles of integrative aesthetics and pneumatic adaptive envelope, (b) solar energy generation and pneumatic air storage, (c) integrated flexible sensors and sensing networks, (d) model-based multi-paradigm simulation and control, and (e) human behavior model and cultural sensitivity. Strong interactions between the faculty and the students are anticipated.

Travel funds are requested in the amount of $5,000 to cover expenses to attend at least two domestic conferences per year and travel between University of Arizona and Indian Reservations.

The objective of the proposed research is to implement a prototype adaptive, autonomous, sensitive sustainable telemedicine building. Funds in the amount of $115,000 per year are requested to support the purchase, construction of necessary infrastructure (e.g. materials for the building envelope, materials for structure footings, flexible sensors and communication network of sensors, compressor/motor modules and energy storage units, wiring, computer system, etc.). The estimated cost of the building envelope including flexible photovoltaic is estimated at ~$200,000.

In view of the complexity but high pay-off of the project, support is requested for a period of four years.

EFRI-SEED Preliminary Proposal: ***Adaptive Autonomous Performance in a Sensitive and Integrative System (AAPSIS) for Telemedicine Unit***

MATERIALS & TECHNOLOGIES
Materials & Sensing
Multifunctional envelope
Polymer membrane/fabric
Automorphic Pneumatic structure
Solar-powered CAES
Micro/Macro Sensing Network
Integrative Aesthetics

NEED
Autonomy & Interdependence
Adaptive
Autonomous Performance
Sensitive
Integrative
Sustainable
***AAPSIS* Telemedicine Unit**

TASKS
Modeling & Simulation
Integrated hardware/software system
Human response model
Model-based computer control
Dynamic predictive resource manager
Integrated sensor/actuator network
Communication Network
Energy storage/recovery system
Multi-paradigm simulations

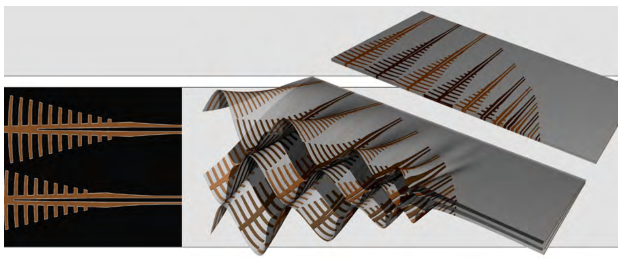

Fig 1. Laminated bi-polymer membranes

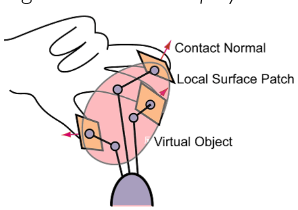

Fig 2. Haptic technologies

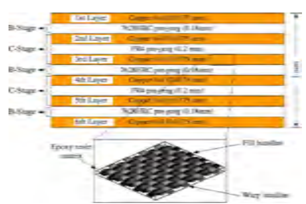

Fig 3. Woven circuit-board

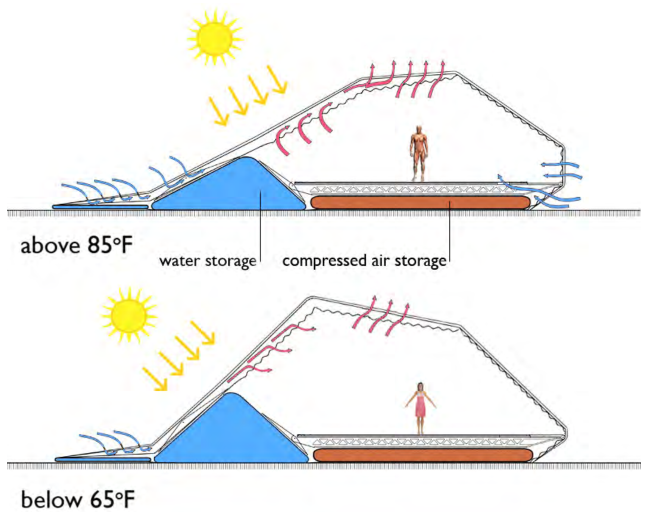

Fig 5. Hypothetical pneumatic structure: transverse sections

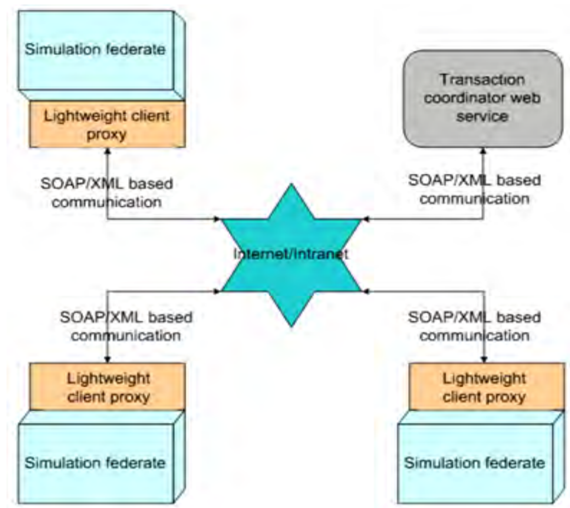

Fig 7. Web services for distributed simulation

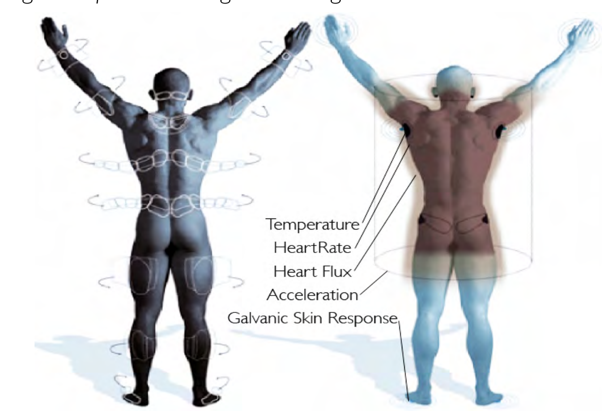

Fig 4. Body-sensing map

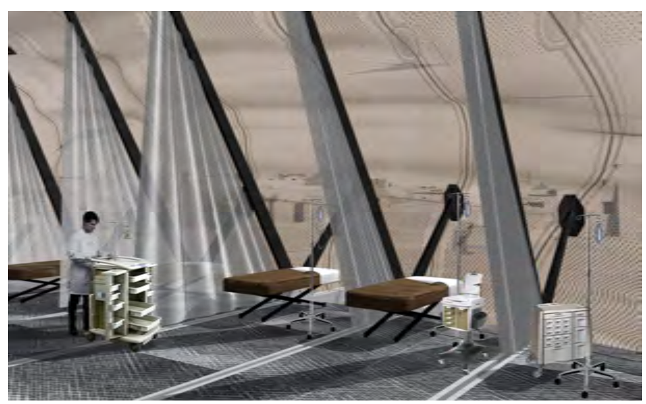

Fig 6. Hypothetical pneumatic structure: interior view

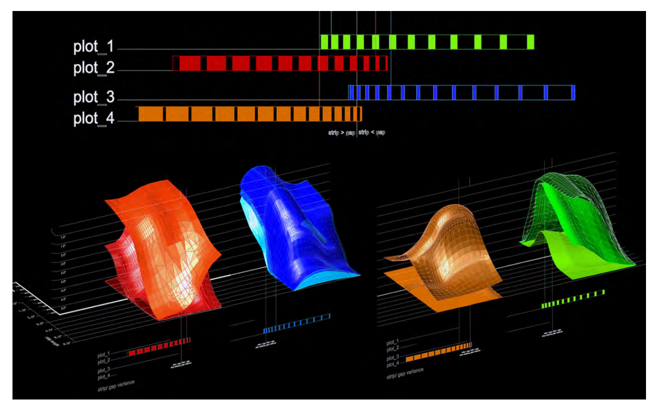

Fig 8. Model composite of membrane morphologies

THE UNIVERSITY OF ARIZONA

FY11 FUNDING REQUEST / PROGRAM TITLE

Adaptive Autonomous Integrative Telemedicine Unit for Indian Health Services

REQUEST	BILL	AGENCY/ACCOUNT
$1,200,000		

SUMMARY of project and request (2 sentence maximum)
To design, build and operate an adaptive, autonomous, sensitive and integrative system (AAPSIS) for a Telemedicine Unit based on fundamental scientific, engineering, technical, aesthetic, social and cultural principles to serve the native American communities.

BACKGROUND & PROGRAM

1. GRANT?

Did you seek a competitive grant award? **Yes**

If so, from where, and what was the result? ***NSF/EFRI: Science in Energy and Environmental Design, Preliminary Proposal submitted 09/13/2009. Fund requested mostly for personnel support.***

If not, why not?

Has this project ever been submitted for an earmark before? **No** When? dd/mm/0000

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2. CONTEXT, NEED, PROGRAM SOLUTION
PLEASE NOTE: in this section, we need a description of specific deliverables or milestones reached previously as a result of funding for each year the project received federal funding.

What need does the program fix? ***Native American populations have urgent need and limited access to health care. The University of Arizona's Telemedicine program is an efficient means of delivering clinical, diagnostic and continuing education for the Indian Health Services system. However, the current telemedicine systems lack facilities that can adapt to variable physiographical settings and functional needs, that are culturally sensitive and user-friendly, and that have sufficient autonomy in off-grid remote locations.***

What specifically will result from funding? ***Integrative design and construction of an efficient and competent Telemedicine Unit with the following attributes: (1) Adaptive to variable programmatic needs, climatic conditions, and cultural settings; (2) Autonomous, self-sufficient of energy and resources in off-grid remote locations; (3) Sensitive to human physiology, material propensities, and environmental factors; (4) Integrative of aesthetic socio-cultural, and ecological systems; and, (5) Sustainable prospect of use and regeneration of natural resources — air, water, light, energy and land.***

Why is this program important to the Nation? ***In addition to its specific programmatic use as a Telemedicine Unit, the autonomous adaptive pneumatic sustainable structure could also serve as a prototype light-weight portable building for use by federal agencies dealing with disaster mitigation, preparedness, response and recovery planning in cases of national and international emergencies and natural disasters. Its technological and ecological innovations could also be effectively transferred to the prefabricated and mobile home building industry sectors.***

What will the local impact be for the state of Arizona, Tucson, etc. ***The Tohono O'odham Nation population exceeds 28,000 members with approximately 24,000 residing on the TON reservation. The TON reservation is predominantly rural and very isolated which greatly hinders economic development. TON's population has one of the highest rates of unemployment in the U.S. The economically depressed environment has also resulted in some of the highest disease burdens in the U.S., particularly diabetes and alcoholism. The Arizona Telemedicine Program was founded by the Arizona legislature in 1996. To date, over 1,000,000 teleconsultations have been conducted resulting in enhanced clinical care for Arizona's population. The initial 8 vanguard sites have expanded to over 100 sites statewide. The principles derived from this telemedicine building will be transferable to numerous IHS renovation projects and other medical facilities.***

FUNDING HISTORY & REQUEST

1. FUNDING REQUEST and BREAKDOWN:
Itemization of the following components is required, and should add up to the total funding request.

Personnel	**$ 100,000**
Equipment	**$1,000,000**
Operations	**$ 100,000**

2. COST SHARING OR OTHER RELEVANT FINANCIAL INFORMATION

Matching funds	$ **NA**

PLEASE NOTE: Many agencies now require 25 – 50% matching funds and source information.

3. How many new jobs will this request create?
Several jobs will be created in Sells, AZ (capital of the Tohono O'odham Nation) resulting from green technologies and sustainable building innovations.

INSTITUTIONAL / TEAM UNIQUENESS

Name	Department	Expertise
E. Brody	Medicine	Clinical Services/Native American Cardiology
P.A. Deymier	Material Sciences Engineering	Materials, Energy Storage, Sustainability
S. Dickinson	Architecture	Building Information Modeling (BIM)
E. Enikov	Aero. Mechanical Engineering	Sensors and sensor networks
S. Fryberg	Psychology	Cultural and Social Psychology
A.M. López	Medicine	Telemedicine
Á. Malo	Architecture	Emerging Materials Technologies in Architecture
M. A. Peterson	Psychology	Cognition and Neural Systems
Y.J. Son	Systems Industrial Engineering	Model-based multiparadigm simulations

1. UA INSTITUTIONAL STRENGTH How is the UA uniquely qualified in your research area?
Interdisciplinary holistic approach in terms of architectural design, renewable energy, systems engineering , materials and sensing, modeling and simulation, CNC fabrication of material components, telemedicine, psychology and cognitive science.

2. OTHER UNIVERSITY PARTNERS
If any, please explain their willingness to work with their Congressional Delegations.
Arizona Research Institute for Solar Energy (AzRISE): Joseph Simmons, Director; Ardeth Barnhart, Co-Director — strong willingness to work with Congressional Delegations.

Key points of contact at partner Universities, including federal relations contact, if known. NA

1. Joseph Simmons, simmonsj@email.arizona.edu	3.
2. Ardeth Barnhart, ardethb@email.arizona.edu	4.

3. INDUSTRY PARTNERS Key points of contact in industry, if known.

1. **FTL Design Engineering Studio**	3.
2. **Buro Happold Consulting Engineers/Los Angeles**	4.

SUPPORT

1. FEDERAL SUPPORT (*mandatory and vitally important to the success of your request)*
AT LEAST ONE NAME (AND FULL CONTACT INFORMATION) IS REQUIRED for a supporter(s) within a federal agency who is knowledgeable about your project, need, and/or UA capabilities.

1. **Indian Health Services**	contact: **Dorothy Dupree, MBA, IHS/TUC Director** dorothy.dupree@ihs.gov

2. COMMUNITY SUPPORT (*mandatory and vitally important to the success of your request)*
AT LEAST TWO NAMES (AND FULL CONTACT INFORMATION) IS REQUIRED for supporters within the community who are knowledgeable about your project, need, and will be willing to write a letter of support.

1. **Tohono O'odham Nation**	contact: **Isidro Lopez, Vice-Chairman TON**
2. **Sells Indian Hospital**	contact: **Priscilla Whitemore, CEO**

3. INDUSTRY PARTNERS Key points of contact in industry, if known.

1. **Nick Goldsmith** (FTL) ngoldsmith@ftlstudio.com	3.
2. **Tom Reiner (**Buro Happold) Tom.Reiner@BuroHappold.com	4.

THE UNIVERSITY OF ARIZONA

UA INTERNAL: CASE FOR UA PRIORITY **NOTE: 2 pages maximum!**

1. PI Contact information including cell phone numbers.

1. **Pierre A. Deymier**	Email: **deymier@email.arizona.edu**
Tel: **(520) 621-6080**	Cell: **(520) 360-0290**

2. PI's travel availability March – May 2010 for travel to Washington DC.

Not available April 18-23

3. How is this project relevant to the UA Strategic Plan or Mission?
This is a project under the auspices of the School of Sustainable Engineered Systems (SSES). The School of Sustainable Engineered Systems (SSES) was formed as part of the University of Arizona's Transformation Initiative as the union of five founding departments in the College of Engineering, namely, Chemical and Environmental Engineering, Civil Engineering and Engineering Mechanics, Materials Science and Engineering, Mining and Geological Engineering, and Systems and Industrial Engineering. The School of Sustainable Engineered Systems' vision is to become a leader in the improved design of linkages between our natural and engineered systems to sustainably provide material resources, water, energy, infrastructure, and manufactured products through innovative education, research, and outreach.
This project is an important part of a coherent strategic plan to develop synergies that will address some of the most importance challenges of the 21st century in Sustainability and the Environment. The project is an example of the vision of SSES in proposing creative sustainable solutions to current problems which will impact and influence the basic human and societal needs in energy and environment, water, manufacturing, transportation and infrastructure.

4. Enhancement to a current UA strength or future strength.
This project is of great importance to the University of Arizona's initiatives in the Environment and Sustainability. In particular it falls into the areas of Sustainable Built Environments, Renewable Energy and Energy Storage, Adaptive Engineering Strategies for Climate Change. Through scientific, engineering and technical discovery this project proposes to build a sustainable energy efficient culturally competent telemedicine building that will serve the native American communities in Southern Arizona and beyond.

5. UA intercollegiate collaboration. ***The following colleges and programs, represented by teams of senior and junior faculty and graduate students, will participate in the program: Architecture, Engineering (Aerospace & Mechanical, Materials Science, Systems Industrial), Medicine (Telemedicine), and Science (Cognitive, Psychology).***

APPENDIX I: student papers

Cone of Vision

Glass Lenses and Conical Columns

Ben McDonald, University of Arizona

Let it be hypothesized that straight lines drawn out from the eye travel a distance of large magnitudes, and that the figure enclosed by the sight-lines is a cone having its vertex at the eye and its base at the limits of the things seen...

Euclid[1]

1. The visual sense

Embedded in Euclid's geometric analysis of vision is the logic that we are able to see things in the world because our eyes emit light rays spread out to sense material objects. The idea that our eyes actively participate in vision, though long ago superseded by Kepler's optical mechanics, remains a provocative statement.

Can architecture participate in vision? It is worth considering architecture as the first eye - first, material senses light; then we sense material. Perhaps the path of light in an architectural space can capture the same primitive geometry that Euclid diagrammed in his geometry of vision (Figure 1)? How could this space allow us to sense a representation of the process of our observation?

This study examines a direct method for merging light and structure based on optical experience. A ring of glass, with properties similar to a fresnel lens, focuses light (Figure 3), suggesting the form for a column that follows the light's conical geometry. When the sunlight is overhead, a column surface that would otherwise be in shadow is uniformly illuminated by direct light focused from the glass lens. This kind of interaction is an example of a light-based architecture designed in concert with natural phenomena.

Light Cone, Material Cone

I am trying to find a detail that creates a logic for the relationship between light and architectural form. To begin, this investigation considers a particular phenomena of light - refraction. A simple diagram[1] to be sure, but also how amazing to 'bend' light! Consider refracted light that passes through a convex lens. The convergence of rays pass through the glass and take the form of a cone - a model of the visual cone.

The introduction of a material cone into the detail affects the kind of light we see along the convergence path. The apex of Euclid's visual cone was the eye. In the proposed model, the apex of the cone is a single point of focused light (Figure 2). Though light must travel to the focal point, we can also think, like Euclid, of the apex as a kind of origin from which structure begins.

The material cone captures only a sectional instance of the light. Even minor variations in the geometry of the material cone will produce significantly different results. Different wavelengths of light (Figure 4) will be visible, or not, depending on whether a material surface is there to expose it.

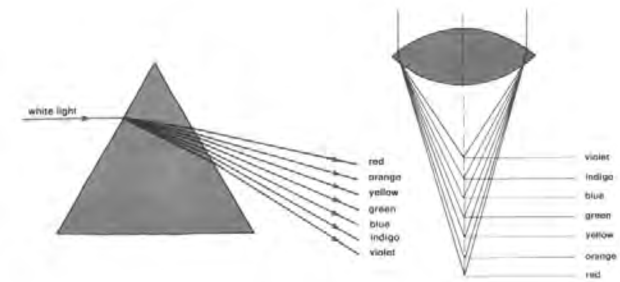
2. Material cone experiment with a prismatic glass torus

3. Fresnel lens behavior of prism torus.

Detail

The cone experiment sets up possibilities for an architectural detail that couples light and form. Both are dependent variables; they depend on each other. By changing the geometry of one of the elements, the other is determined. A process of refining and checking outcomes emerges where the result can be tuned to a high degree of precision.

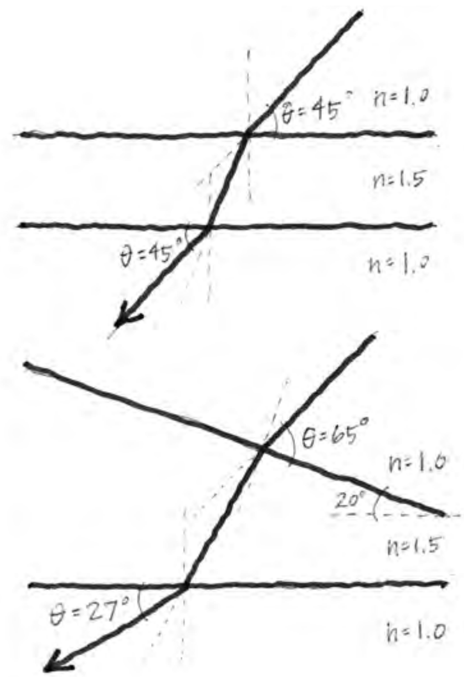
Structure is another factor that will have impact on the range of desirable results. A cone in tension will need to behave differently that a cone in compression. The top of a compressive cone may want to spread out. The bottom of a tensile cone may want to connect at a small point. These forces can be accommodated in the lens/cone relationship.



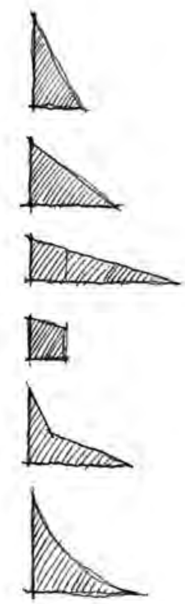
4. Prismatic and lens refraction.

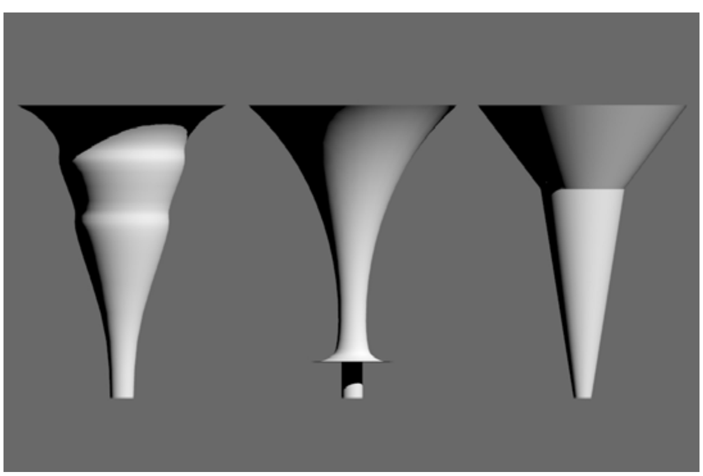
Lens Geometry

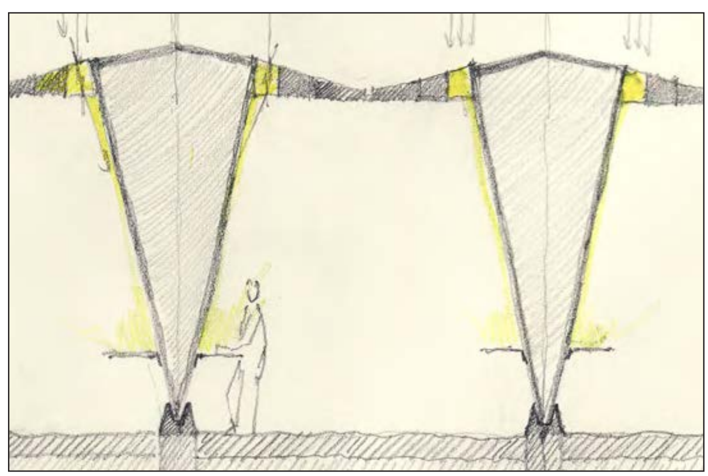
As an outcome, we are most interested in the surface effect of the material cone. Thus, we have no use for the center of the glass lens - only the outer ring (Figure 3). (The result is something very similar to a Fresnel lens which breaks the geometry of a solid lens into a series of smaller sections.) The main characteristic of the lens is its focal length. This determines the overall height of the cone element. Within the focal length, there are many options for shape geometry that affect the form of the cone. A curving slope (like a true convex lens) will have a different column form and light quality than a straight slope. The limiting factor of the lens geometry is determined by Snell's Law (Figure 5). At certain slopes and at specific incident angles, total internal reflection will occur where no light will pass through the bottom of the lens. Another limit of the lens is it's physical size. For my initial experimentation presented here, I have fabricated a 12" diameter solid glass torus. Enlarging this element to the scale of a room is not practical. It is more likely that in actual application the glass would be quite thin, say 3/8", and could be integrated into a typical insulated glass unit for mass fabrication.



5. Application of Snell's Law: $n^1(\sin\theta)^1 = n^2(\sin\theta)^2$.


6. Possible lens sections.

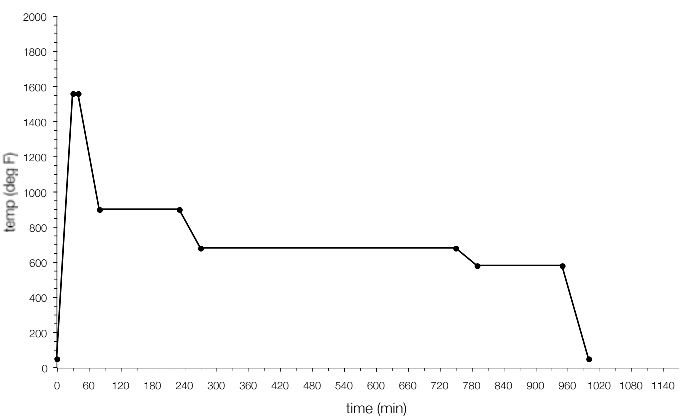

7. Cone geometry studies.


8. Potential use.

Lens Making Process

The fabrication of a glass torus (12" diameter) was required to be able to experiment with the principles of this project. The process began with a computer model of the lens geometry. A CNC router was then used to shape MDF block into the positive shape. Once the MDF was completely sealed with polyurethane, a plaster (50% Hydro Cal, 50% Silica Flour) waste-mold designed to withstand the high temperature of the glass oven was poured into the shape. This plaster will disintegrate with water after the baking, thus allowing the easy removal of the glass. After the plaster dried, glass frit was filled into the negative form and the piece was ready for heat.

The oven temperature is programmed (Figure 9) to rise rapidly to the melting point of glass and then to slowly cool down until the glass can be removed. The controlled cooling (annealing) is a crucial step which allows the glass resolve internal stresses. Once the oven was sufficiently cool, the glass was pulled out and washed to remove any remaining plaster. Finally, the glass required polishing to remove a cloudy texture that was left where it was in contact with the mold.

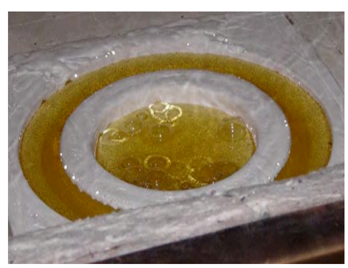


9. Glass annealing schedule.

10. MDF CNC-formed.

11. Plaster mold.

12. Glass frit prior to heating.

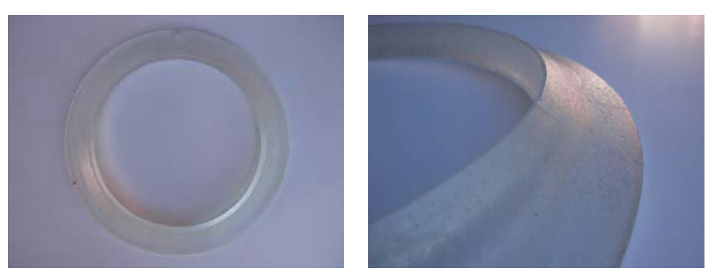


13. Molten glass during annealing process.

14. The waste mold is pulled away from the glass.

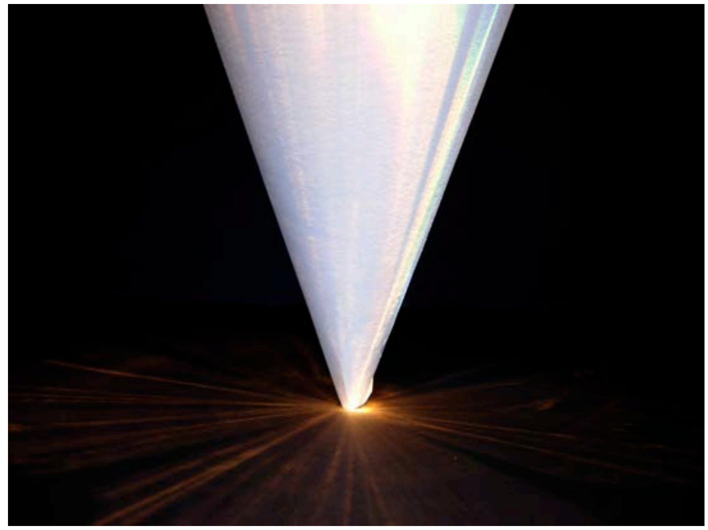
Lens Making Results

The final glass torus came out reasonably well. However, quite a few air bubbles were trapped in the glass. This could be a result of moisture in the plaster releasing during the heating process. Also, polishing the glass to a specular finish requires a lot of effort. It would be good to find a mold material with a much smoother texture than the plaster used here.



15. Final glass lens.

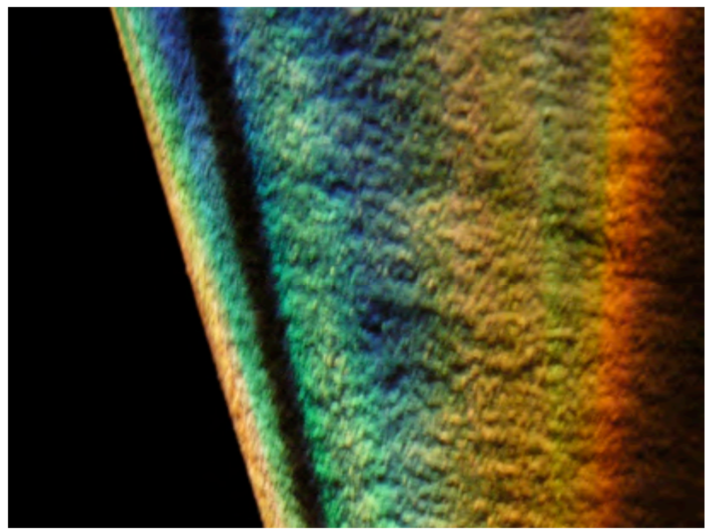
16. Cone of vision.



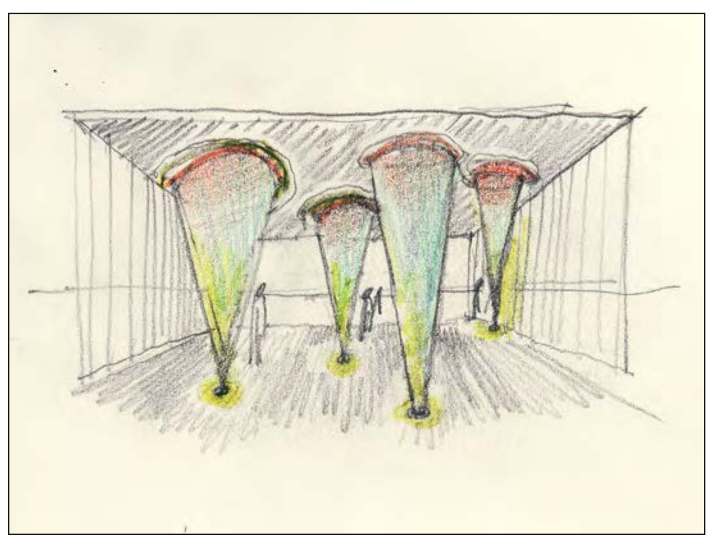
17. Focal point.

Conclusion/Speculation

With the cast glass lens, I was finally able to start testing its behavior with light. When placed under the sun using white paper for the cone, some very interesting prismatic effects occurred (Figure 18). The revealing of the textural quality of the paper is also striking. Future studies on the material of the cone can respond to this unique condition of light delicately grazing its surface. Additionally, the duration of this unique light quality is limited. It will be necessary to consider how the lens will orient to the sun at a particular time of day or day of year - and then to consider what effect is desired for all the other times of day. It is also possible that in a space with multiple columns, each cone could be designed to illuminate at different times of day, forming a kind of light clock.



18. Revealing of texture.



19. Multiple cones.

NOTE: Paper written for ARC 561i - Materials: Properties & Tests, Prof. Alvaro Malo

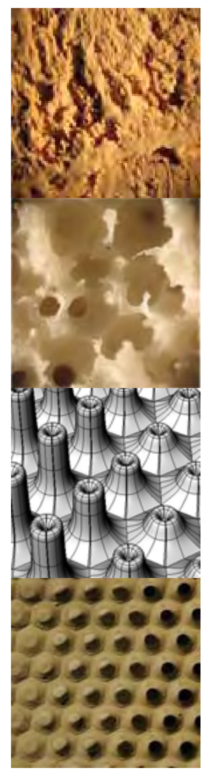
ARC 561i
Materials Properties & Tests
Prof. A. Malo
Nov. 15, 2006

Architectural Ceramics and Sound Response: An Emerging Materials Technologies Investigation

By Kelly Winn
In Collaboration with Matt Gindlesparger

Abstract

The methods and explorations discussed in this paper present an alternative means for the production of ceramic materials by introducing porosity through additives to the clay body or through surface geometry to affect acoustical properties. Utilizing the inherent formative properties of clay bodies new processes and techniques of fabrication and rapid prototyping ceramic materials can be utilized in ways that create complex geometries with acoustic properties that can be examined and measured empirically.



Through a process of fabrication and physical modeling we looked to respond to the basic properties of sound in the built environment through material and geometric solutions. Ceramics was the material family that we focused upon hoping to exploit the versatility in methods of forming and molding clay bodies. We explored geometries and shaping logics to affect the qualities of sound diffusion and reflection, while manipulating the porosity of the ceramic to increase sound absorption and insulation. As a result, our exploration took on two dimensions; the first being a geometric sensibility, and the other as a materials investigation into ceramic materials.

Ceramics

We looked to a method of heuristic investigation of ceramics, using a series of probes and experiments to develop desired properties in the material. In order to increase the capacity for sound absorption of ceramics, the investigation took on a more fundamental approach to the nature of the material. Primarily, we looked into slip casting and the mixing of clay bodies as processes of forming ceramics. In slip casting, a porcelain slip is poured into a plaster mold of the desired piece replicating the object in a solid layer of slip that forms on the surface of the plaster. Because of the relative density of the material, slip casting centered on the reflection and diffusion of sound. However, with respect to sound absorption or focus was on adding porosity to the material. Understanding that the green material would eventually be exposed to extreme heat of the kiln environment, adding porosity to the clay body would not be as simple as aerating the mixture. This is because as the clay is heated to thousands of degrees any air in the material will expand rapidly and, as to the dismay of any potter, result in the destruction of the piece. Therefore, it was necessary to find an appropriate additive that would disintegrate during the firing, or create a network of openings in the material. Respectively, adding porosity would undermine the integrity of an already brittle material, and it would be necessary to find an additive to strengthen the material. Initially we experimented with plastic pellets and stereo lithograph objects as additives to a ceramic slip, which resulted in some intricate, but incredibly fragile pieces. These proved to be unrealistic as well as unsuccessful; the clay would shrink as it dried, while the plastic would not, fracturing the piece considerably. Instead, experiments using polyurethane foam, a method already employed in the production of ceramics to create porosity, proved to be more successful at creating a complex and porous structure.[1] [see figures 1.1-1.2] While other experiments with fiberglass and carbon fiber additives in a clay body produced surprising results as well. We had hoped that the fiber would survive the firing process creating a reinforcing microstructure. Instead, the fibers were disintegrated or absorbed by the ceramic. Surprisingly, this resulted in another type of porosity leaving hollow tubes in the fired ceramic. [see figures 2.1-2.2]

Fig. 1.1 polyurethane foam

Fig. 1.2 fired ceramic from polyurethane foam

Fig. 2.1 fiberglass in clay unfired.

Fig. 2.2 fiberglass in clay fired.

Sound and Ceramic

In consideration for sound resolution through geometry, as in most architectural acoustics, it was important to dramatically increase surface area. Typically, architectural sound diffusers utilize high relief usually through a series of standard grooves in panel form, as in corrugated steel, installed as a wall treatment[2]. This results in a material that affects sound in the same manner across the entire surface. Rather than dealing with acoustics in such a general manner we looked to develop a means for the production of a gradation of relief and depressions across an expansive surface.

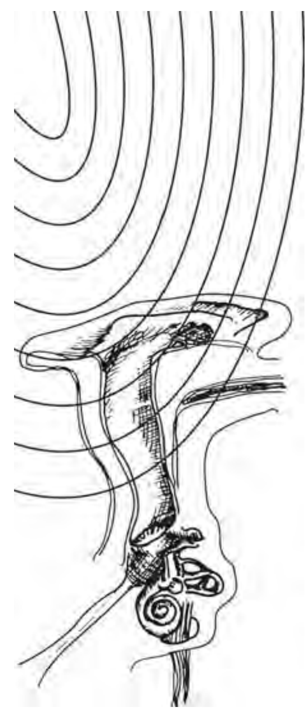


Fig. 3 sound waves and ear canal

In order to create a diffusion of sound it was necessary to explore possible methods for the forming of complex geometries in a ceramic that could potentially provide an acoustical solution. In order to create an even surface gradient we worked with a hexagonal array rather than longitudinal grooves. First, we developed our surface pockets in section. The geometry was developed to reflect sound at varying intervals and wide angles based on the angles of reflection of curved surfaces [see figure 4] [3].

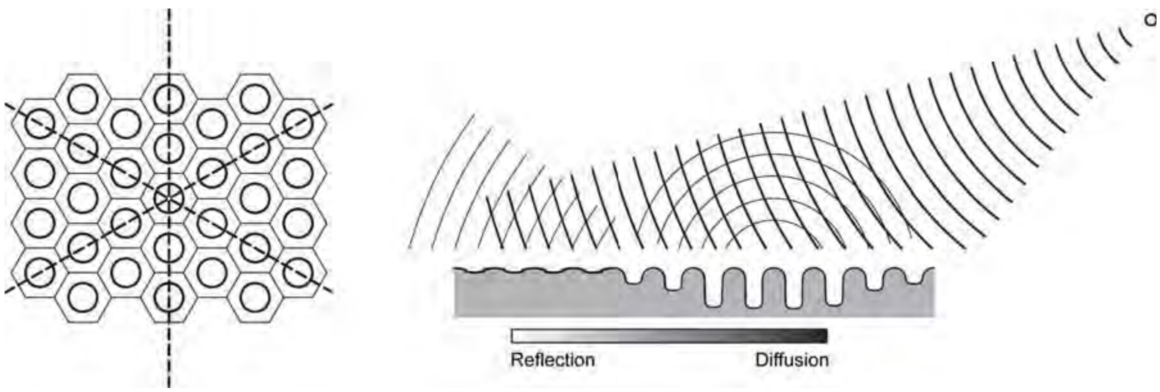
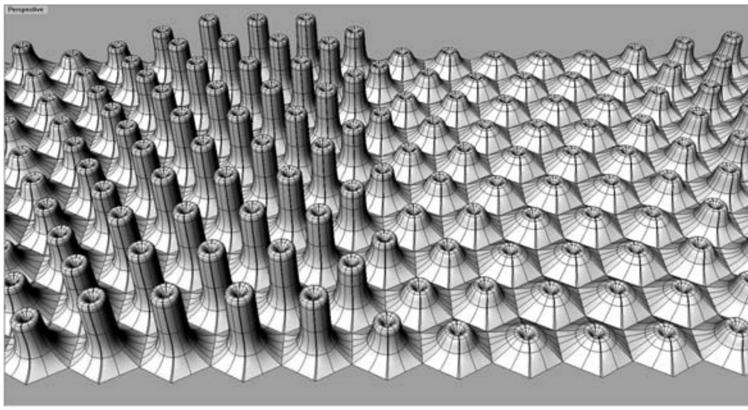


Fig. 4

We looked to digital design and rapid prototyping techniques as a means to design and fabricate complex geometries that could be tuned across a surface in order to create variations in sound performance[4]. We developed a simple hexagonal array of coffers varying in depth in order to create sound diffusion. Unlike sound absorption diffusion reflects sound at intervals in order to create depth in the sound produced. This adds richness to the experience of sound rather than eliminating it as in absorption[5]. We intended to develop a methodology in which the versatility of the computer was directly translated into a material solution.

In this respect, rapid prototyping and CNC [computer numerically controlled] machining were used in the prototyping and form generation process. The visualization of those geometries was then developed using three dimensional computer modeling in Rhinoceros 3.0 software [see figure 5.1] and then transferred to the CNC router.



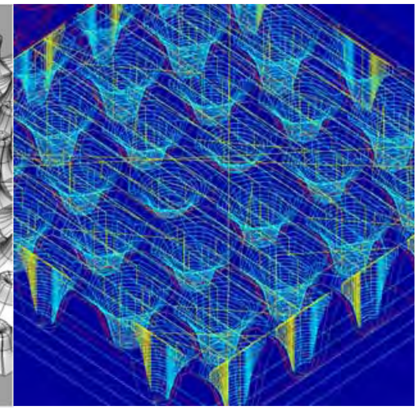


Fig. 5.1 3D model of casting surface in Rhino

Fig. 5.2 Mastercam tool paths

In order to successfully translate form into a ceramic piece the forms produced needed to be easily molded and more importantly de-molded. Even in the early stages of experimentation with ceramic slip it was obvious that the release of the slip cast piece from the mold was a major concern, and would need to be a driving factor in the design and production of geometries. In this case, the three axis CNC router proved to be an effective solution for producing surfaces that would easily release from the mold. Since all the cuts inscribed by the router would automatically be oriented vertically as a result of the orientation of the drill bit, there would be no issues with the casting attaching to the surface of the mold. Additionally, the use of a round drill bit could prevent any undesirable surface edges.

Our explorations into ceramics and rapid prototyping became a production series of molds in order to ultimately slip cast the desired form. First our sound object was developed digitally using 3D modeling and then milled in wood on the CNC router using Mastercam software [see figure 5.2]. This allowed us to produce a great deal of precision in form. Next a soft mold for our diffuser was formed in rubber using our routed model. This allowed us to accurately cast concrete and plaster forms. Concrete was used as an alternate to ceramics during development to avoid the firing process, while plaster was used to make molds for the clay slip casting. We developed our geometry in several different scales of arrays in order affect different wave lengths of sound. A dense patterning of pockets in panel form was designed for shorter wavelengths and at a larger scale in block form for longer wavelengths. The rubber casting surface and the concrete cast panel can be seen in figures 6.1 and 6.2.

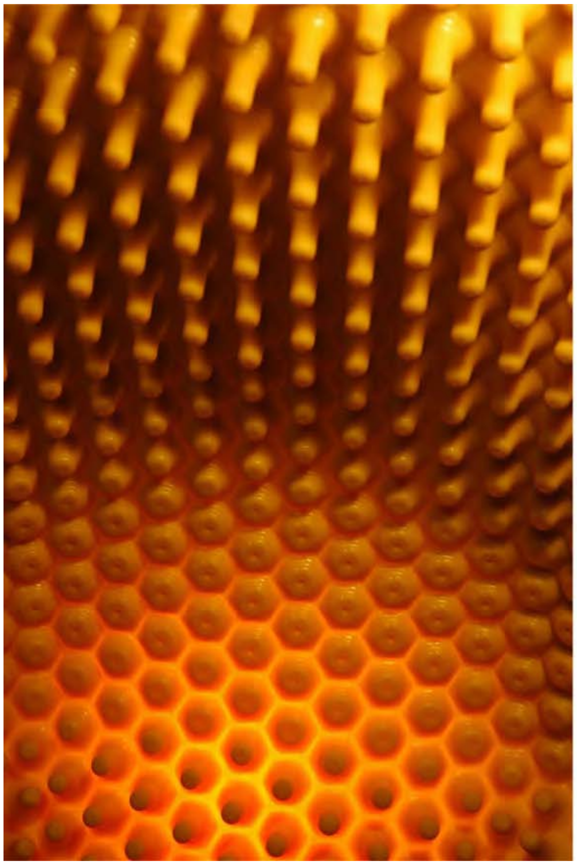


Fig. 6.1 rubber casting surface

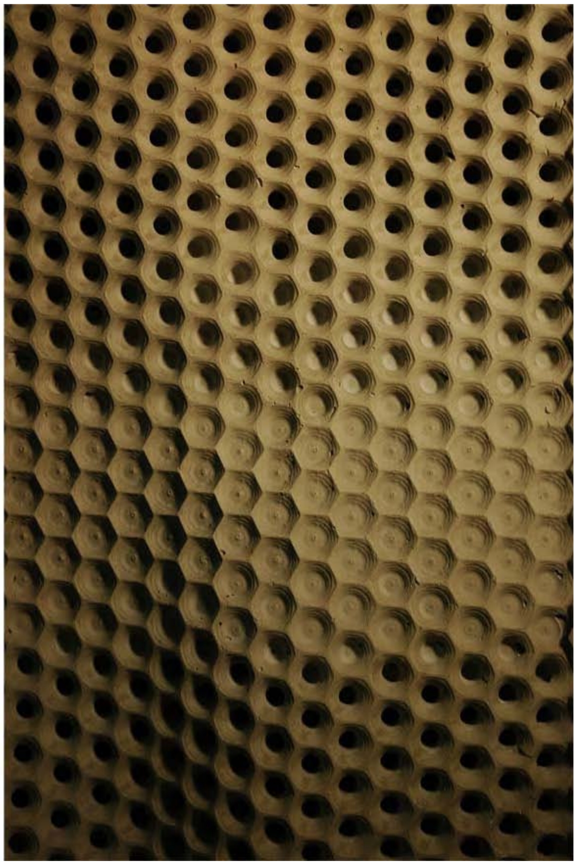


Fig. 6.2 concreter diffuser

Once the negative was produced in plaster, then a slip casting could be performed creating the geometry in ceramic. The pocketing of the block was mirrored so that once it was slip cast in terra cotta the resulting piece would be hollow. This becomes an advantage as an architectural component in several applications. Concrete could be poured to create a rigid wall and add mass or systems could be run through a wall of the hollow blocks. The full slip casting process can be seen in figures 7.1-7.8.

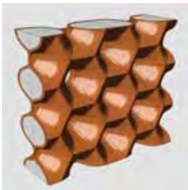


Fig. 7.1 3D model

Fig. 7.2 CNC router

Fig. 7.3 rubber mold

Fig. 7.4 plaster mold

Fig. 7.5 mixing slip

Fig. 7.6 pouring slip from plaster

Fig. 7.7 slip cast plaster mold

Fig. 7.8 finished module

Ultimately, we found that ever step throughout the process became valuable, and whenever we made a mold for something significant, something significant was produced. The rubber mold for the concrete sound panel took on an entirely new meaning as an ergonomic surface. Rather than a random patterning of pockets as in the sound panel, the pockets could be developed to respond to the human body. This allowed us to develop a molded surface in rubber that could interface with the human body with a sensibility to human comfort that the concrete or ceramic could not. The result proved to be testament to the iterative process of mold making, in which a design for a concrete sound wall could produce a rubber soft wall. In this sense, we were able to develop something independent of our original concept that was equally of interest. A simple shift in materials essentially created new possibilities for design. The soft wall could be applied to a wall surface, or just as easily fitted to the surface of a chair. Moreover, the soft surface because of the durability of the rubber could be put to use as a mold for concrete panels, and then utilized as an ergonomic skin when not in use. Similarly to the sound wall the soft wall could respond to scale in a meaningful way, were as the scale of the pockets in the sound wall responds to different wavelengths of sound, the negative in rubber could create a new interface or tactile experience at every different level of scale. [see figures 8.1-8.5]

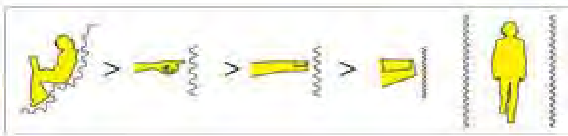


Fig. 8.1 tactile experience of surface qualities.

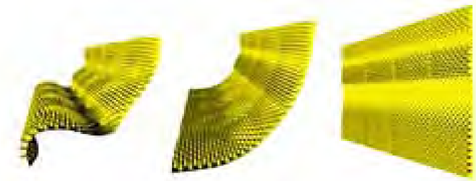


Fig. 8.2 surface from wall to seating.

Fig. 8.3 ergonomic chair.

Fig. 8.4

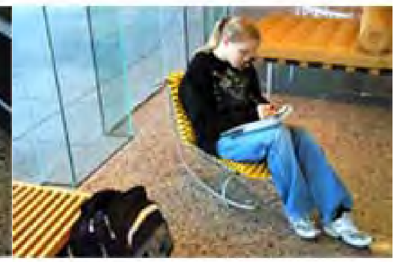


Fig. 8.5

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[1] Antonelli, Paola. Mutant Materials in Contemporary Design. New York : Museum of Modern Art, 1995. pg. 48

[2] Everest, F. Alton. The Master Handbook of Acoustics: Second Edition. Pennsylvania: Tab Books Inc., 1989. pgs. 217-235

[3] Schaudinischky, L. H. Sound, Man and Building. London: Applied Science Publishers LTD, 1976. pgs. 39-47

[4] Kolarevic, Branko. Architecture in the Digital Age : Design and Manufacturing. New York, NY: Spon Press, 2003.

[5] Charles M. Salter Associates Inc. Acoustics. San Francisco: William Stout Publishers, 1998. pgs. 78-79

Images provided by Kelly winn

IN
Compression / *modeling with glass*

Brent Vander Werf, University of Arizona

...smooth space is constantly being translated, transversed into a sriated space; striated space is constantly being reversed, returned to a smooth space. In the first case, one organizes even the desert; in the second, the desert gains and grows; and the two can happen simultaneously.

Gilles Deleuze, A Thousand Plateaus [1]

The masterwork is unknown; only the work is known, knowable...The work is made of forms, the masterwork is a formless fount of forms, the work is made of time, the masterwork is the source of times, the work is a confident chord, the masterwork trembles with noise...

Michel Serres, Genesis [2]

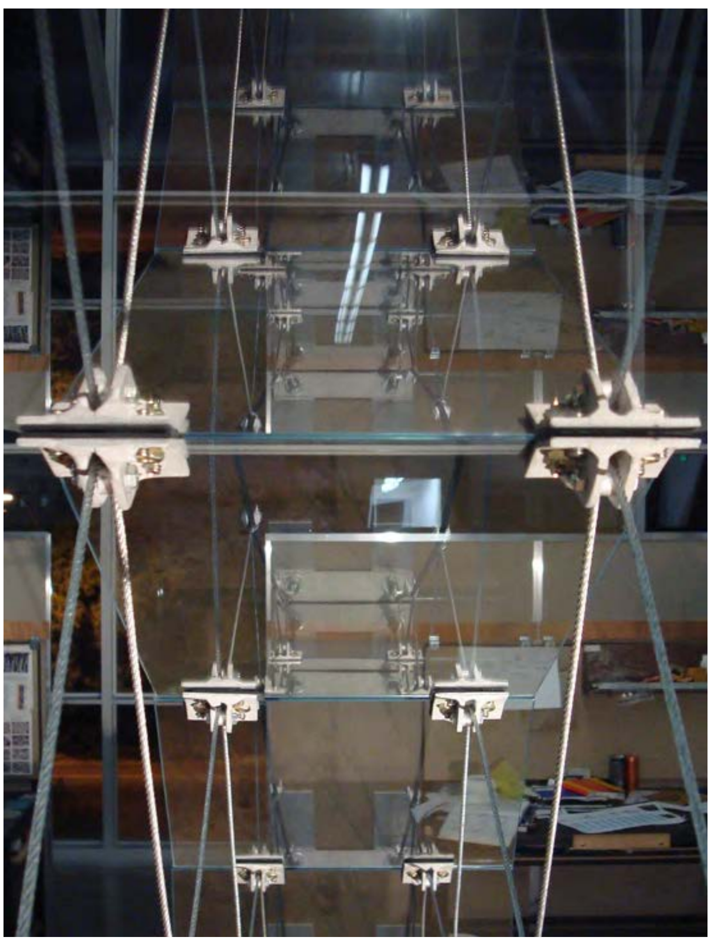


Figure 1: Specular reflection / glass arch

Abstract:

This study is a brief introduction to the chemical, mechanical and optical properties of glass and the relevant empirical and mathematical objectives related to the act of modeling. Modeling is defined and analyzed in regards to structural, factural and tectonic modes which organize the relationship between materials and forces through smooth ~ inductive, and striated ~ deductive methodologies . Finally, a protoype of a systematic and iconic model of a glass arch is physically constructed and defined as an example to validate the physical limits of glass in compression and give proof of it's own reality.

Glass /

Formation Properties:

Glass as a material is an amorphous solid-state composition of highly organized crystal formations of infinite viscosity. Before glass can be typified as such, the elements inherent to the material must be precisely organized and processed. Silicon dioxide is the most abundant chemical compound in glass, however, by itself, silicon dioxide cannot produce glass. Impurities such as calcium oxide, sodium oxide, magnesium oxide and aluminum oxide are needed in minimal percentages in relationship to the whole to interfere with the formation of the quartz crystalline structure, bonding the various elements into highly organized polyhedral geometries (Figure 2).

The process by which the bonding of crystal occurs involves a great deal of heat, between 800-1200 degrees Celsius. Through the heating process the elements are turned from a solid particles to a plastic viscous state and finally a liquid state. The liquid state is maintained until the molten elements are cooled below the critical temperature. The critical temperature refers to a precise quantifiable measurement upon which the heat loss experienced within the liquid causes the atoms to become extremely excited, bouncing one atom off another continuously and repeatedly until eventually the atoms stick to each other, organizing themselves into a geometric amorphous isotropy [3].

This explanatory process of cooling can be classified as annealing, a slow method of cooling. Quenching is another term used frequently in glass manufacturing to identify a liquid which is cooled quickly, altering the formation of bonding crystals as the atoms are forced to align faster.

Structural Properties:

Sheets of glass are typically formed utilizing a twentieth century technique known as the float glass process. Float glass creates flat surfaces by rolling molten glass as the annealing process is underway. The resultant annealed glass is optically pure, however the structural characteristics of the material are minimal and any surface crack or tensile stress placed on the glass will shatter it into large sharp shards. Griffith Flaws is the technical term to identify inherent cracks along the surface of the glass and over time these penetrations can migrate deeper and deeper into the brittle tensile cross-section of the material until failure occurs (Figure 3).

The reason for failure is based on the separation of crystal molecules by means of an external force which is exerted on the brittle inner tensile layer of glass. The

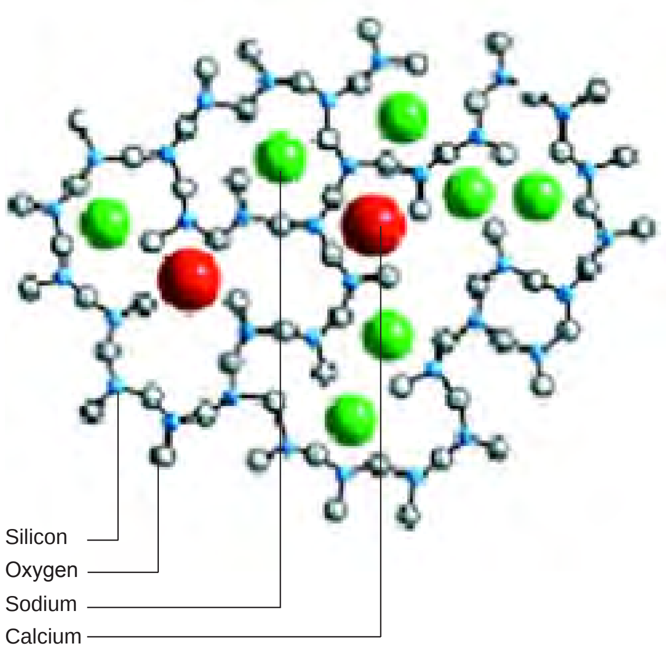


Figure 2: Molecular composite of glass crystal

load thus causes the force to transfer through the crack continuously rather then dispersing the force along the compressive surface of the material. The ability to strengthen annealed glass based on these failure principles lead to a hardening process known as tempering.

Tempering is achieved by heating an annealed piece of glass to around 650 degrees Celsius, upon which the glass becomes malleable. At this point, the glass is rapidly cooled again, causing the exterior layers of glass to cool faster then the interior layers, producing an increased thickness of compressive force along the surface of the glass and a tensile force within the interior. The compressive force exerted on the surface of the tempered glass thus compresses the Griffith Flaws which were present, creating cracks of much smaller and much less obtrusive size. The resultant glass is strengthened significantly and specifically to resist compressive forces. Tensile forces exerted on the glass still causes the glass to fail catastrophically, however the failure of tempered glass is much less dangerous as it breaks into thousands of small, non-sharp pieces, allowing tempered glass to be used as a translucent safety material [5].

Beyond annealed and tempered glass, sheets of annealed glass can also be laminated to one another by means of a thin filmed polymer to further strengthen a system of glass. Poly-vinyl butyral (PVB) is often used to bond sheets of glass to each other without sacrificing optical properties. The advantages of laminated glass are that it provides additional redundancy of safety and structural characteristics [4].

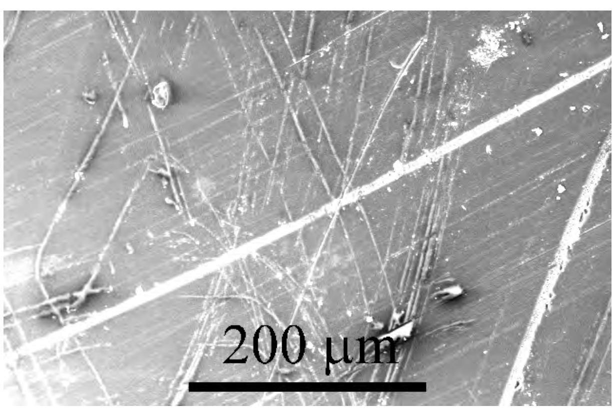


Figure 3: Griffith Flaws on Glass sheet, University of Cambridge [5]

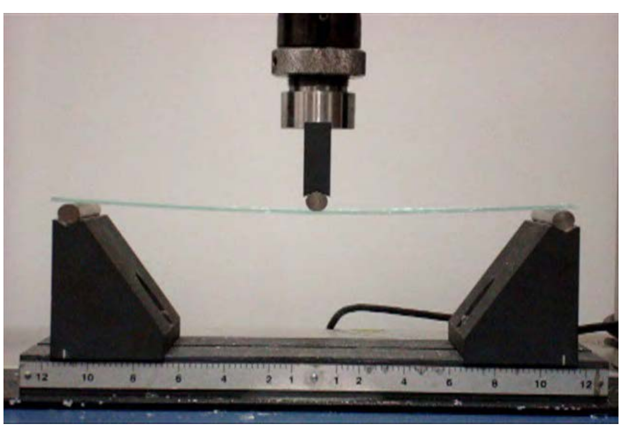


Figure 4: Flexure test - 1/8” annealed glass

Optical Properties:

Optics can be classified simply as the study of light and vision and the function of glass as an optical translucent material provides a congruent relationship. Light, as a property, is understood as variations of wavelengths upon which the human eye absorbs frequency from 400 to 700 nanometers in length. Light extends beyond this frequency range to infrared light as well as below the range to ultraviolet light, however for the human visual spectrum, these characteristics are negligible (Figure 5).

When light strikes a material several inherent characteristics occur, including: reflection, refraction, diffusion and scattering. Each exchange of light from a source, through a material, such as refraction, results in heat lost and spectral scattering, diminishing the wavelength of the light based on the properties of the material and its associated index of refraction.

Glass as a material is specified with an average refractive index of 1.5, meaning that the speed of light is reduced by 1/1.5 = 0.67 times the speed in air or a vacuum. This number not only specifies how the wavelengths of visible light change speed within glass but also is crucial to the optical properties of Total Internal Reflection (TIR).

TIR of glass occurs at the critical angle from glass to air at an angle of 41.8 degrees. At the critical angle, light is refracted from the initial glass surface through the glass structure until it reaches the opposite side, upon which the light refracts at an angle equal to the incident angle (41.8 degrees) and continues the process so much so as the interior surface is free of aberrations and parallel to the initial surface (Figure 6). Decay will occur as the refractive index changes between materials or as the surface quality within the material changes. In addition, the direct shape of the glass will continuously alter the refraction of light waves and makes it possible to change the magnification of objects through a glass material while maintaining the same light amplification.

Many of the optical characteristics of glass are being utilized in the astronomical field as well as in advanced visual correction devices, art and entertainment. For this study, optics is not a primary mode or method for modeling but rather a phenomenal force to be realized as natural and articficial light interacts with the glass structure (Figure 1).

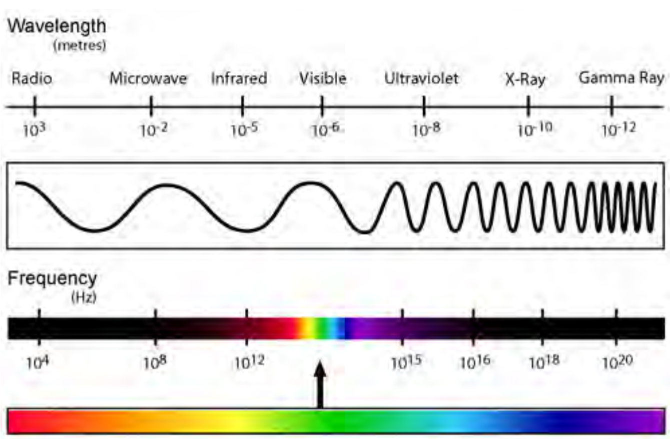


Figure 5: Electromagnetic Spectrum

Figure 6: Example of TIR

Figure 7: Gustave Eiffel's Garabit Viaduct - Cantal, France 1884

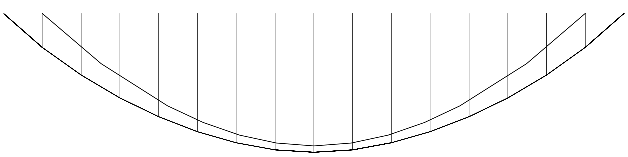


Figure 8: Catenary and parabolic analysis

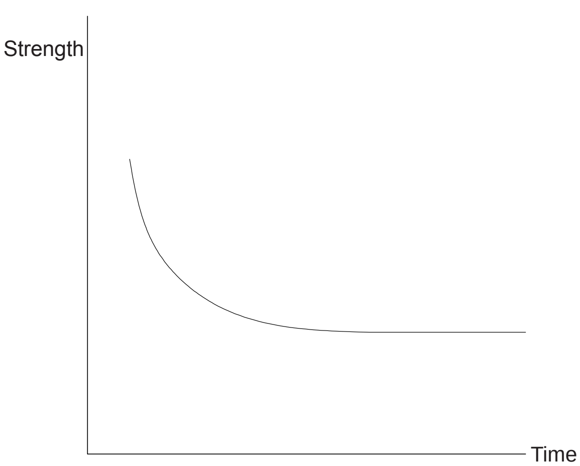


Figure 9: Glass strength and load duration [4]

Glass / Modeling

Structural:

To model with a material is to model with the forces and the resultant form should always follow forces as the genetics of the material are organized "in tension", or for glass, "in compression". Glass is unique as a structural material in so much that its compressive strength is believed to be around 21,000 N/mm^2, versus its tensile stress failure at less than 100 N/mm^2 [4].
The measurable stress levels relevant to glass failure however is theoretical and inconsistent as each individual piece owns particular surface flaws and variable duration of load. For example, the testing of compression forces on glass is impossible to measure completely as the testing procedure, over a period of time, always puts a tensile stress on part of the sample causing the glass to fail, thus diminishing the validity of the materials yield compressive strength, not saying that it could be lower but rather much greater (Figure 9).

How then can the structural modeling of glass minimize the tensile stress exerted on glass while the compressive force is evenly distributed throughout the materials surface area?

Static models are always in a state of equilibrium as the forces are balanced by the particular design of loads and reactions. An arch is an example of a structure in which the specific delineation of stresses is localized to particular members within the system based on uniform and or concentrated loads. The geometry of the arch further demonstrates the inherent static properties and through empirical and mathematical investigation a geometrical curve analysis was utilized to demonstrates the ideal form associated with tension, and therefore compression, ideal to modeling in glass.

Funicular curves are not to be confused with parabolic curves as the two are not the same. The mathematical models of the two curves identifies that a parabolic curve contains a constant quadratic equation to verify the relationship between slope in reference to applied weight and resultant force. The catenary is different as it is never loaded but rather under its own weight, in which the curve length is derived through a calculus derivation based on linear weight density producing a hyperbolic cosine formula (Figure 8). Catenary curves are often investigated initially under controlled empirical investigation upon which a preceding mathematical formula is derived to validate the slope.

A compressive glass arch based on a catenary and parabolic curve analysis was thus initiated and further investigated in regards to factural and tectonic relationships.

Factural:

The compressive capacity of glass as a material established a shaping logic focused on functional characteristics of the arch with a complementary secondary material, steel, to order the tensile forces required for equilibrium. The interplay of these materials is directly and indirectly related to the inherent chemical structuring of each material, glass being amorphous and steel being crystalline.

At this point there was a decision to be made into the structural ordering of these materials and its effect on the overall scheme of the arch. Given that an arch will carry the compressive loads from the keystone down to both reaction points, a high amount of thrust force is concentrated at the bases with an associated horizontal vector. To resolve this force, two options were available: first, a tensile component can be located along the spring line of the arch to pull the bases together, or second, the base conditions can be anchored into a much larger mass, resisting the thrust through additional material. The latter option is often used for bridge construction, while the tensile option is more often used for a building enclosure system were reaction forces on the structure are to be minimized (Figure 7).

To be true to my personal ethics of modeling, a choice was made to resolve the thrust through the first option, utilizing a tensile force to pull the bases together. Furthermore, rather than simply locating this tensile component along the spring line a decision was made to raise the tensile chord up above the spring line to open the span of the arch and work between the geometric analysis of the catenary and parabolic curve.

This then established an arch which contained two chords with an inner tensile net. The upper chord consist of glass in compression (catenary curve), and a lower chord of steel cable in tension (parabolic curve). The steel cable net which is weaved in between the chords was then required to tension the two curves and ultimately keep the glass stressed in compression.

Tectonic:

The tectonic of modeling can be defined as the dynamic synthesis of forces and form between the structural and factural characteristics. Managing the forces and forms through the art of joining thus becomes a poetic welding and understanding of inherent principles and concepts.

The tectonics associated with the glass arch involved three details: a base condition resolving all forces and materials; a compressive glass to glass detail with an integrated tensile net connection; and a tensile steel cable detail connecting the net to the lower chord.

For this model, a sense of lightness was applied to the connections and material cross-section was minimized to demonstrate the forces in action throughout the system.

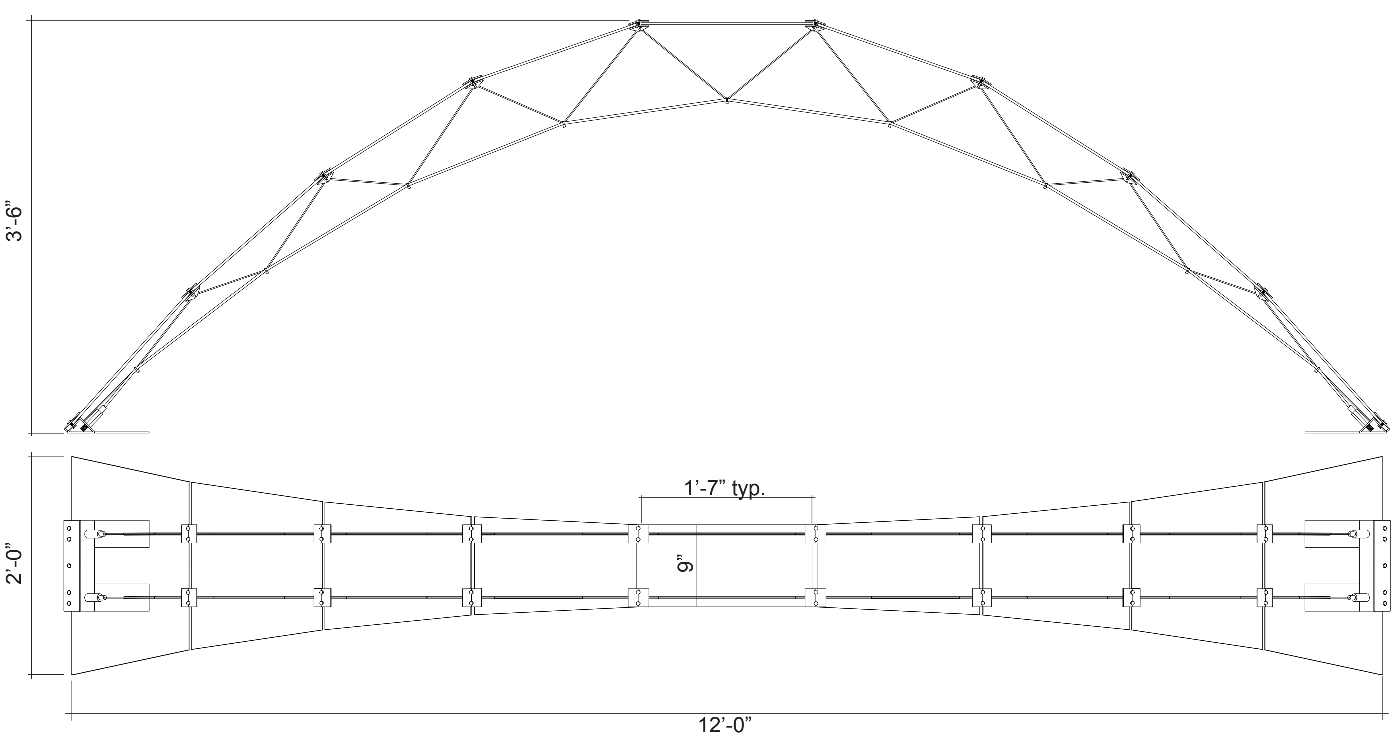


Figure 10: Elevation / Plan

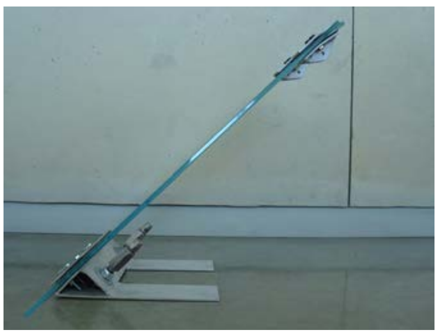
Glass / Prototype

Glass Arch:

A prototype is the physical organization of materials and forces upon which a functional form of a new type is created. The performance of the prototype is required in modeling to fulfill the claim and execution of action within a proto - “first”, type “species”.

The overall form of the glass arch was originally created and evolved digitally, establishing an empirical relationships of the catenary analysis with a mathematical precision of computational drafting templates. The length of the span was restricted by a workbench within the studio at 12’-0”, creating a catenary curve with a maximum depth of 3’-6”. To increase lateral stability within the arch the design of the individual glass pieces were slightly tapered from the base (24”) to the keystone (9”) which in turn derived the limits of the patabolic tensile chord and net below (Figure 10).

Once the design was finalized digitally, physical modeling of the joints and production of the glass was required*. The glass was specified as a 1/4” low-iron float glass which was cut to size by means of a CNC water jet machine. The individual pieces were then flat polished on the edges and later tempered, hardening the compressive layer on the outermost surface of the glass



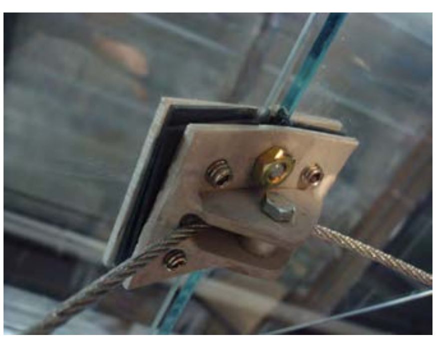


Figure 11: Details

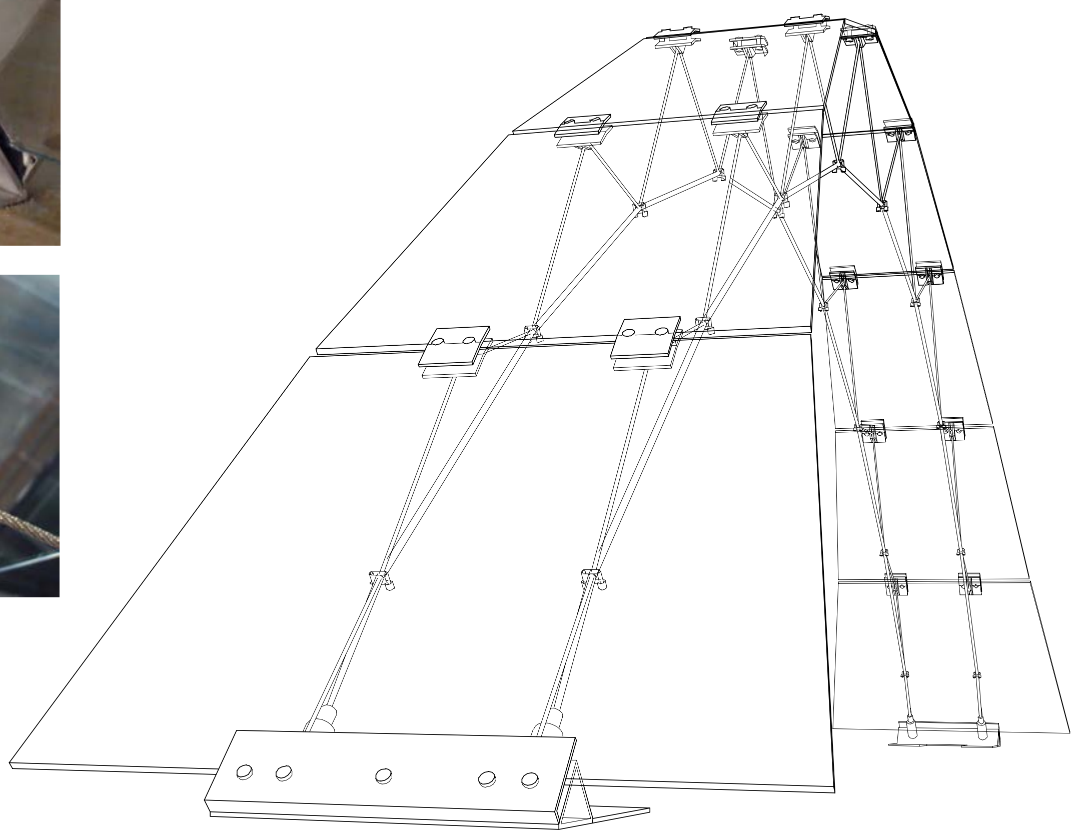


Figure 12: Perspective

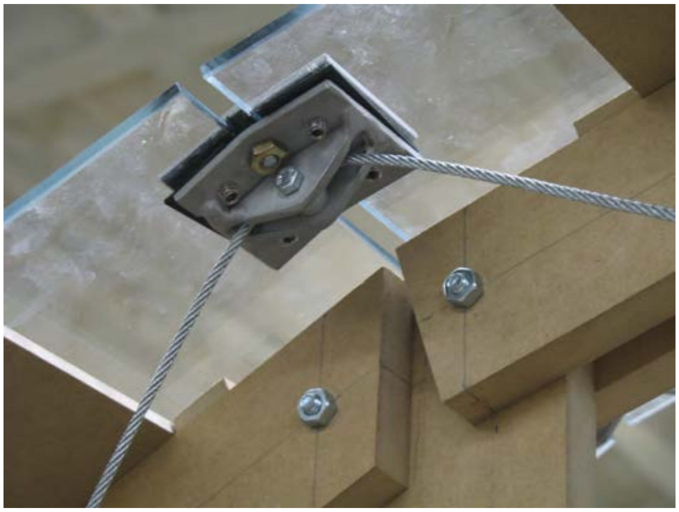


Figure 13: Detail / Scaffolding connection

Figure 14: Erection Sequence

minimizing the probability of stress failures associated with surface flaws.

While the glass was being produced the individual clamping details, base details and tensile steel cable connectors were manufactured. Utilizing the steel manufacturing laboratory at the University of Arizona's Architecture College, the aluminum alloy pieces were break pressed, drilled, TIG welded and finally sand blasted. 16 glass to glass details and two base details were manufactured over a week's time. The tensile chord connections were ordered online as a self-swage detail and designed to resolve appropriately within the base detail. Additionally, the tensile net connections were pre-ordered as U-clamps to secure the net to the lower chord upon installation. The final designed utilized 1/4" steel cable for the lower chord and 1/8" steel cable for the tensile net (Figure 11).

Once the tectonic details were underway a wood scaffolding for an arch known as "centering" was manufactured. The centering supported the glass from bending forces as the system was being erected from two independent cantilevers to a complete arch. The centering device was created as two half-arches of individual wood pieces which were bolted together to allow for ease of assembly and disassembly. Furthermore, slots were placed within the vertical members to allow the supports to adjust tolerances within the arch up to 1/2" (Figure 13-15).

The erection of the final arch took just under two hours and the post-tensioning of the tensile cables through turnbuckle like connections put the glass in compression and secured the system as a whole.

Figure 15: Elevation

Figure 16: Glass “clamp” detail

Figure 17: Base detail

Evaluation:

The functional aspect of the structure as a whole is an objective evaluation which the model validates in that the ordering and relationships between parts and forces was resolved in equilibrium. There was slight difficulty in properly post-tensioning the arch through the multiple tensile cable, leading to an overall structure which was semi-flexible. This flexure could be alleviated in the future however by adjusting the termination of the steel cable to the base detail and determining the appropriate stress required and applied under the post-tensioning sequence.

The use of the arch is less specific then the function however and is subjective in relationship to an external agenda. The optical, weatherproofing, acoustic and thermal forces are unresolved as the use is particular and undefined. The arch is rather a systematic or instrumental model of physical limits, modeling the glass with the forces.

Finally, there is a unique personal and physical affection that is placed on the object as its maintains the ability to create a free play of the five senses; sight, sound, taste, touch and smell.. The glass arch is thus a systematic model as well as a physiognomic or iconic model upon which the care for the object creates an affective relationship, further increasing the models validity of action.

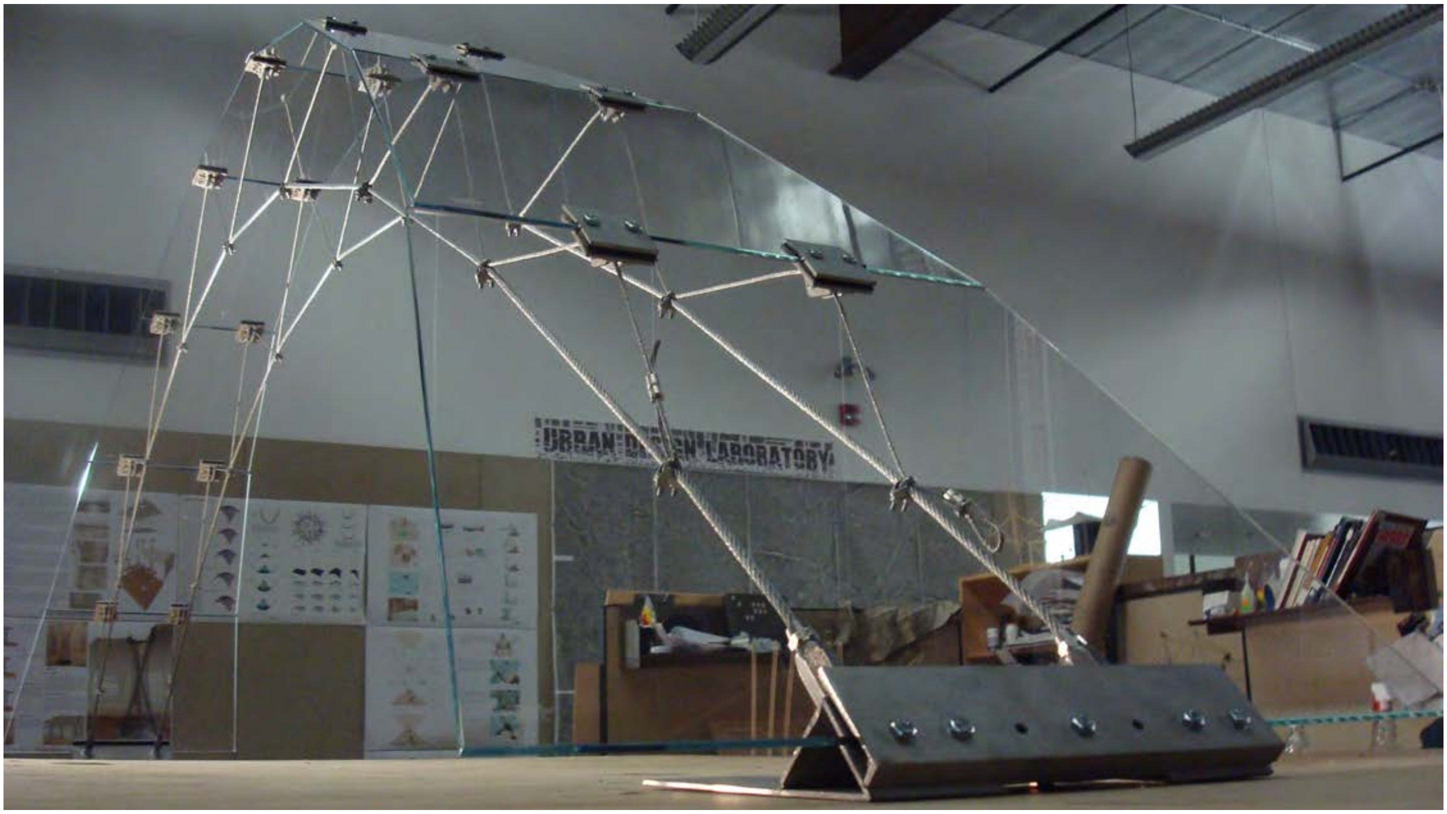


Figure 18: Final Model

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*Acknowledgement: Thanks to an inspirational dialogue with Alex Miramontez, the vice-president of the local glass distributor GlazTech Industries, complementary aid in the cost and production of glass was alleviated.

APPENDIX II

Modernism Comes Home to Tucson

Correspondent's File

By Kenneth Caldwell

DEPARTMENTS

Tucson's young architects are returning to their Modernist roots, and Modernism is returning with them.

Anne-Marie Russell, executive director and chief curator of Tucson's Museum of Contemporary Art, sees the city's early pedigree in Native American and Hispanic adobe building as intrinsically Modernist. She says, "When building in the desert, you are dealing with reduced forms and materials that respond to the climate. Tucson is naturally, indigenously Modern—or, at least, the ethics of Modernism are in line with the 'less is more' ethos that one must adopt while living in what can be a harsh and unforgiving environment. There is no room for waste in the desert; you conserve everything—water, your energy, and so on."

The Southwest's rapid growth immediately after World War II nurtured several skilled Modernists, such as Arthur Brown, William Wilde, Nicholas Sakellar, and later Judith Chafee. Using structural steel, poured-in-place concrete, glass block, and aluminum sliding doors, combined with simple rectangular forms, sculptural sunscreens, and flat roofs, their innovative work responded simply to the desert's austere beauty and continued the sensitivity of the early settlers. Modern architects in the Southwest desert also incorporated steel and glass, making possible an open architecture that embraced the landscape and took advantage of the climate.

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But then, according to John Messina, a research architect at the University of Arizona, the rapid growth of the 1970s and '80s, which was fueled in part by tax laws that played into the hands of developers, encouraged architecture of poor quality. Historical forms were divorced from their desert surroundings; strip malls crowned by plastic-tile mansard roofs lined busy boulevards; and neighborhoods sprouted gated subdivisions of tiny, multicolored stucco faux-pueblos.

A rebirth of Modernism

In the past few years, there have been promising signs of change. Comparatively favorable property prices and Tucson's stunning environs have attracted a knowledgeable client base. In response, locally born (or educated) architects, perhaps inspired by Rick Joy, AIA's national reputation, are expressing new ideas heralding a refreshing return to appropriate and contemporary desert design.

This reemergence can also be linked to the reinvigorated program at the University of Arizona's College of Architecture and Landscape Architecture, where Alvaro Malo, director of the university's architecture program since 1998, has established a Distinguished Visitor Studio and related lecture series that draws design professionals from all over the world.

Judith Chafee's Blackwell House (above), a Modernist landmark in Tucson, was destroyed in 1998. Rob Paulus's Puhler residence (right and below) was built on an infill lot and contrasts dramatically with its older neighbors.

The growing Museum of Contemporary Art has played an important public role, sponsoring several programs on architectural Modernism under the catchy title "Design Lab," such as well-attended lectures, tours, and exhibitions. Anne Nequette and R. Brooks Jeffery's excellent book, *A Guide to Tucson Architecture*, gives Modernism equal weight with earlier styles.

"The choice between Modernism and southwestern kitsch is not one of style but of principle," says local architect Will Peterson, who has designed in the Southwest for years and says he is witnessing a renaissance of his style of choice in Tucson. Peterson's forms take cues from architects such as Frank Lloyd Wright and A. Quincy Jones, designing his houses to recede into

Ibarra Rosano converted a typical postwar Tucson brick bungalow into a Modern showpiece with dramatic vistas (right and below).

the landscape. His Cook House features buff-colored concrete block, sandblasted to reveal the aggregate, and a weathering steel roof complements the color. In a Kahn-like move, Peterson organized the house around parallel masses of masonry, which vary in thickness from 4 to 8 feet.

Creating change

Despite increased awareness of Modern design, clients still have to be convinced. University of Arizona architecture graduates Miguel Fuentevilla and Sonya Sotinsky returned to Tucson from Berkeley in 1999 and began FORS Architecture + Interiors. One of their first commissions was the renovation of a midcentury house designed by William Wilde and owned by a family member of the architects. Fuentevilla and Sotinsky were eventually able to convince the owner of the original design's value. "In the beginning of our practice, it was frustrating, since most clients were asking for some version of an imagined history," says Sotinsky.

Since early commissions can be difficult to secure, friends as well as family are often key. Luis Ibarra and Teresa Rosano grew up in Tucson, met at the architecture school, founded Ibarra Rosano Design Architects six years ago, and have developed a reputation for muscular yet sensitive desert dwellings. One of their first commissions, the Garcia House, came from a trusting friend who gave them a lot of freedom. The carefully framed views, fragmented forms, and multiple levels of the Garcia House brought the architects a lot of publicity, which helped launch their practice.

Beyond the commissions of permissive friends and family, many Tucson architects are also turning to fringe neighborhoods and infill projects, and serving as developers. Rob Paulus, another locally raised and educated architect, has been a codeveloper for two multifamily projects in neighborhoods adjacent to downtown where few had ventured before. Although his Barrio Metallico is the more daring of the two—in an industrial neighborhood and clad in corrugated metal—it contains nine single-family dwellings on two city lots. At the Icehouse Lofts, a converted ice and cold-storage building from the early 1920s, Paulus has created 51 condominium units on 2.66 acres, a density almost unheard of in the desert. Interestingly, the project sold out quickly. Throughout the Icehouse, he reused several ele-

ments, such as lumber, corrugated metal, and box-car siding. Paulus has now embarked on Indigo Lofts, a 22-unit project in a mixed-density neighborhood east of the university.

Another example of innovative development is "Dreamspace," Ibarra Rosano's partnership with a client and locally educated architect/contractor, Page Repp. They are developing a number of imaginative infill projects, for which Tucson's typical lots (50-by-125 to -150 feet) offer plenty of opportunity. Working with one of these lots, Rob Bass, another local who now works for ABA Architects, designed a modest duplex behind a small house. It fills its allowable building envelope with two mirror-image, 1,000-square-foot shotgun units that were constructed for about $80 per square foot in 2002. The sandblasted gray concrete block serves as the interior and exterior finish, and the variety in the facades is created by the placement of the windows and Cor-Ten-steel panels. He comments, "What is positive about the emerging interest in Modernism here is that it is not a trend or a style, but an idea. Clients understand the harsh environment and want an appropriate response."

TUCSON'S LOWER PROPERTY PRICES AND STUNNING ENVIRONS HAVE ATTRACTED A KNOWLEDGEABLE CLIENT BASE.

Like the first generation, the young architects are interested in the idea of Modernism, but they are also concerned with using as little energy as possible and integrating sustainable materials. Some, like Paulus and Ibarra Rosano, are bolder in their use of forms, materials, or color.

Tucson's new identity

In the mid-20th century, most of Tucson's Modernist architects were out-of-towners; these new Modernists have come of age in the desert. However, much of the client interest is coming from outside the area. Most of the buyers in Paulus's Icehouse are new to Tucson, and about half of FORS's clients are from out of state. "It is interesting that the people who are in tune with what the desert can offer are often from somewhere else," comments Sotinsky. As *The New York Times* and National Public Radio (NPR) have reported, many Californians are moving to Tucson because of the relatively low cost of real estate and because it isn't as congested as Phoenix.

Yet, while the principles of Modernism may be moving toward a more sensitive and sustainable architectural movement, its cooperative spirit has far to go in the larger context of planning policy. One promising sign is that Pima County, of which Tucson is the seat, recently created the Sonoran Desert Conservation Plan, which protects natural, historic, and cultural resources while regulating the built environment. Jeffery feels the plan's ranch conservation component could help define a much-needed urban growth boundary around Tucson. In 2003, a controversial zoning ordinance passed, limiting construction on the most visible peaks, but several grandfathered projects are still crawling up the mountainsides. Public transit is insufficient, and city-sponsored transportation improvements have been consistently voted down. Paulus jokes, "Here in Tucson we say there are two things we don't like: sprawl and density." The next challenge for Tucson's new wave of Modernists will be extending themselves beyond designing responsive buildings to finding solutions to this paradox. ■