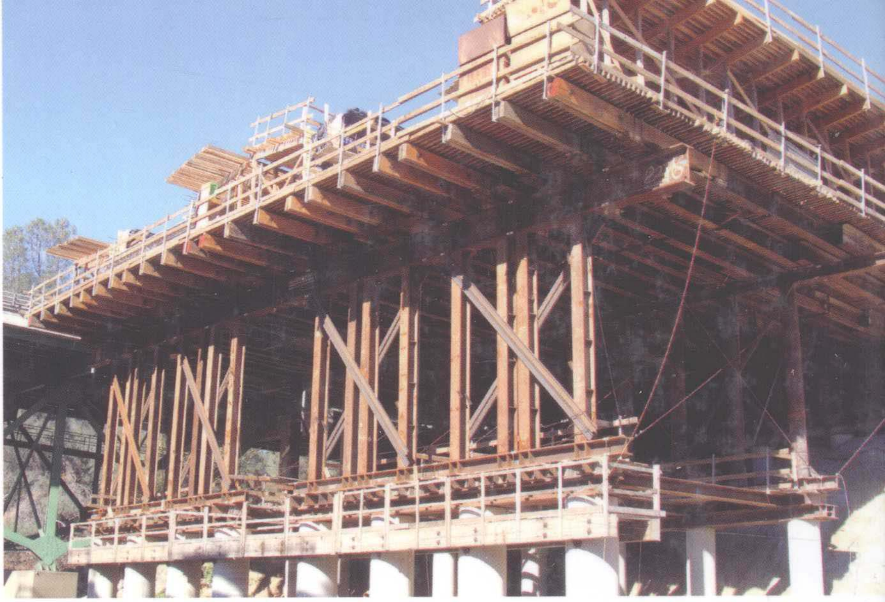

TEMPORARY
STRUCTURE DESIGN

Chris Souder

WILEY

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I would like to dedicate this book to Stuart (Bart) Bartholomew.

I only knew Bart for 14 years, but in this short time he had more influence on me than most. Not only did Bart design the temporary structure class that this book was designed for, he was instrumental in my decision to change to the teaching profession. Countless breakfast and lunch meetings had me listening in amazement to the years of construction, teaching, and consulting experiences. Bart, you are a model of integrity, honesty, and ethical behavior.

ABOUT THE AUTHOR

Chris Souder graduated with an undergraduate degree in construction management in 1988 before going to work for Kiewit Pacific Co. in northern California. Chris had a successful 16-year career with Kiewit and was involved with many projects in the heavy civil arena. Chris held positions from field engineer to project manager to lead estimator. Some of the projects Chris was involved with were the Woodland WWTP expansion in Woodland, California, Highway 85 Bridge construction for CalTrans in San Jose, California, WWTP Expansion and new facilities for the City of Roseville at its Booth Rd. and Pleasant Grove Plants, Highway 101 Retrofit work for CalTrans in San Francisco, California, new Highway 880 construction of bridge structures for CalTrans in Oakland, California, following the 1989 Loma Prieta earthquake, Water storage facilities for the City of Sacramento, new bridge and 2 miles of road construction including a pump station in Oroville, California, an expansion of the Sacramento River WTP facility for the City of Sacramento, and various estimating assignments for both heavy highway and water treatment facilities throughout northern California. These projects as a whole had total revenues in excess of $420 million.

Chris then pursued an Interdisciplinary Master's degree in construction planning at California State University, Chico, while teaching full time in the construction management program. Today, Chris teaches temporary structures and scheduling and project controls to fourth-year students at Chico State while maintaining a continuous portfolio of consulting projects and industry trainings ranging from cost estimating, temporary structures design, and scheduling services. While teaching, Chris received the terminal degree in construction management by completing his M.S. in construction planning at Chico State. This education, combined with 16 years of heavy civil industry experience makes Chris a most effective type of professor in the construction management discipline.

PREFACE

Temporary structure design is not taken lightly by the owner, engineer, or contractor. It has and should always be a practice that is performed by a licensed engineer in its specific discipline. However, the construction manager should be versed in the design procedures to a point where he can request a particular design or review a concept or submittal with the ability to understand the basic components of the design.

In 1989, the fourth edition of *Simplified Mechanics and Strength of Materials* was written. This book is an example of the present book's goal. I was inspired by the simplicity that Parker and Ambrose displayed in their text. I truly believe that this subject can be well understood by the construction manager without the ultimate goal of becoming a licensed engineer. However, if that is the goal of the student, this text will prepare you to take the next step in engineering pursuing your goal to be licensed.

There is a need for this topic in a construction management (CM) degree, both undergraduate and graduate, civil engineering (CE), both under graduate and graduate, or in industry that is simplified enough that the student, intern, or engineer can simply follow the major concepts without sacrificing key engineering principles. Different universities approach the temporary structures topic in several ways. Some, like Chico State, make it the culminating experience following statics and mechanics. This text will compliment a similar program. Others teach a "structure" class that gives the students a basic understanding of how structures are designed. The latter focuses more on permanent design. Many civil engineering students graduate and go on to work for state agencies or heavy civil contractors. Both of these careers rely heavily on the design of temporary structures. With the state agency, one will be reviewing and inspecting temporary structures. With the contractor, one will be involved with helping design and building temporary structures. These two paths are very rewarding for a CM or CE undergraduate or graduate student.

I also wanted students of temporary structures to be able to comprehend the more complicated analysis that come with more difficult loading conditions without the need for a complete understanding or need for indeterminate structure analysis. I want the student to be aware of the available software on the market today that can simplify even the most complicated loading condition.

I also thought it was important that the student or engineer of this subject be able to understand and perform simple cost estimates of the designs that are explained in each chapter. Most chapters have brief explanations of cost analyses so the educated decisions can be made during the design phase.

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To Jessica, Jason and Devon, thank you for putting up with me through this life of construction. To my brothers Greg and Mike, Greg for encouraging me to go into a construction management program and Mike for his constant support. To my parents, Dick and Ines Souder for your constant support, even if you really don't know what I do for a living.

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CHAPTER 1

STATICS REVIEW

1.1 STATICS REVIEW

In construction management and civil engineering programs, students are required to take statics and strength of material classes in preparation for their successor. The successor might be a generic "structures" course, a temporary structure course, or maybe no successor course at all. Whichever direction the curriculum goes, the basics of statics and strength of materials is the common denominator.

This book has been written under the assumption that the student has a background in statics and strength of materials and these skills only need to be refined. Temporary structures utilizes many of the less complicated aspects of statics and strength of materials, so even if the student did not master the two prerequisites, he should still be successful in the subject matter of this book. In addition, temporary structure design is a very practical subject, and the student should be energized to see that the challenges that this book covers are real construction situations that the student will experience for his or her entire career.

1.2 UNITS OF MEASURE

At the time of this writing, local and state projects in the United States continue to use the English "Imperial" unit system (feet, pounds, etc.). While most of Europe and the rest of the world use the metric system, the United States has resisted this movement. Even the California Department of Transportation, which had converted current and future projects to the Imperial system of measures late in the 20th century, has gone back to using the Imperial system in the early 21st century. Since England

TABLE 1.1 Units of Measure

Unit Name	Unit of Measure
Length	
Foot	ft (′)
Inches	in (″)
Area	
Square feet	SF, ft^2
Square inches	in^2
Volume	
Cubic feet	CF, ft^3
Cubic inches	in^3
Force and Pressure	
Pound	lb, #
Kip	k (1000 lb)
Pounds per ft	lb/ft
Kips per ft	k/ft
Pounds per SF	lb/SF, psf
Pounds per linear foot	lb/ft
Kips per linear foot	kpf
Kips per SF	k/SF, ksf
Pounds per CF	lb/CF, pcf
Moment	
Foot-pounds	ft-lb
Inch-pounds	in-lb
Foot-kips	ft-k
Inch-kips	in-k
Stress	
Pounds per ft^2	psf, lb/ft^2
Pounds per in^2	psi, lb/in^2
Kips per ft^2	ksf, k/ft^2
Kips per in^2	ksi, k/in^2
Temperature	
Degree Fahrenheit	°F

has also gone to the metric system, their "English" Imperial system is now referred to as the U.S. units. Because this text has been written for students in the United States, examples will be given in U.S. units only. Table 1.1 shows most of the common units of measure used in this book.

1.2.1 Common Units of Measure

With any engineering subject, the use of variables to represent different engineering values is standard. These symbols derive either from the Greek alphabet or English letters. Regardless, a great number of symbols are necessary to represent the various engineering concepts. Table 1.2 shows the notations and symbols most used in this book.

TABLE 1.2 Notation and Symbols

Subject	Symbol (Variable)	Description
Properties	S	Section modulus
	I	Moment of inertia
	E	Modulus of elasticity
	A	Cross-sectional area
	r	Radius of gyration
	R	Radius of a circle
	e	Eccentricity
	a	Moment arm distance
	b	Beam width
	c	Distance from centroid to top or bottom edge
	d	Depth of beam
	D	Diameter of a circle
	g	Acceleration of gravity
	h	Height or depth
	K	Distance from top of beam to tangent of web
	e	Effective length of a column or strut, distance from top of beam to web tangent
Stress	f_b	Bending stress
	f_v	Shear stress
	f'_v	Twice shear stress used for short-term shear loading
	$f_{c\|}$	Normal compression stress parallel to the grain of the wood
	f_c	Normal compression stress perpendicular to the grain of the wood
Soil Mechanics	c	Cohesion (psf)
	ϕ	Angle of internal friction (degrees)
	β	Passive slip plane angle (degrees)
	α	Active slip plane angle (degrees)
	μ	Coefficient of friction
	γ	Unit weight (pcf)
	π	$\pi = 3.1416$
	k_a	Active soil coefficient
	k_p	Passive soil coefficient
	T	Temperature

1.3 STATICS

Statics is the study of an object that is not moving, hence static or equilibrium. A force is a motion or change of motion in a body. A common force that is produced on Earth naturally is gravity. Gravity is the tendency of the weight of a body to be attracted to the center of the Earth. The mass of some unit weight is placed in motion by gravity or other means. The force of the mass originates at the center of gravity of the body in question. Thus, there is direction and a known weight. Another way to describe a force is something that has magnitude and direction.