Statement of Teaching Philosophy

How students learn naturally, and how one can promote learning have been major interests of mine for over 25 years. Toward the beginning of my teaching career, I listened to a lecture given by John Holt on Cambridge Forum (radio broadcast). John Holt was an educator who had spent his life grappling with questions of how people (especially children) learn naturally, and how structured education often inhibits this. I was very impressed by the lecture, and quickly read a couple of the books Holt had written; *How Children Learn* and *Why Children Fail*. Holt reinforced for me several basic concepts dealing with how people learn that I was already seeing in my students.

One point which Holt makes is that students often are taught to learn to please the instructor (do assigned work, get grade, etc.) rather than learn to satisfy themselves or for some larger goal. The idea that you yourself must first want to do something in order to really be successful at doing it, is so basic that it would seem to be common sense. Nonetheless, to make use of this concept in the classroom takes a conscious effort. While teaching a course in CAD usage, for example, I developed a set of projects covering a core set of skills which all students need to approach the subject. Then, students were allowed to choose or suggest other optional directions to explore, in addition to the core skills, as their interests lead them. Such an approach usually works well in a course of that sort because the students are eager to try new techniques, and often have a specific goal in mind. The student response to this approach was always very positive. They appreciated being able to follow what interested them even if it was more difficult than what would have otherwise been suggested for a first semester course.

In the structures courses which I currently teach the situation is a little different. Because the structures courses are required rather than an elective courses, some students have further to go in accepting the challenges of the material with interest. In lectures, a special effort is made to always relate the specific analysis method being covered to the broader application in architectural design. Also, physical models are used whenever possible to help interest students in the physical significance of the mathematical theories. Opportunities are taken to show how structural phenomena can be used as a basis for architectural concepts. The late Mario Salvadori, teaching at Columbia University, was a master at this, and I was fortunate early on to get a copy of his teacher's manual for his book *Why Buildings Stand Up*. The manual is filled with examples of how to demonstrate structural concepts with simple materials and models. Although the quantitative vector analysis using trig equations is essential for analysis, initial understanding of force behavior is much more quickly grasped and retained by pulling on ropes and pushing on sticks. This followed by examples from Gaudi, Nervi, Otto, Schlaich, Calatrava, etc. show how structural theories can be applied to architecture not just in a code book "correct size" way, but in a way which finds form by utilizing the physical and structural characteristics of the material. The importance of making the subject matter exciting to the students reinforces Holt's position that if the students have some real interest in the subject they will learn faster and retain more.

Another important skill to be gained from the structures courses is the ability to reason analytically. Working problems yourself is essential in building analytical thought patterns, and in understanding the material. Over the years, I have developed a few ways to engage more students in problem solving. On the outset I noticed that students tend to fall into two work styles, lone workers and group workers. Students working in either style will range in ability from the most able to the least. There are pitfalls and benefits attached to either style. Students working alone have the benefit that they certainly do all the work. In getting to the correct solution they learn the lesson of the problem. The pitfall is that the journey might be needlessly long and frustrating. In fact, given the typical time lag from turning in, scoring and getting back a solution, in the end many students remain unsure (or worse uninterested) if they even arrived at the right destination.

Students using the second work style know solving problems in study groups can also be a productive and efficient way to learn. However, in a group there is always the danger that some of the members will *work* the problem, while others, not being able to keep up, will simply *observe* the solution. Problem working is valuable in that one is often first aware of questions only at the moment when one truly works the problem (versus watching someone else work the problem). In addition, one is more interested in the material at the time the problem is actually being worked, and, therefore, one is more apt to remember the solution. This presumes that one is in a *working* mode, and not an *observing* mode. The more common scenario in study groups is for one or two students to function in a working mode and the rest to fall into an observing mode. I have tried to take the best of these two work styles while reducing the potential for excessive frustration and aimless wandering.

To insure that *everyone* stays in a working mode, I give each student a parametrically different problem. They are encouraged to work in groups, but they each have to solve their own problem. To avoid fruitless wandering in erroneous directions I wrote an interactive web based program that allows the students to enter their own interim answers step by step, and obtain immediate feedback. Another point that Holt makes is that when students feel the pressure of making a grade they respond by shifting their orientation toward "learn to please the instructor", and away from "learn to please yourself". To lessen the intimidating effect of a wrong answer, there is a built in, second chance option in the web problems. If you try a procedure and it does not work out, you are given the option of a second try with a new set of data. This simple second chance option converts the frustrating, negative effect of missing an answer, into a positive learning effort. It encourages a try and try again attitude. When they miss a question, they will usually ferret out the reason why, so that they are sure to get it right the second time around. This, of course, provides a much better learning experience than the traditional "one shot" homework assignment.

The programming support for this technique has evolved over several years. For the courses I now run at Michigan, each course has a separate web site where students can access a library of worked examples, download videos and PowerPoint notes from lectures, work the homework assignments interactively or check their current score for the class. The web site uses PHP to access an SQL database, which allows it to be used interactively at anytime by anyone with a network connection and browser. You are welcome to have a look. The URL for the undergraduate structures courses is: http://www.umich.edu/~arch314 and http://www.umich.edu/~arch324 for Structures I & II respectively, with login name = guest and ID number = 123.

Some advantages to this approach are as follows:

- Each student works the problem. They can not passively copy another student's work because they each have different numbers.
- Students are guided to work the problem correctly. If they miss an interim step of the problem, they are corrected and set back on the right course. This happens as they work the problem - while they are interested in the solution - not a week later when it is "file and forget".
- Students can genuinely benefit from working in groups. They see several different scenarios presented by other students' problems and learn many more "what if" lessons.
- Students work harder and with more interest because the goals and rewards (on one level) are very immediate and clear.
- Students are given the chance, if they like, to totally rework a problem with new numbers. This takes some of the pressure off mistakes, and encourages a positive "try and try again" learning atmosphere.

Overall, the students have reacted very positively to the approach. In fact their candid suggestions for improvement have been a great help in directing new aspects of the program and correcting bugs. And everyone seems to agree that the interactive program represents a more productive alternative to writing down a whole solution "blind" on a sheet of paper and passing it in. In 2011 the students elected to give me the Donna M. Salzer Award for Teaching Excellence. The University has also taken an interest in these courses, and starting in 2009 hosted material and lectures from the undergraduate structures sequence on the Open.Michigan website provided by Open Educational Resources (OER). These remain to date the only courses in the college hosted by Open.Michigan. This is certainly not to say these are representative of the best lectures our school produces, but simply my sincere commitment to open education.

I continue to look for ways to interest students in structures, and the role it plays in design, using different media. Video media has great potential (like Salvadori's models) for transmitting a fundamental understanding to students of how structures work. Seeing how structures respond to loads including failure gives students a feeling for correct behavior that is the necessary complement to computational analysis. In the end, the calculations they learn in class should only verify the intuition they develop through experience. To me the critical part of teaching is to build up the student's experience so that the calculations verify their understanding. To this end, I also include building and testing structures as part of the course. In teaching I have found that the students tend to forget what you tell them, although they may remember things they see. If they actually make it, then they have it!

Statement of Research Philosophy

My main research effort over the past five years has been the development of a framework for digital design aids particularly suited to the early phases of a project. The framework is really a method which combines parametric form generation with various computational simulation and analysis techniques to explore geometric solutions to architectural design problems. The results are stored in a graphic database, which can be interactively searched by the designer to find solutions which both respond well to integrated performance criteria as well as qualitative design aspects. The method is unique in combining performance optimization with form exploration. This work has been disseminated in 26 published articles which have been cited in over 100 other papers. The method, which I call ParaGen, is being used by other researchers and designers at TU Delft, Princeton, Aalborg Univ. and the TU Eindhoven. This past year I was invited to present the work at MIT and ILEK at the University of Stuttgart, and at the last ACADIA conference the work was cited by the keynote speaker, Manuel DeLanda. So there seems to be growing interest in the appraoch.

There are several aspects of ParaGen which make it significant. To begin with, the method focuses on the most critical part of design – early design. Because most of the form giving decisions in an architectural project are made in the early phases, input at this juncture has the greatest impact on the final outcome of the project. In later phases sub-systems can be optimized, but in order to influence a design in its conceptual geometry, the input needs to be made at the critical front end. Although other methods and software are available to simply generate form (for example newer developments in parametric modelers), very few methods are able to combine the form generation with integrated performance optimization to give the designer an intelligent exploration framework.

ParaGen is intended to show the designer the implications, in terms of various performance values, that different geometries will have on the final building. This allows the designer to bring integrated performance criteria into the initial decision making process. ParaGen is effective because it is conceived to work with the designer in expanding the possibilities rather than constricting them too early in the design process. Rather than functioning as a traditional optimization approach that shows the user one "best" solution, ParaGen explores the range of solutions and shows the user a selection of "pretty good" solutions. By selecting solutions from a well performing set, the designer can bring other non-computational qualities into the decision process. These can include aesthetics, context, historical reference, etc. It is also simply good design practice to avoid early fixation on a single solution and instead explore different options. It is often through such exploration that the actual design problem will be more completely understood and defined. This is the nature of what Herbert Simon called an ill-defined problem, and it is often the case in architectural design.

ParaGen is tuned to the way designers work in several ways. As mentioned above, the interface always displays a selection of solutions rather than just one in an effort to expand conceptualization. In searching for new solutions, ParaGen also makes use of a specially developed form of a genetic algorithm which I call a non-destructive dynamic population genetic algorithm (NDDP GA). The formulation is unique in that it combines a relational database with the GA. This allows all solutions to be saved for possible inspection by the designer, rather than only the fittest. This is valuable to a designer because seeing a bad solution can sometimes be beneficial in understanding what makes for a good solution.

Normally, progress in evolutionary design algorithms is sequential. Parents for the next generation come from the current generation. If an individual solution dies out due to poor performance, then it is eliminated from any future consideration or breeding. This makes changing the fitness criteria very ineffective, since the current breeding population would not be based on the changed criteria. However in ParaGen, since all solutions are maintained, breeding populations can be generated dynamically to find each parent at the time of breeding. If criteria shift the breeding population instantly shifts as well. This has the effect of being able to move through the solution space with a magnifying glass. It is the difference between design exploration and solution optimization. Exploration needs to happen before optimization and again it makes the critical difference in early design phases.

Using ParaGen the designer is able to move between both exploration and optimization. Again since all solutions are saved, by searching through the solution database, the designer can explore the different performance combinations that are possible. This is actually a key difference between the ParaGen method and other search or optimization methods. ParaGen creates a solution database that can be used as a basis for multiple explorations of a problem with a variety of post processing features which include visualization as well as performance assessment. During the run, by giving preference to certain criteria, the designer steers the search in the direction of those criteria. More solutions will then be visible that meet the selected criteria, and more optimal solutions in that area of the solution space will be exposed. Also, since all solutions are saved, there is no reason to ever have a duplicate solution. Each solution is checked as soon as it is generated to ensure that it is unique. If not it is discarded and another generated in its place. Since time is not spent evaluating duplicate solutions, the process is more efficient. This is in contrast to traditional GA methods that find convergence in duplicate solutions. ParaGen finds better solutions through better performance rather than number of occurrences.

The interaction of multiple objectives can also be investigated through interactive plotting functions. By selecting different design parameters or performance variables, the designer can visualize the solution space in the form of point plots. By clicking on any of the points in the plot, the image of the solution is displayed. In this way Pareto front investigations are easily made, and the designer can see not just performance values that make the plot, but also the images of the solutions behind the values. This allows the user to begin to understand the relationship between form and performance.

Some problems can be effectively evaluated visually, but may be hard to quantify computationally. In these cases ParaGen allows the designer to either directly choose breeding parents from the display of solutions or to choose a breeding population that will generate further solutions of a similar nature. Because the designer visually selects the breeding solutions, special visual qualities can be considered such as aesthetics. This has proved to be effective particularly in some initial explorations where the results are hard to predict or where there may even be flaws in the parametric geometry model. Geometry flaws are often easy to see but hard to describe in terms of functionality. By allowing the form generation to continue with a specific set of parents, the user can also better understand how the parametric model is working.

As mentioned at the start, I have made the software available to several other researchers and designers and continue to expand the range of example problems that have been worked. Partially since my background is structural engineering, but also since structural efficiency is fundamental to building design, most of the examples include performance parameters that center on a structural analysis. This includes tower design for wind loads, geodesic dome designs for snow loads and moving loads on bridges. In order to expand the range of examples into other areas of architectural performance, I have partnered with other researchers at other universities. Michela Turrin is an architect working at the TU Delft on the integration of structural form and daylighting performance. With her input we ran several examples of lattice shells with shading panels that were part of the structural bracing. The influence of the overall geometry of the shells on the interaction of structural behavior and solar performance was explored. We published several papers together including a journal article in *Advanced Engineering Informatics* (Elsevier) that was rated in the top 10 "Hottest Articles" in the first quarter of 2012. With another architect from Aalborg University, Dr. Andreas Falk, I collaborated on timber shell structures based on folded plate geometries. Again the effort continued through several design iterations and was published and presented at several different conferences. At each occasion the reception was quite good and lead to further collaborations. This past summer Professor Arno Pronk asked me to collaborate in an ongoing research project at the TU Eindhoven. The project utilizes fabric formwork for concrete lattice beams. Here form and structural behavior were the key parameters. Both visual appearance and stiffness of the supporting units were part of the exploration. The results were used as part of a master's thesis (for which I was one of the advisors) and will be presented in September at the 2013 symposium of the International Association of Shell and Spatial Structures. Several concrete elements were actually constructed based on the ParaGen design, and there is some expectation that a full structure will be built in the near future. In each of these projects the collaboration with design architects confirmed the general approach used by ParaGen, and resulted in further developments and improvements to the interface. Overall the success has been very good, and the current development of the method makes it ready for application to further "real world" problems. This then is the logical next step, to match problems to the method, and thereby to further the development of ParaGen both through funding and through application.

Statement of Service

While at the University of Michigan I have been fortunate enough to have had opportunities to serve the academic community at all levels: department, college, university and internationally. In each case the interaction with fellow colleagues has given me a greater appreciation for administrative duties and broadened contacts with other faculty that has often resulted in positive feedback to my own teaching and research.

At the college level my duties have shifted over the years from student oriented (admissions committees) to faculty oriented (search and tenure review committees). This past year I served on the performance review committee for our non-tenure track faculty, as well as a search committee for new tenure track faculty and also the search committee for a new chair for the School of Architecture. Currently I am on the interim tenure review committee. In addition I am still active in curricular discussions centered on my area of the curriculum. For example both last year and currently I am the technical area representative in the PhD advisory committee. In the undergraduate area I am part of the physics requirement review committee. Since I teach in the different degree programs, undergraduate, graduate and PhD, I am regularly involved in curricular issues in all three programs.

At the university level I am in my second, 3-year term as Faculty Senator for the college. This is a three year commitment which requires monthly meetings to review issues brought by the faculty or to the faculty at the university level. I have also severed several years on the University Rules Committee. This is a committee that reports to SACUA and the Senate Assembly on issues related to their rules. The University of Michigan has also given me several opportunities to serve as a reviewer for internal research grants through the Office of the Vice President for Research (OVPR). This was my third year to participate in proposal reviews. I have also been able to offer service for other universities. This year I was invited to be a reviewer for a tenure and promotion case at Washington State University.

In recent years I have also become more involved with service to the larger academic community. This generally takes the form of international conference committees. Here duties include review of papers, judging for awards and chairing sessions. I am particularly active in the International Association of Shell and Spatial Structures, IASS (since 1994) and am a member of the working group in Structural Morphology. This year again I served on the conference committee (chairing two sessions and reviewing papers) and was also asked to serve on the review committee for the Hangai Prize. Contacts in the IASS have also lead to several invitations to review articles for the *International Journal of Space Structures.*

Also through involvement with the IASS, other international organizations have invited me to either join their scientific committees or to serve as a guest presenter. This year for the second time I was invited to join the scientific committee of the bi-annual *Design Modelling Symposium Berlin*. This is a somewhat smaller and more specialized group, but very active. Koge, the Institute for Structure and Design at the University of Innsbruck, has also invited me to join in their symposium in January 2014, "Form-Rule | Rule-Form".

Besides international symposia, I serve on the review committees of several journals. These include *Built* journal, the *Journal of Architectural Education, Automation in Construction International Journal* and *Buildings.* I have also served as a reviewer for several book publishers including, Cambridge University Press, Laurence King Publishing, and John Wiley & Sons Publishers.

Because of my background as a structural engineer, opportunities occasionally preset themselves to offer service in a professional capacity. There have been numerous small research/design projects on the part of our faculty that include a level of construction which requires structural analysis or consultation. For me it is generally a pleasure to have the chance to learn more about different faculty members' activities, and lend some support to their efforts. I have also served pro bono as a structural consultant for several of the over 100 year old churches in Detroit, by making inspections and recommendations for repair of hazardous conditions.

Certainly one of the most rewarding projects I have been able to participate in has been the Craig VanLaanen Treehouse and Woodland Retreat at Trail's Edge Camp near Mayville, Michigan. This structure was built for use in the summer camp run by the University of Michigan Mott Children's Hospital for children needing to use ventilator assistance and wheelchairs. It was a project conceived of by Mary Buschell, RRT, and her camp staff to allow children with limited mobility to experience the height and excitement of spending time in trees. What resulted was a 300 square foot house, cantilevered through the boughs of the tree, held 22 feet in the air by a branching steel "tree" support. The project which took over a year to realize was immensely successful, and was published in newspapers, medical magazines and periodicals on steel construction. My part in the project was basically the branching steel tree support. This included all analysis, detailing and drawing documentation, as well working with the steel fabricator and site engineering. The steel was erected in winter 2003, and after countless hours of volunteer labor, the completed Treehouse was dedicated in the summer of 2004. Our four member design team received special recognition from the University of Michigan Council for Disability Concerns for the effort.

Branching columns have continued to interest me and have lead to further research on optimization of the structural form. Presenting the work at an IASS symposium lead to several other contacts and collaborations with colleagues from Stockholm and Delft.

T e a c h i n g

From 1982 to 1995 I taught at the School of Architecture at the University of Tennessee. During that time my activity was centered on structural design and computer utilization. I also taught design courses at the first and fifth year levels.

From 1996 to 2001 I was at the University of Stuttgart, where I worked on a doctorate in engineering. In 2001 I joined the faculty at the University of Michigan where I teach undergraduate and graduate structures courses as well as seminars in the doctoral program. In 2009 I was promoted to Associate Professor with tenure.

In 2011 I received the Donna M. Salzer Award for Teaching Excellence.

Courses at Michigan

Primary teaching responsibility

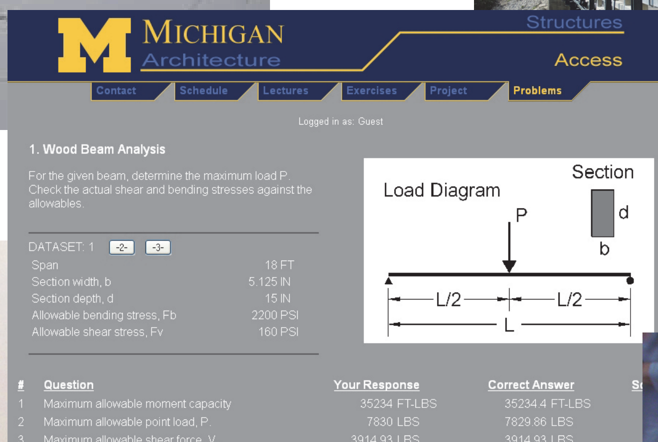
ARCH 314	Structures I (3 credit hrs.)
ARCH 324	Structures II (3 credit hrs.)
ARCH 514	Frame Structures (3 credit hrs.)
ARCH 544	Wood Structures (3 credit hrs.)

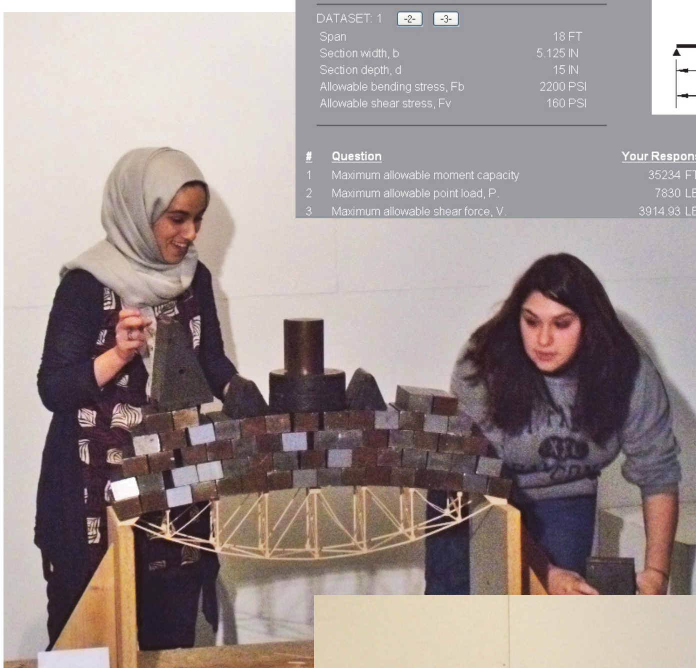
Dissertation Committees

2017	Anahita Khodadadi	co-chair	
2016	Omid Torghabehi	chair	
2014	Nuri Bae	committee member	
2014	Michela Turrin	committee member	(dissertation at TU Delft)
2014	Sung Kwon Jung	committee member	
2013	Joost van de Koppel	committee member	(thesis at TU Eindhoven)
2013	Stan van Dijck	committee member	(thesis at TU Eindhoven)
2012	Aysu Berk	co-chair	
2012	Sentagi Utami	committee member	

ARCH 314: STRUCTURES I (3)

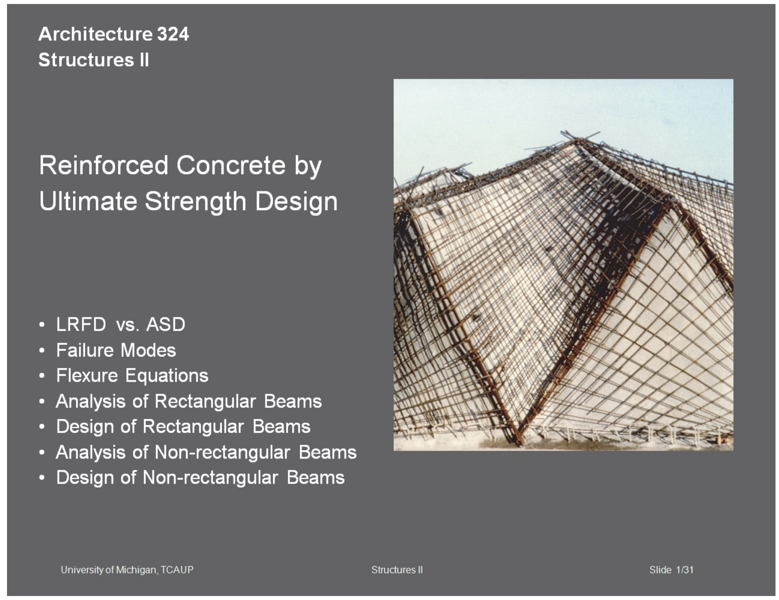
This course covers the basic principles of architectural structures, including the influence of geometric, sectional, and material properties related to flexure and shear in beam and framed systems; vector mechanics with application to analysis of trusses, catenaries, and arches; diagrammatic analysis of beams for bending moment, shear, and deflection as well as the study of structural framing systems for vertical and lateral loads.

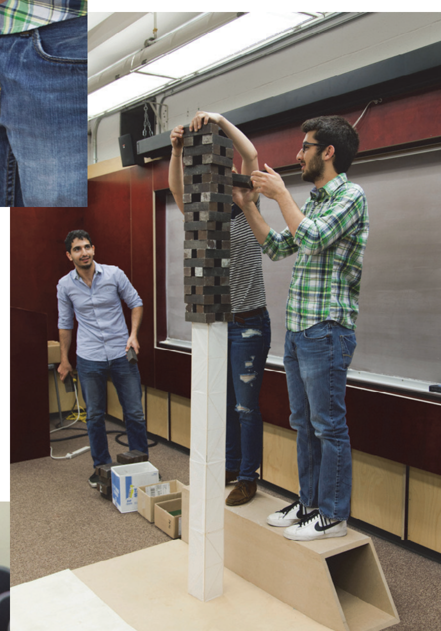




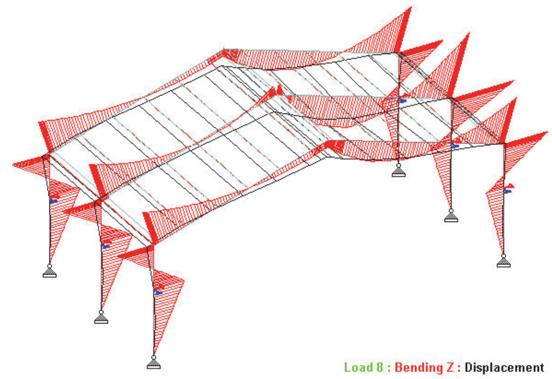
ARCH 324: STRUCTURES II (3)

This course covers the basic principles of elastic behavior for different materials such as wood, steel, concrete, and composite materials and compares the properties and applications of materials generally. It investigates cross sectional stress and strain behavior in flexure and in shear, and torsion as well as the stability of beams and columns. The qualitative behavior of combined stresses and fracture in materials is also covered.

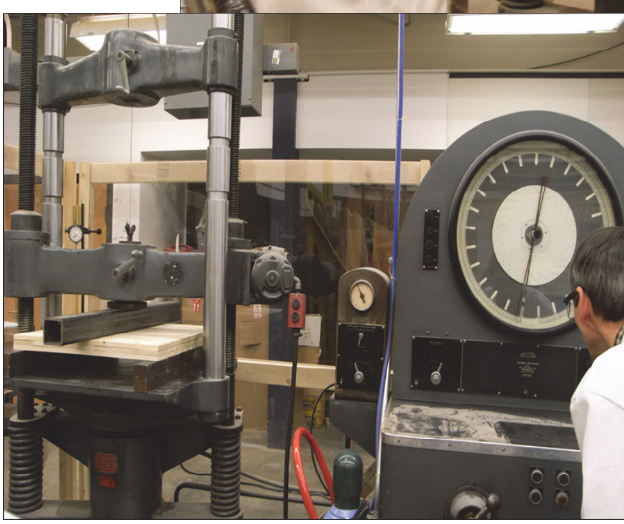


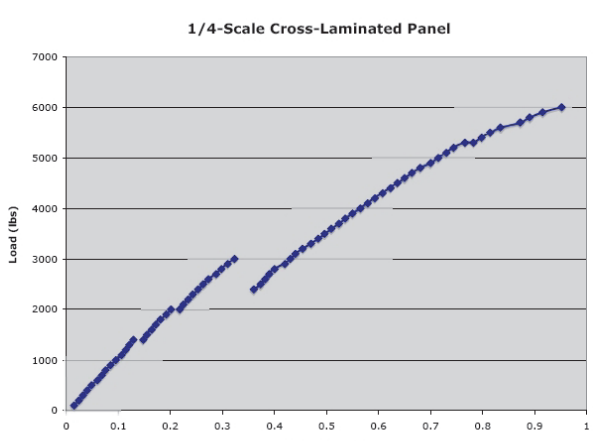


Arch 514: FRAME STRUCTURES (3)
This course provides an understanding of the behavior and strength of framed structures such as portal frames, arches, trusses, and grids as well as an introduction to non-linear behavior. Their behavior is explored through the use of computer programs where students learn to prepare input data, analyze the structures, and use materials design post processors to evaluate the results, including model building and laboratory testing.



Arch 544: WOOD STRUCTURES (3)
This course covers wood framing in architectural structures including its properties in the design, manufacture, and erection of typical elements including laminated timber. Typical forms of construction are studied, including methods of connection using nailing, bolting, and connectors. The use of the material is explored through case studies including the fabrication of model structures that are tested in the laboratory.





Summary of Formal Teaching Since Fall 2008

Architecture Program

Course No	Course Title	Year	Term	Credits	Students	Student Credits	GSI / fraction
Undergraduate							
314	Structures I	2008	fall	3	145	435	5@.2
314	Structures I	2009	fall	3	143	429	5@.237
314	Structures I	2010	fall	3	123	369	1@.3 + 4@.237
314	Structures I	2011	spring	3	20	60	1@.237
314	Structures I	2011	fall	3	122	366	5@.237
314	Structures I	2012	spring	3	20	60	1@.237
314	Structures I	2012	fall	3	108	324	5@.237
314	Structures I	2013	spring	3	15	45	
314	Structures I	2013	fall	3	90	270	5@.237
Undergraduate							
324	Structures II	2009	winter	3	153	459	5@.237
324	Structures II	2010	winter	3	150	450	5@.237
324	Structures II	2011	winter	3	132	396	5@.237
324	Structures II	2011	summer	3	14	42	1@.237
324	Structures II	2012	winter	3	132	396	5@.237
324	Structures II	2012	summer	3	17	51	1@.237
324	Structures II	2013	winter	3	111	333	5@.237
324	Structures II	2013	summer	3	14	42	
Graduate							
514	Frame Structures	2008	fall	3	20	60	
514	Frame Structures	2010	fall	3	20	60	
514	Frame Structures	2011	fall	3	21	63	
514	Frame Structures	2012	fall	3	23	69	
Graduate							
544	Wood Structures	2009	winter	3	12	36	
544	Wood Structures	2011	winter	3	27	81	
544	Wood Structures	2012	winter	3	27	81	
544	Wood Structures	2013	winter	3	19	57	
				Totals	**1533**	**5034**	

Thesis/Dissertation Committees

Roll	Student	Area	Thesis Title	Year
Co-Chair	Anahita Khodadadi	Building Technology	pre-candidate	2017
Chair	Omid Torghabehi	Building Technology	pre-candidate	2016
Committee Member	Nuri Bae	Building Technology	Uncertainty and Risk Management of Building Performance Optimization by Using a Decision Theory	2014
Committee Member	Michela Turrin	TU Delft	Performance Assessment Strategies. A computational framework for conceptual design of large roof.	2014
Committee Member	Sung Kwon Jung	Building Technology	Control Methods for PV Integrated Shading Devices	2014
Committee Member	Joost van de Koppel Stan van Dijck	TU Eindhoven	Rigidized Inflatable Structures: An innovative production method for structurally optimized elements	2013
Committee Member	Sentagi Utami	Building Technology	Characterizing the Audibility of Sound-Field with Diffusion in Architectural Spaces	2012
Co-Chair	Aysu Berk	Building Technology	A Structural Basis for Free Form Surface Discretization: Integration of Geometry, Materials and Fabrication	2012

R e s e a r c h

My major research interests center on the exploration of architectural form guided by structural behavior. In the context of both funded academic research and professional practice, I have had opportunity to design, analyze and construct several structures of this type. In the process, I have used several methods of form exploration including computational and model based methods. The types of structural systems that I have worked with include thin shells, tensile membranes, grid shells and branching structures. I have developed my expertise in this area particularly through:

- Fulbright Fellowship for one year at the Institute for Lightweight Structures (IL) under the direction of Frei Otto in Stuttgart
- MS in Civil Engineering involving design and testing of grid shells
- Design and testing of thin shell blast structures for the US Air Force
- Design and development of a modular family of tent structures for the US Marine Corps
- Dissertation written at the Institute for Lightweight Structures and Conceptual Design (ILEK) under the direction of Werner Sobek at the University of Stuttgart
- Work in the architectural office SL Rasch with steel truss domes
- Work in the office of Greiner Engineering with fabric structures and rapid prototyping.

The research contracts, on which I was either principal or co-principal investigator, have totaled about 1.2 million dollars with another approximately 2 million dollars spent on the projects outside the University (by the Air Force in testing). Although a dollar amount may not be the best indicator of the quality of the work, it does at least say something as to the satisfaction of the groups granting the contracts. The two largest contracts, with the Air Force and with the Navy, both continued over several years, and were seen as successful by all involved.

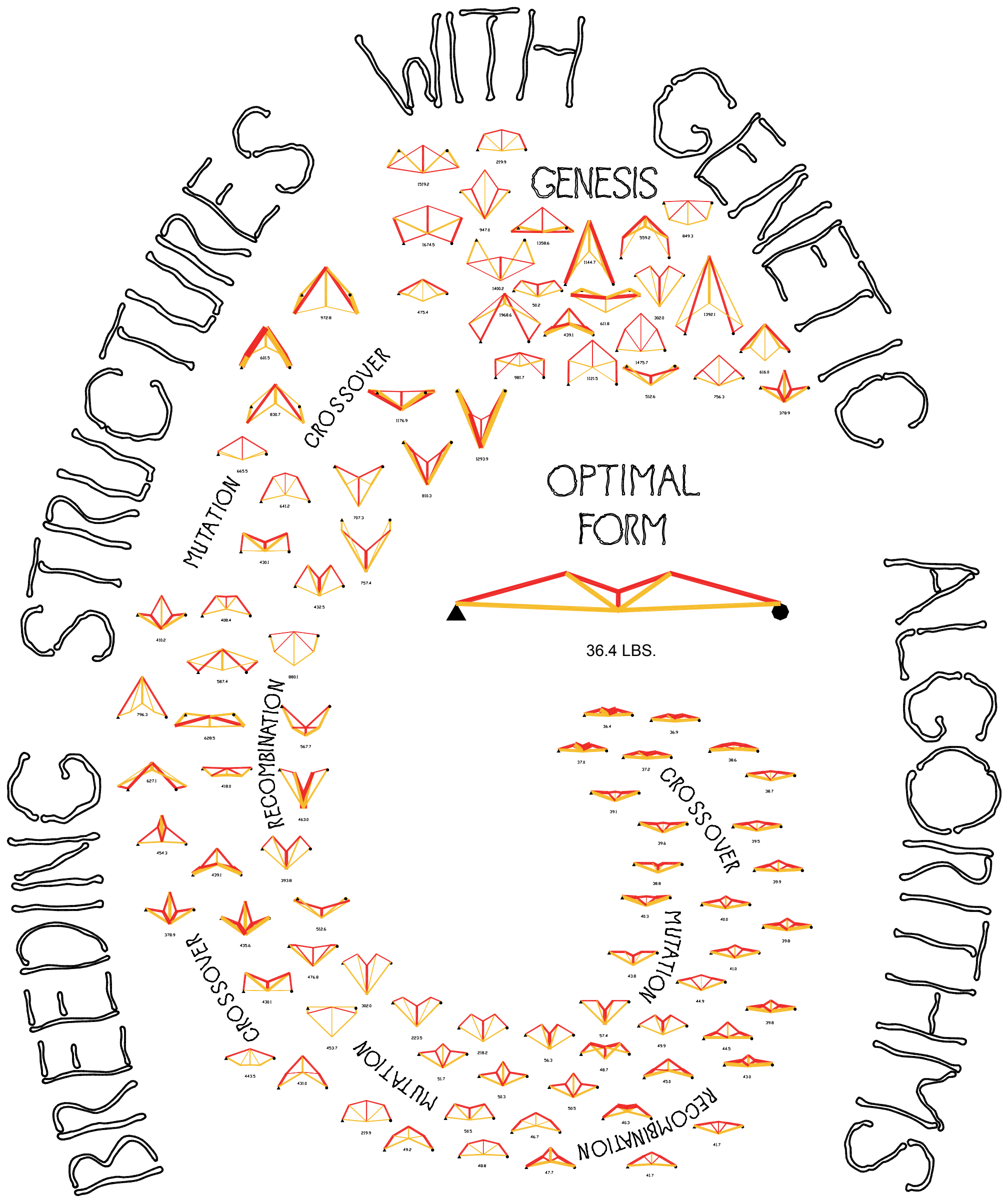
Since coming to the University of Michigan, I have concentrated on continuing development of a computer program used to explore structural form. The program uses genetic algorithms to find a range of good solutions to fit integrated performance criteria. So far a variety of systems have been explored including bridges, long span roof supports, folded plates, geodesic domes, towers, branching structures and others. The program has been utilized by other researchers at the Technical University of Delft, University of Stockholm, and the Technical University of Eindhoven. Also the program is used in my graduate structures class as well as by some thesis students.

Genetic Engineering

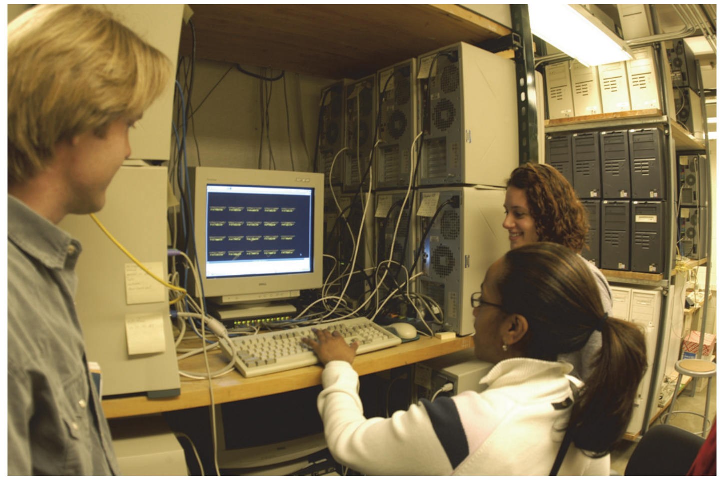
University of Stuttgart — University of Michigan

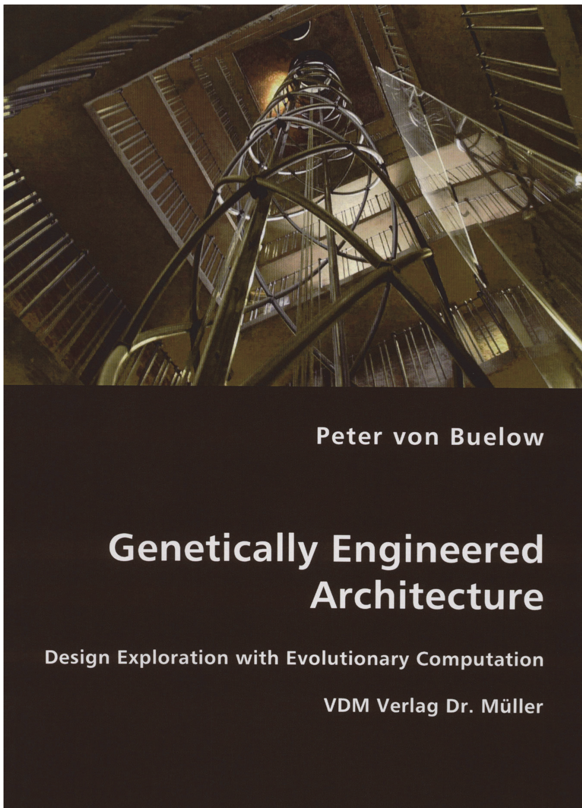
The focus of my research for the past 15 years has been the development of computational design aids which assist the designer in the exploration of structural forms. The thrust of my effort differs from traditional analysis oriented programs, in that it seeks different classes of good solutions rather than a single, optimal 'best' solution. Either by defining specific objectives or making interactive preferential selections, the designer can guide the program to explore targeted, areas of the design space.

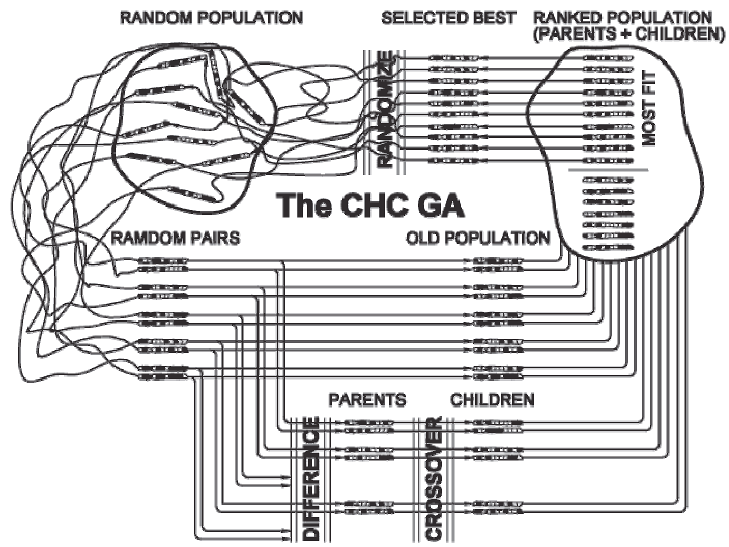
This was the topic of my dissertation in Stuttgart, and I have since written 30 refereed papers and journal articles on this topic. Exploratory design techniques based on Evolutionary Computation (EC) have generated increased interest in the fields of architecture and engineering in recent years. My published works have been cited by nearly 100 other articles in the field. I am a member of both the Structural Morphology and the Computational Morphogenesis working groups of the International Association for Shell and Spatial Structures (IASS) and contribute regularly to their activities.

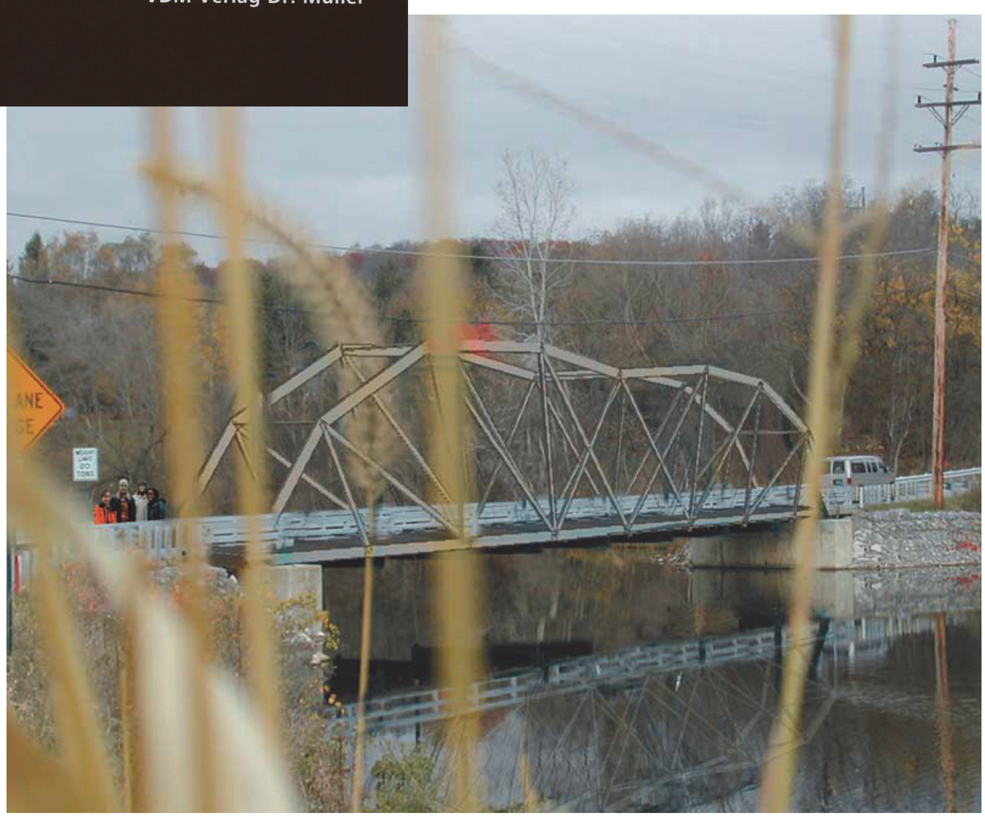


Evolutionary Computation is well suited for exploration in a way which promotes creative design. The multiplicity of solutions generated by EC techniques is less likely to cause design fixation, and so promotes a more thorough exploration of possible solutions. The use of such tools also allows the designer greater latitude in exploring design criteria, such as aesthetics, by utilizing an interactive human-computer interface.



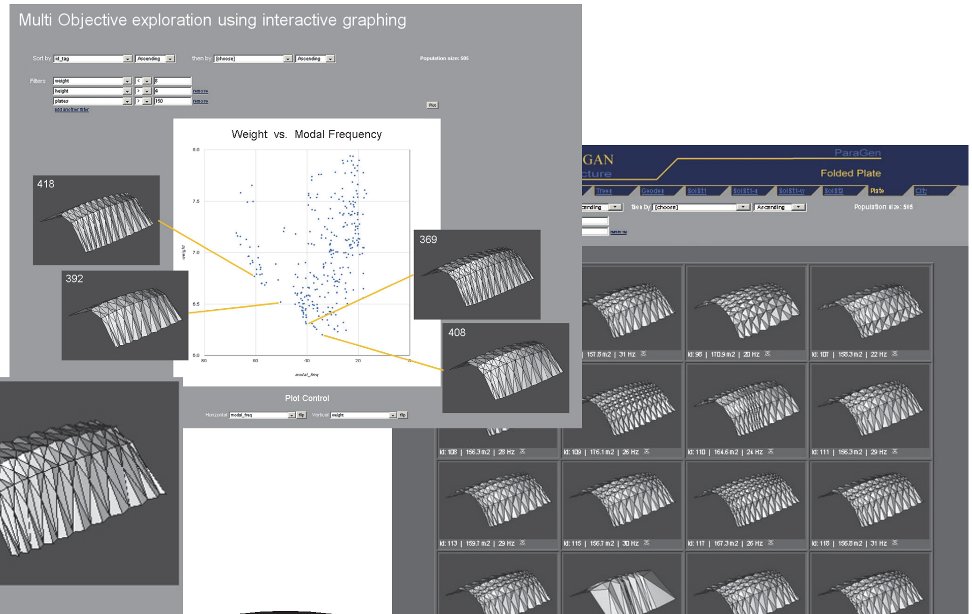


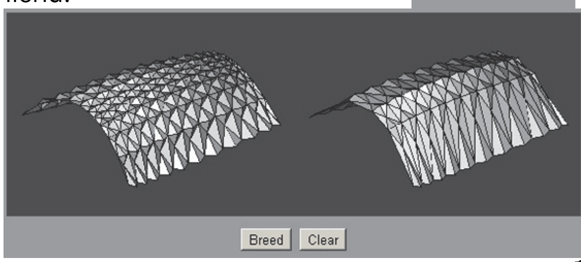


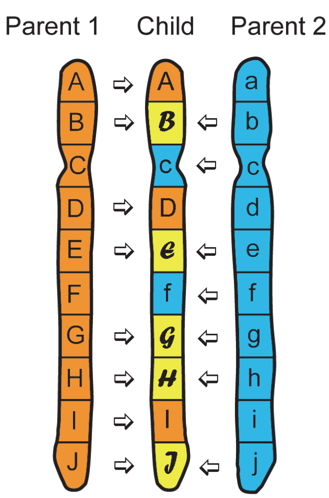


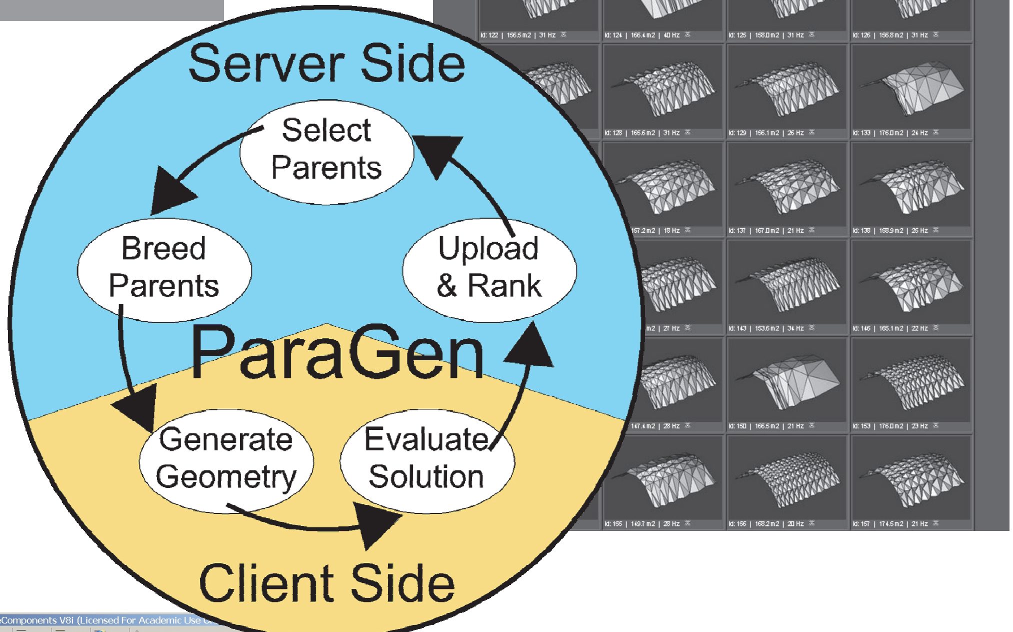
ParaGen

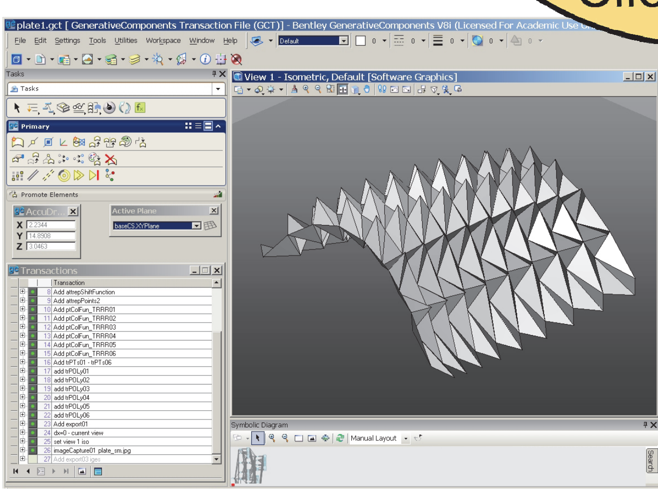
ParaGen combines several commercial and custom programs cyclically running on a Windows cluster to generate a searchable database of solutions. The database can be sorted and filtered to find sets of solutions which perform well for different objectives. Pareto graphs are used to explore multiple performance criteria.

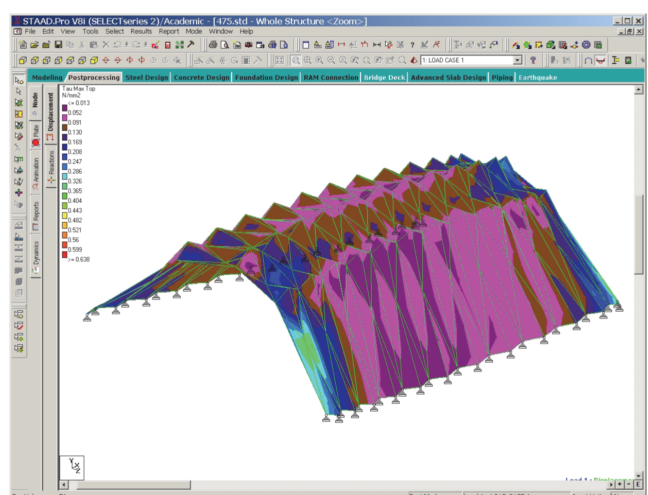




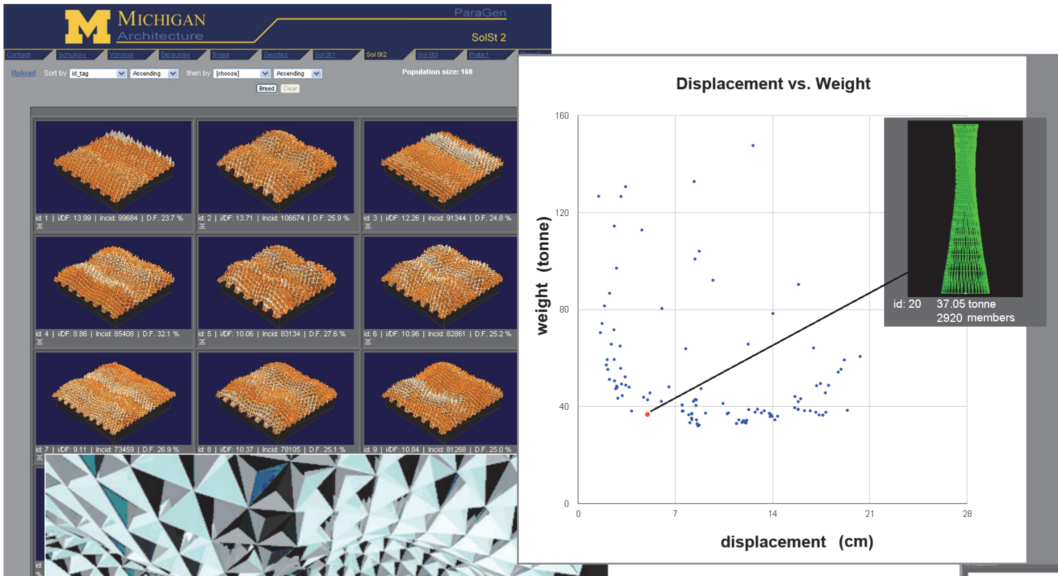


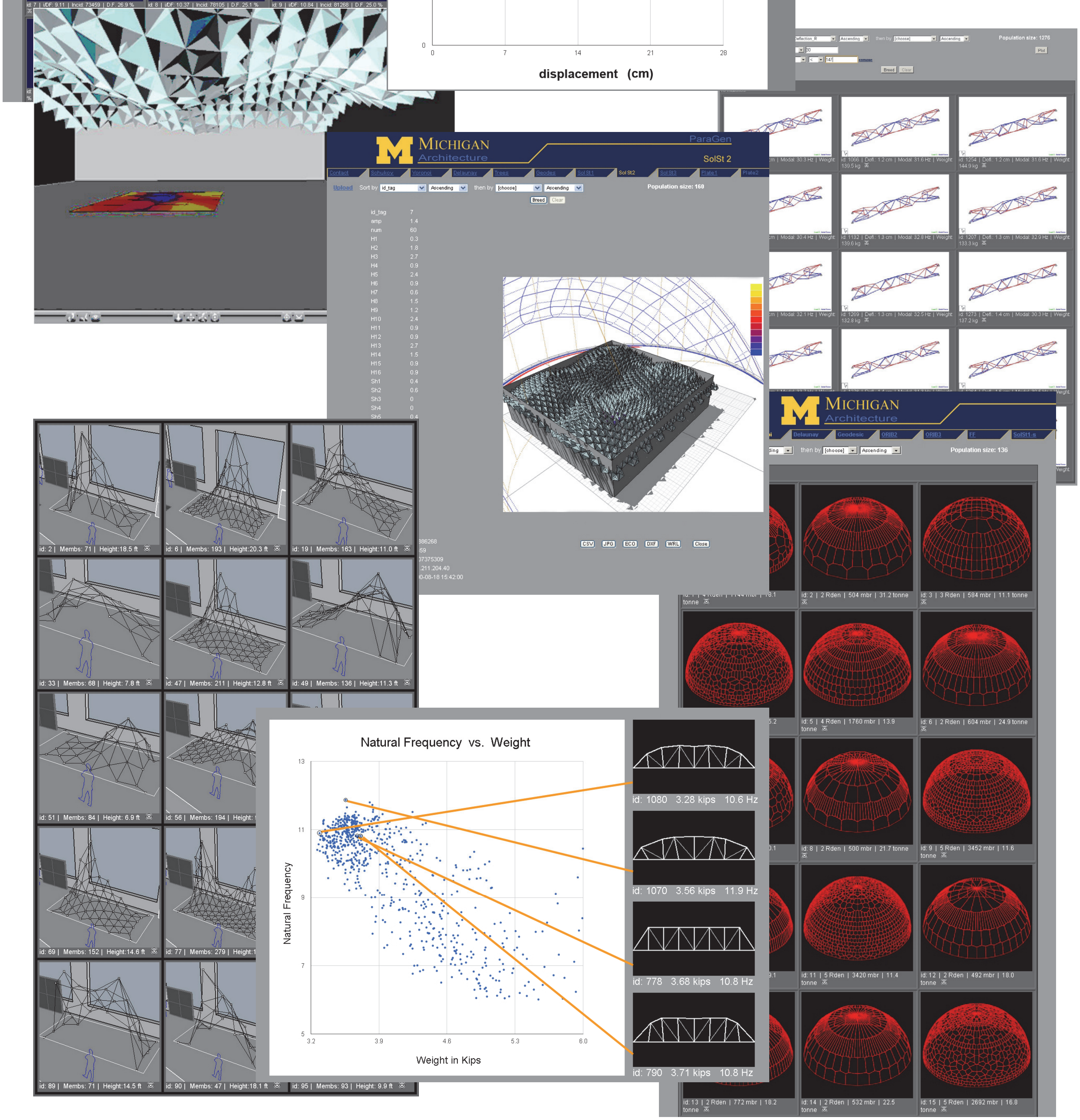






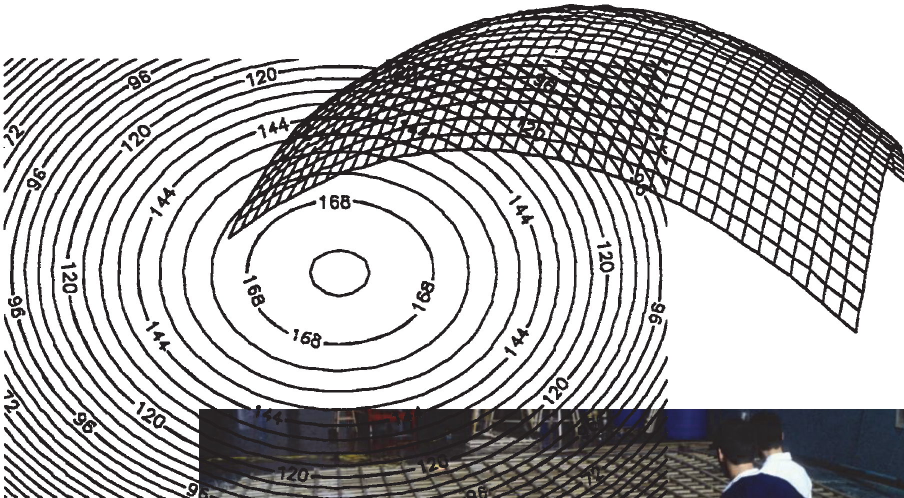
The approach combines any parametric software with the appropriate simulation and analysis software to capture both images and performance values that are able to aid the designer in making selections based on both qualitative and quantitative design criteria.



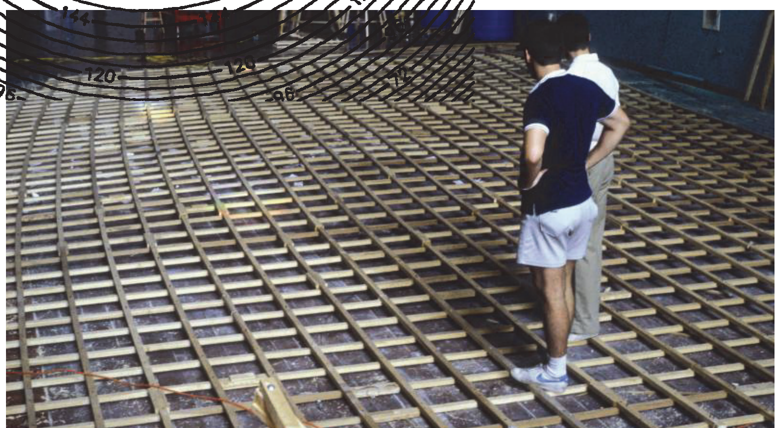


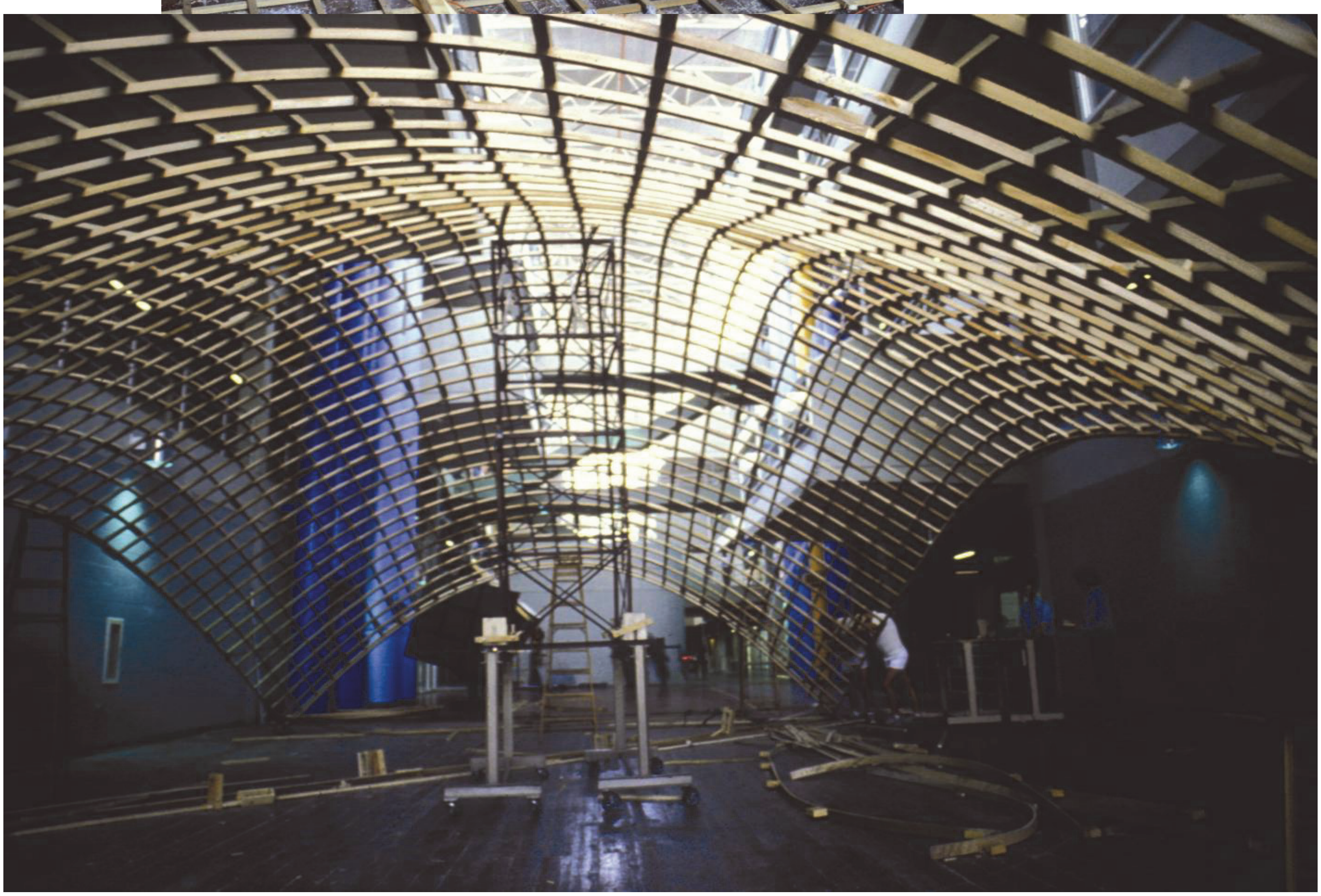
W o o d e n G r i d S h e l l

University of Tennessee Structural Innovations Lab

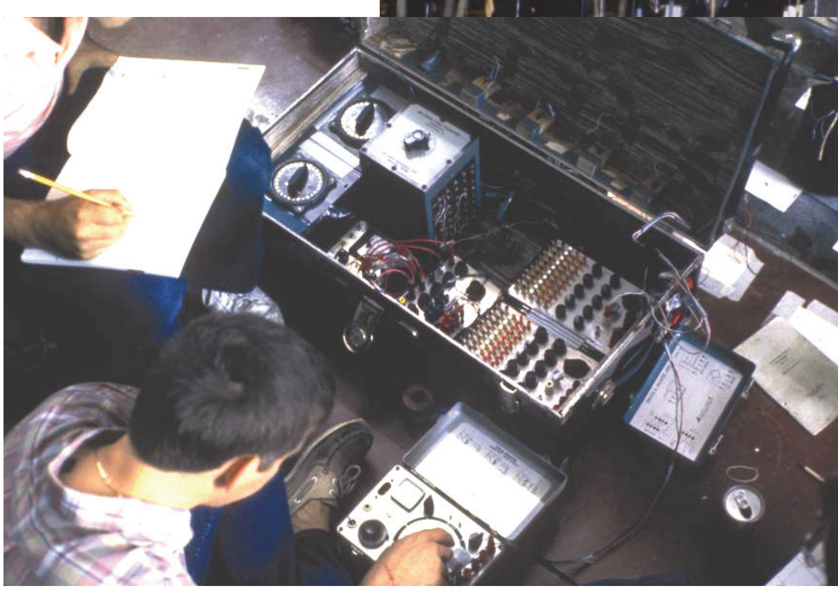


Grid shells are reticulated thin shell structures with continuous members arranged in a gridded manner. In the context of a first year design lab under the topic of structural form exploration, a class of 20 students designed and built this shell patterned after the work of Frei Otto. The students spent the majority of the semester in material testing and developing connection details. Catenary models were used to explore appropriate forms. Structural models were built to test stiffness. Full scale connection details were built and tested. In the last three weeks of the semester, the shell was erected.





One year after the erection of the grid shell, a fifth year special topics lab designed and executed a series of load tests culminating in a test to failure. A detailed structural model of the build design was made, and tested to estimate load capacity and critical loading patterns. The shell was instrumented with electric strain gages and mechanical deflection gages. Data was collected and analyzed, and a report was assembled by students.

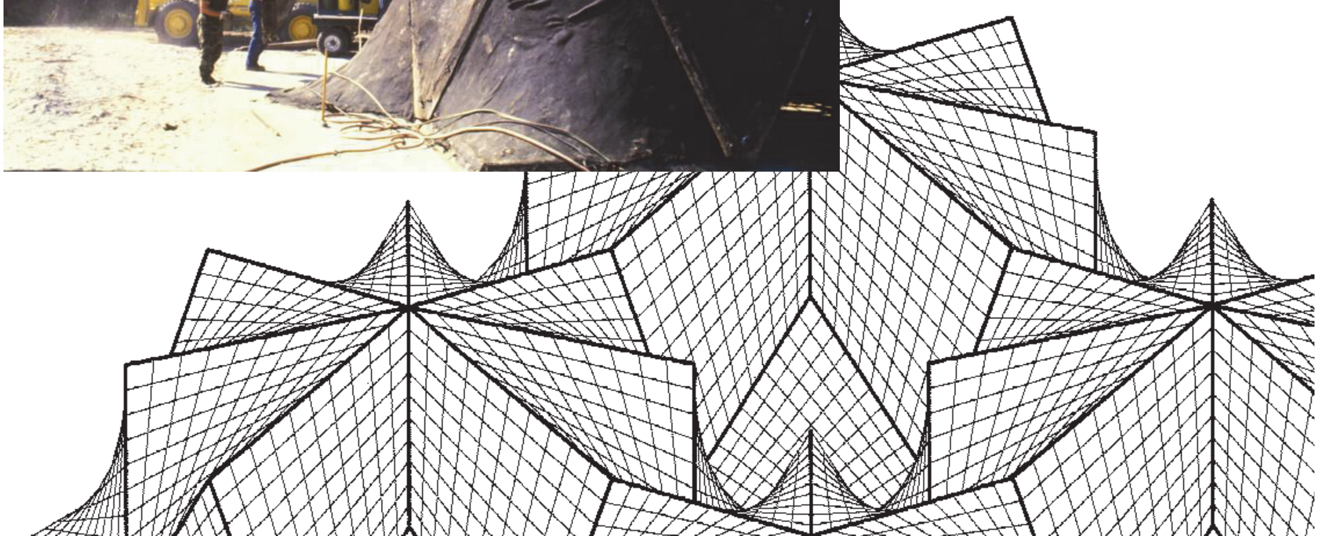


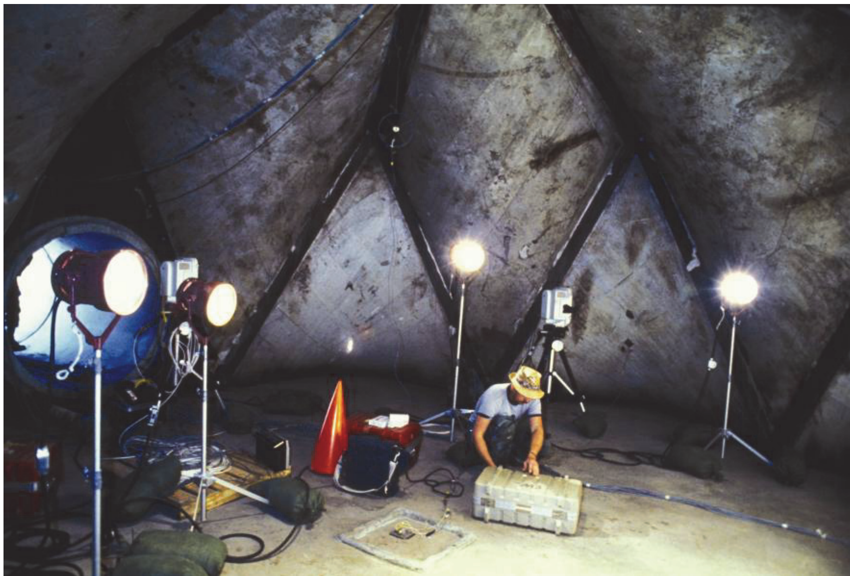
Blast Shelter

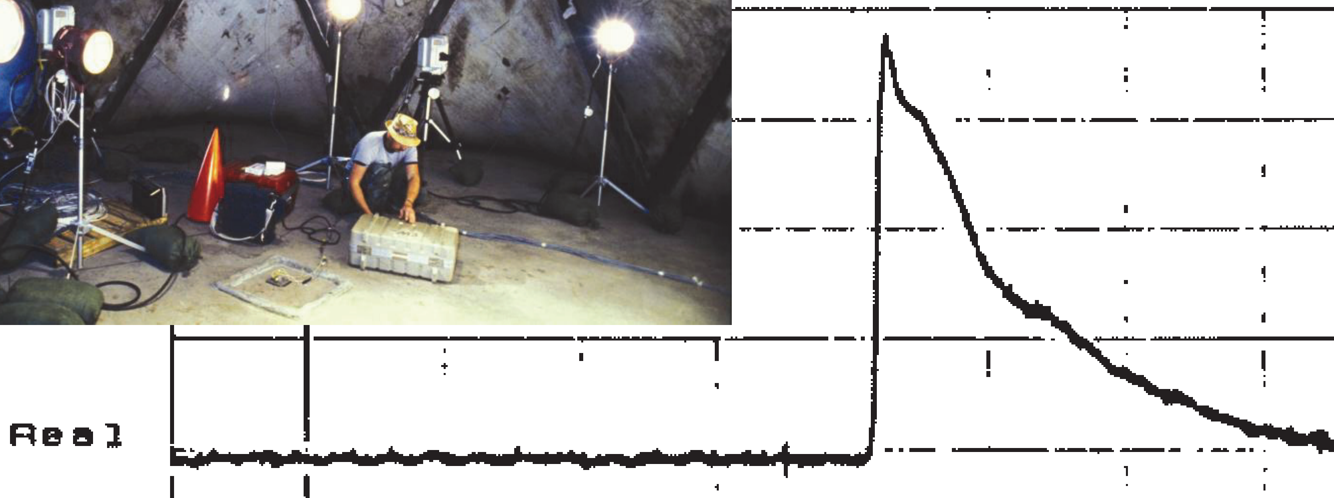
University of Tennessee United States Air Force

This effort represented the continuation of development of high strength shelters. The designs developed through model tests were detailed for full scale construction. A 750 sq.ft. shelter consisting of two connected modules was produced using pneumatically applied concrete and tensile membrane forms. The shelter was bermed, and two blast tests were carried out using 1000 lb. general purpose bombs. After the tests the shelter was uncovered, and a detailed dissection of the shell composite was made. Improvements to the system were recommended. Final or interim reports document each phase of the effort.

This effort represented the continuation of development of high strength shelters. New composite materials, shell configurations and erection methods were designed. Two full scale shelters of 500 sq.ft. each were prefabricated in Knoxville, TN exploring six different material composites and joining methods. The panels were shipped via truck and rail to Tyndall Air Force Base in Florida, thus confirming the transportability of the system. Both modules were erected at a test site and bermed.







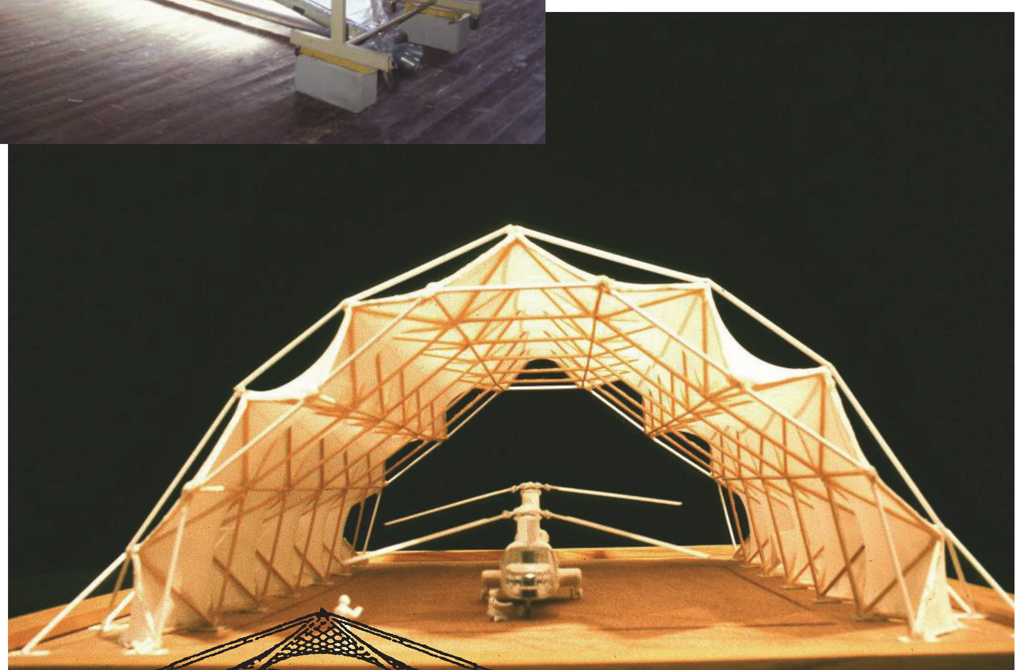
Six blast tests were conducted using 1000 lb. general purpose bombs. The bolted type connection proved superior in both erection and strength. Despite multiple shots on the same panel, no breach, spall or deflection into the usable area of the shelter was incurred. A detailed post test dissection of the shell revealed that over all the tested panels remained sound with only minor cracking.

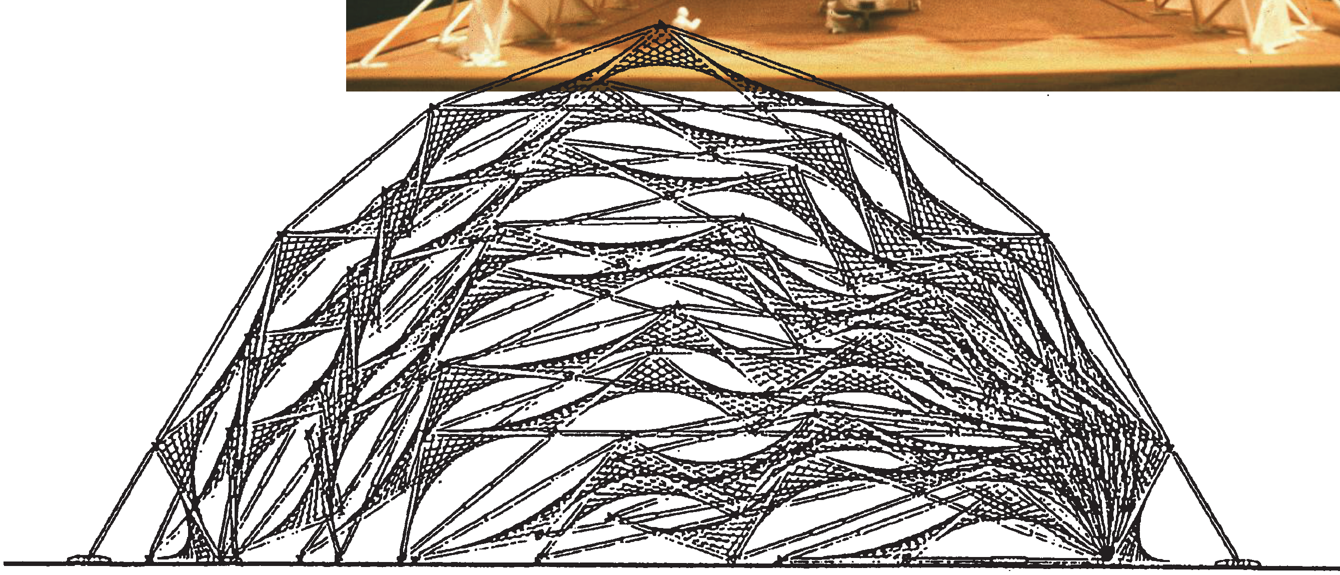
Mobile Hangar

University of Tennessee

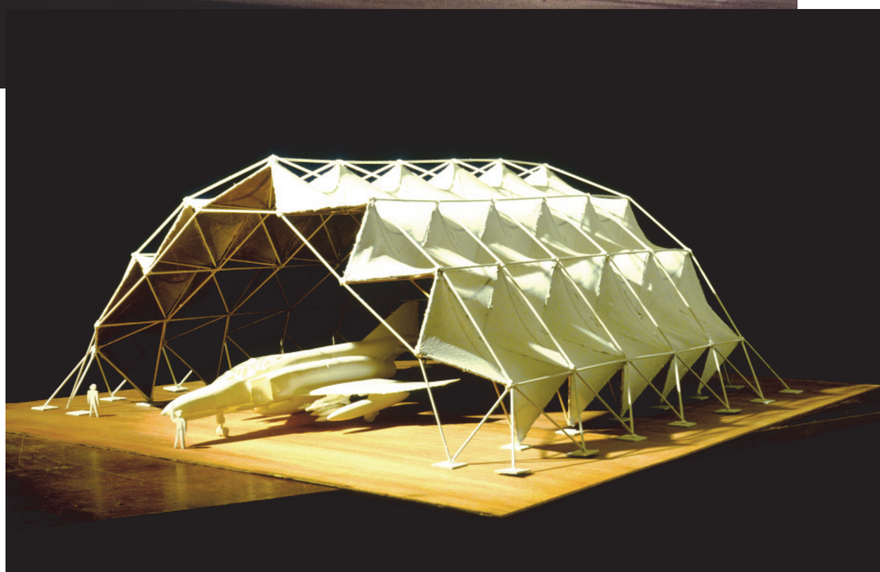
United States Marine Corps

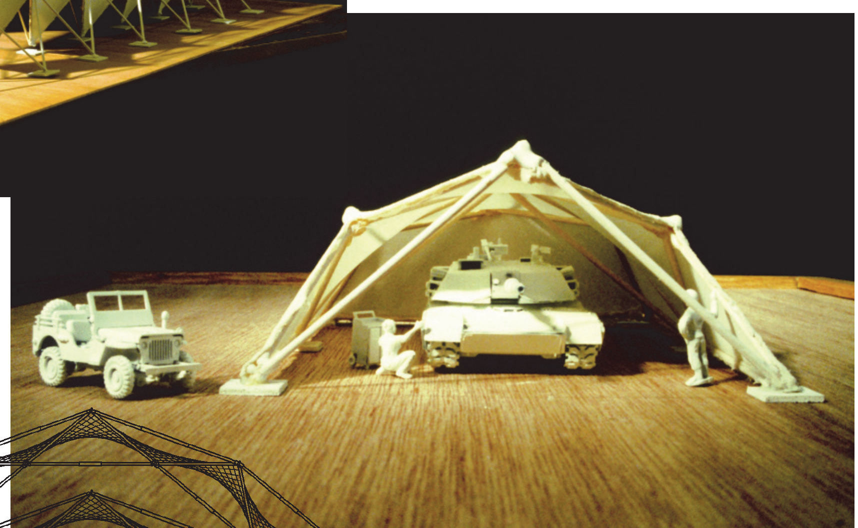
This effort developed a modular family of tents ranging in size from 20ft x 40ft to 60ft x 120ft to satisfy requirements of high wind and snow loads, rapid erection, low weight, small packing cube, and simple rugged connections. Several geometries were explored. Methods of rapid erection were investigated with study models. A design approach was chosen for continued development. A set of level 1 C-size engineering drawings were produced. A final report documents the effort.

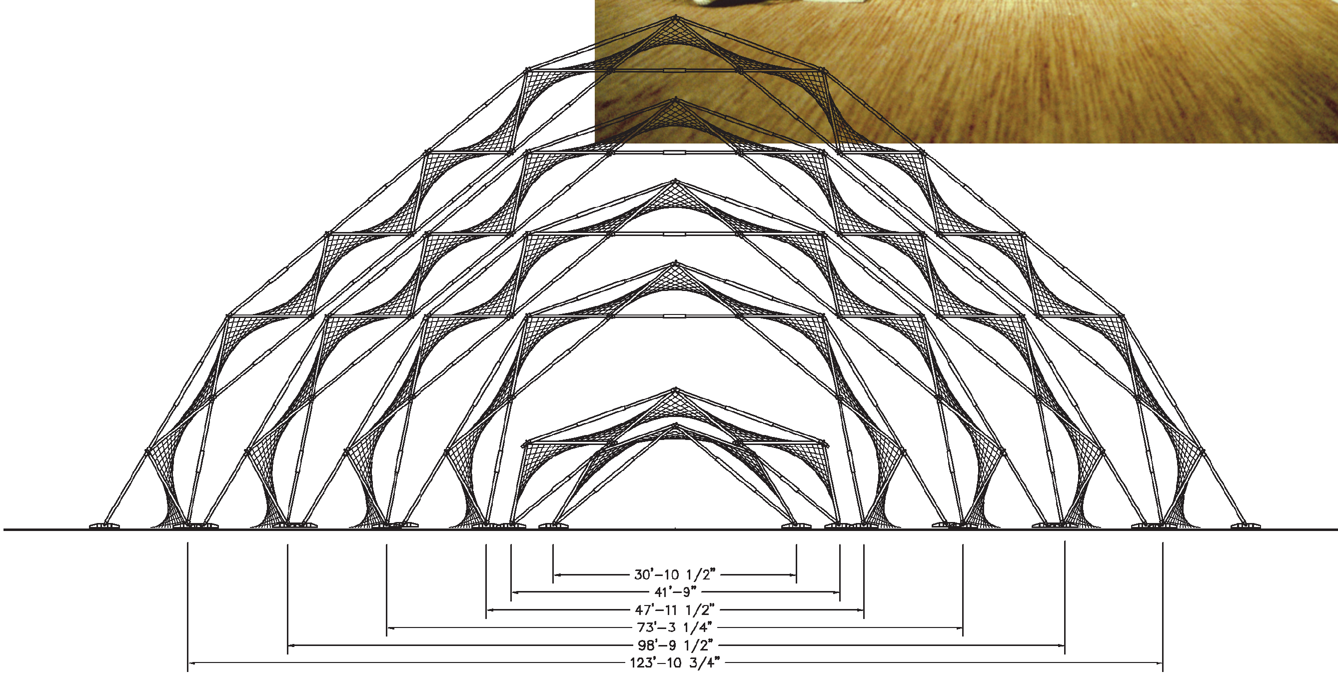




In further development of the modular family of tents, details were designed and engineered. These included: aluminum frame members, rotatable hub frame connectors, foundation anchors, fabric panels (including cutting patterns for warped surfaces), connections of the fabric panels to the frame, and main access doors. In addition other details were outlined including: side access kits (personnel access, truck docking shroud, heat and power access), storm kit, insulation kit, and lighting and electrical kits. A structural analysis was performed on each different size for several load cases. Cost, weight and cubage were calculated. A set (over 100 D-size sheets) of level 2 engineering drawings was produced to DOD-STD-100C specifications. A final report documents the effort.







Craig VanLaanen Tree House

University of Michigan C.S. Mott Children's Hospital

Peter von Buelow structural engineer, design & analysis of steel tree structure

Professional Practice

Professional Registration

Architecture - Architektenkammer Baden-Württemberg (German registration)

Engineering - Ingenieurkammer Baden-Württemberg (German registration)

Practical Training

Before joining academia, I worked as a journey architect in Germany and in the USA.

1977 Baubehörde Hamburg - Schulbau (Hamburg City Building Office - School Design)

1978 Büro Anders - Bonn (Architecture Office Anders in Bonn, Germany)

1980 Robert Kennedy, Architect - Office in Knoxville, Tennessee

Professional Practice

From 1996 to 2001 I worked in three offices in Stuttgart, Germany.

Sonderkonstruktion und Leichtbau (SL)

In 1996 I joined the architectural office Sonderkonstruktion und Leichtbau (SL). The office is internationally distinguished for projects involving lightweight structures, and has collaborated with Frei Otto on numerous occasions. The principal architect is Bodo Rasch. I was hired to perform all in house engineering for the firm, and specifically to design structural steel details for a 100 foot diameter dome in Kuala Lumpur, Malaysia. http://www.sl-rasch.de/

Ingenieurbüro Dr. Switbert Greiner

In 1998, after the completion of the dome project at SL, I was invited by Dr. Greiner to join his engineering consulting firm. Dr. Greiner studied with Professor Jörg Schlaich in Stuttgart, and has worked with Frei Otto at IL and Bodo Rash at SL. His practice specializes in engineering design and analysis of lightweight membranes (pneumatics and tents), thin shells and reticulated structures (grid shells). Upon joining the firm I was able to participate in several projects including the detailing of demountable tent coverings for a pair of courtyards in the Oberbaum City complex in Berlin, wind analysis of the Shanghai 21st Century Tower, a high-rise by Helmut Jahn and Werner Sobek, and a small but structurally complex pavilion for the Expo 2000 in Hannover. http://www.greiner-engineering.com/

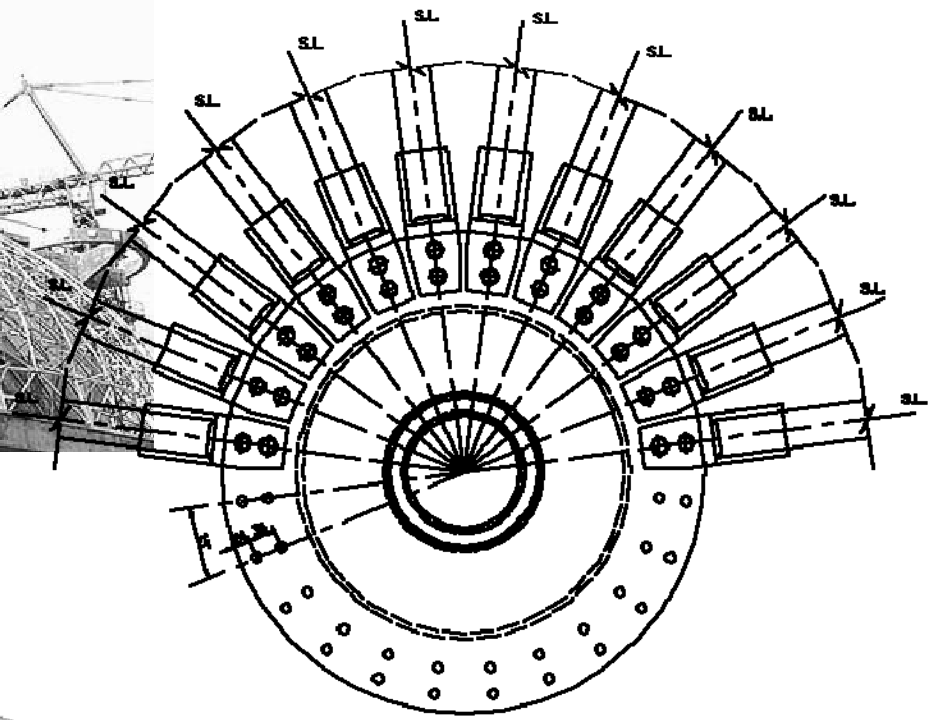
RFR Stuttgart

In January 2001, I was invited by Dr. Mathias Kutterer to join the Stuttgart office of the Paris based engineering firm, RFR (founded by Peter Rice). Until I left Stuttgart in July, I worked on the analysis and detailing of the Petritorbrücke, a pedestrian bridge in Braunschweig. This included all finite element modeling to investigate static behavior as well as dynamic oscillation of the cable suspended structure. http://www.rfr-stuttgart.de/rfr-website/

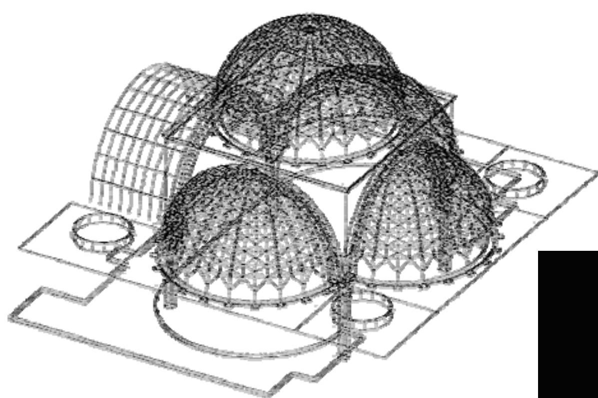
Masjid Wilayah Mosque

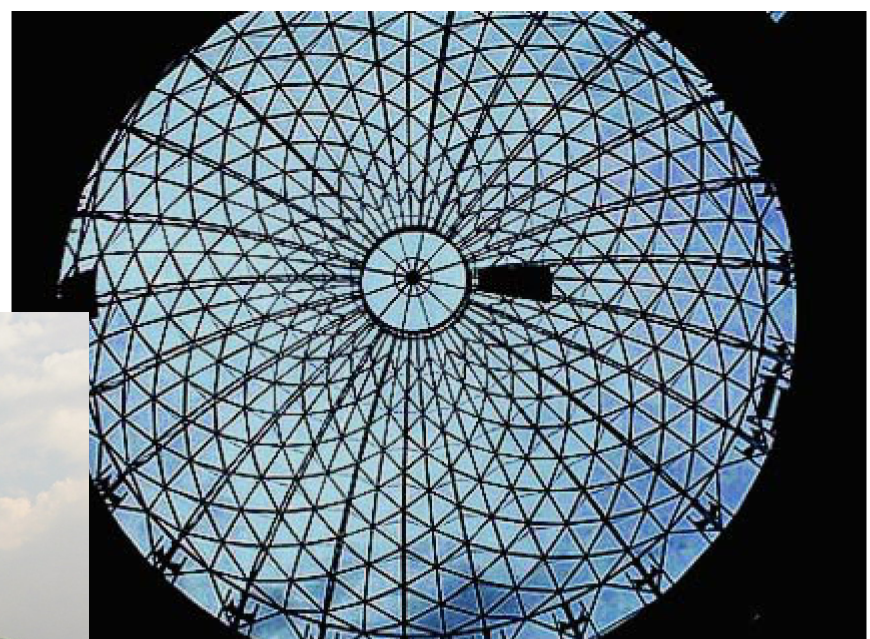
Kuala Lumpur, Malaya — Sonderkonstruktion und Leichtbau

Peter von Bülow — steel detailing and supervision of construction documents



SECTION B-B

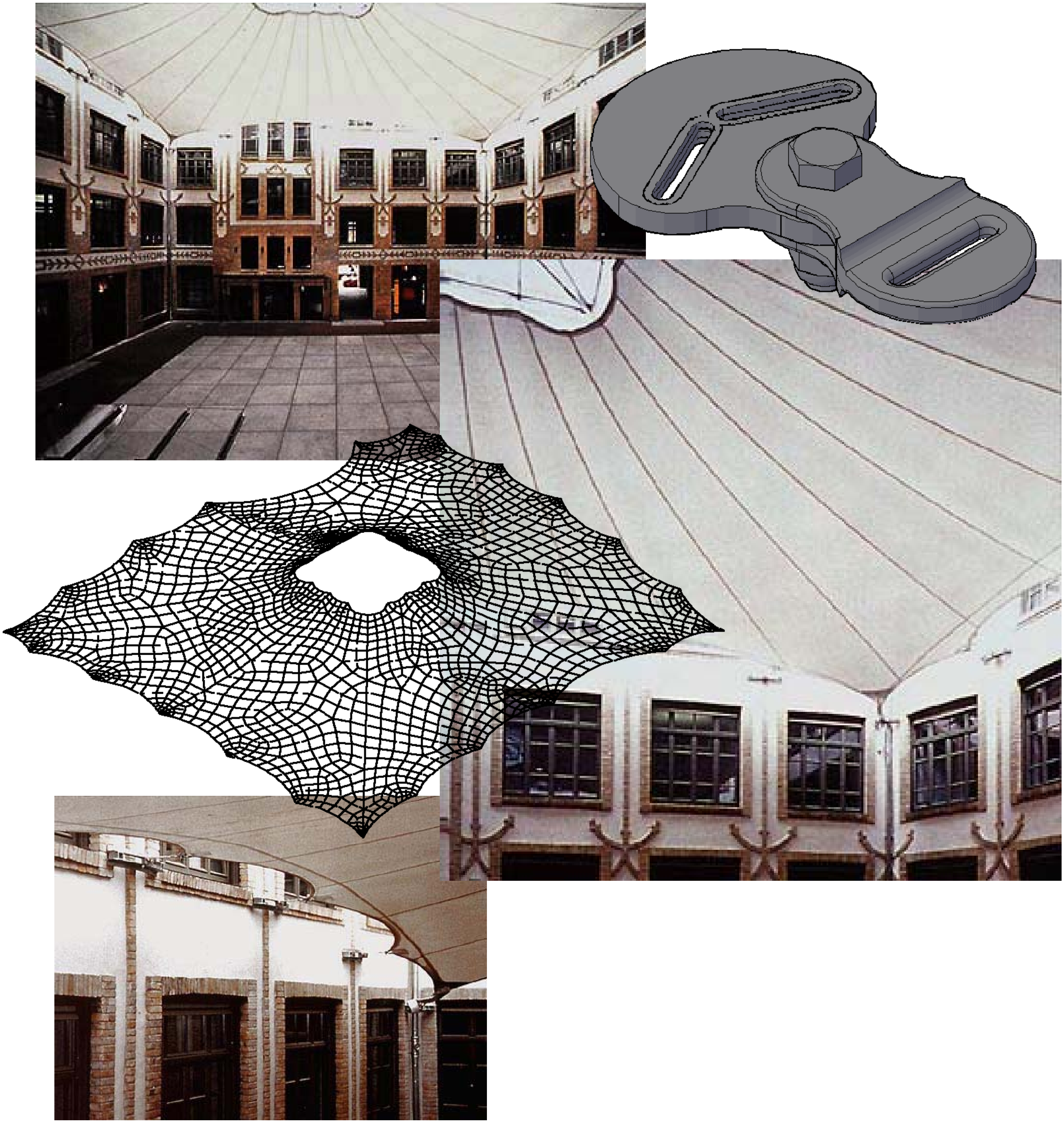




Courtyard Cover Oberbaum City

Berlin, Germany — Ingenieurbüro Dr. S. Greiner

Peter von Bülow — *fastener detailing, fabric pattern calculation, and construction documents*



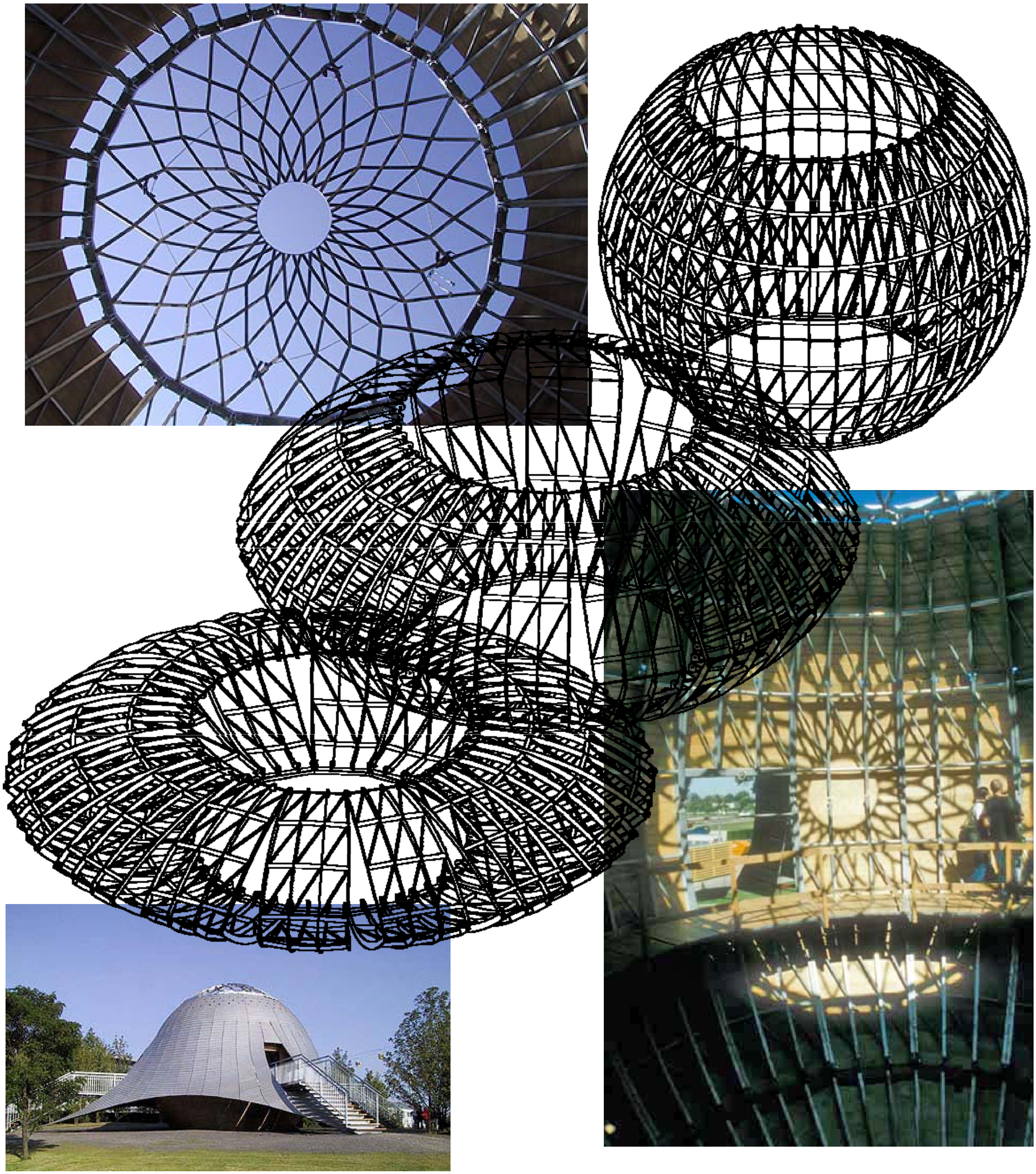
Expo 2000 - Pavilion

Hannover, Germany

Ingenieurbüro Dr. S. Greiner

Peter von Bülow

steel detailing, and construction documents



P e t r i t o r b r ü c k e

Braunschweig, Germany RFR - Stuttgart

Peter von Bülow static and dynamic analysis, detail design and analysis