



What is Optimal Design

An optimal design will utilize a maximum amount of purchased needed material while minimizing waste, construction cost and time.

Adjustments to design parameters can be done in a manner to either utilize a budget or material usage target. Research focus and design development should identify optimal methods of and design and analytic tools.

Understanding Methods and Materials

Each construction method or building material or systems, have limitation which constrain a design.

Identified Constraints:

- Structural / Code
- Budget / Cost
- Available Stock X, Y, and Z
- Client Demand

Each of the properties has a logical relationship to each other, and can be mapped to develop a graphical method of optimal relationship.

Logic Mapping

Uses common properties shared by each material or system. Mapping should allow for the identification of further constraints, or limitations to an optimal design return. Mapping allows for the development of common profiles of design and a field of possible solutions.

A Residential Contraction Profile may show the mapped relationships between:

- Cost / Unit Cost
- Material Size / Available Stock
- Maintenance Cost / Lifetime
- Acceptable Construction Methods / Spacing, Loads

Four Methods of Optimal Analysis

Experimental architectural design used in manner to create adaptive forms of value engineering which links aesthetic design principles with optimal numerical methods.

Manual, Common Sense

Manual application of optimal practices without upfront numerical analysis, optimization by doing. Performed on the fly adjustment to effect an change in performance or quality.

Linear Programming

Uses Linear Algebra in a graphical method to define a field of optimal conditions bounded by linear arguments reflecting model constraints.

Simplex Analysis

Uses Simplex Algorithm to mathematically solve a system of linear arguments defined by user input.

Logic Modeling

Uses automated program defined by construction assembly type. Uses logic gates and logical statements to generate an optimal condition.

Limitation to Optimality

A main limitation to generation of a optimal solution is the correct defining and correlation of variables and objectives. The correct definition of variables is important, and needed in the formation of a prescriptive informative model.

Value Engineering

Value engineering is a systematically structural way of approaching design by developing an optimal solution to design projects, products, and processes. Value engineering is a commonly practiced method of critical design and analysis in construction and manufacturing. It provides both methods and philosophical doctrines for the evaluation and development of building performance to economic solutions. Value model analysis, analyses the performance variables of the designed environment to derive the lowest cost per opportunity optimal solution. This would be defined in common terms, "the best bang for your buck." In this type of modeling terms or factors can be defined as either quantified or qualified variables of both endogenous and exogenous nature and measure. This type of analysis is mechanically scientific and principally holistic. It has the possibility for further application in architectural design.

Routes to Optimal Construction

General Practices

Use available stock as much as possible, limiting when possible the use of custom applications.

Use materials in a manner that minimizes or eliminates cuts and excess milling. The minimizing of field cuts minimizes construction time, construction cost, and material waste.

Design and building systems should be simplified to the basic, acceptable elements needed for the completion of construction.

Determine the dominant measurement for each assembly or construction type. This is accomplished through logic mapping. The standardization of design to a dominant measure will allow for a high rate of optimality.

Construction should be performed in a method that minimizes wasteful practices, and use quality as a doctrine throughout.

Design using grid that reflects the dominant measurements. In nominal materials available within this occurs at one foot vertical and four foot horizontal. This design by grid is historically seen within practice.

Manual, Common Sense

Inputs to system

- Acceptable uses of Materials
- Understanding of Construction Systems
- Review of Code
- Quality Assurance
- Construction Practices

Optimal Practices are applied during design and construction.

Known Issues:

Manual application provides little or no foresight to complicated issues during design and initial construction phases.

Individuals involved in work need a high level of practical construction knowledge and optimal practices.

Have a need to perform post occupancy to evaluate performance.

Linear Programming

Inputs to system

- Acceptable uses of Materials
- Understanding of Construction Systems
- Review of Code
- Quality Assurance
- Construction Practices
- Cost Profiles
- Economic Analysis

Linear Programming uses a system of linear equations from logic mapping to numerate an optimal return subject to an Objective Function. Linear methods can be applied as either as generative process or as post occupancy numerical analysis. Linear methods can be applied as either as generative process or as post occupancy numerical analysis.

Objective Function:

An Objective Function is any metric chosen by a designer which they want to optimize, or desired outcome.

Logical Operators:

Each linear argument is resolved to a matching logical operator selected by the user. This controls the range of return.

- Equal To
- Less Than
- Greater Than
- And
- Or
- Dose Not Equal

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Linear methods can be applied as either as generative process or as post occupancy numerical analysis.

A need to develop and understand the working mathematics of Linear Algebra used in analysis.

A need to find numerically similar attributes of the materials and processes used. Linear Analysis works best in systems with fewer linear equations.

Linear programming cannot account accurately for functions that are exponential.

A need to select appropriate model limits and constraints. The choosing of incorrect or poorly weighted constraints can result in false optimal or resolution to a local minimum. Linear reduction tends to favor materials with sizes and prices that easily dividable or of lower cost.

Advantages:

Linear Programming can provide in an accurately weighted model an optimal condition, numerically.

Methods can be used in programmed automated systems.

Simplex Analysis using Solver Application

Automation of Linear Programming

Inputs to system

- Acceptable uses of Materials
- Understanding of Construction Systems
- Review of Code
- Quality Assurance
- Construction Practices
- Cost Profiles
- Economic Analysis

Simplex optimization provides the optimal method for solving linear equations presented by critical architectural design. The Simplex method of solving linear programming problems returns a optimal solution in to a user defined objective function by iteration of designer selected decision variables. This performed by means of Gaussian reduction and back substitution to return a final optimized tableau in optimal resolved form.

The automation of this numerical method of design optimization is easily implemented and performed by digital computation. The automating of modeling in this manner allows for an accurate level of analysis across thousands of input variables and constraints.

Optimization in the model is performed by the use of the Solver application. Model defining parameters are entered into the application from model properties in the tableaux as either as a decision variable or constraint. The application allows for the optimization of an objective function at a maximum, minimum, or user defined target numerical value.

Known Issues:

Simplex Analysis has the same known issues as traditional Linear Programming methods.

Advantages:

Automation of modeling allows for quick, accurate iteration of model variables.

Allows for the programming and storing of model variables with a single, searchable database.

Logic Modeling

Inputs to system

- Acceptable uses of Materials
- Understanding of Construction Systems
- Review of Code
- Quality Assurance
- Construction Practices
- Cost Profiles
- Economic Analysis

Linear Programming and Simplex analysis are highly limited when deriving system attributes that are numerically similar. Many of the attributes of residential construction do not share an appropriate compatible numerical variable. A Need exist for the accurate accounting of these non conforming variables present in residential construction.

System analysis is performed by iteration of model variables through a system of Logical Statements which generate a series of optimal assemblies.

Linear Argument:

IF A=B, Then C, ETC

The logic modeler uses the same basic logical operators as Simplex Analysis. It however, expands to allow the nesting of multiple functions within one logical statement. Each variable is dynamically chained to each in the assembly.

Importing of Logic Data:

Data is imported into the model is derived from logic graphics; which display the numerical and non-numerical interactions of construction methods, materials, and design principles. Each interaction is then converted to a logical statement.

Known Issues:

This type of modeling, though hyper accurate, requires an excessive time of upfront programming. The development of each logical statement requires an individual with a high knowledge of model parameters and system inputs.

Advantages:

Logical Modeling allows for the quick, accurate, iteration of model variables based on user controlled input and programmed variables.

This type of modeling allows for the accurate accounting of material use and waste product, with an attached cost profile.

Logical modeling allows for the introduction of dynamic shape data, allowing the quick and accurate output of a vector graphic with accurate dimensions.

Note:

Logical Modeling is a learning system and improves through application to different construction techniques and building styles.

Possible Future Implications for Practice:

Logic Modeling and the linking of shape data to numerical analysis, allows for the introduction of advanced formulas relating to structural design and environmental systems.

The type of model provides economic sensitive data, and allows the introduction of non-numerical attributes relating to client beliefs and larger social patterns.

Experimental Architecture Development of Design

The initial design work was completed without regard to optimal philosophy. This was done in order to preserve aesthetic qualities present by innate interactions of volumes and style. The design was translated from sketches to a parametric model. Once completed, optimal logic is applied to the initial parametric model. Modeling the design in this manner provides a test bed for the application of optimal design practices which can be translated into analytical methods. The manually optimal design is considered ideal, It remains unchanged as a benchmark.

Major Project Elements

The project is a mid size residential structure, of one to two stories. The structure is not to exceed 2400 square feet. The residence is a single family home. The layout consists of at least two bedrooms, with a minimum square footage of seventy and a maximum of 250 square feet. Bathrooms at minimum will be one full bath, located adjacent to bedrooms, and half bath located near the family space. General use spaces are a family space of 550 square feet, and a kitchen of 550 square feet. The entry space will be adjacent to the kitchen and family space. A mechanical room is adjacent to the kitchen and half bath.

Spaces



Primary Spaces	Living-Kitchen	423.6
Master Bedroom	Half Bath	40
Bedroom Two	Full Bath	78.3
Full Bath	Mechanical	63.9
Half Bath	Bedroom One	107.145
Kitchen	Master Bedroom	156.5
Family Space		
Mechanical		
Entry	Total Final Usable	1130.6