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**MODELLING OF DIMENSION LUMBER IN AXIAL
COMPRESSION AT ELEVATED TEMPERATURES**

by

INEKE MARIA VAN ZEELAND, B.ENG.

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfillment of
the requirements for the degree of

MASTER OF ENGINEERING (CIVIL)

Department of Civil and Environmental Engineering
Carleton University
Ottawa, Ontario
December 2000

The Master of Engineering
in the Civil and Environmental Engineering Program
is a joint program with the University of Ottawa,
administered by
the Ottawa-Carleton Institute for Civil Engineering

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Department of Civil and Environmental Engineering

The Undersigned recommend to
the Faculty of Graduate Studies and Research
acceptance of the thesis

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Abstract

The design of wood-frame structural systems to withstand exposure to fire depends on knowledge of the fire endurance (time-to-failure) of the wood members used in the system. In fires, wood loses part of its load-carrying capacity due to charring and part due to strength degradation. This thesis examines the reduction in compression strength experienced by dimension lumber when exposed to elevated temperatures.

A program of experimental testing of nominal 2×4 Machine Stress Rated (MSR) lodgepole pine lumber concentrically loaded in compression and exposed to elevated temperature was undertaken by Forintek Canada Corp., Canada's wood products research institute. A computer program entitled HTEposure was written to simulate the experimental time-to-failure data gathered in Forintek's testing program. This computer program combines a modification of an existing heat-transfer model with various published compression-strength reduction models. This was done in order to determine which of those strength-reduction models could predict times-to-failure comparable to the observed values. As well, a new compression-strength reduction model was proposed. When predicted results were compared to the observed data, it was determined that the computer program predicted results closest to those observed when using the new compression-strength reduction model proposed in this study.

Acknowledgements

The author is gratefully indebted to the many people involved in this thesis work. Particularly, the author thanks the thesis supervisors, Dr. Jim Mehaffey and Dr. Juan Salinas, for their enthusiastic support, helpful comments and patient guidance during this work. The author would also like to thank Mr. Les Richardson for his valuable review of this manuscript, and Dr. Nouredine Bénichou for his interest in and guidance during this research.

The author acknowledges Forintek Canada Corp., who would like to thank its industry members, Natural Resources Canada (Canadian Forest Service), and the Provinces of British Columbia, Alberta, Québec, Nova Scotia, New Brunswick and Saskatchewan for their guidance and financial support for this research. As well, the author would like to acknowledge: Dr. Peter Lau who initiated the research program and oversaw the experimental work; the management team at Forintek who approved the project and supported the author and the work; and, the technical staff at Forintek for their assistance in collecting the experimental data.

The author thanks her husband Greg Adams, and all her family, for their encouragement, love and support.

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Nomenclature

$A =$	empirically-determined material parameter
$a =$	empirical parameter dependent on time and temperature
$a_i =$	empirically-determined parameters for kinetic strength and damage accumulation models
$a_T =$	function dependent on temperature and activation energy
$\alpha =$	sum of accumulated damage
$\alpha _{t=0} =$	initial damage within a member, due to member's history of loading and unloading
$B =$	empirical parameter dependent on temperature
$B_1, B_2 =$	empirically-determined material parameters
$b =$	initial breadth of member cross-section before fire (larger dimension), mm
$\beta =$	rate of charring of member, mm/second
$C_e =$	"effective" thickness of char layer, mm
$c_1, c_2 =$	empirically-determined material parameters
$\chi^2 =$	resulting value of χ^2 -test method used for comparison of two data sets
$D_i =$	depth of a layer, or "zone", within heated specimen, inches
$d =$	initial depth of member cross-section before fire (smaller dimension), mm
$\frac{df}{dt} =$	rate of fracture of member experiencing elevated temperature and loading, seconds ⁻¹
$\left(\frac{df}{dt}\right)_\sigma =$	rate of fracture dependent on external stress, seconds ⁻¹
$\left(\frac{df}{dt}\right)_T =$	rate of fracture dependent on temperature, seconds ⁻¹
$dx =$	finite length of a single element in x-direction, mm
$dy =$	finite width of a single element in y-direction, mm
$\frac{d\alpha}{dt} =$	rate of damage accumulation in a member experiencing elevated temperature and loading, seconds ⁻¹
$\frac{\partial f}{\partial t} =$	rate of change of fraction of unbroken bonds, seconds ⁻¹
$\delta =$	an equivalent finite thickness below char layer of zero strength to represent any temperature-weakened residual unburnt wood, mm

$E_0 =$	room temperature modulus of elasticity
$E_{CB} =$	modulus of elasticity as determined by a Cook-Bolinders MSR machine, MPa
$E_I =$	instantaneous modulus of elasticity, MPa
$E_i =$	reduced modulus of elasticity, due to elevated temperature
$E_j =$	delayed modulus of elasticity, MPa
$e_i =$	number of "expected", or observed, data values in the i -th data interval for the χ^2 -test method
$\varepsilon =$	strain, mm/mm
$\varepsilon_c =$	long-term creep deformation, or strain over time, mm/mm
$\varepsilon_T =$	strain experienced under constant compression load at constant temperature, mm/mm
$\varepsilon_t =$	strain experienced at different temperatures at a specific time, mm/mm
$f =$	fraction of unbroken elements or bonds
$fn_1(\sigma), fn_2(\sigma) =$	functions dependent on stress
$fn_2(t) =$	function dependent on time
$g =$	empirical parameter
$\gamma_0 =$	modification factor for energy barrier as a consequence of applied stress in the direction of each bond
$h =$	empirical parameter dependent on time
$J =$	creep compliance function
$J_0 =$	empirically-determined material parameter for creep compliance
$J_i =$	empirically-determined material parameter for creep compliance
$J_v =$	empirically-determined material parameter for creep compliance
$\varphi =$	longitudinal stress per bond
$K_r =$	function describing rate of reformation of broken bonds
$K_b =$	function describing rate of rupturing of unbroken bonds
$k =$	ratio of compression load to load-carrying capacity of member, kN/kN
$\kappa_0 =$	modification factor for energy barrier as a consequence of applied stress in the direction of each bond
$\lambda =$	residual strength of unburnt wood expressed as a fraction of room-temperature short-term strength, MPa/MPa
$M =$	moisture content, %
$m =$	the number of data intervals required by the χ^2 -test method
$\mu_{\ln(\sigma_0)} =$	<i>Lognormal</i> mean value of initial room temperature compression strength
$\mu_{\sigma_0} =$	mean value of initial room temperature compression strength, MPa
$N =$	empirical parameter dependent on temperature
$n =$	total number of values in a given data set
$\eta =$	material parameter
$P =$	percentage of initial room-temperature strength reduction, %

$p_i =$	number of predicted data values in the i -th data interval for the χ^2 -test method
$q =$	empirically-determined linear parameter
$R =$	universal gas constant
$r =$	empirically-determined linear parameter
$r_1, r_2 =$	empirically-determined material parameters
$\rho =$	density, kg/m ³
$\rho_0 =$	base or initial density, kg/m ³
$SD_{\ln(\sigma_0)} =$	<i>Lognormal</i> standard deviation of initial room temperature compression strength
$SD_{\sigma_0} =$	<i>Normal</i> standard deviation of initial room-temperature ultimate compression strength, MPa
$SG =$	specific gravity
$\sigma =$	stress, MPa
$\sigma_0 =$	room temperature compression strength, MPa or psi
$\sigma_c =$	constant stress, MPa
$\sigma_i =$	reduced compression strength, due to elevated temperature, MPa
$\sigma_{25\text{kN}}, \sigma_{37\text{kN}}, \sigma_{50\text{kN}} =$	stress applied by concentric compression load of 25 kN, 37 kN, and 50 kN, respectively, MPa
$T =$	temperature, Celsius or Kelvin
$T_0 =$	base or initial temperature, Celsius or Kelvin
$T_p =$	temperature at interface between charred wood and uncharred wood, or "char front", Celsius
$t =$	time, seconds
$t_i =$	retardation time, seconds
$t_f =$	time to failure of a specimen, seconds
$ttf_{Pi} =$	the i -th time-to-failure value predicted by a model, in a set of sorted time-to-failure data, seconds
$ttf_{Ei} =$	the i -th time-to-failure value expected or observed in a set of sorted time-to-failure data, seconds
$\tau_j =$	retardation time, seconds
$V =$	volume of wood specimen, mm ³
$\nu =$	viscosity
$\omega_r =$	frequency of forming bonds
$\omega_b =$	frequency of breaking bonds
$X_{05} =$	5 th percentile value of ultimate room temperature compression strength, MPa
$X_{95} =$	95 th percentile value of ultimate room temperature compression strength, MPa
$x =$	depth into wood member from the char front, mm
$x_{th} =$	thermal penetration depth, mm
$\xi =$	activation energy
$\xi_r =$	activation energy for bond reformation

$\xi_b =$	activation energy for bond rupture
$\xi_T =$	activation energy of thermal degradation
$\psi =$	parameter dependent on anatomical properties of material, i.e. "species effect"
$Z =$	a load factor; includes effect of effective column length factor and unsupported length of column

1.0 INTRODUCTION

Many modern engineered wood structural systems are assembled from small-dimension lumber. They rely on nails, screws, metal-plate connectors or structural adhesives to transmit loads between members or systems of members. Under Canadian and US grading rules (Canadian Lumber Grading Manual, 1994; Standard Grading Rules for Canadian Lumber, 1994; Western Lumber Grading Rules, 1995), the lumber employed in these systems is called "Light Framing" or "Structural Light Framing". This class of dimension lumber has a thickness between 38 and 89 mm and a width between 89 and 286 mm. Knowledge of the structural performance of such lumber, particularly composite behaviour and load sharing between elements within a building system, has increased since the 1970's. As well, improvements in grading structural lumber have increased accuracy so that confidence in the assigned member strength characteristics within each grade has also increased. The design of wood structural systems to perform under standard conditions, using this knowledge and recent engineering techniques, has meant that such systems have become more structurally efficient. The total aggregate cross-sectional area of wood members within a structural system that in the past was redundant under normal performance conditions has been removed in the design process. Either smaller dimensions of lumber are now used, or members are spaced farther apart. However, the effect of the reduction of the total cross-sectional area of members on the level of fire safety provided by such system designs has not been fully examined or understood. In addition, prescriptive regulations and standards related to fire resistance were developed decades ago and have remained fairly unchanged. Consequently, the

ability of these systems to perform their load-carrying function during fire exposure has been questioned.

Currently, the National Building Code of Canada (NBCC) (National Building Code of Canada, 1995) is undergoing a significant change in format. From its inception in 1941, the NBCC has been a prescriptive code. This means that the code has been made up of a series of authoritative directives or prescriptions that dictate the use of specified requirements based on generalized construction types and occupancy classifications (Meacham, 2000). However, there are a number of well-recognized limitations to prescriptive codes. One is that the prescriptions cannot anticipate and adequately address the wide variety of buildings that are designed and built. Sometimes it is difficult to apply a code prescription to a given building situation; at other times, the prescription is applied but the implicit safety objective is not actually achieved (Bartlett, 2000). Another difficulty is that the objectives that each prescription was intended to meet are not explicit, so that designers may not always know what was meant to be achieved by specific prescriptions. Because objectives are not explicit, and because prescriptions are often developed in isolation, changing of prescriptions or additions of new ones can cause contradictions within a code. As well, prescriptions are based on a certain set of conditions and assumptions; over time, some of these conditions and assumptions may become either invalid or are discovered to have been unfounded. For example, the assumption made in the 1950s and 1960s that structural light-framing building systems provided a sufficient level of fire safety has been questioned because,

over the intervening years, the structural redundancy that existed within such systems has been removed. For these reasons and others, there has been a world-wide trend towards adopting codes which state clear objectives and leave actual design to the designers, who must then demonstrate that their design meets the stated objectives and performs as required. These are called objective-based or performance-based codes.

Canada is in the process of transforming its prescriptive national building code to one that is objective-based. It will consist of a set of objectives which will be described in more detail by qualitative functional requirements. Each functional requirement will be followed by a series of "intents" that will explain the thinking behind each requirement in plain language. Many of the current NBCC prescriptions will form part of a reference document of suggested solutions that are deemed to meet the stated objectives.

One result of this change from prescriptive to objective-based codes will be that safety objectives with respect to fire will be explicitly stated. Designers will have the freedom to apply engineering principles to fire safety design in order to meet these objectives rather than just following the current prescriptions. The application of engineering principles to design for fire safety is called fire safety engineering.

There are international efforts currently underway to develop fire safety design as an engineering discipline. One way this is being done is by addressing the issue of fire safety design of wood-frame structural members from the viewpoint of reliability. In

recent years, Canadian engineering structural design methodologies for steel, concrete, and wood have moved from purely deterministic formats to ones that include reliability-based approaches. It is believed that fire safety design can benefit from a similar format.

The reliability of a structural member, or system of members, is a measure of the probability of success of the member or system. Reliability measures the probability that the capacity of the member or system will not be exceeded by the load or demand on it. In designs based on probabilistic theory, the goal is to limit the probability of failure with respect to a performance function so as to increase the reliability of the design. This approach could provide a means of measuring the level of fire safety of a given design. With the use of a reliability-based approach, fire safety engineering can provide a framework within which the ability of different competing structural building materials to furnish a target level of fire safety can be compared.

Current prescriptive regulations and standards tend to restrict the use of wood simply because it is combustible. The effect of elevated temperature exposure on the strength of all structural building materials is not considered in the current categorizing of such materials as either combustible or non-combustible. The wood industry should take advantage of the opportunity that is provided by objective-based codes and probabilistic fire-safety design methodologies for wood-based assemblies to be treated equitably. In order to do so, however, the wood industry must be prepared to provide adequate and reliable data so that the behaviour of wood structural systems during fire exposure can be

accurately predicted. Standards for testing members at elevated temperatures have not been set. Also, more data is required to model wood's material behaviour than is required for steel and concrete. This is because wood is a natural material from a formerly living organism. As a result, it has significant variability between species, within a specie, and even within an individual plant. Consequently, information regarding this variability needs to be gathered to be able to characterize its effect on the material properties of wood. As well, wood's material properties are affected in a more complex manner, when exposed to elevated temperatures (Schaffer, 1971), than those of steel and concrete.

Attempts have been made to model the structural behaviour of gypsum board-protected generic wood-stud wall assemblies exposed to fire. Some models are able to predict temperature as a function of time within the wall structure quite accurately, as well as the time to failure of the assembly due to heat transmission (Mehaffey *et al.*, 1994). However, the effects of elevated temperatures on individual structural members and the system as a whole have not been fully evaluated or incorporated in such modelling. Some of these effects include structural instability, change in level of resistance to axial loading and bending, and member breakage resulting in the redistribution of loads, which is sometimes called the "system effect".

For structural members exposed to the effects of fire, a decrease in their load capacity creates a significant increase in the probability of failure, and a decrease in reliability. In predicting decreases in the load-carrying capacity of wood structural

systems exposed to fire while under axial loads, two critical inputs are: (1) charring of the members; and, (2) the degradation effect of heat on the strength of the framing members, that is, the effect of temperature on the visco-elastic properties of the members. Although knowledge of structural behaviour of wood under standard conditions has increased markedly, as has comprehension of the role that charring plays in loss of strength, a greater understanding of changes in visco-elastic behaviour in compression at elevated temperatures is required (Lau, 1996).

Information about the compression strength of lumber at temperatures ranging from 60°C to 300°C, the approximate temperature at which charring of wood begins, is lacking. The available data pertains mainly to the response of very small clear wood specimens to a particular exposure time. Existing information does show, however, that members in compression are more adversely affected by temperature than those in tension or bending (Schaffer, 1971), (Gerhards, 1982), (König and Walleij, 2000). Because of the natural defects in lumber, the degree of temperature effect may also be influenced by the lumber's grade. Such a strength-dependence on lumber grade is common in wood. However, in fire safety design, lower wood quality does not necessarily imply shortened performance because, to satisfy a given level of standard structural requirements, lower-quality material will generally need to have a larger cross-sectional area, or more commonly, will require members to be spaced closer together. The latter may provide a better overall fire endurance, because it may result in greater

overall structural stability, a possible increase in the level of resistance to axial bending, or more effective redistribution of loads when member breakage begins to occur.

2.0 OBJECTIVES

This thesis is intended to advance knowledge of the behaviour of structural dimensional lumber in compression at elevated temperatures, as part of a continuing research program to characterize the reliability of structural lumber during fire events.

Specifically, the objectives of this thesis are:

- to explore the ability of published mathematical strength-reduction models to describe the rupture of a single structural lumber member concentrically loaded in compression and exposed to elevated temperatures, by comparison with experimental data collected on nominal 2×4 Machine Stress Rated (MSR) Spruce-Pine-Fir (SPF) structural lumber loaded in compression and exposed to temperatures up to 250°C, a temperature just below that at which char formation occurs in wood;
- to accomplish this by coupling each strength-reduction model in turn with a computerized heat-transfer model, and comparing predicted results with test data; and,
- to propose a new strength-reduction model that, when coupled with the heat-transfer model, may yield predictions closer to experimental results than those previously-published models explored in the first objective.

3.0 PROBLEM ANALYSIS AND LITERATURE REVIEW

At elevated temperatures, wood experiences a reduction of strength by two means. The first is charring, which reduces the cross-sectional dimensions of the member so that the area over which the load is carried becomes smaller. This has been examined by several researchers, including Lau *et al.* (1999). The second means of member strength reduction is through the changes in material properties of the visually unburnt portion of the cross-section, that result from chemical and mechanical degradation of the wood (Schaffer, 1971). These changes result in increased strain and rupture occurring in structural dimension lumber loaded in axial compression. Modelling of both of these phases has been attempted in the past, using various methods. The following sections discuss the variety of approaches taken in those modelling efforts.

3.1 Theoretical Modelling

3.1.1 Strain of Polymers at Standard Environmental Temperatures

Schaffer (1971) concluded that, at constant environmental conditions, the following general theoretical equation could be used to model the total strain ε , as a function of time t , that a polymer may experience under loading:

$$\varepsilon(t) = \frac{\sigma}{E_l} + \frac{f_1(\sigma) \cdot t}{\nu} + f_2(\sigma) \sum_{j=1}^n \frac{1}{E_j} \left(1 - e^{-\frac{t}{\tau_j}} \right) \quad [1]$$

where σ is stress, E_I is instantaneous modulus of elasticity, E_j is delayed modulus of elasticity, $f_1(\sigma)$ and $f_2(\sigma)$ are functions of stress, ν is viscosity (Newtonian or non-Newtonian), and τ_j is retardation time. The first term, $\frac{\sigma}{E_I}$, represents the instantaneous elastic response of the material under loading; the second term, $\frac{f_1(\sigma) \cdot t}{\nu}$, is the irrecoverable viscous flow of the material under constant load; and the third term, $f_2(\sigma) \sum_{j=1}^n \frac{1}{E_j} \left(1 - e^{-\frac{t}{\tau_j}} \right)$, represents the recoverable delayed elastic response.

Schaffer's model can be related to the molecular structure in most polymers. The first term is the basic relationship used to describe the instantaneous elastic response of many materials to a load, including wood. The magnitude of the second term depends on the resistance of individual molecules to relative slippage. It is a function of intermolecular attraction and the degree of cross-linking of molecules - a lower degree of cross-linking increases the term's magnitude. Physically, the third term represents the uncoiling, disentangling, and temporary re-orientation of the material's molecular chains. The time that this process takes for each molecular chain is called retardation time. In a complex amorphous mass, one can visualize that there are chains of different sizes. Some will be more tightly tangled than others (Schaffer, 1971). The summation in the third term represents the effect that molecular chain variation within a material has on modulus of elasticity. This model led Schaffer to state:

"It can be concluded from the universal success of elastic stress analysis [$\varepsilon = \sigma / E_I$] of simple wood members that the viscous nature of wood is suppressed at normal temperatures."

(Schaffer, 1971)

3.1.2 Strain of Polymers at Elevated Temperatures

At elevated temperatures, many polymeric materials exhibit "thermo-rheological simplicity". This means that the molecular processes that occur when the material is heated always occur, and in the same order, no matter what final temperature the material is heated to, or at what rate it is heated, as long as it is heated for a long enough period of time. Therefore, it is only the speed at which those molecular processes take place that changes when heating conditions change. As a result, a simple translation of the response curve at one temperature along an axis of the natural log of time will superimpose on another at a different temperature (see Figure 1). The response curve can be in the form of a natural log of creep compliance. Creep compliance is a function that when multiplied by constant stress describes irrecoverable strain experienced by a specimen.

The translation parallel to the time axis is called $\ln(a_T)$, and is a function of temperature and activation energy. The translation parallel to the response axis is given by correcting the response at a given temperature (T) to the one at a base temperature (T_0) using the ratio of density at T (ρ) multiplied by T with respect to density at T_0 (ρ_0) multiplied by T_0 .

Figure 1. Temperature-time superposition for "thermo-rheologically simple" material properties, where ρ is density and T is temperature in Kelvin.

In materials that are not "thermo-rheologically simple" the sequence of molecular events can vary at different temperatures, or it may be that at a certain temperature certain molecular events may occur that do not occur at other temperatures. Although some studies have shown that the visco-elastic response of wood can be modelled over narrow temperature ranges as if it was thermo-rheologically simple (Davidson, 1962), generally it has been recognized that the superposition of time and temperature should be used with caution because of the structural changes that occur in wood as temperature changes. Schaffer (1971) compiled a table, reproduced in part as Table 1, of thermally-induced changes in wood as reported in the literature for the larger temperature range examined by the current project. It has been suggested that these changes are dependent only on the level of exposure temperature. If that is the case, wood cannot be considered "thermo-rheologically simple" over the temperature range to be examined.

3.1.3 Strain of Wood at Standard Environmental Temperatures

Nielsen (1972) used the following general form of equation to describe strain over time, ε_c , of wood:

$$\varepsilon_c(t) = Fn[\sigma, t, M, T, V] \quad [2]$$

where σ is stress, t is time, M is moisture content, T is temperature, and V is specimen volume. He stated that if σ , t , M , T , and V could be considered independent, then for a single specimen under constant load and standard environmental conditions:

$$\varepsilon_c(t) = f_1(\sigma) \cdot f_2(t) \cong \sigma_c^\eta \cdot J(t) \quad [3]$$

where σ_c is constant stress, $J(t)$ is the creep compliance, and η is a material parameter; for example, η would equal 1 if the material was considered to be linearly viscoelastic (Nielsen, 1972). Some examples of creep compliances can be found in Table 2 (Palka, 1989). The parameters of the creep compliance equations are determined by curve fitting to experimental creep data, and represent the material properties of a specimen.

Table 1. Thermally induced changes in dry wood in an inert atmosphere (Schaffer, 1971).

Temperature (°C)	
55	Natural lignin structure is altered; hemicelluloses begin to soften.
110	Lignin slowly begins weight loss.
120	Hemicellulose content begins to decrease, α -cellulose begins to increase. Lignins begin to soften.
140	Bound water is freed.
160	Lignin is melted and begins to reharden.
180	Hemicelluloses begin rapid weight loss after losing 4% of their weight. Lignin in torous flows.
200	Wood begins to lose weight rapidly; cellulose dehydrates above this temperature.
210	Lignin hardens, resembles coke; cellulose softens and depolymerizes.
225	Cellulose crystallinity decreases and recovers.
280	Lignin has reached 10% weight loss; cellulose begins to lose weight.
288	Approximated wood charring temperature.

Table 2. Creep compliances used to describe long-term creep deformation, where J_0 , A , B_1 , B_2 , c_1 , c_2 , r_1 , r_2 , J_i , G_i , with $i = 1, 2, \dots, p$, and J_v are material parameters determined by linear or non-linear curve fitting to experimental data (Palka, 1989).

Creep Compliance Equations	Equation
$J(t) = J_0 + r_1 t^{r_2}$	[4]
$J(t) = J_0 + A \log(t + 1)$	[5]
$J(t) = J_0 + B_1 \log(t + 1) + B_2 \log^2(t + 1)$	[6]
$J(t) = J_0 + J_0 \cdot c_1 \ln\left(\frac{1+t}{c_2}\right)$	[7]
$J(t) = J_0 + \sum_{i=1}^p J_i \cdot (1 + e^{-G_i \cdot t}) + J_v \cdot t$	[8]

The material parameters for these creep compliance equations have been empirically fit for particular instances of constant load and constant environmental conditions. However, constant environmental conditions do not apply when a specimen is being heated, even if the assumption of constant loading could be made. There is little in the literature with regard to using the concept of creep compliance to describe the changing behaviour of wood at elevated temperatures.

3.1.4 Wood at Elevated Temperatures - Kinetic Strength and Damage Accumulation Models

Another approach used to describe changes in structural behaviour of wood at elevated temperatures has been that of "damage accumulation". This approach is based on the kinetic strength model of materials that relates the strength of a material to the degree of broken elements, or bonds, within the material, and to the rate at which bonds are broken or reformed. Equation 9 is one form of the kinetic strength model, proposed by Hsiao *et al.* (1968):

$$\frac{\partial f}{\partial t} = K_r(1-f) - K_b f \quad [9]$$

where f is the fraction of unbroken elements or bonds, K_r (Eqn. 10) describes the rate of reformation of broken elements, and K_b (Eqn. 11) describes the rate of rupturing of unbroken elements.

$$K_r = \omega_r e^{-\frac{\xi_r}{RT} - \gamma_0 \varphi(t)} \quad [10]$$

$$K_b = \omega_b e^{\frac{\xi_b}{RT} + \kappa_0 \varphi(t)} \quad [11]$$

where ω_r and ω_b are the frequencies of forming and breaking bonds; ξ_r and ξ_b are the activation energies for bond reforming and bond rupture, respectively; γ_0 and κ_0 modify the energy barrier as a consequence of the applied stress in the direction of each element; R is the universal gas constant; T is the temperature in Kelvin; and, φ is the longitudinal

stress per bond. It should be noted that φ must always be considered positive in the direction of the applied stress.

The relationship of individual bond stress to external stress can be stated as follows:

$$\varphi(t) \propto \frac{\sigma(t)}{f(t)} \quad [12]$$

This is a reasonable statement, assuming that the elements are oriented in the direction of the applied stress. As the fraction of unbroken elements decreases, the stress on the individual elements becomes greater because the external stress must be distributed over fewer elements. Therefore, we can state that:

$$\frac{\partial f}{\partial t} = \left(\frac{df}{dt} \right)_{\sigma} \quad [13]$$

where the subscript σ denotes that the rate of fracture under these conditions is only a function of external stress.

The kinetic strength model in Equation 9 addresses only materials loaded at constant standard environmental temperature. At elevated temperatures, the effect of the fracture of bonds due to thermal degradation needs to be incorporated. Roberts (1970) proposed that this effect be expressed by an equation in Arrhenius form:

$$\left(\frac{df}{dt}\right)_T = -\Psi e^{-\frac{\xi_r}{RT}} \quad [14]$$

where Ψ is a coefficient dependent on anatomical properties of the material, often called a "species effect" in wood, and ξ_r is the activation energy of thermal degradation. If it can be assumed that the fracture effects of stress and temperature are additive, the sum of the stress and thermal degradation fracture equations as well as the substitution of the term $\varphi(t)$ by the relationship shown in Equation 12 results in:

$$\begin{aligned} \frac{df}{dt} &= \left(\frac{df}{dt}\right)_\sigma + \left(\frac{df}{dt}\right)_T \\ &= -\Psi e^{-\frac{\xi_r}{RT}} + (1-f)\omega_r e^{-\frac{\xi_r}{RT} - \gamma_0 \frac{\sigma(t)}{f(t)}} - f\omega_b e^{\frac{\xi_b}{RT} + \kappa_0 \frac{\sigma(t)}{f(t)}} \end{aligned} \quad [15]$$

In the case of loading of wood in tension, it has been argued that the term corresponding to the rate of reformation of bonds, K_r , can be ignored because loading rates are generally fast enough that bond reformation is unlikely (Liu and Schaffer, 1991). Therefore, the stress component of the kinetic strength model consists only of the rate of bond rupture function.

$$\left(\frac{df}{dt}\right)_\sigma = -K_b f \quad [16]$$

Zhurkov, as described by Bartenev and Zuyev in 1968, found that activation energies in thermal degradation are of the same order of magnitude as those derived from strength tests. Therefore, it can be stated that:

$$\xi_T = \xi_b = \xi \quad [17]$$

As a result, wood in tension and exposed to elevated temperatures that varying with time $[T=T(t)]$ can experience a bond fracture rate that is described by the following simplification of Equation 15:

$$\frac{df}{dt} = \left(e^{-\frac{\xi}{RT(t)}} \right) \left(-\Psi - f\omega_b e^{\kappa_0 \frac{\sigma(t)}{f}} \right) \quad [18]$$

This equation can be generalized as a four-parameter model where the parameters can be fit to experimental data:

$$\frac{df}{dt} = \left(e^{-\frac{a_1}{T(t)}} \right) \left(-a_2 - fa_3 e^{a_4 \frac{\sigma(t)}{f}} \right) \quad [19]$$

The "damage accumulation" model (Lau, 1996) looks at the sum of broken elements, or accumulated damage, within the material rather than the fraction of unbroken elements, such that:

$$\alpha = 1 - f \quad [20]$$

where α represents the sum of accumulated damage. Therefore, the equation for the rate of accumulated damage would be:

$$\frac{d\alpha}{dt} = \left(e^{-\frac{a_1}{T(t)}} \right) \left(-a_2 - (1-\alpha)a_3 e^{a_4 \frac{\sigma(t)}{(1-\alpha)}} \right) \quad [21]$$

The result of this change is that instead of time-to-failure, t_f , being defined as the time when there are no more unbroken bonds ($f = 0$), t_f is the time when $\alpha = 1$ and the following relationship holds true:

$$\int_0^{t_f} \frac{d\alpha}{dt} dt = 1 - \alpha|_{t=0} \quad [22]$$

where $\alpha|_{t=0}$ represents an initial damage condition.

However, for the case of wood in compression, bond reformation is likely to occur and cannot be ignored. This means that the K_r term must remain in Equation 15. So that, if it can be said that $\xi_r = \xi_T = \xi_b = \xi$, the generalized damage accumulation model requires 6 parameters:

$$\frac{df}{dt} = \left(e^{-\frac{a_1}{T(t)}} \right) \left(-a_2 - (1-\alpha)a_3 e^{a_4 \frac{\sigma(t)}{f}} + \alpha a_5 e^{-a_6 \frac{\sigma(t)}{f}} \right) \quad [23]$$

Even so, Schaffer (1971) concluded that the phenomenon he observed of an increase in compression strength with simultaneous decrease in tensile strength at some temperatures could not be incorporated in a single kinetic strength model without including consideration of the change in wood structure. He stated that "... the simple

inclusion of the term which includes bond production is inadequate for this purpose" (Schaffer, 1971).

3.2 Empirical Modelling

3.2.1 Strain of Wood at Elevated Temperatures

Another approach that has been used to describe behaviour of lumber at elevated temperature is that of empirical modelling, that is, the fitting of a model to experimental data. When examining the change in strain behaviour of wood loaded in compression, Arima (1966) began with the following two equation forms.

$$\varepsilon_T(t) = Bt^N \quad [24]$$

where B and N are temperature dependent, and

$$\varepsilon_t(T) = he^{gT} \quad [25]$$

where h and g are parameters, and only h is a function of time. Equation 24 describes the strain with respect to time that is experienced by a member under a constant compression load at a constant temperature. Equation 25 represents a group of curves that show the relationship between temperature and strain at a definite time. Arima concluded that these two equations could be combined to account for the effects of both time and temperature.

$$\varepsilon(t, T) = at^N e^{gT} \quad [26]$$

where a is the combination of parameters B and h , and thus is a function of both temperature and time. Since B and N are functions of temperature and are determined empirically, testing must be done at all temperatures at which the equation is to be used.

Arima conducted tests between 100°C and 180°C at intervals of 20 °C. As well, Arima's tests were conducted using the Hinoki (*Chamaecyparis obtusa*) species of wood. Because any change of species often has an effect on experimental results, testing would have to be carried out on each species to which the equation was to be applied.

3.2.2 Wood at Elevated Temperatures - Time-to-Failure Models

A number of semi-empirical and empirical methods are currently used to predict the time to failure of heavy timber at elevated temperatures. For glued-laminated heavy timber columns, Lie (1977) used the semi-empirical method of "critical size" of a member's cross-section to determine time-to-failure. This critical size is a function of the rate of charring, residual strength and stiffness of the unburnt cross-section, and applied load (Lie, 1977). For members exposed to fire on all sides, the equation is:

$$\frac{k}{\lambda} \left(\frac{b}{b - 2\beta t_f} \right) = 1 - \frac{2\beta t_f}{d} \quad [27]$$

where b and d are the initial breadth and depth of the member before fire exposure; k is the ratio of actual load to load-carrying capacity of the member; λ represents the residual strength of the unburt wood expressed as a fraction of room-temperature short-term strength; and, β is the rate of charring. Values for λ and β are empirically determined. Recommended λ values range from 0.5 in New Zealand to 0.83 in France. Lie (1977) recommends a value of 0.80. The differences in λ values are due to uncertainty and to differences in design load and desired level of safety (White, 1995). Eurocode 5 (1995),

the voluntary timber building code of the European Union, refers to this approach as the "reduced strength and stiffness" method .

Appendix D of the National Building Code of Canada (NBCC, 1995) includes a method for large columns heated on all four sides that is similar to the "reduced strength and stiffness" method (White, 1995):

$$t_f = 0.1 Z b \left[3 - \frac{b}{d} \right] \quad [28]$$

where d is the larger side of the cross-section before fire; b is the smaller side of the cross-section before fire; and, Z is a load factor that includes the effect of the effective column length factor and the unsupported length of column (1995, *The SFPE Handbook of Fire Protection Engineering*).

The "effective cross-section" method (Bender *et al.*, 1985) can be used for glued-laminated beams and columns:

$$C_e = \beta t + \delta \quad [29]$$

where C_e is the "effective" thickness of the char layer which has no load-carrying capacity, t is the elapsed time of fire exposure, and δ is an equivalent zero-strength layer of finite thickness to represent any temperature-weakened residual unburnt wood below the char layer. For designs where compression governs, it is recommended that $\delta = 6$ mm (Williamson, 1982). For any given time during fire exposure, the value of C_e is subtracted from the initial cross-sectional dimensions and the remaining "effective"

cross-sectional area is calculated. The stress due to loading on that area is also calculated. In this method, the time to failure is defined as the time that the working stress design load exceeds the product of the member strength and the remaining "effective" cross-sectional area.

3.2.3 Wood at Elevated Temperatures - Strength-reduction Models

Another approach to determining the time to failure of wood members is the use of empirical strength-reduction models. The "effective cross-section" method described above uses a two-layer approach - one "effective" layer of zero strength and a remaining layer of 100% initial strength. For this reason, it can be considered a simple form of strength-reduction model for glued-laminated members.

King and Glowinski (1988) proposed a four-layer approach for timber beams. Figure 2 shows these layers in a cross-section of a timber beam exposed to fire on three sides. Table 3 shows the percentages with which each layer's initial room temperature strength (σ_0) and modulus of elasticity (E_0) are to be reduced.

Using this model, a layer "fails" when the calculated stress exceeds previously-estimated critical values. The load-carrying capacity of the whole member is reached when all layers "fail". Although this method estimates t_f reasonably well for large members under partial loading, it under-estimates t_f for members under full design load (King and Glowinski, 1988).

Figure 2. Cross-section of timber beam exposed to fire on three sides, demonstrating the four-layer strength and modulus of elasticity reduction approach.

Table 3. Percentage of loss of strength and modulus of elasticity in each of four layers of timber members loaded at elevated temperature. Note that all dimensions must be in inches, and charring rate β must be in inches/min. (King and Glowinski, 1988)

Layer	Description	Depth of Layer (D_i , inches) (See Fig. 2)	Strength $\left(\frac{\sigma_i}{\sigma_0} \times 100\%\right)$	MOE $\left(\frac{E_i}{E_0} \times 100\%\right)$
1	Outer char layer	$D_1 = \frac{4}{3}\beta t$, when $t \leq 15$ min. $D_1 = \beta(t + 5)$, when $t > 15$ min.	0	0
2	"Hot" layer	$D_2 = \frac{2}{3}(1 - e^{0.07685t})$	60	75
3	"Warm" layer	$D_3 = \frac{4}{3}(1 - e^{0.07685t})$	80	90
4	"Unaffected" layer	$D_4 = b - 2(D_1 + D_2 + D_3)$	100	100

The two-layer and four-layer approaches described above relate the percentage loss of strength to depth within the member. Another type of strength-reduction model relates the percentage of strength remaining to the temperature of the material. One common form that this type of model takes is:

$$P = q - rT \quad [30]$$

where P is percentage of strength remaining, T is temperature of the wood in Celsius, and q and r are empirically determined linear parameters.

As well, it is possible in some cases to convert a model that relates the loss of strength to depth within a heated member, to one that relates loss of strength to

temperature. This can be done using the following equation from Eurocode 5 (Janssens and White, 1994):

$$T = T_0 + (T_p - T_0) \left(1 - \frac{x}{x_{th}} \right)^2 \quad [31]$$

where T is the temperature of the wood ($^{\circ}\text{C}$) at a specific depth; T_0 is the initial temperature of the member ($^{\circ}\text{C}$); T_p is the temperature at the interface between charred wood and uncharred wood, which is called the "char front" ($^{\circ}\text{C}$); x is the depth into the member from the char front (mm); and, x_{th} is the thermal penetration depth (mm), which is recommended to be 40 mm (Janssens and White, 1994).

Equation 31 was used in this study to transform a model by Schaffer *et al.* (1986) that reports relative compressive strength as a function of distance below the char layer. An initial temperature of 25°C (Schaffer *et al.*, 1986) and a char-front temperature of 300°C were used for the transformation. The model by Schaffer *et al.* (1986) is represented by a multi-point graph that is assumed linear between points (White, 1995). It was determined that, although the transformed model is not exactly linear from point to point, the variance is small enough to be negligible, so the transformed model can be approximated with reasonable accuracy by linear equations between the transformed points. Table 4 lists the approximated transformed model, as well as some of the other published compression-strength reduction models.

Table 4. Percentage-compression-strength reduction models from literature.

	MODEL	TEMPERATURE RANGE (°C)	WOOD SPECIES	SPEC. SIZE	MOISTURE CONTENT	TESTING CONDITIONS
Kollman (1940)	$P = 105 - 0.25T$	$20 \leq T \leq 220$	Fir and Beech	$2 \text{ cm} \times 2 \text{ cm} \times 3 \text{ cm}$	some kiln-dried, some air-dried, some 12% MC;	clear specimens;
Schaffer (1971)	$P = 102.8 - 0.1139T$ $P = 126.1 - 0.4509T$ $P = 80.25 - 0.155T$ $P = 119.9 - 0.3502T$	$25 \leq T < 68.9$ $68.9 \leq T < 154.8$ $154.8 \leq T < 203.2$ $203.2 \leq T \leq 342.4$	Douglas-fir	$1/8" \times 1" \times 3-3/4"$	vacuum-dried;	clear specimens; fully heated to exposure temperature, then constant strain-rate applied to failure;
Knudson & Schniewind (1975)	$P = 106 - 0.29T$	$20 \leq T \leq 288$	Douglas-fir	$3/16" \times 3/16" \times 3/4"$	12% MC	clear specimens; fully heated to exposure temperature, then ramp-load applied to failure;
Rykov (1980)	$P = 122.3 - 1.114T$ $P = 72 - 0.2T$	$20 \leq T < 55$ $55 \leq T \leq 190$	Unknown	Unknown	Unknown	Unknown

Table 4 (cont'd). Percentage-compression-strength reduction models from literature.

	MODEL	TEMPERATURE RANGE (°C)	WOOD SPECIES	SPEC. SIZE	MOISTURE CONTENT	TESTING CONDITIONS
Schaffer <i>et al.</i> (1986)	$P = 62 - 20.8T$ $P = 149.9 - 2.366T$ $P = 78.01 - 0.5545T$ $P = 55.26 - 0.1747T$ $P = -19.38 + 0.5315T$ $P = 124.6 - 0.3526T$ $P = 20.2 - 0.699T$	$25 \leq T < 25.5$ $25.5 \leq T < 39.7$ $39.7 \leq T < 59.9$ $59.9 \leq T < 105.7$ $105.7 \leq T < 162.9$ $162.9 \leq T < 235.5$ $235.5 \leq T \leq 256.1$	Douglas-fir/Larch	5.12 in × 16.5 in cross-section;	12 % MC;	glued-laminated beams exposed on three sides to fire;
Hosser <i>et al.</i> (1994)	$P = 111.4 - 0.57T$	$20 \leq T \leq 160$	Unknown	Unknown	Unknown	Unknown
Young & Clancy (1998)	$P = 115 - 0.75T$ $P = -760 + 8T$ $P = 168.9 - 0.444T$ $P = 240 - 0.8T$	$20 \leq T < 100$ $100 \leq T < 110$ $110 \leq T < 200$ $200 \leq T \leq 250$	<i>Radiata</i> pine	90 mm × 35 mm × 300 mm	~12% MC below 100°C, oven-dry above 100°C;	fully heated to exposure temperature, then constant strain-rate applied to failure;
König & Walleij (2000)	$P = 118.8 - 0.9375T$ $P = 37.5 - 0.125T$	$20 \leq T < 100$ $100 \leq T \leq 300$	Unknown	45 mm × 195 mm cross-section	Unknown	relatively clear specimens; bending tests used; exposed to fire on compression side;

One advantage of this form of model is that, if one can determine the temperature distribution throughout the cross-section of a member as a function of time, a more accurate calculation of load-carrying capacity of that member at any time during exposure to elevated temperatures may be made than when using a simple layer strength-reduction model. However, König & Walleij (2000) observed that experimental "...strength versus temperature values reported in different sources exhibit a large scatter and are partially in contradiction to each other." Because most strength-reduction models are empirical, that is they are based on test data, they are highly influenced by differences in the test methods used to collect those data and in the material properties of the test specimens examined. This can be seen in Figure 3, which compares the various compression-strength reduction models from Table 4. There is great variability among the published models, in the values of reduced compression strength relative to initial room temperature compression strength at any given temperature.

Kollman (1940), Schaffer (1971) and Knudson & Schniewind (1975) all used small, clear specimens that were heated until the entire specimen reached exposure temperature. Young & Clancy (1998) and König & Walleij (2000) used larger specimens with cross-sectional dimensions comparable to those of structural lumber. Young & Clancy also fully heated their specimens to exposure temperature; then, a constant compressive strain rate was applied until failure occurred. Schaffer, too, applied a constant compressive strain rate. Knudson and Schniewind applied a constant compressive ramp load rate until failure. König & Walleij tested their specimens in

Figure 3. Comparison of various compression-strength reduction models from literature.

bending, exposing the compression side of specimens to heating. The various test specimens were at a variety of initial moisture contents. Some were conditioned to approximately 12%, others were air-dried, kiln-dried or oven-dried, and still others were vacuum-dried. A variety of wood species were also used: Douglas-fir, beech, *Radiata* pine and others. The model by Schaffer *et al.* (1986) was based on the behaviour of glued-laminated Douglas-fir timber beams exposed to fire on three sides. Little information could be found regarding the types of specimens or the testing conditions that were used by Rykov (1980) or Hosser *et al.* (1994) as the basis for their models. The many differences in types of specimens and test methods account for much of the variation found between the examples of this form of empirical model.

The calculation of the percentage of strength remaining in dimension lumber exposed to elevated temperatures was the method used in this study to predict time to failure of members. As a result, particular characteristics of each of the compression-strength reduction models shown in Figure 3 are discussed in a later section of this thesis.

4.0 EXPERIMENTAL WORK

This section provides an extensive description of the materials and methods used to collect test data relating to the behaviour of nominal 2×4 Machine Stress Rated (MSR) Spruce-Pine-Fir (SPF) structural lumber in compression at elevated temperatures. Results of the testing that were important to the objectives of this thesis are also discussed. The testing described here was performed as part of a larger research program conducted by Forintek Canada Corp. The overall purpose of the program was to gather data about the effects of elevated temperatures on the material properties of wood structural members under loading, for input into continuing efforts to model the reliability of structural light-framing wall and floor systems exposed to fire.

4.1 Scope and Assumptions

The experimental work was designed to provide data to model the change in behaviour of wood axially loaded in compression and exposed to elevated temperatures. Toward this end, samples of structural light framing lumber were exposed to elevated temperatures up to 250°C, that is temperatures below the charring temperature of wood, and tested in compression. Temperature, load and displacement (change-in-length) histories of the specimens were recorded relative to time of exposure.

The current prescriptive requirements in the National Building Code of Canada (NBCC, 1995) specifies a fire-endurance rating of 45 minutes for many structural light-framing walls. It is possible to infer from this that the behaviour of such structures in the

first 45 minutes of exposure to elevated temperature is more critical than their behaviour during subsequent times (Lau, 1996). As a result of this inference, and due to the large number of specimens that were proposed to be tested, elevated temperature exposure of specimens at constant load was limited to approximately 45 minutes per specimen.

If a structural system is designed to be load-bearing, it is likely that the members of that system will experience loading from the beginning of a fire event. Therefore, it was decided that specimens tested at elevated temperatures would be loaded at a constant level from the outset of heating, as opposed to being loaded only after the entire specimen had reached full exposure temperature as had been done in many experiments reported in the literature. This was considered to follow more closely the conditions that structural light-framing systems experience during real fire situations.

The testing concentrated on one major Canadian species group primarily used for structural applications, and attempted to cover as wide a range of compression strengths as possible. For these reasons, MSR lumber from the SPF group was chosen. Specimens were taken from three different MSR grades, 1650-1.5E, 2100-1.8E, and 2400-2.0E, (where the first part of the MSR label refers to modulus of rupture in pounds-per-square-inch (psi), and the second part of the label refers to modulus of elasticity $\times 10^6$ in psi), to widen the strength range (O86.1-94 Engineering Design in Wood (Limit States Design), 1994). Because testing took place at Forintek Canada Corp.'s Western Laboratory in

Vancouver, British Columbia, a Western Canadian wood specie, lodgepole pine (*Pinus contorta*), was chosen from the SPF species group.

4.2 Experimental Design

For the compression testing of 2×4 MSR SPF members at elevated temperatures, the experimental variables were load and exposure temperature. Seventeen groups of sixty specimens each were tested (Table 5). Group numbers were assigned to test groups as indicated in Table 6 for referencing purposes.

Table 5. Experimental sample sizes at various compression load levels and exposure temperatures.

Compression Load Level	Exposure Temperatures (°C)				
	Room Temperature	75	150	200	250
No Load			60	60	60
12 kN				60	60
25 kN		60	60	60	60
37 kN		60	60	60	
50 kN		60	60		
Ramp Load Rate of 1.0 kN/s	180				

The load levels used for those groups tested at elevated temperatures (no load, 12 kN, 25 kN, 37 kN, and 50 kN) were chosen to yield stress levels of approximately 0%, 20%, 40%, 60% and 80% of room temperature design capacity (*Wood Design Manual*, 1995) for the specimens tested.

Table 6. Group numbers for test groups for referencing purposes.

Group No.	Exposure Temperature (°C)	Load (kN)
1, 2, 3	Room Temperature	Ramp to Failure
4	75	25
5	75	37
6	75	50
7	150	25
8	150	37
9	150	50
10	200	25
11	200	37
12	200	12
13	250	25
14	250	12
15	250	No Load
16	150	No Load
17	200	No Load

Although the temperature of charring of wood is often taken to be 288°C, and is sometimes suggested to be as high as 300°C, it was decided to limit specimen exposure to 250°C. At temperatures between 200°C and 280°C wood slowly chars (Schaffer, 1971). The effect is more pronounced at the higher end of this temperature range, and at longer times of exposure. Active and rapid pyrolysis begins at temperatures above 280°C (Schaffer, 1971). Because loss of strength prior to charring was the objective of this experiment, and testing exposure times of up to 45 minutes were proposed, it was decided that 250°C was the highest temperature of exposure that could be used with reasonable assurance that char formation would not be significant.

4.2.1 Specimen Preparation

Approximately 800 pieces of 4880-mm-long (16-foot-long) 2×4 lodgepole pine lumber, made up of equal numbers of pieces in each of the 1650-1.5E, 2100-1.8E and 2400-2.0E MSR grades, were sampled. For this testing, short specimens were used to reduce the occurrence of failure due to buckling at the given load levels before measurable compression displacement took place. Therefore, each 2×4 was cut to yield three specimens 1220 mm (4 feet) long. Pieces with visually obvious defects situated near the sample ends (region not to be exposed to heating) were discarded to minimize premature failures in this region. The remaining specimens were stored indoors in Forintek Canada Corp.'s Western Laboratory in Vancouver, British Columbia, for approximately three months. During this period, the moisture content stabilized at 8-12%. After this "conditioning", the specimens were planed to a thickness of 35 mm, from their nominal thickness of 38 mm, in order to provide a uniform surface for heating. The entire sample was then evaluated for modulus of elasticity using a Cook-Bolinders MSR machine (E_{CB}). Based on a ranking of these E_{CB} values, twenty groups of specimens each were formed as described below. Each group of specimens was wrapped and sealed in plastic sheets to prevent significant changes in moisture content while they awaited testing.

4.2.2 Sampling Methods

The experimental design is based on a technique referred to by the wood community as the *matched statistical sample* technique, or "matched" groups. The

technique is used to create sample groups with distributions of material characteristics similar to those found in the whole of the population sampled. In this case, the specimens were matched using the modulus of elasticity as evaluated by a Cook-Bolinders MSR machine. The E_{CB} of each specimen was recorded, and the resulting list of E_{CB} 's was ordered from greatest to least. Then, the first 20 specimens were taken from that ranked list and distributed randomly one per group; the next 20 specimens on the list were then also randomly distributed one per group; this process continued until the list was exhausted, resulting in 20 groups of approximately 60 specimens.

The accuracy of the group matching depends in part on the size of the sample group chosen. In the past, 60 specimens have been found to provide sufficient statistical robustness (Jones, 1989). As well, for a similar program examining elevated-temperature testing of dimension lumber in tension that used the *matched statistical sample* technique, Lau (1996) concluded that "...the sampling errors of 60 specimens represented an acceptable compromise between accuracy and cost of experiment".

4.2.3 Testing Apparatus

When designing the testing apparatus, consideration had been given to the heating characteristics of wood. When a piece of lumber is heated from the outside, its surface temperature rises much faster than its center temperature. The temperature gradient within the material depends on the applied heat flux, the method of heat transfer at the surface, the thermal conductivity of the material, and the moisture content. In the

literature, large-scale tests on lumber usually employed radiant heating. A high heat flux was generally used to minimize the time required for the entire specimen to reach the target temperature. However, a higher heat flux tends to induce a greater temperature gradient early in the exposure and there is a greater tendency for volatile gases to be generated and ignited. Because changes in strength characteristics prior to charring were the focus of the present experiment, a high temperature gradient was thought undesirable. It was decided that test materials would be heated by conductive heat transfer.

Figure 4 shows cross- and longitudinal-section views of the heating apparatus used in this study. The heating apparatus consisted of a pair of aluminum platens that were insulated on the outside. Each platen was 660 mm long by 175 mm wide by 100 mm thick and was constructed from two 50-mm-thick aluminum plates laminated together. Three electrical heating rods per platen were embedded between these aluminum plates; they were 660 mm long and ran parallel to the longitudinal axis of the platens. The temperature of the platens was controlled by a microprocessor-based controller, which monitored the exposure surface temperature of the platens via two K-type thermocouple probes inserted through the platens. A manually-operated mechanical clamping device forced the platens against the wide-faces of a specimen during testing. Heat was transferred from the heated platens to specimens by conduction. The length of

(a)

(b)

Figure 4. (a) Longitudinal-sectional view of specimen heating apparatus; and, (b) cross-sectional view of specimen heating apparatus.

specimen exposed to the heating platens, called the "exposed region", was approximately 660 mm. The platens were designed to provide lateral support to specimens in order that they would not fail prematurely by buckling. The complete heating mechanism was housed within a lumber compression machine, so that specimens could be exposed to heat and tested in compression at the same time. Figure 5 shows the heating platens housed within the mechanical clamping device and compression-loading apparatus.

4.2.4 Test Procedures

Before initial contact was made between the platens and each specimen, the platens were pre-heated to and then maintained at the assigned temperature of exposure. Generally, the average temperature of the wood was lower than the platen temperature at any given time during the experiment because exposure time of each specimen was not sufficiently long enough for the entire specimen to reach exposure temperature. Figure 6 (a) shows schematically a typical heating and loading sequence used in the experiment. The "start-time" ($t_0 = 0$ seconds) was the moment when contact was made between platens and specimen. Once in contact with the specimen, the platens were held in position and the temperature of the platens was maintained at the exposure temperature throughout. The cross-sectional center-point temperature of the specimen at two points 115 mm from mid-span was measured with ungrounded, type-K thermocouple probes sleeved with stainless steel. These probes had an outside diameter of 1.6 mm. Holes of the same diameter were drilled to a depth of 44.5 mm from the narrow face of the specimens to accommodate the probes.

Figure 5. Heating platens attached to mechanical clamping device and compression loading apparatus.

Also at $t_0 = 0$ seconds, compression loading was initiated for those tests requiring loading. In those cases, the specimen was quickly ramp-loaded, at a rate of 1 kN/sec to the specified load for that test, within the initial 60 seconds of the experiment. The constant load was maintained until t equaled 2700 seconds (45 minutes), or until specimen failure, whichever occurred first. In some loaded test groups, if failure did not occur within 2700 seconds, the specimen was subjected to additional ramp loading until failure did occur.

The heating and loading histories were recorded with a microprocessor-based data acquisition system. The displacement history up to the time of failure was also recorded using linear displacement transducers.

Figure 6 (b) shows a typical loading history for the room-temperature tests. The specimens for these tests were ramp-loaded at a rate of 1 kN/sec in compression until failure.

4.2.5 Other Physical Data

The moisture content of the specimens was obtained just prior to testing using a resistance-type moisture meter near mid-span of the specimens.

(a)

(b)

Figure 6. (a) Typical heating and loading sequence used in tests at elevated temperature; and, (b) typical heating and loading sequence used in room-temperature tests.

The relative density of the specimens was obtained based on the weight (g) of the specimens at zero moisture content and the volume (mm^3) of the specimens at conditioned moisture content determined from actual dimensional measurements.

4.3 Test Results

This section summarizes the results of approximately 1020 compression tests divided into 17 testing groups. Summaries of test data for individual specimens can be found in Appendix I.

4.3.1 General Observations and Results

As expected, all specimens that were tested to failure failed by crushing. Failures most often occurred near a visible knot or knot cluster. Figure 7 shows an example of the crushing failure associated with a knot; the specimen is held in one of the heating platens. This figure also shows the staining caused by escaping water vapor and volatile gases that was in evidence around many knots and other defects in the heated specimens, especially those at the higher exposure temperatures.

The average mass density, ρ , and moisture content, M , of all tested specimens was 506 kg/m^3 and 9.95%, respectively, with standard deviations of 41.4 kg/m^3 and 0.84%, respectively. These result in coefficients of variation of 8.2% for density and 8.4% for moisture content. The cumulative relative frequency distribution of the densities and moisture contents at room temperature prior to testing from each of the seventeen test

Figure 7. Example of specimen that failed in crushing near a knot after heating and load application.

groups are compared in Figures 8 and 9, respectively. The comparison in Figure 8 shows that there were no significant differences between the tested groups in the distribution of material density. This may be taken as an indicator that the sample matching of groups based on the Cook-Bolinders modulus of elasticity was satisfactory with respect to density.

The cumulative relative frequency distribution comparison in Figure 9 indicates that, even though all test specimens were "conditioned" in the same way and matched groups were sealed until tested, there was some variety in moisture contents among the groups, at least when measured just prior to each specimen's testing. This was probably the result of the varying lengths of time required to test an entire group of specimens, and of not resealing the remaining specimens within a group once testing on that group had begun. It is interesting to note that the three groups with the lowest moisture contents are those ramp-loaded at room temperature, Groups 1, 2 and 3. Individual tests in those three groups lasted only a few minutes, so those groups were tested quickly.

4.3.2 Room Temperature Tests

The three groups that were tested at room temperature provided reference or "baseline" data, against which the effect of heating on the population's mechanical properties, such as ultimate compression strength and compressive modulus of elasticity, could be judged.

Figure 8. The cumulative relative frequency distribution curves of densities at room temperature prior to testing, from each of the seventeen test groups, are compared.

Figure 9. The cumulative relative frequency distribution curves of moisture contents at room temperature prior to testing, from each of the seventeen test groups, are compared.

The cumulative relative frequency distribution of the ultimate compression strength (σ_0) at room temperature from each of the three groups is compared in Figure 10. The mean value of σ_0 was 43.9 MPa with a standard deviation of 8.13 MPa. This results in a coefficient of variation of 18.5%. Statistical analysis using the *Maximum Probability Paper Plot Correlation Coefficient* method (MPPPPCC method) indicated that the probability distribution of the ultimate room temperature compression strength would be best described by a *Lognormal* distribution function. Therefore, for modelling, the ultimate room temperature compression strength of specimens could be generated from a *Lognormal* distribution using the *Monte Carlo Simulation* method. Figure 11 shows that the σ_0 data gathered fits to a *Lognormal* distribution with an R^2 factor of 0.99.

Assuming a *Lognormal* probability distribution, the 5th (X_{05}) and 95th (X_{95}) percentile values of σ_0 are 29.7 MPa and 54.2 MPa, respectively. Table 6 shows test stresses due to the test loads as a percentage of the mean value (μ_{σ_0}), and X_{05} and X_{95} , of the ultimate room temperature compression strength. These values are much lower than was anticipated in Section 4.2 when identifying the stress levels that were to be used as a percentage of room temperature design capacity. This indicates that even the actual 5th percentile strength of the test specimens was much higher than the design capacity listed in the Wood Design Manual (1995) for MSR grades of SPF lumber.

Due to a recording-equipment error, all the linear displacement data for Group 1 are invalid. Therefore, all values calculated from that data including compressive

Figure 10. Cumulative relative frequency distribution curves of ultimate compression strength, σ_0 , as determined by room temperature testing.

Figure 11. Graph of initial ultimate compression strength (σ_0) data from room temperature testing using the *Maximum Probability Paper Plot Correlation Coefficient* method (MPPPC method) indicating that σ_0 can be accurately described by a *Lognormal* probability distribution curve.

Table 6. Test stresses due to test loads as a percentage of mean value ($\mu\sigma_0$), and 5th (X_{05}) and 95th (X_{95}) percentile values, of ultimate room temperature compression strength (σ_0).

Note: Test stress is calculated using the average cross-sectional dimensions of the test specimens, 35.2 mm $\times$ 87.7 mm.

Test Load (kN)	Test Stress (MPa)	Percentage of $\mu\sigma_0$ (%)	Percentage of X_{05} (%)	Percentage of X_{95} (%)
12	3.9	8.9	13	7.2
25	8.1	18	27	15
37	12	27	40	22
50	16	37	55	30

Figure 12. Cumulative frequency distribution curves of compressive modulus of elasticity as determined by room temperature testing.

modulus of elasticity, E_0 , were also invalid. Consequently, the cumulative frequency distributions of E_0 from only Groups 2 and 3 are compared in Figure 12. The average value of E_0 was 13.2×10^3 MPa with a standard deviation of 2.58×10^3 MPa. This results in a coefficient of variation of 19.5%.

The cumulative frequency distribution comparisons in Figures 10 and 12 show that there was no significant difference among the room-temperature-tested groups in the distribution of the material properties of σ_0 and E_0 . This may be taken as an indicator that the sample matching of groups based on E_{CB} was satisfactory with respect to compression strength and compressive modulus of elasticity.

The data from the room temperature tests were examined for relationships between σ_0 , ρ and M . No correlation of M to either ρ or σ_0 was found. The data did show a general trend of increasing σ_0 for increasing ρ ; however, no linear relationship of statistical significance was found. Therefore, these three material properties were considered independent properties.

4.3.3 Elevated Temperature Tests

For each specimen, linear displacement and cross-sectional center-point temperatures with respect to time were recorded. Figure 13 shows net linear displacement results for all specimens exposed to elevated temperatures. In that figure, positive displacement represents shortening of specimens, and negative displacement

Figure 13. Net linear displacement for all specimens exposed to elevated temperature.

Note: Positive displacement represents shortening of specimen; negative displacement represents lengthening of specimen.

represents lengthening of specimens. It can be seen from the graphs of those groups tested with no applied load that there was some expansion of the specimen initially, due to heating, followed by contraction of the specimen at higher exposure temps. It can also be seen that no expansion was recorded for all specimens under application of a constant load, even at the lowest compression load levels. It should be noted that graphs in Figure 13 demonstrate that specimens in groups tested at exposure temperatures of 200°C and 250°C under constant load were ramp-loaded (at 1 kN/s) to failure if they did not fail under their constant load within 2700 seconds (45 minutes). Five of the graphs in Figure 13 show data lines with a short, sharp increase in displacement at 2700 seconds. This is the effect of ramp-loading specimens until failure following exposure to elevated temperature and constant load for 2700 seconds.

Figure 14 shows average cross-sectional center-point temperature results for all specimens exposed to elevated temperatures. The graphs in this figure show that the center of specimens reached exposure temperature only in those groups exposed to the lowest elevated temperature level used, 75°C. This was due to the time limit of 45 minutes that was placed on each test. At higher exposure temperatures, 45 minutes was not sufficient time to allow the entire cross-sectional area of a specimen to heat to exposure temperature. Consequently, very few specimens that failed had a uniform cross-sectional temperature at the time of failure. What can also be seen from the graphs in Figure 14 is that variability among specimens becomes more evident as center-point temperatures exceed approximately 110°C, but becomes less pronounced again as center-

FIGURE 14. Average cross-sectional center-point temperatures for all specimens exposed to elevated temperature.

point temperatures approach 200°C. However, at the higher load levels variability appears to be much less even in that temperature range than at lower load levels. This results from the greater incidence of specimen failure that occurred at higher load levels. Because more specimens failed quickly, there were fewer surviving specimens for comparison of center temperatures at later times of exposure at the higher load level.

5.0 COMPUTER MODELLING

Taking into consideration the modelling approaches discussed in Chapter 3 and the experimental program as described in Chapter 4, it was decided that this thesis would examine the empirical modelling of compression-strength reduction and time-to-member-failure as experienced by structural dimension lumber concentrically loaded in compression and exposed to elevated temperatures. It was determined that a suitable medium of this examination would be a computer program.

The modelling of structural dimension lumber's time to failure due to compression-strength reduction requires three main components. First, a model predicting loss of compression strength is required to determine when a load on a member exceeds the reduced strength, or capacity, of that member. Second, a means of predicting the temperature history of a member due to its exposure to elevated temperatures is required because, as can be seen from Table 4 in Chapter 3, many strength-reduction models directly relate loss of compression strength to a member's temperature history. And third, many of the material properties of the members to be modelled are required because they affect both the member's temperature history and its strength.

Figure 15 shows a flowchart that outlines the steps for modelling the time-to-failure of structural dimension lumber loaded in compression and exposed to elevated temperatures using these three components. The computerized model created for this

study, entitled HTE Exposure, followed the general approach shown in Figure 15. It combined a modification of an existing heat-transfer model with various published compression-strength reduction models in order to determine which of those strength-reduction models could predict times-to-failure comparable to those observed during experimentation. HTE Exposure was written in Fortran PowerStation 4.0 using Microsoft Developer Studio. A copy of the source code for it can be found in Appendix II. Samples of the input data files required by the program can be found in Appendices III and IV. The content of the input data files will be discussed in detail in the next section.

In the computer program, the initial material properties assigned to specimens to be modelled were assumed to be an average value that was uniform throughout a specimen's cross-section. However, the temperature of the wood does not remain uniform throughout the cross-section. When a specimen is exposed to heat, a temperature gradient is produced. Furthermore, because a loss of strength can be related directly to temperature, it can be said that a related strength gradient is also produced within a specimen's cross-section as it is heated. One method for describing the temperature gradient, and thus the strength gradient, is the "layer" approach discussed in Chapter 3, where the cross-sectional area of a member is divided into layers of varying depths. Another method divides the cross-sectional area of a member into multiple elements, instead of layers. This is the method that was selected for both the temperature and strength modelling in this study.

Figure 15. General flowchart for computer modelling of time to failure of structural dimension lumber loaded in compression and exposed to elevated temperature.

The cross-sectional area elements were defined as the area surrounding nodes spaced equally in the x- and y-directions of the cross-section in a Cartesian coordinate system. Figure 16 shows an example of one quarter of a specimen's cross-sectional area divided into elements. Only one quarter of a specimen's cross-sectional area needed to be considered due to symmetry in heating and assumed uniformity of initial material properties. The sections of this thesis that discuss the heat-transfer and strength-reduction modelling within the HTExposure computer program describe how this system of multiple cross-sectional elements was applied.

5.1 Material Properties

There were three main material properties of the wood specimens which had to be defined for the modelling process: initial room temperature compression strength (σ_0), density (ρ), and moisture content (M). As the flowchart in Figure 15 indicates, material properties could be either input from actual specimen data or generated from population distributions. A combination of these two methods was used as described below.

As stated in Chapter 4, there was no significant correlation found between σ_0 and either M or ρ ; therefore, σ_0 was considered an independent variable. As well, it was shown in Chapter 4 that the initial compression strengths of the population as found from

Figure 16. Diagram indicating the division of 1/4 of the cross-sectional area of a specimen into elements defined by nodes spaced equally in the x- and the y-direction; also indicates the different types of nodes for calculation of heat transfer and strength reduction.

Note: Only 1/4 of the cross-sectional area is shown because conditions at all other nodes can be calculated as a result of symmetry of specimen and heating; therefore,

$$m = (\text{total number of nodes in x-direction} + 1) / 2, \text{ and,}$$

$$n = (\text{total number of nodes in y-direction} + 1) / 2,$$

where the total number of nodes in the x- and y-directions must be an odd number.

the room temperature testing results followed a *Lognormal* probability distribution. And, the actual σ_0 of each specimen tested at elevated temperature was not known. For these reasons, σ_0 was generated for each modelled specimen from a *Lognormal* distribution using the *Monte Carlo Simulation* method. This distribution can be defined by the *Normal* mean and standard deviation values of σ_0 , as calculated from the room temperature test data, using the following equations:

$$SD_{\ln(\sigma_0)} = \sqrt{\ln\left(1 + \frac{SD_{\sigma_0}^2}{\mu_{\sigma_0}^2}\right)} \quad [32]$$

and,

$$\mu_{\ln(\sigma_0)} = \ln(\mu_{\sigma_0}) - \frac{1}{2}SD_{\ln(\sigma_0)}^2 \quad [33]$$

where $SD_{\ln(\sigma_0)}$ is the *Lognormal* standard deviation of σ_0 , SD_{σ_0} is the *Normal* standard deviation of σ_0 , $\mu_{\ln(\sigma_0)}$ is the *Lognormal* mean value of σ_0 , and μ_{σ_0} is the *Normal* mean value of σ_0 . The *Normal* mean and standard deviation values were contained in the input data file entitled "Test.dat" (Appendix III).

The input data file "Test.dat" included other information required to define parameters for modelling purposes. The exposure temperature and constant compression load to be applied during each run of the model was specified in that file, as well as the initial ambient temperature of specimens. The maximum length of time that each specimen was to be "tested" and the size of each calculation time step were defined in

that file. The sample size, or number of specimens, to be modelled in a particular run was also listed.

It was decided that actual density and moisture content data would be used as input for those values during modelling because these data were known for all specimens tested. These values were contained in the input data file entitled "WMCRHO.dat" (Appendix IV).

The specific gravity (SG) of each specimen was needed by the subroutine predicting specimen temperature history. The Wood Handbook, published by the United States Department of Agriculture Forest Products Laboratory (1999), provides the following equation:

$$SG = \frac{\rho}{1000(1+M)} \quad [34]$$

where ρ is density (kg/m^3) and M is moisture content (decimal fraction). This relationship was used to calculate SG from the density and moisture content data.

The actual cross-sectional dimensions of each specimen were required for load capacity calculations. Because the variation in cross-sectional dimensions of all specimens from the experimental testing was less than 1%, it was decided that average values of 35.2 mm for cross-sectional width and 87.7 mm for cross-sectional depth would be used. These values were set as default values within the computer program.

5.2 Heat-transfer Modelling

To predict the loss in compression strength due to exposure to elevated temperatures, the temperature history of the test specimens needed to be simulated. As previously indicated, it was decided for modelling purposes that the cross-sectional area of a member be divided into multiple elements. This meant that the temperature history of a specimen could be defined by a time-dependent temperature cross-sectional profile, that is a three-dimensional temperature array, $T(t, x, y)$. A sample temperature array for one point in time, t , for the cross-section found in Figure 16, can be found in Table 8. As stated earlier, only temperatures for one quarter of a specimen's cross-sectional area needed to be calculated. Because test specimens were exposed to the same temperature on all four sides, temperatures for the other three-quarters of the cross-section could be determined from those calculated for the first quarter by symmetry.

Table 8. Sample array of temperatures at nodes for 1/4 of a specimen divided as shown in Figure 16, exposed at 200 °C at one point in time, t .

Y X	1	2	3	. . .	n-2	n-1	n
1	200	200	200	. . .	200	200	200
2	200	200	199	. . .	199	199	199
3	200	199	199	. . .	198	198	198
.	.	.	.	.	.	.	.
.	.	.	.	. . .	.	.	.
.	.	.	.	.	.	.	.
m-2	200	199	198	. . .	139	138	138
m-1	200	199	198	. . .	138	137	136
m	200	199	198	. . .	138	136	135

The values shown in Table 8 represent the temperature at an element's node. The temperature calculated at each node was assumed to be the average temperature of its corresponding element. For elements not along the specimen edges, this is a reasonable assumption when the elements are small. Defining the average temperature of edge elements using the temperature of the nodes at their exposed edges results in an over-estimation of their average temperature for the first few seconds of exposure. This was not considered critical since failure of specimens did not occur within the first few seconds of experimental testing. After the first few seconds of exposure, the entire area of the edge elements rises to exposure temperature, and so the temperature of the edge nodes quickly becomes representative of the average temperature of the whole edge element. Therefore, the assumption would not significantly affect failure time predictions. In any case, the overall effect would be to shorten the times to failure by a very small amount, thus erring on the conservative side.

There were nine different types of cross-sectional elements for the calculation of temperature at the nodes, based on tributary area and whether the element had any edges directly exposed to heating. Table 9 defines the nine types, as indicated in Figure 16.

It was decided that a heat-transfer model would be used to predict temperature history. *WALL2D* is a two-dimensional computer model devised by researchers at

Forintek Canada Corp. to predict heat transfer through gypsum-board-protected wood-stud wall assemblies exposed to fire. The program uses convection, conduction and

Table 9. Table of nine different types of cross-sectional elements for calculation of heat transfer.

Element No.	Example Node Coordinates	Direct Heat Exposure	Tributary Area
①	(1,1)	2 edges, $dx/2$ & $dy/2$	$(dx/2) \times (dy/2)$
②	(1, n)	1 edge, $dy/2$	$(dx/2) \times (dy/2)$
③	(m, n)	None	$(dx/2) \times (dy/2)$
④	(m, 1)	1 edge, $dx/2$	$(dx/2) \times (dy/2)$
⑤	(1, 2)	1 edge, dy	$(dx/2) \times (dy)$
⑥	(2, n)	None	$(dx) \times (dy/2)$
⑦	(m, 2)	None	$(dx/2) \times (dy)$
⑧	(2, 1)	1 edge, dx	$(dx) \times (dy/2)$
⑨	(2, 2)	None	$(dx) \times (dy)$

radiation, as well as the relationship between temperature and enthalpy, to calculate the temperature with respect to time at various points within a wall assembly exposed to fire on one side (Mehaffey *et al.*, 1994). The program also uses explicit finite-difference techniques to solve the two-dimensional partial differential equation that describes the rate of change of enthalpy in the wood elements (Takeda and Mehaffey, 1998). This computer model has been presented extensively in the literature (Bénichou *et al.*, 1999; Bénichou *et al.*, 2000; Mehaffey *et al.*, 1994; Takeda and Mehaffey, 1998). A copy of the source code for the program was obtained and modified for use in this study.

The *WALL2D* computer model was modified so that it would be able to predict heat transfer within a single structural lumber member exposed to elevated temperatures from all four sides. The modifications included removing all programming code dealing with gypsumboard, insulation, and wall-cavities, and verifying all enthalpy equations. Altering the equations of heat transfer for each type of element of a specimen's cross-sectional area, as listed in Table 9, to reflect the experimental conditions was also required. Because the modified heat-transfer program was intended to model specimens that were heated at the surface by direct conduction during testing, all radiation and convection terms could be eliminated from the heat-transfer calculations made in *WALL2D*.

The resulting modified heat-transfer subroutine was then tested to see how accurately it predicted center-point temperature data from the experiments. The subroutine was run using actual density and moisture content data from the tests at all load-level and exposure-temperature combinations used in the experiments. The predicted center-point temperatures were compared to those measured during testing. This comparison demonstrated that, while center-point temperatures were reasonably well-predicted prior to reaching 100°C, the model under-predicted center-point temperatures after they reached 100°C. Figure 17 shows these results for one specimen at each of the exposure temperatures. It can be seen in Figure 17 (c) and (d), in particular, that the predicted rate of rising of the center-point temperature significantly decreases at 100°C, and then increases again at approximately 120°C.

Figure 17. Comparisons between experimental and predicted center-point temperatures at exposure temperatures of (a) 75°C, (b) 150°C, (c) 200°C, and (d) 250°C.

The possible causes of this under-prediction of center-point temperatures were discussed with the authors of *WALL2D*. It was suggested that the discrepancy might result from *WALL2D*'s treatment of water vaporization. When wood reaches about 100°C, free moisture contained in its cellular structure begins to migrate and to vaporize. The heat required to vaporize adsorbed water is substantial - 2.89 MJ per kg of water. It seemed significant that in its calculations *WALL2D* assumes that this free water is completely vaporized in the temperature range of 100°C to 120°C. This requires large amounts of heat to be used over a short time period - heat that thus used could not be available to heat the center of the wood at that time. As well, the heating conditions to which dimension lumber is exposed during standard testing are considerably different from those experienced by experimental specimens in this study. Figure 18 graphically demonstrates the differing heating conditions and their effect on adsorbed moisture. In a wall assembly during a standard fire test, dimension lumber experiences heating on three sides of its cross-section. Consequently, moisture within the wood not only vaporizes, but also is driven towards the fourth unexposed side and is lost into the surrounding environment. In contrast, in the experimental conditions of this study dimension lumber is heated on all four sides. Moisture vaporizes and is driven toward the center of the specimen. There is very little moisture loss possible from any of the sides of the cross-section due to the encasing heating platens. All moisture eventually vaporizes.

Figure 18. Differing heating conditions and their effect on adsorbed moisture:
 (a) experimental conditions in this study; and,
 (b) standard fire test conditions.
Note: The relative size of the heating arrows in (b) indicates degree of heating.

As a result of these differing conditions, it was possible that vaporization might have taken place over a larger temperature range under the experimental conditions of this testing program than the range used in *WALL2D*. This would spread the total amount of heat used for vaporization within the model over a longer time period, and thus allow more heat to be available earlier, which could raise a specimen's predicted center temperature more rapidly.

It was decided that the experimental center-point data would be used to empirically calibrate the modified heat-transfer model. This calibration was attempted, and it was determined that the optimum temperature range to use for vaporization of adsorbed water in this study was 100°C to 170°C. Figure 19 shows one example of the change in predicted center-point temperatures using different temperature ranges for moisture vaporization. It can be seen that changes in the vaporization temperature range do not significantly affect the prediction of center-point temperatures under 100°C, nor over approximately 200°C.

It must be noted that the change in the temperature range for vaporization does not affect the prediction by the modified heat-transfer model of time to the onset of charring. As can be seen in Figure 19, the predicted temperature curves converge at approximately 200°C. The temperature for charring is usually assumed to be approximately 300°C, so that the predicted time taken to reach charring would be the same for all temperature ranges of vaporization between 100°C and 200°C.

Figure 19. An example demonstrating the change in predicted center-point temperatures when different temperature ranges are used for moisture vaporization within a single specimen; the range over which moisture vaporization is predicted to occur for each instance is 100°C to {100+deltaT}°C.

5.3 Compression-Strength Reduction Modelling

While the data gathered in testing may be insufficient to directly formulate an independent compression-strength reduction model, it could be used to validate existing strength-reduction models found in the literature. This could be accomplished by using each of the published compression-strength reduction models listed in Table 4 (page 27), to predict the times-to-failure of 2×4 s in compression and exposed to elevated temperatures, using the member temperature history predicted by the modified heat-transfer model. The modelled times-to-failure, and rates of non-failure, could then be compared to the observed experimental data to determine how well the various published models predicted compression failure within the set of experimental conditions used for this testing program.

Because each strength-reduction model directly relates the percentage of strength remaining to temperature, the reduced strength of each cross-sectional element for a specimen could be calculated based on the average temperature predicted for that element at each time step. Knowing the reduced strength and the cross-sectional area of each element, the total reduced capacity of the member could then be determined. It was assumed that full load sharing occurred between elements; that is, when one element reached its full capacity, it was assumed that the additional load was taken up by other elements until their capacity was also reached. At each time increment, the total reduced capacity of the member was compared to the load that the member was expected to carry; once the load exceeded the capacity, the member was considered to have failed.

There were only four different types of cross-sectional elements for the calculation of strength, based on the area of the element. Table 10 defines the four types, and gives corresponding element numbers from Figure 16.

Table 10. Table of four different types of cross-sectional elements for calculation of strength.

Element Type	Element Nos.	Tributary Area
Corner	①, ②, ③, ④	$(dx/2) \times (dy/2)$
Edges in x-direction	⑥, ⑧	$(dx) \times (dy/2)$
Edges in y-direction	⑤, ⑦	$(dx/2) \times (dy)$
Bulk	⑨	$(dx) \times (dy)$

The computer program HTE Exposure used the approaches described in this chapter to generate and input material properties for specimens that were to be modelled, to predict the temperature history of those specimens, and to calculate the compression-strength reduction experienced by the specimens as a result of the predicted temperature history. The results of the computer program's modelling, using each compression-strength reduction model from Table 4, are discussed in the next chapter.

6.0 PREDICTED VERSUS EXPERIMENTAL RESULTS

6.1 Validation of Existing Compression-Strength Reduction Models

The computer program HTEposure was executed using each compression-strength reduction model from Table 4 in turn. Because the objective was to compare each strength-reduction model's predictions to experimental results, the same combinations of exposure temperatures and constant applied compression loads used for experimental testing were used when running the program. The same number of specimens was simulated as were found in each of the test groups.

The computer program's function was to predict time-to-failure of simulated specimens. Therefore, the first step taken was to run the program for each strength-reduction model using only those combinations of exposure temperature and constant applied compression load that had produced failures during experimental testing within the first 45 minutes, that is, the highest temperature and load combinations. It can be readily seen in Figure 13 (page 52) that there were five such combinations: 150°C/37 kN, 150°C/50 kN, 200°C/25 kN, 200°C/37 kN, and 250°C/25 kN. Even though computing power and speed have greatly increased over the last 10 years, the many calculations to be made by HTEposure over multiple time steps still require significant processing time. It was thought possible that some of the compression-strength reduction models could be eliminated from further examination if they could be found to inadequately predict the observed results of those five load and exposure temperature combinations. The result was that the computer model initially was run five times, using one of these five

temperature/load combinations each time, for each of the eight compression-strength reduction models from Table 4.

The models of Kollman (1940), Schaffer (1971), Knudson & Schniewind (1975), and Young & Clancy (1998) predicted no failures using any of these five exposure-temperature/load-condition combinations. This indicated that each of these models greatly over-predicted the actual average percentage of compression strength remaining during exposure, since all five of the temperature/load combinations produced failures during experimental testing. Because no specimen failures were predicted by these four models, there were no data with which to perform a statistical comparison to the observed data. As a result, the program output produced by these models is not included in this document. It was decided that, since the four models were not able to predict the experimental results, no further computer runs using these models were required.

The model by Schaffer *et al.* (1986), that was converted from strength-reduction-with-respect-to-depth to strength-reduction-with-respect-to-temperature as described in Section 3.2.3, predicted no failures for four of the five initial temperature/load combinations. However, for the combination of 150°C and 50 kN, approximately one third of the specimens were predicted to fail much more rapidly than during experimental testing, while the rest did not fail at all. The tabulated output of this model for the five temperature/load combinations can be found in Appendix V. The main factor that seems to have precipitated this result is that the Schaffer *et al.* model predicts significantly

lower strengths between 50°C and 100°C than it does at 150°C, and only at approximately 250°C does predicted strength return to such low levels (Figure 3, page 30). Therefore, when a specimen is heated using an exposure temperature of 150°C, a larger proportion of the cross-sectional area of that specimen experiences temperatures in the 50°C to 100°C range at any given time than if it were exposed to 200°C or 250°C. So, if a specimen does not fail while a large percentage of its cross-section is in the 50°C to 100°C temperature range and thus at a lower residual strength, it will not fail once the whole cross-section of the specimen reaches 150°C and a higher residual strength. Because this model did not predict well the experimental results for the five highest temperature/load combinations, no further program runs using the Schaffer *et al.* strength-reduction model were performed.

The Rykov (1980) compression-strength reduction model did predict some failures at four of the five highest exposure-temperature/compression-load combination conditions. No failures were predicted at 200°C and 25 kN. The tabulated output for the five combinations can be found in Appendix VI. Figure 20 compares the cumulative relative frequency distribution (CRFD) of the Rykov model's predicted times-to-failure to that of the observed experimental times-to-failure. It must be noted that if a specimen did not fail within the first 45 minutes (2700 seconds) of either experimental or simulated testing, the CRFD curve shows that specimen as having failed at 2700 seconds. This was done to maintain the same number of results in both experimental and simulated groups

Figure 20. Cumulative relative frequency distribution diagrams comparing time-to-failure results predicted by HTE exposure using Rykov (1980) compression-strength reduction model to observed results.
Note: Specimens indicated to have a time-to-failure of 2700 seconds are those specimens that did not fail at all, but were retained to maintain an equivalent number of results for comparison purposes.

for accuracy in comparison. As a result, in all the following CRFD diagrams "failures" at 2700 seconds mean that a specimen did not fail at all.

It can be seen in Figure 20 that the Rykov model predicted significantly lower rates of failure and much higher failure times when compared to the experimental results. As well, because the model was presented in the literature as valid only up to 180°C, a linear extrapolation was required for its use at exposure temperatures of 200°C and 250°C. This extrapolation may not be justifiable. As a result of these factors, additional runs of the program HTExposure using this model were not considered necessary.

The compression-strength reduction models by Hosser *et al.* (1994) and König & Walleij (2000) predicted failures in all five of the initial exposure temperature and applied compression load level combinations. The tabulated output using these two models can be found in Appendices VII and VIII. Figures 21 and 22 compare the CRFDs of the models' predicted times-to-failure to the observed times-to-failure.

It can be seen in Figure 21 that at the lowest temperature/load combination, 150°C/37 kN, the Hosser *et al.* compression-strength reduction model predicted longer times-to-failure and a lower failure rate than observed in testing. However, at the same exposure temperature but a higher load level, the model more accurately predicted the experimental times-to-failure and failure rates. At the higher exposure temperatures, the

Figure 21. Cumulative relative frequency distribution diagrams comparing time-to-failure results predicted by HTE exposure using Hosser *et al.* (1994) compression-strength reduction model to observed results.

Note: Specimens indicated to have a time-to-failure of 2700 seconds are those specimens that did not fail at all, but were retained to maintain an equivalent number of results for comparison purposes.

Figure 22. Cumulative relative frequency distribution diagrams comparing time-to-failure results predicted by HTEXposure using König & Walleij (2000) compression-strength reduction model to observed results.

Note: Specimens indicated to have a time-to-failure of 2700 seconds are those specimens that did not fail at all, but were retained to maintain an equivalent number of results for comparison purposes.

model predicted times-to-failure that were shorter than observed and higher rates of failure.

Figure 22 indicates that the König & Walleij model consistently predicts higher failure rates and faster times to failure than was observed during testing. It was the only model from the literature that produced such results.

It was decided that runs of HTExposure would be performed using the remaining exposure-temperature/compression-load combinations with the Hosser *et al.* and König & Walleij models. The tabulated output from these runs can also be found in Appendices VII and VIII. No comparative diagrams of CRFD curves can be shown because almost no failures occurred under those combinations of exposure temperature and constant applied compression load during experimental testing. The tabulated results, however, indicate that the Hosser *et al.* model continued to exhibit the same trend as previously. That is, at lower temperatures of exposure a lower failure rate than observed was predicted and at higher temperatures of exposure much higher rates of failure were predicted when compared to observed test results. The tabulated output resulting from the König & Walleij model continued to predict higher rates of failure than observed in all combinations of exposure temperature and applied compression load used.

Although the Hosser *et al.* compression-strength reduction model was one of only three models from the literature that predicted values comparable to the experimental

data, it was originally presented in the literature for use with a limited temperature range, that is, temperatures between 20°C to 100°C. Hosser *et al.* (1994) does show an extrapolation to 160°C, though. However, for use in predicting strength reduction in HTExposure, that extrapolation was further extended to 250°C. This extrapolation extension, as in the case of the Rykov model, may not be justifiable.

6.2 Validation of Proposed Compression-Strength Reduction Model

As seen in the previous section, the compression-strength reduction models from the literature were not able to closely predict the experimental results of this study. But, it was believed possible that part of one or more of those models could be used to form a compression-strength reduction model that would more accurately predict the experimental data than any of the models in their original form. An examination of all the strength-reduction models determined that the model by Young & Clancy was based on data gathered under test conditions more similar to those of this study than any other model from the literature whose conditions are known.

It seemed that the main difference between the two sets of test procedures was that Young & Clancy heated each specimen until it completely reached exposure temperature and then applied a compression load, while in this study the load was applied from the outset of heating. This would seem to not cause any major variance in results between their testing and the testing in this project when exposure temperatures remained below 100°C, as not much water in the wood can be vaporized at those temperatures.

However, above 100°C, their model is based on the assumption that all moisture within the specimen has already been vaporized and driven off as the temperature reaches 110°C. This assumption is valid for their test conditions. Because a specimen was heated until its entire cross-section reached exposure temperature before a load was applied, this meant that specimens were heated for 90 to 150 minutes, more than sufficient time for all moisture to be driven off. As shown in Figure 3 (page 30), this assumption results in a significant increase in remaining compression strength relative to initial compression strength – from 40% to 120 % of initial strength. Because "wet" wood at a given temperature has less strength than dry wood at the same temperature (Schaffer, 1971), it is possible to have a percentage of initial strength greater than 100%. Young and Clancy (1998) found under their experimental conditions that dry wood at 110°C was stronger than the same wood at room temperature when "wet".

It is this assumption, though, that caused the model by Young & Clancy to not predict well the test data from this study for exposure temperatures over 100°C. As was seen in Section 5.2, the temperature range of vaporization with no moisture migration that best predicted this study's heat-transfer results was 100°C to 170°C, not 100°C to 110°C. This means that the percentage of initial strength exhibited by our test specimens should be significantly lower in this temperature range than that predicted by Young & Clancy's model, because the specimens in this study remained "wet". Although the complete Young & Clancy compression-strength reduction model did not predict the observed test results well, it seemed reasonable to use the portion of that model from

room temperature to 100°C as the first part of a new proposed model to better predict the experimental results of this study.

A simple analysis of the experimental data for exposure temperatures of 150°C, 200°C and 250°C was performed. It indicated that a straight line from the percentage of initial strength predicted at 100°C by the first equation of the Young & Clancy model (40%) to 0% of initial strength at 300°C may work well to predict the observed results. A temperature of 300°C was chosen as the point where the percentage of initial strength should reach zero because that is a generally accepted temperature for forming char and char is assumed to have zero strength. Therefore, the new proposed model that was tested in HTExposure consisted of the first equation of the Young & Clancy model for the range of room temperature to 100°C:

$$P = 115 - 0.75T \quad [35(a)]$$

and a second equation,

$$P = 60 - 0.20T \quad [35(b)]$$

for $100^\circ\text{C} \leq T \leq 300^\circ\text{C}$. This results in a model that falls within the boundaries of the original Young & Clancy model that predicts some of the highest residual strengths, and the König & Walleij model that predicts the lowest residual strengths at most temperatures. Figure 23 shows this proposed model in comparison to the three compression-strength reduction models from the literature that predicted results comparable to those found in experimentation.

Figure 23. Those compression-strength reduction models from the literature that predicted results comparable to experiment, including proposed model.

The tabulated output from running HTExposure using this compression-strength reduction model at all exposure-temperature/applied-compression-load combinations from experiment can be found in Appendix IX. Figure 24 compares the CRFD of the proposed model's predicted times-to-failure to that of the observed times-to-failure for the five highest exposure-temperature/applied-load combinations. It can be seen that for the combinations of 150°C/50 kN, 200°C/25 kN, and 200°C/37 kN, the proposed model predicted the observed times-to-failure and the rates of specimen failure reasonably well. The proposed model does not predict well the experimental results for the highest or the lowest temperature/load combinations. Again, no comparative diagrams of CRFD curves can be shown of the results of the other temperature/load combination conditions because almost no failures occurred under those conditions during experimental testing. The tabulated results in Appendix IX, however, indicate that under most of the remaining temperature/load combinations this model predicted results that compare relatively favorably to experimental results.

There is a way to examine how the use of each compression-strength reduction model reduces the predicted strength of a specimen with a particular temperature history. Using each of the strength-reduction models, one can observe the average percentage-strength reduction over time of a specimen with a specific initial compression strength, moisture content, and density, as predicted by HTExposure at the three highest exposure temperatures. Figures 25 and 26 show the percentage-strength reduction over time predicted by each of the eight models from the literature, as well as by the new proposed

Figure 24. Cumulative relative frequency distribution diagrams comparing time-to-failure results predicted by HTExposure using the proposed compression-strength reduction model to observed results.

Note: Specimens indicated to have a time-to-failure of 2700 seconds are those specimens that did not fail at all, but were retained to maintain an equivalent number of results for comparison purposes.

Figure 25(a). Predicted percentage-compression-strength reductions over time of exposure for a single specimen of identical material properties, using the 5th-percentile initial compression strength (X_{05}), at an exposure temperature of 150°C. Indication is also made of the percentage strengths that need to be reached for failure to occur at the stress levels applied (σ_{25kN} , σ_{37kN}) at that exposure temperature, using initial strength boundaries of 5th (X_{05}) and 95th (X_{95}) percentile values.

Figure 25(b). Predicted percentage-compression-strength reductions over time of exposure for a single specimen of identical material properties, using the 5th-percentile initial compression strength (X_{05}), at an exposure temperature of 200°C. Indication is also made of the percentage strengths that need to be reached for failure to occur at the stress levels applied ($\sigma_{37\text{kN}}$, $\sigma_{50\text{kN}}$) at that exposure temperature, using initial strength boundaries of 5th (X_{05}) and 95th (X_{95}) percentile values.

Figure 25(c). Predicted percentage-compression-strength reductions over time of exposure for a single specimen of identical material properties, using the 5th-percentile initial compression strength (X_{05}), at an exposure temperature of 250°C. Indication is also made of the percentage strength that needs to be reached for failure to occur at the stress level applied (σ_{25kN}) at that exposure temperature, using initial strength boundaries of 5th (X_{05}) and 95th (X_{95}) percentile values.

Figure 26(a). Predicted percentage-compression-strength reductions over time of exposure for a single specimen of identical material properties, using the 50th-percentile initial compression strength (X_{50}), for an exposure temperature of 150°C. Indication is also made of the percentage strengths that need to be reached for failure to occur at the stress levels applied ($\sigma_{25\text{kN}}$, $\sigma_{37\text{kN}}$) at that exposure temperature, using initial strength boundaries of 5th (X_{05}) and 95th (X_{95}) percentile values.

Figure 26(b). Predicted percentage-compression-strength reductions over time of exposure for a single specimen of identical material properties, using the 50th-percentile initial compression strength (X_{50}), for an exposure temperature of 200°C. Indication is also made of the percentage strengths that need to be reached for failure to occur at the stress levels applied (σ_{37kN} , σ_{50kN}) at that exposure temperature, using initial strength boundaries of 5th (X_{05}) and 95th (X_{95}) percentile values.

Figure 26(c). Predicted percentage-compression-strength reductions over time of exposure for a single specimen of identical material properties, using the 50th-percentile initial compression strength (X_{50}), for an exposure temperature of 250°C. Indication is also made of the percentage strength that needs to be reached for failure to occur at the stress level applied (σ_{25kN}) at that exposure temperature, using initial strength boundaries of 5th (X_{05}) and 95th (X_{95}) percentile values.

model, for a single specimen at temperatures of exposure of 150°C, 200°C and 250°C. The same values of moisture content and density were used to define the specimen in each case. Because each strength-reduction model is based only on temperature, as the temperature of an entire specimen approaches the exposure temperature the specimen's average percentage of initial room-temperature compression strength approaches a minimum value. Figure 25 shows the effect of each strength-reduction model on a specimen with an initial compression strength equal to the 5th percentile value of strength, while Figure 26 shows a specimen with a 50th percentile initial strength.

Shown for comparison are lines indicating the three highest constant applied stress levels as a percentage of the 5th and 95th percentile values of room-temperature ultimate compression strength. If the minimum percentage-strength reduction predicted by a model for a specific specimen exposed at a given temperature does not fall within these stress-level percentage lines, HTE Exposure would not predict failure of that specimen at that applied level of stress using that strength-reduction model, regardless of how large a value was given for the length of time to run the program. It can be easily seen from these graphs, especially those of Figure 25, why the models of Kollman, Schaffer, Knudson & Schniewind, and Young & Clancy did not predict any failures under the temperature/load conditions found in this project. Even when the initial compression strength of a specimen was as low as the 5th percentile strength, these four models did not predict sufficient average strength reduction to bring a specimen within the applied stress-level range. Similarly, these figures also indicate why the model by

König & Walleij under-predicted times-to-failure and over-predicted rates of failure, and why the proposed model performs reasonably well.

6.3 Analysis of Predicted versus Experimental Results

From a visual inspection of the cumulative relative frequency distribution diagrams found in Figures 20, 21, 22 and 24, it may be concluded that the proposed compression-strength reduction model appears to provide the "best fit" of predicted results to observed data. However it was decided that a more quantitative comparison among the models should be made.

It was discovered that there were limiting factors when attempting to find a method of measuring the "goodness of fit" of modelled results to observed results. These limiting factors related to particular aspects of the experimental or the predicted sets of data. The main limiting factor seemed to be that the desired "goodness of fit" measurement was to be performed between two sets of data, neither of which could be described by a defined function. Many methods were found to determine how well a given set of data can be modelled by a standard theoretical function or distribution. But in this study many of the data sets to be compared, both observed and predicted, are "incomplete" because the time-to-failure of all specimens is not known. If a specimen did not fail within the first 2700 seconds (45 minutes) of either experimental or modelled testing, the test ended; and, it can not be known if such a specimen would have failed in just a few more seconds, or hours, or even days, of exposure to elevated temperature and

constant load. Due to the "incompleteness" of most data sets, it is not reasonable to compare either the experimental or predicted results with a defined distribution function.

Another limiting factor was that the number of specimens that did not fail in a group during experimental testing was often not equal to the number predicted not to fail by any of the models using the same exposure-temperature/applied-load combinations. Some comparison methods require the same number of data points in each of a pair of data sets to be compared. This is one reason why all specimens that were either observed or predicted not to fail are included in Figures 20, 21, 22 and 24 as if they failed at 2700 seconds. Therefore, a method was required that would either not require equal numbers of data points once the "non-failures" were removed from the data sets, or that would not be adversely affected by the inclusion of "non-failures" of 2700 seconds.

As well, as stated in Chapter 5, the actual initial compression strengths of the specimens tested at elevated temperature were not known. Even though actual moisture content and density values could be assigned to the modelled specimens, initial strengths were assigned using the *Monte Carlo Simulation* method as described in Section 5.1. This created modelled groups of specimens with a *Lognormal* distribution of initial compression strengths similar to that found in the experimental population. For this reason, there was no physical method that could be applied to make a one-to-one correspondence between the experimental and model data points based on initial compression strength.

It was determined that, due to these limiting factors, only a relative measure of "goodness of fit" could be made; no absolute measure could be accurate. In this way, a comparison of one model to another might be made. Three different methods were used. Each method uses a different basis for comparison which allows more than one aspect of the compression-strength reduction models to be examined.

The first method used was that of the "mean square error". This method measures the average squared distance between an observed and a predicted *Cumulative Relative Frequency Distribution* (CRFD) curve. The two sets of data to be compared are sorted into ascending order. The two data sets must have the same number of data points. The following formula is then applied:

$$\text{mean square error} = \frac{\sum_{i=1}^n (tff_{Pi} - tff_{Ei})^2}{n} \quad [36]$$

where tff_{Pi} is the i -th predicted time-to-failure, tff_{Ei} is the i -th expected, or observed, time-to-failure, and n is the total number of values in each data set. The distance or "error" between each pair of data points is squared in order to counter the cancelling-out that occurs if the sorted values of one set of data begin lower than the other, but then become greater; that is, if one set of data "crosses over" the other as seen in a CRFD plot. Smaller values of the mean square error indicate a better "fit" than larger values.

The second method of relative measure that was used was the "mean deviation" method. This measures the average distance between an observed and a predicted CRFD curve. Again each of the sets of data to be compared is sorted into ascending order, and must have the same number of data points. Then the following formula is applied:

$$\text{mean deviation} = \frac{\sum_{i=1}^n (t_{tf_{Pi}} - t_{tf_{Ei}})}{n} \quad [37]$$

It is very similar to the "mean square error" method, except that the distance, or "deviation", between each pair of data points is not squared. This method was used because it was observed that only a few modelled data sets "crossed-over" their comparable experimental data set in the CRFD diagrams. For that reason, this method could provide a measure of the "safety" or "conservativeness" of each model. A negative mean deviation indicates that, overall, the predicted times-to-failure were lower than the observed values, and therefore, such a model would err on the "safe" or "conservative" side - the larger the negative value of a mean deviation, the "safer" the model for those conditions. A positive mean deviation indicates the predicted times-to-failure were higher than those observed, and thus, such a model would err on the "unsafe" side. These conclusions about level of safety can only be made if there is no "cross-over" between the two data sets compared, as was the case in most instances here. Values of mean deviation closer to zero indicate a better "fit" to experimental results than larger values, either positive or negative.

The third method attempted was that of the " χ^2 -test". Although this method often is used to compare a data set to a theoretical distribution function, it can be used to compare two data sets as long as certain conditions are met. It compares the number of data points in specific sections of a CRFD curve of predicted values to the number of data points found in corresponding sections of a CRFD curve of observed or "expected" values. The range of values spanned by the data to be examined is divided into intervals. These intervals do not need to be equal in size, but each interval must hold at least five observed values for a given set of experimental data. The number of intervals required, m , is related to the total number of data points in a single data set, n :

$$m = (1 + 3.3 \log_{10} n) \quad [38]$$

where m is rounded to the next largest integer.

Once the intervals for a given set of observed data are determined, the number of observed or "expected" data values, e_i , is determined for each interval. The number of predicted data values, p_i , from the predicted data set to be compared is also determined using the same intervals. Then, the following summation is made:

$$\chi^2 = \sum_{i=1}^m \left[\frac{p_i - e_i}{e_i} \right]^2 \quad [39]$$

Smaller values of χ^2 indicate a better "fit" than larger values of χ^2 .

Tables 11, 12, and 13 tabulate the results of these three methods using the data presented in the time-to-failure CRDF diagrams (Figures 20, 21, 22, and 24) and allow

Table 11. Analysis results from "mean square error" method (mean square error $\times 10^5$).
Note: Smaller values of the mean square error indicate a better "fit" than larger values.

Conditions	Compression-Strength Reduction Model			
	Rykov	Hosser <i>et al.</i>	König & Walleij	Proposed Model
150°C/37kN	18	5.6	17	7.6
150°C/50kN	24	0.27	7.8	1.6
200°C/25kN	4.9	19	31	0.13
200°C/37kN	25	2.4	6.8	0.80
250°C/25kN	11	19	24	4.5
average = $(\Sigma x)/5$	17	9.2	17	2.9

Table 12. Analysis results from "mean deviation" method (mean deviation $\times 10^3$).
Note: Values of the mean deviation that are closer to zero indicate a better "fit" than larger values, either positive or negative.

Conditions	Compression-Strength Reduction Model			
	Rykov	Hosser <i>et al.</i>	König & Walleij	Proposed Model
150°C/37kN	1.1	0.62	-1.1	0.63
150°C/50kN	1.4	0.098	-0.71	-0.24
200°C/25kN	0.32	-1.3	-1.7	0.0072
200°C/37kN	1.5	-0.37	-0.70	0.064
250°C/25kN	0.79	-1.2	-1.4	-0.54
average = $(\Sigma x)/5$	1.0	-0.43	-1.1	-0.016

Table 13. Analysis results from " χ^2 -test" method.
Note: Smaller values of χ^2 indicate a better "fit" than larger values.

Conditions	Compression-Strength Reduction Model			
	Rykov	Hosser <i>et al.</i>	König & Walleij	Proposed Model
150°C/37kN	15	4.7	105	5.4
150°C/50kN	77	0.96	56	9.5
200°C/25kN	N/A	N/A	N/A	N/A
200°C/37kN	72	6.1	38	4.9
250°C/25kN	6.0	71	118	5.1
average = $(\Sigma x)/4$	42	21	79	6.2

for comparison among the four models that predicted results that could be compared to those observed during testing. It should be noted that the χ^2 -test method could not be used for the 200°C/25 kN temperature/load combination data sets because that group could not meet the condition of at least five observed data points in each of the required number of intervals.

All three methods indicate that the proposed compression-strength reduction model provided an overall "better fit" of predicted results to those observed. They also indicate that the Rykov model predicted results closer to those observed than did the König & Walleij model, statistically making the König & Walleij model the "least-best fit" of the four models that could be compared. But it must be noted that the Rykov model consistently predicted much longer times-to-failure than those observed, thus erring on the "unsafe" side, while the results of the "mean deviation" method in Table 12 confirm the observation that the strength-reduction model by König & Walleij does err on the "safe" side in all five exposure-temperature/applied-load combination cases where statistical comparison is possible. As a result, the model by König & Walleij could be useful for design purposes.

Because no absolute measure of "goodness of fit" could be made, it cannot be stated that the program HTExposure using the proposed compression-strength reduction model provides an accurate prediction of experimental results. However, it can be said

that the proposed strength-reduction model provides a closer prediction than the use of any of the original eight models from the literature.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

As part of a larger research strategy to characterize the reliability of structural light-framing during real fire events, a program of experimental testing of nominal 2×4 Machine Stress Rated lodgepole pine lumber concentrically loaded in compression and exposed to elevated temperatures was executed by Forintek Canada Corp. staff. In this study a computer program, HTE Exposure, was written to model the experimental time-to-failure data gathered in the testing program. HTE Exposure combined a modification of an existing finite-difference heat-transfer model (*WALL2D*) with various published compression-strength reduction models, in order to determine which of those strength-reduction models could predict times-to-failure comparable to the observed values.

Although three out of eight strength-reduction models from the literature predicted results comparable to those observed during experimental testing, only one of those three models was originally designed for use for the complete temperature range examined, that of König & Walleij (2000). The other two models, Rykov (1980) and Hosser *et al.* (1994), required extrapolation for use in the full range of temperatures examined. However, of these three models, the extrapolated Hosser *et al.* model provided the best fit of predicted times-to-failure when compared to the experimental results. But for design purposes, the use of the König & Walleij model would always allow a margin of safety. All other models from the literature did not predict results that could be compared to those observed.

A new compression-strength reduction model was proposed. Using the proposed model, HTExposure predicted results closer to those observed than when using any of the original eight models from the literature.

7.2 Recommendations

While a simple proposal for a compression-strength reduction model was attempted for this thesis, a more rigorous statistical calibration should be carried out to provide a better fit of HTExposure's predicted times-to-failure to the observed results. Also, an independent set of experimental tests should be performed in order to validate the HTExposure computer model.

The experimental data gathered during the testing conducted by Forintek Canada Corp. contains within it more information regarding the behaviour of structural dimension lumber, and thus the data need to be further analyzed. For example, the data may be able to be used to characterize the reduction in compression modulus of elasticity that has been seen to occur during heating and that results in increasing strain in a heated member.

The task of assembling and integrating computer models into user-friendly applications for use under the new objective-based National Building Code of Canada has begun. It is hoped that the experimental data gathered in this project and the model developed in this thesis may contribute in a small way to the current effort to provide

computer-based calculation methods for engineered fire-safety design of wood-based building systems.

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APPENDIX I
Experimental data summaries

DATA SUMMARY
Room Temperature Testing - Group 1

Specimen No.	Failure location 1 (mm)	Failure location 2 (mm)	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Maxload (kN)	Initial Strength (MPa)	Density kg/m ³
							Platen 1 End (°C)	Platen 2 End (°C)	Wood End (°C)	Wood End (°C)				
1	370		35.1	87.7	8.7	1837	22.5	23.5	27.6	25.3	163	163	53.0	497
27	910	1185	35.1	88.1	9.3	1856	22.5	21.6	24.8	23.1	155	161	52.2	501
49	60		35.1	86.0	9.0	2111	22.5	23.6	27.7	25.3	185	195	64.5	583
53	720		35.2	87.5	8.6	2087	22.5	21.6	26.9	24.6	139	144	46.9	565
59	190	765	35.2	87.2	8.9	1709	22.5	21.5	27.1	25.1	108	111	36.0	464
99	600		35.1	89.0	8.8	1717	20.5	21.5	25.0	23.1	114	118	37.7	458
100	230		35.2	88.2	8.8	1806	20.5	21.5	23.4	22.3	138	145	46.6	485
101	350		35.1	86.2	8.4	2154	22.5	21.5	26.2	24.0	141	147	48.5	593
104	600		35.1	88.1	8.3	1786	20.8	21.6	16.8	23.2	131	136	44.1	482
105	370	860	35.1	87.5	8.6	2017	21.1	21.6	24.6	22.8	146	150	48.9	548
107	130		35.1	87.8	8.3	1748	22.4	21.6	26.5	24.2	151	157	51.0	472
119	10		35.2	87.9	8.7	1993	22.4	21.6	26.3	24.1	161	169	54.6	537
138	300		35.1	87.4	8.6	1983	22.5	23.6	26.6	24.5	130	136	44.2	539
153	780		35.1	87.0	8.5	2046	22.4	21.5	27.2	25.2	146	150	49.0	558
165	315		35.1	87.7	8.5	1900	22.4	21.6	27.2	25.1	140	143	46.5	514
183	510	740	35.1	87.4	8.3	1869	22.5	21.7	25.6	23.5	132	138	45.1	508
208	910		35.0	85.7	9.0	2059	22.5	23.6	27.3	25.3	155	162	54.0	572
233	930		35.1	87.7	9.1	1960	22.5	21.6	24.2	22.9	138	145	47.0	531
234			35.1	86.4	8.5	2200	22.4	23.6	26.6	24.2	200	208	68.7	605
236	225		35.2	87.4	8.6	1979	22.4	23.6	27.1	24.3	147	152	49.5	537
290	170		35.1	88.2	8.6	1928	22.5	21.5	26.3	24.3	144	150	48.3	519
350			35.1	87.7	8.9	1879	22.5	21.6	26.5	24.4	150	156	50.7	509
381	600		35.1	87.3	8.4	1968	22.4	21.6	26.6	24.3	158	164	53.6	535
392	240	480	35.1	88.1	9.2	2003	22.6	21.5	25.0	23.2	154	158	51.1	540
5010	735	20	35.0	88.0	9.8	1627	24.2	23.6	28.7	27.2	86	90	29.1	440
5021	600		35.1	87.6	10.0	1656	24.4	23.6	29.4	27.7	95	99	32.1	449
5030	600		35.1	86.7	9.8	1791	24.4	23.6	28.8	27.3	107	112	36.6	490
5063	100		35.2	88.1	7.9	1606	22.4	23.4	26.3	25.1	112	116	37.5	432
5116	700		34.8	87.5	9.0	1690	24.4	23.5	26.8	25.1	105	109	35.9	462
5153	775		35.2	87.8	9.0	1797	22.4	21.5	25.3	24.1	126	132	42.6	485
5155	860		34.9	87.6	8.4	1741	22.3	23.5	26.4	25.1	82	85	27.8	475
5169	305	180	35.1	87.7	9.3	1557	24.4	23.6	29.1	27.4	127	132	43.0	422
5174	600		34.9	87.6	9.1	1698	22.4	23.6	27.4	25.0	107	111	36.5	463
5224	1009		34.8	87.3	8.5	1871	24.3	23.5	26.6	25.0	110	115	37.9	514
5230	440		35.0	86.2	8.2	1915	22.5	21.7	26.4	24.3	118	122	40.5	529
5231	1030		35.1	87.4	8.5	1914	22.5	21.6	26.3	24.4	120	125	40.6	520
5243	290		35.0	87.8	10.6	1818	24.3	23.6	29.7	28.1	127	132	42.9	493
5273	320		35.0	86.2	8.6	1776	22.5	21.6	26.9	24.8	100	103	34.1	491
5279	220		35.1	88.2	8.3	1524	22.4	21.6	23.0	22.3	102	104	33.7	410
5292	1040		35.2	87.4	7.9	1645	20.5	21.6	25.6	23.7	111	114	37.1	446
5350	375	685	35.2	87.9	8.8	1728	22.3	21.6	26.6	24.9	121	125	40.4	466
5372	120		35.2	87.1	8.2	1835	20.6	21.6	25.6	23.6	129	133	43.4	499
5377	780		35.0	88.7	8.4	1669	22.5	21.5	26.6	24.3	98	98	31.6	448
5390	970		35.1	88.1	9.0	1737	22.4	23.6	26.9	24.8	99	104	33.6	468
5420	730		35.1	87.4	8.6	1679	22.5	23.7	27.2	25.1	103	108	35.3	457
8064	880		35.1	87.0	8.5	1866	22.5	21.6	26.8	24.6	147	153	49.9	508
8081	1025		35.2	86.3	8.5	1928	22.4	23.6	26.9	24.7	123	128	42.0	529
8084	170		35.1	86.9	8.5	1950	24.4	23.5	26.8	25.1	148	155	50.7	533
8124	600		35.1	86.4	8.8	2032	24.3	24.2	19.9	25.5	171	163	53.8	559
8153	75		35.1	86.3	8.4	2071	22.5	21.6	25.0	22.6	175	166	54.8	571
8214	140	325	35.1	87.4	8.5	1819	22.5	21.5	27.5	24.9	97	100	32.6	494
8262	180		35.1	87.4	8.6	1945	20.6	21.6	25.3	23.2	133	136	44.3	528
8285	940		35.1	86.3	7.9	1802	20.6	21.6	25.4	23.2	141	145	48.0	496
8293	1010	650	35.1	88.0	9.2	1854	22.5	21.6	25.9	24.1	100	103	33.2	500
8306	285		35.1	87.1	8.1	1768	22.5	21.6	25.3	23.8	124	128	41.8	482
8325	850		35.0	87.5	9.0	1888	22.4	21.6	27.2	25.0	110	113	36.8	513
8365	570	885	35.1	87.8	8.4	1756	22.5	21.6	26.9	24.6	139	143	46.3	475
8375	360	730	35.1	88.3	8.5	1826	22.4	21.6	22.8	24.7	150	153	49.3	491
8390	600		35.1	87.1	8.6	1847	20.5	21.6	25.8	23.4	139	144	47.1	503
8421	140		35.1	88.3	8.8	1894	22.5	21.6	25.0	23.5	140	144	46.5	509
8426	940		35.2	88.1	8.6	2003	22.4	21.5	24.3	22.8	136	140	45.3	539
average =			35.1	87.4	8.7	1854	22.5	22.3	26.1	24.5	131	135	44.0	504
st.dev. =			0.08	0.70	0.5	148.5	1.0	1.0	2.0	1.2	24.6	24.9	8.2	42.4
cov (%) =			0.2	0.8	5.6	8.01	4.6	4.4	7.7	5.1	18.8	18.4	18.7	8.4

DATA SUMMARY
Room Temperature Testing - Group 2

Specimen No.	Failure location	Failure location	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Stiffness (kN/mm)	Maxload (kN)	Initial Strength (MPa)	MOE (MPa)	Density kg/m ³
							Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)						
10	630		35.1	87.8	8.7	1817	22.5	21.5	25.0	23.0	152	-63.0	158	51.3	13,504	491
15	600		35.2	86.8	8.8	2151	22.4	21.7	27.1	25.4	153	-63.4	160	52.4	13,745	588
54	5		35.2	85.4	8.9	1887	22.5	21.6	23.4	25.0	162	-69.3	165	55.0	15,275	524
69	700		35.1	87.2	8.4	1926	22.4	21.6	26.5	24.3	158	-76.1	164	53.6	16,408	524
79	860		35.2	87.4	8.4	1982	22.5	21.7	26.6	24.5	131	-64.3	137	44.5	13,831	538
91	600		35.2	88.1	8.7	2069	22.4	21.6	24.9	23.2	132	-65.6	137	44.3	13,983	556
95	320		35.1	87.9	8.8	2001	22.4	21.6	25.3	23.0	117	-62.5	122	39.4	13,388	540
102	420	685	35.1	87.6	8.8	1941	22.5	21.6	25.8	23.8	147	-68.9	154	50.1	14,804	526
109	600		35.2	87.2	9.5	2094	22.3	21.7	24.8	22.8	185	-79.9	192	62.6	17,209	569
151	300	440	35.2	86.6	8.5	2124	22.5	21.7	26.7	24.2	154	-72.9	161	53.0	15,840	582
180	170		35.0	86.6	8.5	2048	22.5	21.7	26.7	24.2	117	-77.7	123	40.5	16,945	563
206	600		35.2	88.0	8.6	2024	22.5	21.5	26.3	24.4	160	-51.7	166	53.6	11,032	545
219	600		35.2	86.8	8.4	1860	22.4	21.6	26.7	24.4	128	-74.8	133	43.6	16,177	507
222	235		35.2	86.9	8.3	1985	22.4	21.7	27.1	25.0	144	-74.6	148	48.6	16,149	542
248	255	400	35.2	86.5	8.6	1957	22.6	21.7	25.1	23.5	169	-76.4	177	58.1	16,617	537
254	400		35.2	87.4	8.6	1752	22.5	21.7	27.4	25.2	135	-65.7	141	45.8	14,130	475
282	221		35.1	82.4	8.9	1899	22.4	21.6	24.6	22.9	136	-71.8	141	48.8	16,400	547
352	620		35.1	87.0	9.6	2205	22.5	21.7	27.5	25.4	154	-73.3	161	52.5	15,852	601
354	80		35.1	88.0	8.6	1828	22.5	21.6	26.9	24.6	127	-55.4	132	42.8	11,839	493
429	780	620	35.1	88.0	8.8	1935	22.5	21.6	27.2	25.0	161	-68.2	166	53.9	14,595	522
5012	1110		35.3	88.2	9.0	1861	22.4	21.7	27.4	25.2	108	-49.2	112	35.9	10,455	499
5050	1200		35.3	87.9	8.2	1697	22.4	23.7	25.5	23.3	104	-44.7	108	34.8	9,522	456
5107	440		35.0	87.0	8.2	1650	22.4	21.6	24.6	22.8	112	-56.0	116	38.1	12,159	451
5139	420		35.2	87.5	8.5	1804	22.4	21.6	27.5	25.1	91	-46.2	94	30.5	9,913	488
5176	450		35.1	87.8	8.6	1748	22.4	21.6	27.6	25.3	105	-44.4	109	35.4	9,525	473
5213	100		35.2	87.3	9.5	1663	22.4	21.7	27.1	25.1	105	-53.9	109	35.6	11,582	451
5218	125	530	35.1	88.3	8.5	1715	22.4	21.6	28.6	26.3	106	-50.4	109	35.3	10,749	461
5276	665	980	34.9	88.2	8.0	1704	22.5	21.7	26.6	24.3	96	-39.0	100	32.5	8,369	461
5284	860		35.2	87.8	9.5	1764	22.5	21.6	21.4	24.8	99	-40.0	102	32.9	8,560	476
5305	700	880	35.2	88.3	8.2	1851	22.4	21.6	28.2	25.8	122	-52.5	127	40.8	11,168	497
5315	360	760	35.1	87.9	8.8	1776	22.4	21.6	27.5	24.7	119	-47.2	124	40.1	10,089	479
5322	540		35.1	86.4	8.6	1956	22.4	23.6	28.1	26.1	100	-54.5	104	34.4	11,873	538
5360	320	760	35.1	88.4	8.8	1618	22.5	21.7	25.7	23.3	110	-51.0	112	36.2	10,867	434
5370	145		35.2	87.7	8.1	1782	22.3	21.5	27.9	25.2	107	-51.8	111	36.0	11,089	481
5396	285		35.3	87.0	8.4	1631	22.4	21.7	27.5	25.2	121	-56.2	126	41.1	12,119	443
5514	845		35.2	86.5	8.6	1886	22.4	23.7	25.3	23.2	132	-73.0	138	45.2	15,843	516
5518	190		35.3	86.6	8.7	1849	22.3	21.7	25.2	22.9	95	-39.6	99	32.5	8,583	505
5521	690		35.1	87.4	8.8	1878	22.4	23.6	25.3	23.4	150	-56.4	156	50.7	12,138	510
5522	870		35.1	87.9	8.8	1874	22.5	23.7	25.9	23.5	147	-78.7	153	49.5	16,835	506
5542	900		35.1	88.0	8.5	1898	22.4	21.6	25.3	23.2	129	-54.8	134	43.4	11,721	512
8008	250		35.2	87.1	8.2	1784	22.5	21.7	25.5	23.3	164	-77.2	170	55.5	16,646	485
8051	840		35.2	87.0	8.6	2006	22.3	21.7	25.1	23.0	126	-65.8	130	42.5	14,223	547
8085	775		35.1	86.8	8.7	1970	22.3	23.6	26.1	23.8	142	-67.8	147	48.4	14,713	539
8101	370		35.2	86.6	9.0	1729	22.4	23.7	25.9	23.6	99	-53.3	103	33.8	11,558	472
8147	600		35.2	87.3	8.9	2064	22.5	21.5	25.5	23.2	182	-71.6	189	61.6	15,412	560
8158	210		35.0	86.9	7.9	1739	22.5	21.6	12.6	25.2	118	-48.5	122	40.1	10,525	476
8175	490		35.1	87.6	8.3	1528	22.4	21.7	27.6	25.3	108	-58.8	113	36.6	12,615	414
8182	600		35.2	88.1	8.5	1565	22.5	21.6	25.3	23.9	111	-52.0	116	37.5	11,074	420
8184	380		35.1	87.5	9.0	1672	22.4	21.7	25.3	23.0	112	-56.0	117	38.0	12,048	453
8209	970		35.2	87.5	8.4	1818	22.5	21.7	26.9	25.1	112	-51.0	116	37.8	10,962	492
8221	620		35.1	87.4	8.2	1835	22.5	21.6	26.6	24.5	111	-62.4	115	37.5	13,428	498
8226	1095		35.0	87.6	8.7	1915	22.4	21.6	26.3	24.4	150	-58.3	156	50.8	12,570	521
8233	675		35.2	87.7	8.5	1683	22.5	21.6	27.0	24.9	99	-39.0	103	33.4	8,364	455
8238	775		35.1	87.7	8.6	2032	22.5	21.5	26.9	24.9	166	-71.6	172	55.9	15,381	550
8256	610		35.2	86.8	8.5	1803	22.3	21.6	26.9	24.8	125	-71.3	130	42.5	15,431	492
8274	880		35.0	87.2	8.4	1798	22.4	21.5	26.9	24.7	134	-56.7	140	45.7	12,283	491
8286	1000		35.0	86.9	8.8	1920	22.3	21.6	26.4	24.4	103	-70.6	108	35.4	15,365	527
8314	260		35.2	86.5	8.1	1924	22.4	21.6	24.1	23.1	140	-69.2	146	47.9	15,055	528
8318	610		35.1	87.9	8.2	1867	22.4	21.7	27.1	25.3	130	-55.3	135	43.8	11,846	504
8345	1010		35.2	86.9	8.1	1718	22.4	21.7	27.6	25.2	134	-57.4	140	45.7	12,405	468
8397	190		35.2	87.3	8.5	1810	22.4	21.7	27.0	25.3	124	-67.8	129	42.0	14,599	491
average =			35.1	87.3	8.6	1857	22.4	21.9	26.0	24.3	129	-60.6	134	43.7	13,072	505
stdev. =			0.07	0.88	0.4	147	0.1	0.6	2.2	0.9	23.3	11.3	24.3	8.0	2,484	41.3
cov (%) =			0.2	1.0	4.2	7.90	0.3	3.0	8.3	3.9	18.0	18.6	18.1	18.3	19.00	8.2

DATA SUMMARY
Room Temperature Testing - Group 3

Specimen No.	Failure location (mm)	Failure location (mm)	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Stiffness (kN/mm)	Maxload (kN)	Initial Strength (MPa)	MOE (MPa)	Density kg/m ³
							Platen 1 End (°C)	Platen 2 End (°C)	Wood End (°C)	Wood End (°C)						
16	640		35.2	86.1	8.5	2164	22.6	23.6	27.2	24.9	174	-94.2	180	59.4	20,533	594
31	640		35.2	87.2	9.4	1931	22.4	21.6	25.0	23.2	150	-63.9	157	51.1	13,755	524
65	560	760	35.3	88.1	8.5	1717	22.4	23.6	26.9	24.7	109	-63.5	113	36.4	13,510	461
72	690		35.2	87.7	9.0	1886	22.4	21.8	26.9	24.5	158	-76.7	165	53.4	16,449	510
86	600		35.2	87.1	8.5	2054	22.3	21.6	25.9	24.8	175	-102.4	182	59.5	22,087	559
106	765		35.1	86.9	8.6	1874	22.6	23.5	21.8	25.8	112	-60.4	116	37.9	13,067	511
115	700		35.1	87.4	8.4	1836	22.4	21.6	23.6	22.4	119	-55.3	124	40.5	11,917	499
139	600		35.1	86.8	8.9	2208	22.5	23.6	27.1	24.7	117	-77.3	121	39.8	16,760	604
157	260		35.2	87.1	8.8	1908	22.5	21.6	26.6	24.7	125	-74.4	130	42.2	16,023	518
211	725		35.1	87.9	8.3	1851	22.6	23.6	27.5	25.4	126	-61.0	131	42.4	13,065	500
212	980	850	35.2	87.4	8.7	1867	22.5	23.5	27.2	24.8	129	-63.8	135	43.9	13,689	505
218	585		35.2	85.5	9.3	2039	22.5	21.6	25.8	23.6	175	-61.5	181	60.2	13,518	565
243	495		35.2	87.3	8.5	1935	22.6	23.5	26.8	25.0	144	-69.4	150	48.8	14,954	526
278	335	170	35.2	87.1	8.8	1838	22.6	23.5	26.8	24.8	144	-60.8	150	48.7	13,103	499
327	645		35.1	86.7	9.4	2027	24.5	23.6	25.8	23.5	178	-72.1	186	61.2	15,653	555
331	600		35.2	87.6	8.3	2084	22.6	23.6	27.5	25.3	116	-76.1	121	39.4	16,340	564
334	795		35.1	87.1	9.2	1888	22.5	21.6	27.0	24.7	153	-81.2	160	52.3	17,580	515
346	685		35.2	87.5	8.8	1916	22.5	21.6	25.7	24.0	125	-64.7	130	42.2	13,890	518
371	740		35.2	88.2	8.8	1982	22.6	23.5	27.2	25.0	146	-62.5	151	48.6	13,324	532
383	480		35.1	87.5	8.5	1955	22.5	21.6	26.2	24.3	121	-89.4	125	40.8	19,223	530
388	985		35.1	87.3	8.8	1951	22.4	21.6	26.8	24.7	121	-63.6	129	41.9	13,710	530
405	660		35.1	87.7	8.6	1783	22.6	23.6	27.3	25.0	149	-65.9	155	50.5	14,158	483
432	130		35.1	88.4	8.8	2106	22.5	23.6	26.9	24.8	166	-73.5	173	55.5	15,635	565
5036	640		35.3	86.6	8.4	1624	22.4	21.6	25.5	23.3	102	-53.8	104	34.1	11,627	443
5051	990		35.3	88.4	9.0	1680	22.5	21.7	25.3	23.1	110	-44.1	114	36.6	9,347	449
5072	610		35.3	87.9	9.2	1798	22.5	21.6	25.6	23.8	113	-54.7	117	37.8	11,664	483
5113	360		34.3	87.8	8.7	1668	22.5	23.7	26.8	24.7	111	-55.2	115	38.1	12,126	462
5129	940		35.3	88.5	9.0	1833	22.5	21.6	26.1	24.3	108	-53.1	112	35.8	11,227	489
5132	665	955	35.0	88.3	9.2	1785	22.4	21.6	25.2	23.1	106	-46.2	110	35.5	9,858	481
5172	810		35.2	87.9	8.4	1766	22.4	21.7	25.2	23.0	108	-45.2	112	36.1	9,667	476
5193	1000		35.2	87.1	8.8	1829	22.5	21.5	25.2	23.2	124	-47.6	128	41.8	10,260	497
5266	370		35.2	88.3	9.1	1814	22.4	23.6	25.7	23.5	128	-53.9	134	43.1	11,460	487
5314	1000		35.2	87.7	8.9	1655	22.3	21.5	24.8	22.8	99	-41.5	102	33.0	8,902	447
5321	1090	860	35.3	88.1	8.7	1540	22.5	21.6	25.0	23.2	101	-52.4	104	33.6	11,147	413
5332	800	700	35.2	87.7	8.7	1583	22.4	21.6	25.6	23.4	90	-50.2	93	30.1	10,775	428
5353	470	740	35.2	87.2	9.3	1693	22.4	21.6	26.3	24.3	103	-48.0	107	34.8	10,342	460
5361	390		35.3	87.3	9.3	1714	22.3	21.6	25.3	23.3	113	-60.4	117	37.9	12,965	464
5374	820		35.3	88.4	9.0	1855	22.4	21.5	25.1	23.2	101	-41.6	105	33.7	8,823	496
5396	1090		35.2	87.9	9.1	1635	22.4	21.6	24.8	22.9	101	-46.1	105	34.0	9,860	441
5418	355		35.2	86.3	9.3	1700	22.4	21.6	26.8	24.3	109	-55.3	113	37.3	12,027	466
8056	1000		35.2	87.3	8.6	1906	22.4	21.5	21.6	20.9	158	-64.4	165	53.7	13,844	517
8093	915		35.1	87.1	9.1	1844	22.5	21.5	23.1	21.5	155	-62.8	162	52.9	13,561	502
8106	1035		35.1	86.4	9.1	1777	22.4	21.6	26.5	24.4	123	-62.9	128	42.2	13,706	488
8121	560		35.1	87.3	8.3	1872	22.5	23.6	27.3	24.7	142	-59.9	148	48.2	12,907	508
8143	250		35.2	87.7	8.3	1812	22.5	23.6	27.3	25.4	120	-49.8	125	40.4	10,657	489
8146	860		35.2	88.1	8.7	1799	22.3	23.5	25.4	23.2	102	-64.6	106	34.1	13,754	483
8148	680		35.0	88.2	8.6	1729	22.5	21.6	26.7	24.7	124	-67.7	129	41.9	14,482	467
8180	795		35.2	86.8	8.9	2127	22.5	21.6	24.9	23.4	164	-72.8	170	55.8	15,757	581
8189	420	675	35.2	88.3	8.7	1874	22.5	21.5	25.5	23.4	93	-54.8	95	30.7	11,653	503
8192	1110		35.2	87.6	8.7	1925	22.5	21.6	25.4	23.2	120	-49.7	124	40.2	10,658	520
8195	980	460	35.1	87.2	8.9	1954	22.5	23.6	26.9	25.0	160	-72.6	166	54.2	15,679	532
8234	525	905	35.1	87.4	9.0	1804	22.4	21.7	26.1	24.2	126	-51.8	131	42.7	11,153	490
8248	460		35.2	87.4	8.0	1744	22.5	23.5	27.2	24.9	124	-57.9	129	42.0	12,449	473
8261	555	340	35.0	88.4	8.2	2050	22.4	21.6	24.5	22.9	152	-66.3	159	51.3	14,157	552
8278	750		35.1	87.2	8.4	1977	22.6	23.6	28.0	25.6	129	-60.5	133	43.5	13,059	538
8358	890		35.1	86.9	8.4	1992	24.4	23.6	26.9	24.3	162	-65.9	169	55.4	14,260	544
8384	1010		35.2	87.7	8.7	2035	22.4	23.5	27.1	24.6	154	-69.0	160	51.9	14,790	550
8408	5		35.1	87.3	8.2	1905	22.6	23.6	27.0	24.8	164	-60.7	170	55.5	13,087	518
8413	200		35.2	87.9	8.7	1744	22.5	23.6	27.0	24.7	126	-59.9	131	42.3	12,798	470
8440	180	300	35.2	87.7	8.9	1998	22.5	23.5	27.2	24.7	150	-76.0	156	50.6	16,251	539
average =			35.2	87.5	8.8	1864	22.5	22.5	26.0	24.1	130	-62.2	135	44.0	13,378	505
st.dev. =			0.13	0.61	0.3	146.0	0.37	0.99	1.30	0.99	23.9	12.3	25.0	8.3	2,683	40.8
cov (%) =			0.37	0.70	3.8	7.83	1.63	4.40	5.01	4.11	18.3	19.8	18.5	18.9	20	8.1

DATA SUMMARY

75°C - 25kN

Specimen No.	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
					Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)		
28	35.2	88.5	9.4	1804	76.7	75.6	76.5	73.9	N/A	483
55	35.3	87.7	9.8	1853	76.3	75.8	75.4	73.6	N/A	500
71	35.2	87.9	9.3	2125	76.7	76.1	75.2	73.4	N/A	572
155	35.2	88.2	9.9	1987	76.5	75.9	75.7	73.6	N/A	534
168	35.1	85.1	9.3	2060	76.5	75.7	74.5	71.9	N/A	575
246	35.1	87.3	9.9	1881	76.4	73.8	74.4	71.9	N/A	512
258	35.1	87.4	9.6	2001	76.5	76.0	75.6	73.4	N/A	544
288	35.2	88.6	9.4	1791	76.6	75.6	75.6	73.1	N/A	479
300	35.2	87.2	9.5	1885	76.4	75.7	75.3	73.4	N/A	511
332	35.2	88.9	9.6	1737	74.7	75.8	77.1	74.1	N/A	463
342	35.2	88.0	9.2	1968	76.7	75.8	75.1	73.0	N/A	529
349	35.2	88.3	9.5	1810	76.6	75.9	76.1	73.9	N/A	485
357	35.3	88.2	9.3	1939	76.5	75.8	75.4	73.3	N/A	519
369	35.1	88.7	9.6	1854	76.5	76.0	75.7	73.8	N/A	496
376	35.4	86.7	9.4	2207	76.5	74.0	73.6	70.2	N/A	599
382	35.1	88.1	9.8	2176	76.7	75.8	74.8	71.9	N/A	585
401	35.3	86.9	9.6	2029	76.6	75.7	74.9	73.2	N/A	551
412	35.2	88.3	9.5	1961	76.4	75.9	75.8	73.5	N/A	525
1900	35.3	87.1	9.6	2019	76.7	75.9	75.8	74.0	N/A	547
5083	35.3	88.4	9.4	1824	76.5	75.8	76.6	74.0	N/A	487
5092	35.3	88.0	9.6	1757	76.5	74.0	75.3	73.3	N/A	472
5100	35.3	88.6	9.4	1720	76.7	75.7	76.3	73.9	N/A	458
5108	34.8	88.4	9.3	1763	76.6	74.0	75.9	73.6	N/A	478
5147	35.2	88.2	9.0	1726	76.4	75.6	76.1	73.7	N/A	463
5149	35.3	88.3	8.8	1691	76.6	75.8	76.3	74.2	N/A	452
5175	35.2	88.0	9.5	1848	76.4	75.7	76.7	74.8	N/A	497
5177	35.1	87.9	8.9	1665	76.6	73.8	75.0	72.2	N/A	449
5244	35.3	87.7	9.8	1959	76.7	76.0	76.8	74.4	N/A	528
5262	35.1	87.1	9.6	1619	76.7	75.9	77.1	74.9	N/A	441
5282	35.1	86.6	9.1	1755	76.7	75.8	75.1	72.9	N/A	482
5283	35.2	87.4	9.1	1469	76.6	73.6	74.8	72.9	N/A	398
5335	35.1	87.2	8.9	1651	76.6	75.6	76.5	74.3	N/A	450
5348	35.2	88.7	9.0	1708	76.6	75.8	75.8	73.6	N/A	456
5384	35.1	88.3	9.2	1580	76.6	75.8	77.1	74.5	N/A	425
5402	35.2	87.1	9.0	1639	76.6	75.9	75.6	74.0	N/A	446
5519	35.2	88.4	9.1	1883	76.4	73.7	74.9	72.7	N/A	505
5533	35.1	87.6	9.1	1864	76.7	75.9	74.9	73.4	N/A	505
8003	35.3	87.2	9.2	1834	76.7	75.8	75.4	73.6	N/A	497
8007	35.3	87.6	9.4	1906	76.3	74.0	74.1	72.5	N/A	514
8057	35.3	86.8	9.0	1945	76.4	73.7	75.0	72.7	N/A	529
8073	35.3	87.3	9.1	1936	76.4	75.9	75.5	73.2	N/A	524
8083	35.3	86.4	9.2	1914	76.8	76.0	74.5	72.4	N/A	524
8107	35.3	86.6	9.2	2115	76.6	75.9	73.8	71.2	N/A	577
8115	35.1	86.9	9.9	1682	76.6	75.6	77.2	73.9	N/A	460
8181	35.2	87.8	9.3	1539	76.7	75.9	76.4	73.9	N/A	415
8187	35.2	88.5	8.9	1775	76.6	75.9	76.5	73.9	N/A	475
8264	35.1	86.6	8.9	1782	76.5	75.9	76.1	73.5	N/A	488
8275	34.8	86.8	10.1	2078	76.4	75.9	75.0	72.7	N/A	573
8289	35.2	87.7	9.1	1798	76.6	75.6	75.8	73.9	N/A	485
8297	35.0	86.4	9.6	1993	76.8	75.6	75.1	72.8	N/A	549
8317	35.2	85.8	8.7	2054	76.7	75.8	75.3	72.6	N/A	567
8337	35.2	86.9	8.8	1725	76.6	75.7	76.2	73.6	N/A	471
8338	35.3	87.1	9.2	1858	76.7	75.9	75.2	73.6	N/A	503
8340	35.2	87.7	9.4	1888	76.6	76.0	76.0	74.4	N/A	510
8343	35.1	87.2	8.9	1908	76.7	75.6	75.4	73.6	N/A	520
8359	35.1	88.2	9.4	1900	76.4	75.6	76.1	74.0	N/A	512
8392	35.2	88.4	9.0	1825	76.7	75.7	76.4	74.1	N/A	489
8411	35.2	88.1	9.2	1871	76.7	75.6	76.4	74.4	N/A	503
8416	35.2	87.8	9.3	1981	76.7	75.7	76.1	73.9	N/A	535
8429	35.2	88.1	9.0	2041	76.7	76.0	76.0	73.7	N/A	549
8436	35.3	87.8	8.9	1926	76.6	75.9	75.6	73.8	N/A	518
average =	35.2	87.6	9.3	1860	76.5	75.5	75.6	73.4	N/A	503
st.dev. =	0.10	0.78	0.3	155.0	0.3	0.7	0.8	0.9	N/A	43.4
cov (%) =	0.30	0.89	3.4	8.33	0.4	1.0	1.1	1.2	N/A	8.6

DATA SUMMARY

75°C - 37kN

Specimen No.	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
					Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)		
7	35.1	86.8	9.9	1872	76.5	76.0	75.2	73.1	N/A	512
13	35.2	87.4	9.5	2124	76.7	75.7	75.4	73.3	N/A	575
29	35.1	87.2	9.1	1912	76.6	75.8	75.7	73.5	N/A	521
83	35.3	84.5	9.4	1944	76.6	75.9	75.0	72.1	N/A	543
121	35.2	86.8	9.3	1918	76.5	75.8	75.8	72.9	N/A	523
192	35.3	86.0	10.0	1977	76.6	75.6	75.3	72.4	N/A	542
200	35.2	87.5	9.8	2015	76.2	75.7	76.3	74.0	N/A	545
224	35.1	88.1	9.4	1824	76.7	75.8	75.4	73.5	N/A	492
228	35.3	86.8	9.3	1898	76.4	75.9	75.4	73.0	N/A	516
244	35.2	87.1	9.6	1947	76.5	75.7	75.9	73.2	N/A	529
249	35.2	87.7	9.3	1863	76.7	75.9	76.1	74.1	N/A	503
255	35.2	86.7	10.0	2003	76.4	75.9	75.6	73.6	N/A	547
267	35.1	87.7	9.9	2027	76.4	75.5	75.7	72.7	N/A	548
271	35.2	88.0	9.7	2212	76.5	75.9	73.8	71.2	N/A	595
319	35.2	87.4	9.7	2063	76.6	75.6	75.7	72.7	N/A	558
338	35.5	86.4	9.6	2187	76.4	75.8	75.1	72.5	N/A	595
359	35.3	87.0	9.9	2086	76.3	75.9	75.6	73.1	N/A	567
404	35.3	87.9	9.7	1984	76.6	75.6	75.8	73.8	N/A	533
422	35.3	87.7	9.5	2102	76.6	75.6	75.8	73.0	N/A	566
423	35.2	87.7	9.8	2007	76.7	75.9	75.5	73.2	N/A	542
428	35.3	87.4	9.6	2003	76.4	75.9	74.5	72.4	N/A	541
5008	35.3	87.9	9.3	1701	76.5	75.9	76.1	74.1	N/A	457
5009	35.4	87.4	10.0	1733	76.4	75.7	75.6	73.0	N/A	467
5047	35.4	86.7	10.1	1650	76.5	75.9	75.9	73.9	N/A	449
5065	35.3	87.5	9.7	1811	76.5	75.9	76.0	73.4	N/A	489
5069	35.2	88.4	9.5	1798	76.3	75.7	75.6	73.6	N/A	482
5073	35.2	88.4	9.6	1886	76.7	75.9	75.2	73.1	N/A	505
5077	35.2	87.8	9.7	1857	76.5	75.6	75.9	73.5	N/A	501
5126	35.3	88.1	9.4	1705	76.5	75.9	75.9	73.7	N/A	458
5214	35.2	87.6	9.3	1542	76.5	75.8	76.5	73.8	N/A	416
5223	35.2	88.3	9.4	1750	76.5	75.6	76.1	73.6	N/A	469
5240	35.0	88.1	9.6	1907	76.6	75.6	76.1	72.9	N/A	515
5293	35.1	87.3	9.9	1670	76.5	75.7	75.9	73.6	N/A	454
5338	35.3	87.4	9.3	1766	76.7	75.9	76.3	74.4	N/A	478
5362	35.3	87.9	9.7	1787	76.7	75.6	76.0	73.8	N/A	480
5364	35.3	88.5	9.3	1687	76.3	75.8	76.7	75.2	N/A	449
5381	35.3	88.1	9.2	1782	76.5	75.9	75.6	73.8	N/A	477
5386	35.2	88.0	9.4	1655	76.4	75.6	75.8	74.0	N/A	446
5389	35.2	88.1	9.3	1714	76.7	75.9	76.4	74.1	N/A	461
5393	35.2	88.4	9.5	1627	76.4	75.7	76.4	73.8	N/A	435
5400	35.2	87.6	8.8	1593	76.7	75.8	75.9	73.9	N/A	430
5504	35.3	86.6	10.0	1767	76.6	75.8	75.9	73.9	N/A	482
5510	35.2	86.9	9.3	2052	76.5	75.8	74.8	72.5	N/A	560
5541	34.9	87.8	9.4	1894	76.5	75.6	76.2	74.0	N/A	516
8018	35.5	87.7	9.6	1978	76.8	75.9	75.2	73.6	N/A	530
8022	35.3	87.7	9.7	1967	76.4	75.9	76.3	73.9	N/A	530
8023	35.1	87.5	9.2	1754	76.2	75.6	76.5	73.6	N/A	476
8027	35.3	88.5	9.3	1805	76.6	75.7	76.5	74.1	N/A	482
8029	35.3	87.0	9.2	1863	76.3	75.6	75.8	73.3	N/A	506
8050	35.1	86.5	9.7	2070	76.6	75.7	74.7	71.5	N/A	569
8075	35.2	87.7	9.2	1892	76.7	76.0	75.8	73.8	N/A	510
8145	35.3	86.9	10.1	1799	76.6	75.9	76.0	73.9	N/A	489
8176	35.3	87.9	9.5	1823	76.6	75.9	76.2	73.6	N/A	490
8228	35.3	87.9	9.8	1946	76.6	75.6	75.3	73.5	N/A	523
8313	35.4	87.5	9.5	1931	76.6	75.9	75.3	72.9	N/A	520
8339	35.1	87.3	9.4	1852	76.6	75.8	74.8	73.1	N/A	504
8342	35.3	86.2	10.0	1843	76.7	75.7	75.6	73.4	N/A	505
8382	35.1	87.7	9.6	1827	76.6	75.8	76.2	73.7	N/A	494
8425	35.2	88.0	9.1	1838	76.5	75.9	76.3	73.1	N/A	495
8431	35.2	88.1	9.5	1726	76.3	75.6	75.9	73.6	N/A	464
8439	35.1	87.1	9.1	1876	76.5	75.6	74.6	72.1	N/A	512
average =	35.2	87.5	9.5	1870	76.5	75.8	75.7	73.4	N/A	506
st.dev. =	0.1	0.7	0.3	147	0.1	0.1	0.6	0.7	N/A	41
cov (%) =	0.29	0.81	3.01	7.83	0.17	0.16	0.74	0.94	N/A	8.10

DATA SUMMARY

75°C - 50kN

Specimen No.	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
					Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)		
44	35.2	86.9	9.4	2083	76.3	75.9	75.9	72.9	N/A	567
50	35.1	88.0	9.6	2000	76.3	75.6	75.3	73.2	N/A	540
74	35.3	88.8	9.4	1945	76.4	75.8	75.8	73.7	N/A	518
78	35.2	87.7	10.3	1833	74.7	75.9	75.0	72.0	N/A	495
110	35.2	87.9	9.5	1864	76.5	75.9	75.6	73.2	N/A	502
118	35.2	86.7	9.5	1948	76.5	75.8	75.8	72.8	N/A	532
120	35.2	88.2	9.7	1516	76.5	75.8	76.5	72.9	N/A	407
169	35.3	88.2	9.9	2006	76.5	75.9	75.3	72.7	N/A	537
184	35.2	86.8	10.0	2183	76.7	75.9	75.1	72.1	N/A	596
232	35.1	88.4	10.4	2034	76.3	75.6	77.9	74.8	N/A	546
259	35.2	88.1	9.7	1988	76.5	75.8	76.0	72.9	N/A	535
266	35.2	87.6	9.4	1926	76.5	75.5	75.9	73.0	N/A	520
273	35.2	88.3	9.8	1839	76.5	75.8	75.8	73.0	N/A	493
279	35.1	87.6	9.6	1842	76.5	75.5	75.2	73.0	N/A	499
293	35.2	87.2	9.5	2077	76.2	75.6	75.4	72.4	N/A	564
294	35.2	88.2	10.5	1908	76.4	75.8	75.5	73.5	N/A	512
297	35.1	86.0	9.5	1960	76.3	75.9	75.4	73.0	N/A	541
302	35.2	87.6	10.2	2051	76.5	75.7	75.0	73.0	N/A	555
321	35.3	87.3	9.9	1873	76.3	75.8	75.7	73.4	N/A	507
364	35.2	87.9	10.6	1891	76.5	75.8	76.2	73.7	N/A	510
385	35.2	88.0	9.6	1855	76.3	75.8	75.6	72.8	N/A	500
399	35.2	88.2	9.5	1962	76.3	75.9	76.7	74.1	N/A	527
402	35.1	87.2	9.9	1949	76.6	75.5	75.2	72.9	N/A	530
5004	35.4	88.5	9.7	1651	76.5	75.9	76.8	73.9	####	440
5011	35.3	88.3	9.9	1826	76.6	75.9	76.9	74.3	N/A	488
5026	35.3	88.2	9.6	1677	76.4	75.8	74.5	72.0	N/A	449
5042	35.3	88.6	9.2	1655	76.6	75.6	75.8	73.4	N/A	441
5057	35.3	88.5	10.2	1630	76.5	75.7	76.3	73.7	####	436
5066	35.5	88.5	9.9	1553	76.5	75.8	67.5	63.4	####	412
5068	35.3	88.7	9.8	1818	76.5	75.8	76.8	74.7	N/A	484
5079	34.9	88.1	9.5	1717	76.5	75.8	75.9	73.7	N/A	465
5080	35.2	87.8	9.1	1593	76.6	75.5	69.3	66.2	####	429
5102	35.2	88.2	9.8	1919	76.5	75.6	77.0	74.4	N/A	516
5134	35.3	88.2	10.1	1914	76.4	75.8	75.5	72.7	N/A	512
5145	35.4	88.1	10.2	1880	76.2	75.8	75.6	72.4	N/A	503
5156	35.3	87.8	9.4	1809	76.5	75.7	76.9	73.7	N/A	486
5203	35.2	82.8	9.6	1767	76.6	75.9	76.5	72.7	N/A	505
5236	35.4	88.4	9.8	1857	76.5	75.8	76.2	73.6	N/A	495
5297	35.2	88.0	9.5	1755	76.6	75.9	76.5	73.3	N/A	472
5341	35.2	87.6	9.4	1727	76.5	75.6	76.3	73.3	N/A	467
5355	35.1	87.0	10.0	1786	76.4	75.9	76.9	74.0	N/A	487
5383	35.0	88.0	9.5	1837	76.5	75.8	76.1	73.5	N/A	497
5406	35.3	87.2	9.2	1686	76.6	75.8	76.5	73.6	N/A	456
5508	35.3	87.7	10.2	1745	76.5	75.9	76.3	73.5	N/A	470
8028	35.3	86.9	9.8	2150	76.3	75.7	76.0	73.0	N/A	584
8031	35.3	88.0	9.8	1865	76.5	75.8	76.3	73.4	N/A	501
8069	35.2	87.4	9.5	1701	76.5	75.8	76.2	74.1	N/A	461
8090	35.3	87.3	9.5	2240	76.6	75.8	74.9	71.7	N/A	605
8094	35.2	88.5	10.0	1818	76.4	75.5	75.8	73.6	N/A	486
8213	35.3	87.9	10.3	1924	76.3	75.9	76.7	73.7	N/A	517
8219	35.2	87.4	9.5	2015	76.5	75.9	75.5	73.4	N/A	546
8230	35.1	87.8	9.7	1939	76.3	75.6	75.6	72.2	N/A	524
8279	35.2	87.7	9.9	2123	76.5	75.7	75.5	72.7	N/A	573
8287	35.3	86.4	9.8	2078	76.6	75.6	76.1	73.3	N/A	569
8310	35.2	88.9	9.7	1708	76.7	75.8	76.9	74.2	N/A	455
8312	35.2	87.9	9.5	1797	76.3	75.8	76.5	74.1	N/A	484
8351	35.1	87.8	10.0	1898	76.3	75.8	76.1	73.3	N/A	513
8355	35.2	87.2	9.5	1889	76.6	75.8	75.9	73.8	N/A	512
8356	35.2	86.7	9.7	1779	76.5	75.5	76.6	73.8	N/A	487
8391	35.0	88.1	9.5	1755	76.3	75.9	76.3	73.7	N/A	475
8404	35.3	87.9	9.5	1737	76.6	75.6	75.2	73.1	N/A	467
average =	35.2	87.7	9.7	1861	76.4	75.8	75.7	73.0	N/A	503
st.dev. =	0.1	0.9	0.3	153	0.3	0.1	1.5	1.7	N/A	43.1
cov (%) =	0.26	1.00	3.3	8.2	0.3	0.2	2.0	2.3	N/A	8.6

DATA SUMMARY

150°C - 25kN

Specimen No.	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
					Platen 1 End (°C)	Platen 2 End (°C)	Wood End (°C)	Wood End (°C)		
3	35.2	88.0	9.7	1969	150.8	152.3	130.5	124.2	N/A	530
12	35.2	88.1	10.8	1807	151.1	152.0	120.1	117.7	N/A	485
17	35.2	86.8	10.2	2178	150.9	150.3	132.7	131.7	N/A	594
19	35.1	87.6	10.3	1934	150.6	152.4	134.7	131.1	N/A	524
45	35.2	87.6	10.5	1965	150.6	152.3	129.1	124.9	N/A	531
64	35.2	85.2	10.0	2020	150.6	151.9	120.8	117.8	N/A	562
66	35.2	87.8	10.1	2002	151.0	150.2	123.7	120.3	N/A	540
81	35.2	82.1	9.7	2135	150.9	150.1	136.2	134.8	N/A	615
89	35.0	86.8	9.7	1876	150.7	151.8	134.6	130.3	N/A	514
125	35.2	87.6	9.7	1989	148.8	152.3	125.6	125.5	N/A	538
129	35.3	87.0	9.9	2242	150.8	150.0	124.9	121.5	N/A	609
136	35.2	87.7	10.2	2115	151.1	152.1	138.0	133.4	N/A	572
199	35.1	87.3	9.9	1901	150.6	152.4	135.1	135.7	N/A	516
223	35.3	88.3	10.1	1900	151.1	149.9	123.7	119.6	N/A	509
291	35.2	88.5	10.4	2055	150.5	152.3	123.6	120.1	N/A	551
298	35.2	88.6	10.4	2083	150.6	150.6	124.7	122.3	N/A	557
299	35.2	88.2	10.3	1859	150.9	150.1	133.8	131.1	N/A	499
322	35.1	88.5	10.2	1920	150.9	152.0	128.2	123.6	N/A	515
339	35.1	88.4	10.6	1853	151.0	150.3	130.1	127.7	N/A	499
411	35.1	88.2	10.8	1911	150.7	150.4	121.9	121.5	N/A	514
415	35.2	88.3	10.3	1915	151.0	150.1	130.9	129.8	N/A	514
439	35.1	88.1	10.8	1935	151.2	151.9	119.6	117.0	N/A	522
5032	35.4	88.2	10.3	1976	150.7	150.3	132.5	129.3	N/A	528
5071	35.1	88.5	10.2	1825	151.1	151.9	128.0	129.6	N/A	489
5074	35.3	88.3	11.2	1763	151.1	151.9	126.0	122.8	N/A	472
5091	35.3	87.4	9.7	1668	150.9	151.9	139.4	136.9	N/A	450
5106	35.0	88.0	9.9	1680	150.7	152.5	133.4	128.0	N/A	455
5135	35.2	88.0	11.5	1751	150.6	152.5	121.8	120.1	N/A	471
5151	35.3	88.6	10.0	1604	151.1	152.4	135.8	133.4	N/A	428
5154	35.1	87.7	10.3	1795	151.1	150.3	128.2	124.5	N/A	485
5164	35.2	87.4	10.3	1747	150.6	152.2	135.3	135.0	N/A	473
5186	35.2	88.2	10.2	1894	150.8	152.4	137.3	134.2	N/A	508
5189	35.1	87.9	9.8	1734	151.1	150.1	124.8	119.8	N/A	468
5190	35.2	88.5	10.3	1634	151.2	152.4	127.0	123.0	N/A	438
5249	35.2	87.9	9.9	1692	149.0	152.2	123.6	122.2	N/A	456
5267	35.2	88.7	10.2	1552	151.2	151.8	136.2	132.2	N/A	414
5286	35.2	87.6	10.3	1792	151.1	150.3	129.8	124.6	N/A	484
5290	35.3	88.1	10.0	1847	151.1	150.0	130.8	126.8	N/A	495
5298	35.2	86.1	11.2	1654	150.6	150.1	121.7	119.6	N/A	455
5300	35.2	88.6	10.6	1958	150.7	152.3	114.7	108.7	1170	523
5331	35.0	86.3	10.0	1853	150.7	151.9	135.0	130.0	N/A	511
5515	35.2	86.6	11.0	1831	150.8	152.5	117.7	113.9	N/A	501
5520	35.1	88.5	10.1	1956	150.6	151.9	136.6	133.6	N/A	525
5538	35.1	87.6	10.2	1876	150.9	152.4	129.6	130.1	N/A	508
8001	35.3	86.6	10.2	1871	150.7	152.3	138.5	135.4	N/A	511
8082	35.2	87.3	9.9	2098	151.2	150.5	128.6	124.4	N/A	570
8137	35.3	87.7	9.8	1943	150.6	152.4	138.1	135.3	N/A	523
8138	35.3	88.4	10.5	1729	150.8	149.9	126.6	120.9	N/A	462
8144	35.2	87.2	10.2	2024	151.1	152.1	126.6	123.7	N/A	549
8178	35.2	87.2	10.0	1834	150.9	150.5	132.9	129.4	N/A	497
8242	35.3	88.0	10.1	1840	149.0	152.0	131.4	129.8	N/A	494
8273	35.3	86.6	10.5	2003	150.6	151.9	137.4	136.4	N/A	546
8277	35.1	87.2	10.1	2068	150.8	152.1	130.6	125.3	N/A	563
8307	35.3	87.8	10.6	1819	151.2	152.0	126.8	125.3	N/A	490
8316	34.2	87.5	9.8	1812	150.8	151.9	138.2	134.6	N/A	505
8319	35.3	88.2	10.2	1780	151.2	150.0	130.6	132.2	N/A	477
8330	35.4	88.1	10.1	1772	151.1	151.9	138.9	136.6	N/A	474
8348	35.2	87.5	9.1	1865	151.1	151.9	126.4	122.5	N/A	505
8406	35.2	88.0	10.0	2041	151.2	150.1	137.5	133.3	N/A	549
8424	35.2	87.8	9.7	1790	150.9	151.9	136.6	134.2	N/A	483
average =	35.2	87.6	10.2	1882	150.8	151.5	129.9	127.0	N/A	509
stdev. =	0.15	1.01	0.42	145	0.48	0.95	6.10	6.45	N/A	41.6
cov (%) =	0.43	1.15	4.08	7.68	0.32	0.63	4.70	5.08	N/A	8.2

DATA SUMMARY

150°C - 37kN

Specimen No.	Failure location	Failure location	Width	Depth	Meter MC	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
							Platen End	Platen End	Wood End	Wood End		
	(mm)	(mm)	(mm)	(mm)	(%)		(°C)	(°C)	(°C)	(°C)		
14	930.0		35.1	88.5	10.1	1830	151	152	123	119	2040	491
58	835.0		35.2	86.3	10.4	2032	151	150	126	129	2190	557
124			35.2	86.7	10.0	2046	151	150	129	125	N/A	558
131			35.2	88.0	10.4	2084	151	150	130	129	N/A	561
148			35.3	86.4	10.5	2183	151	152	129	127	N/A	597
160	625.0		35.2	86.9	10.4	2099	151	152	117	114	1680	572
173			35.3	87.4	10.2	1868	151	150	132	131	N/A	505
251	735.0		35.2	88.6	10.1	1814	151	152	118	113	1350	485
268			35.3	88.1	10.6	1949	151	152	130	130	N/A	523
277			35.1	88.7	10.5	1880	151	150	127	127	N/A	503
344			35.2	88.0	10.3	1996	151	150	136	132	N/A	537
355	935.0		35.2	86.5	10.8	1892	151	150	119	119	2130	517
375	275.0		35.3	87.4	11.1	1951	151	150	123	117	540	528
398	435.0		35.2	88.3	10.4	2020	151	152	115	113	1560	542
414	470.0		35.2	87.5	10.4	1986	151	151	123	116	1590	538
417			35.2	88.6	10.3	2234	151	152	132	128	N/A	597
5003	330.0	410.0	35.4	87.5	9.9	1914	151	152	121	119	1500	515
5022	870.0	580.0	35.4	87.8	10.5	1936	151	152	111	108	1170	520
5034	700.0		35.4	88.1	10.3	1659	151	152	101	95	750	444
5038			35.4	87.8	9.9	1775	151	150	118	114	1530	476
5086	925.0		35.3	87.7	10.2	1752	151	150	123	122	1920	471
5105	450.0	860.0	35.3	88.4	10.3	1849	151	150	96	98	780	494
5137	340.0		35.2	88.3	9.2	1711	151	150	95	90	780	459
5143	510.0		35.3	88.5	10.6	1896	151	150	123	117	1740	506
5182	810.0		35.3	88.0	10.2	1807	151	150	117	113	1290	485
5188	610.0		35.1	88.4	10.3	1722	151	152	77	74	360	462
5211	775.0		35.3	87.4	9.9	1665	151	152	87	82	570	450
5234	390.0		35.2	87.8	10.1	1829	151	152	93	89	780	494
5241	770.0		35.2	86.1	9.7	1851	151	150	117	113	1440	510
5255	470.0	815.0	35.3	88.0	10.3	1796	151	152	112	108	1050	482
5272	370.0	800.0	35.3	88.3	10.4	1760	151	152	108	104	900	471
5288	560.0		35.4	88.2	10.1	1554	151	152	81	80	480	415
5295	600.0		35.1	87.6	10.2	1794	151	150	103	104	990	486
5301	860.0		35.5	88.5	9.9	1677	151	152	91	87	630	445
5318	610.0	730.0	35.1	86.8	9.8	1857	151	152	106	106	1110	508
5329	740.0		35.3	87.7	10.4	1695	151	152	101	95	750	456
5333	720.0		35.3	88.4	9.8	1626	151	150	101	96	870	434
5337	790.0		35.2	83.0	10.0	1601	151	152	95	91	690	457
5351	670.0	730.0	35.4	87.3	9.8	1735	151	152	108	109	1080	468
5399	820.0		35.3	87.1	9.6	2070	151	150	115	111	1230	562
5412	630.0	690.0	35.1	87.8	10.2	1746	151	152	71	66	390	472
5415	510.0		35.2	87.5	9.7	2130	151	152	109	97	1140	576
5524	530.0		35.3	87.0	10.2	2013	151	152	104	99	930	546
5535	400.0	600.0	35.2	88.2	10.7	1920	151	150	116	113	1320	516
8032	610.0	735.0	35.3	88.0	10.5	1917	151	152	108	113	1410	515
8041			35.3	86.9	9.7	1887	151	150	133	128	N/A	513
8062	660.0		35.3	87.7	9.7	1782	151	150	111	116	2040	480
8154			35.3	87.4	10.1	2159	151	153	129	127	N/A	583
8191			35.2	87.5	9.9	1841	151	150	131	127	N/A	498
8237			35.2	87.3	9.9	1973	151	152	135	133	N/A	536
8266			35.3	88.1	9.9	1900	151	150	135	129	N/A	510
8300	275.0	930.0	35.3	86.6	10.5	1966	151	152	126	121	2520	536
8303	760.0		35.2	87.2	10.2	2019	151	152	111	101	1020	548
8305	345.0		35.3	87.9	10.0	1821	151	152	86	86	630	489
8320	325.0		35.3	87.8	9.7	1862	151	152	121	121	1890	501
8326	800.0		35.2	87.5	9.7	1866	151	150	106	106	990	505
8335	550.0		35.2	87.6	10.1	1938	151	152	103	102	1050	524
8341	280.0	455.0	35.2	87.4	9.8	1704	151	150	127	120	2070	461
8376			35.1	87.2	9.7	1982	151	152	130	124	N/A	540
8410	610.0	760.0	35.2	87.6	9.4	1757	151	150	117	113	1260	475
8438			35.2	88.0	10.1	1940	151	150	124	123	N/A	522
average =			35.2	87.6	10.1	1877	151	151	114	111	1220	507
st.dev. =			0.08	0.86	0.35	147.9	0.24	1.02	15.5	15.8	535.5	40.9
cov. (%) =			0.23	0.98	3.47	7.88	0.16	0.67	13.6	14.3	43.9	8.1

DATA SUMMARY

150°C - 50kN

Specimen No.	Failure location (mm)	Failure location (mm)	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
							Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)		
5	485.0		35.2	87.7	9.9	1911	151	152	95.0	90.2	840	516
42			35.3	86.4	10.6	2182	151	150	129.5	122.7	N/A	596
46	365.0		35.0	87.3	10.8	2016	151	150	125.8	121.1	2040	549
62	640.0		35.1	85.2	10.4	1988	151	152	88.0	83.6	720	554
84	710.0	510.0	35.3	88.9	10.2	2036	151	152	117.5	113.3	1590	542
88	790.0		35.2	88.7	10.0	1919	151	152	118.7	115.4	1500	512
112	460.0		35.3	87.6	10.0	2045	151	152	113.1	107.6	1230	552
161	275.0		35.2	88.7	10.6	2103	151	150	128.4	124.3	2280	562
201	490.0	780.0	35.2	86.9	10.8	2073	151	152	114.4	111.7	1350	565
231	630.0	925.0	35.2	88.6	10.6	2029	151	152	115.6	111.2	1620	543
330	470.0		35.2	88.4	10.6	2123	151	150	118.8	115.1	1860	568
413	600.0	810.0	35.2	88.5	10.2	1928	151	150	98.1	92.7	870	516
426	835.0	570.0	35.2	88.3	10.3	2003	151	152	100.6	95.4	1020	536
434	435.0	640.0	35.1	88.6	10.9	1933	151	152	87.0	84.4	690	517
5018	710.0		35.4	88.4	10.4	1617	151	150	38.9	36.3	180	431
5082	820.0		34.9	88.0	10.4	1679	151	152	71.9	69.3	420	455
5093	715.0		35.3	88.1	10.6	1832	151	152	77.2	70.5	510	491
5118	420.0		35.4	88.3	10.3	1721	151	152	63.9	61.8	270	459
5136	480.0		35.3	87.6	10.4	1836	151	152	81.5	80.3	660	495
5173	555.0	745.0	35.3	87.4	10.0	1874	151	152	61.7	55.5	330	506
5179	385.0	510.0	35.3	88.5	10.3	1855	151	152	82.0	79.2	570	495
5191	790.0		35.2	88.2	10.4	1809	151	152	77.9	79.3	570	485
5212	810.0	615.0	35.2	88.6	10.5	1716	151	152	63.0	57.1	360	458
5228	395.0	610.0	35.3	88.6	10.2	1767	151	152	78.1	73.7	510	471
5246	720.0	870.0	34.9	88.0	10.3	1698	151	152	50.0	46.7	210	461
5257	580.0	365.0	35.2	88.2	10.7	1745	151	152	68.3	68.4	450	469
5259	835.0	390.0	35.3	87.6	9.7	1669	151	152	76.7	69.7	540	450
5260	755.0		35.3	88.5	10.2	1753	151	152	70.4	67.1	450	468
5285	890.0		35.3	87.7	10.0	1804	151	152	90.5	88.9	750	486
5289	385.0		35.2	88.4	10.1	1782	151	152	53.7	53.7	240	478
5294	535.0		35.1	87.4	10.9	1705	151	152	52.1	50.4	240	463
5303	525.0	805.0	35.2	88.2	10.6	1839	151	152	57.8	55.6	330	493
5342	750.0		35.1	88.0	10.1	1628	151	152	67.4	59.2	300	439
5373	430.0	590.0	35.3	87.6	10.4	1781	151	152	59.6	58.8	390	480
5387	550.0		35.2	87.3	10.5	1548	151	152	74.8	72.3	480	420
5395	570.0	705.0	35.3	87.6	9.7	2076	151	152	106.9	104.5	1140	560
5397	700.0		35.2	88.0	9.8	1652	151	152	81.5	76.3	480	444
5529	675.0		35.3	87.7	9.8	1963	149	152	93.1	103.5	1230	528
5532			35.2	87.7	10.3	1879	151	152	80.9	82.2	690	507
8012	880.0		35.1	87.9	10.2	1860	151	152	80.6	76.4	540	502
8019	675.0	820.0	35.4	88.2	10.3	1952	151	152	88.0	83.2	750	521
8052	920.0	860.0	35.2	86.7	10.9	2244	151	150	118.3	118.2	2220	613
8074	720.0		35.3	87.8	9.9	1733	151	150	97.1	92.0	810	466
8104	920.0	860.0	35.3	87.7	10.5	1884	151	151	116.3	113.4	1560	507
8118	560.0	875.0	35.2	87.5	9.7	1789	151	152	108.9	103.9	1170	484
8139	815.0	670.0	35.3	87.7	9.9	1893	151	152	83.2	76.0	600	510
8142	540.0	880.0	35.1	88.1	9.7	1886	151	152	74.2	70.2	540	508
8162	890.0	655.0	35.2	86.9	10.2	1968	150	152	75.6	71.9	510	536
8164	740.0		35.2	87.9	10.1	1958	151	150	111.1	111.3	1500	528
8173	490.0	725.0	35.3	87.1	9.8	1861	151	152	91.9	88.9	840	504
8193	780.0	630.0	35.3	87.9	10.3	1985	151	150	96.0	89.0	900	534
8200	685.0	920.0	35.2	87.7	10.0	2017	151	153	113.5	114.8	1560	544
8220	490.0		35.2	88.3	10.0	1756	151	152	81.0	75.9	600	471
8253	920.0		35.2	86.4	10.3	1886	151	153	111.1	107.5	1380	516
8265	700.0		35.4	87.7	9.7	1960	151	150	108.3	104.7	1290	527
8268	380.0	540.0	35.2	86.7	9.9	1819	151	152	95.6	90.5	840	496
8276	495.0	685.0	35.2	88.0	9.8	1849	151	152	106.7	102.0	1110	497
8298			35.2	86.9	9.6	2152	151	152	128.7	126.3	N/A	586
8333	910.0		35.2	86.9	9.5	1897	151	152	104.5	100.1	1050	516
8352	710.0	405.0	35.2	87.7	9.5	1808	151	152	80.7	76.7	570	489
8422	530.0	690.0	35.2	87.0	9.7	1905	151	150	120.1	117.4	1770	519
average =			35.2	87.8	10.2	1878	151	152	90.5	87.2	882	507
st.dev. =			0.09	0.69	0.37	148	0.3	0.8	22.5	22.5	535	41.0
cov (%) =			0.26	0.79	3.60	7.86	0.2	0.6	24.9	25.8	60.7	8.1

DATA SUMMARY

200°C - 12kN

Specimen No.	Failure location (mm)	Failure location (mm)	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
							Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)		
9	945		35.2	88.9	11.0	1805	200.8	200.3	153	151	2730	481
18	260	945	35.2	87.6	11.4	2126	201.0	200.6	154	150	2732	574
22	270	940	35.2	87.4	10.8	1928	200.8	200.1	157	149	2732	522
34	940		35.2	88.4	11.1	1871	201.1	200.6	167	163	2732	501
77	270	935	35.3	87.6	10.4	1894	200.8	200.3	164	162	2732	511
122	935	400	35.2	87.3	10.8	1700	200.7	200.3	169	162	2718	462
130	545	940	35.2	88.9	10.9	1922	200.8	200.4	162	160	2736	512
149	270	935	35.2	88.7	11.4	1995	201.1	200.3	167	165	2722	533
186	265	945	35.3	88.7	11.1	1957	200.7	200.1	163	157	2728	520
187	280	940	35.3	87.7	11.2	1921	201.2	200.1	166	159	2730	517
193	800	270	35.4	88.5	11.0	1890	200.8	200.5	170	171	2730	502
196	270	375	35.3	87.1	11.0	2108	201.4	200.6	152	145	2734	572
202	945		35.3	87.3	11.1	2014	200.8	200.2	157	161	2732	544
210	940		35.3	88.1	11.1	1771	201.1	200.1	159	155	2726	474
226	265	940	35.3	88.4	11.0	1860	201.2	200.1	166	163	2724	498
242	330	710	35.6	87.9	10.6	2257	201.1	200.5	171	167	2736	601
262	270	940	35.2	88.4	11.5	1731	200.7	200.1	164	161	UNK	463
307	630	270	35.5	86.8	11.1	2004	201.2	200.1	168	158	2726	542
313	935		35.2	88.8	11.3	1952	201.2	200.3	169	163	2724	521
367	275	940	35.4	88.2	11.1	2087	201.3	200.7	160	163	2726	558
372	275	940	35.3	88.7	11.1	2075	200.8	200.3	158	146	2736	552
394	270	935	35.3	87.6	10.8	1941	201.2	200.1	160	163	2726	523
440	265		35.3	88.1	11.1	1835	200.8	200.3	152	150	2724	492
5001	270	940	35.2	88.2	11.2	1638	201.3	200.6	158	158	2718	440
5024	270	940	35.4	88.8	11.0	1704	201.0	200.3	168	163	2722	451
5033	430	540	35.3	88.2	11.0	1997	200.8	200.3	165	168	2726	535
5046	270	940	35.3	88.3	11.0	1620	201.1	200.2	149	140	2726	433
5070	270	935	35.3	88.0	11.2	1746	200.7	200.6	154	146	2724	468
5076	940		35.3	87.7	11.1	1754	201.0	200.6	155	153	2720	473
5090	940		35.4	87.9	11.2	1809	200.8	200.3	162	162	2722	485
5098	735	935	35.5	88.5	11.0	1862	201.1	200.5	157	156	2724	493
5127	670	920	35.4	88.5	10.2	1872	201.0	202.6	84	81	UNK	499
5131	370		35.2	87.5	10.7	1749	200.8	202.8	72	72	UNK	473
5141	270	940	35.3	88.5	11.2	1785	201.2	200.3	165	158	2720	476
5227	560	270	35.2	86.5	11.8	1562	201.2	200.3	161	163	2712	427
5250	855	285	35.2	87.2	10.7	1660	200.8	200.3	168	161	2718	451
5358	270	940	35.3	88.2	11.3	1837	201.2	200.5	163	159	2724	492
5382	705	270	35.4	88.3	10.8	1678	201.0	200.2	168	167	2718	447
5513	940		35.7	87.6	10.9	1817	201.2	200.5	159	152	2722	484
5526	270	940	35.6	87.8	11.3	1833	201.2	200.3	164	161	2724	489
8033	270	940	35.3	87.0	11.2	2070	201.1	200.5	138	130	2732	562
8045	265	970	35.4	88.5	11.1	1854	201.0	200.1	160	157	2722	493
8046	410	680	35.3	86.5	10.9	2200	201.0	200.5	170	170	2730	601
8053	550	720	35.3	87.7	11.2	1876	200.8	200.5	164	160	2726	505
8061	510	910	35.4	87.6	11.1	2003	201.1	200.3	165	164	2724	539
8103	270	935	35.2	87.0	11.7	2175	201.2	200.1	167	164	2732	591
8110	920	940	35.3	87.7	11.2	1924	200.8	200.5	161	154	2728	517
8134	270	940	35.4	88.4	11.3	1802	201.0	200.1	146	142	2724	479
8136	265	940	35.4	87.5	11.2	1763	200.8	200.4	159	150	2722	474
8171	265	940	35.3	88.9	11.4	1681	201.3	200.5	157	152	2718	447
8210	270	945	35.5	87.6	10.5	1883	201.2	200.1	174	167	2722	506
8251	275	940	35.3	88.9	11.4	2047	201.1	200.3	155	160	2726	544
8267	925		35.2	88.3	11.1	1953	201.1	200.2	160	164	2720	523
8288	270	940	35.2	88.2	10.6	1712	200.6	200.6	162	158	2720	459
8290	260	930	35.3	87.2	11.2	1796	200.9	200.5	160	165	2726	487
8291	270	945	35.3	87.5	11.9	1847	200.8	200.7	149	152	2726	498
8321	455	270	35.2	86.8	10.8	2024	201.0	200.1	160	165	2732	553
8367	950		35.3	86.4	10.6	1895	201.2	200.5	155	148	2722	517
8388	260	950	35.4	88.1	11.7	1912	200.8	200.4	162	153	2724	512
8444	575	755	35.3	87.6	10.9	2035	200.7	200.4	171	169	2734	548
8445	270	555	35.2	88.0	11.1	1974	201.0	200.1	159	156	2736	531
average =			35.3	87.9	11.1	1886	201.0	200.4	158	155	2726	506
st.dev. =			0.1	0.6	0.3	150	0.20	0.46	16.5	16.7	5.5	41
cov (%) =			0.3	0.7	2.9	8.0	0.10	0.23	10.4	10.8	0.2	8.1

DATA SUMMARY

200°C - 25kN

Specimen No.	Failure location (mm)	Failure location (mm)	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
							Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)		
37	735	270	35.2	87.6	9.8	2027	201	200	156.71	156	2720	547
38	270	935	35.3	87.3	9.7	2183	201	201	166.75	165	2730	591
48	935	890	35.3	87.6	9.9	2073	201	201	162.82	160	2722	560
116	940		35.3	88.1	10.2	1908	201	201	165.11	160	2712	512
126	940		35.3	86.3	9.9	2052	199	200	165.99	165	2714	562
135	575	270	35.2	88.0	10.3	1996	199	201	158.73	153	2712	537
145	935		35.3	87.4	10.2	1976	201	201	163.81	162	2716	534
150	265	940	35.5	88.6	11.6	1881	201	201	153.29	144	2718	499
164	270	935	35.2	87.3	10.9	2172	201	200	169.95	166	2718	589
185	530	265	35.4	88.4	11.3	1937	201	201	143.22	138	2712	516
225	305	940	35.4	87.1	11.8	2140	201	200	145.97	142	2718	578
256	880	270	35.3	87.7	11.0	2003	201	201	162.6	162	2722	540
261	935		35.3	87.1	10.9	2033	201	200	160.82	158	2710	551
281	940		35.2	88.0	11.2	2077	201	200	165.93	155	2716	559
306	450	775	35.3	88.0	10.4	1809	199	200	151.05	156	2714	485
312	640	850	35.0	87.5	11.2	1943	201	201	167.17	163	2716	529
316	370	705	35.3	88.2	10.7	1962	201	201	171.8	166	2712	525
366	750	940	35.4	87.8	11.3	2023	201	200	157.7	149	2718	543
377	520	270	35.2	88.8	11.3	1901	201	201	156.04	148	2712	506
378	695	265	35.3	88.9	10.5	1954	201	201	152.62	146	2720	519
427	425	270	35.4	88.2	11.6	1870	201	200	143.91	145	2714	500
5055	405	265	35.5	87.9	10.4	1751	199	200	140.1	137	1740	468
5060	270	935	35.4	88.1	11.3	1763	201	200	115.76	113	1410	471
5111	450	480	34.9	88.5	10.7	1740	199	200	150.2	146	1680	470
5123	500	780	35.5	87.4	10.9	1881	201	200	164.45	156	2708	506
5124	360	605	35.5	88.3	11.3	1944	201	200	144.16	141	1170	517
5166	565	670	35.4	88.5	10.3	1717	201	200	115.7	109	690	457
5171	565	845	35.4	88.6	10.9	1830	201	203	109.17	109	630	487
5239	580	610	35.4	88.6	10.4	1799	201	200	158.97	159	2700	478
5251	540	830	35.3	88.5	10.4	1659	201	200	136.26	134	1230	442
5269	400	270	35.3	87.7	11.0	1644	201	201	162.3	164	2706	443
5281	340	850	35.2	87.4	10.8	1673	201	200	111.95	110	750	453
5306	695		35.2	88.0	9.9	1674	201	200	154.35	152	1920	450
5310	810	940	35.3	86.6	10.3	1992	201	200	160.85	162	2712	543
5328	480	270	35.1	88.8	11.3	1623	201	200	118.03	114	1260	434
5343	270	940	35.2	87.4	10.0	1854	201	201	144.55	147	2714	502
5368	601		35.5	89.0	11.0	1564	201	202	108.5	106	720	413
5404	350	475	35.4	87.9	10.0	1800	201	200	137.84	135	1260	482
5413	400	265	35.3	86.5	12.2	1805	201	201	128.61	124	2310	493
5417	565	265	35.3	86.7	11.0	1856	201	200	155.59	156	2714	506
8014	325	675	35.3	86.3	10.1	1837	201	200	171.22	163	2712	502
8037	340	805	35.4	86.5	10.3	2108	199	201	157.07	151	2722	574
8047	450	675	35.3	88.0	11.4	2259	201	201	146.61	149	2718	606
8054	420	795	35.4	87.8	10.7	1826	201	201	155.07	154	2490	490
8070	265	940	35.3	87.6	10.7	1855	201	201	160.58	157	2708	501
8071	840	905	35.4	87.8	10.3	1775	199	201	144.79	146	2710	477
8072			35.3	87.6	10.0	1907	201	201	157.43	151	N/A	514
8091	265	940	35.3	87.1	10.6	1753	201	201	156.95	155	2710	475
8095	445	265	35.2	88.6	9.6	1722	199	200	157.19	149	2712	460
8116	510	720	35.2	88.0	9.6	1693	201	200	162.24	158	2718	455
8160	270	940	35.2	87.6	10.7	1925	201	200	145.4	143	2714	520
8201	400	270	35.5	86.5	9.7	1974	201	200	158.01	153	2720	536
8204	520	640	35.4	87.7	10.3	1828	201	200	162.06	162	2706	491
8250	601		35.1	88.2	9.7	1893	201	200	172.07	167	2710	510
8255	270	940	35.2	87.6	10.8	1955	201	200	155.77	155	2722	528
8299	385	270	35.3	87.5	11.3	1869	201	200	148.75	147	2710	504
8347	510	755	35.3	87.3	10.7	1893	201	201	160.18	164	2706	513
8372	630	270	35.3	88.7	10.2	1778	201	200	154.08	148	2710	473
8377	265	940	35.1	88.2	10.1	2018	201	201	158.22	143	2718	543
8393	270		35.6	86.8	10.8	1767	201	201	149.84	145	2010	477
8443	455	270	35.3	87.9	10.4	1887	201	200	162.06	156	2714	507
average =			35.3	87.8	10.6	1885	201	200	151.72	148	2390	507
st.dev. =			0.12	0.68	0.60	147	0.59	0.38	15.712	15.6	635.9	41.2
cov (%) =			0.33	0.78	5.61	7.81	0.29	0.19	10.356	10.5	26.6	8.13

DATA SUMMARY

200°C - 37kN

Specimen No.	Failure location (mm)	Failure location (mm)	Width (mm)	Depth (mm)	Moisture Content (%)	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
							Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)		
21	280	940	35.5	86.2	10.8	2259	201	201	152	146	2070	616
23	600	925	35.3	87.0	11.0	2121	201	200	147	144	1800	575
80			35.3	87.4	11.4	1848	201	201	117	115	1080	499
94	280	925	35.3	88.3	11.3	1975	201	200	118	116	1200	528
140	270	940	35.2	88.6	11.2	1969	201	200	132	126	2430	525
174	565	333	35.3	87.3	11.2	1807	201	202	116	109	600	488
175			35.4	88.0	11.8	2012	201	201	115	110	840	539
227	465	680	35.3	87.5	10.6	1899	201	200	110	107	780	512
230	760	935	35.3	88.4	11.5	2100	201	201	161	156	2714	561
286	270	930	35.2	88.6	11.4	1901	201	200	123	119	1080	509
287	928		35.2	87.4	11.3	2025	201	200	125	122	1200	548
351	930		35.2	88.3	11.7	1947	201	200	118	113	1050	521
386	410	650	35.4	88.1	10.7	2063	201	200	153	144	1890	551
406	275	385	35.2	87.9	10.9	1948	201	201	130	130	1290	525
407	355	760	35.3	84.9	11.2	2199	201	203	112	105	930	612
425	905	940	35.3	89.0	11.4	1988	201	200	143	138	1890	527
5019	600	790	35.4	88.3	10.8	1693	201	200	63	58	300	451
5028	345	480	35.5	88.6	10.8	1774	201	203	87	85	450	470
5125	330	650	35.4	87.8	11.3	1832	201	203	91	85	540	491
5148	385	560	35.5	86.9	11.1	1788	202	203	99	95	630	483
5205	760	925	35.1	88.5	11.2	1619	201	203	97	92	510	434
5209	550	755	35.4	87.8	11.1	1756	201	203	80	79	450	471
5221	410	565	35.3	88.4	11.2	1844	201	200	103	102	630	493
5291	360	590	35.3	87.8	10.9	1715	201	202	81	76	390	461
5296	685	930	35.3	88.2	11.1	1776	201	202	109	100	690	475
5311	425	585	35.4	88.3	11.0	1677	201	201	68	62	330	448
5320	930		35.2	87.7	10.5	1695	201	203	113	109	780	458
5356	645	765	35.4	88.2	9.9	1559	201	202	93	87	420	416
5375	695		35.3	88.3	12.0	1750	201	200	97	94	600	468
5376	350		35.4	87.7	11.3	1840	201	200	66	61	330	494
5385	490		35.3	88.4	11.0	1642	201	202	79	76	330	439
5401	930		35.3	87.9	12.0	1833	203	203	98	94	600	492
5523	400	800	35.3	87.6	11.6	1884	201	200	108	103	840	507
5530	465	565	35.5	88.0	12.0	2074	201	202	100	97	750	554
8035	415		35.1	88.1	10.8	1892	201	202	99	101	630	509
8049	930		35.2	87.8	11.4	1995	201	201	119	118	1200	538
8058	510	720	35.2	88.8	11.5	1798	201	200	110	107	630	479
8065	415		35.2	87.6	11.1	1932	201	201	124	118	1140	522
8066	585	680	35.3	87.4	11.1	1863	201	202	92	85	570	503
8080	330	655	35.4	87.8	11.2	1825	201	203	90	86	480	490
8096	495		35.5	88.4	11.5	1669	201	203	106	99	600	444
8097	930		35.3	87.8	11.2	2182	201	200	119	111	1170	586
8135	890	925	35.4	87.4	11.2	1969	202	201	123	117	1110	530
8151	410	530	35.4	87.1	11.1	1895	201	200	123	121	1170	513
8163	480	900	35.4	88.2	10.6	1919	201	200	121	120	1020	513
8165	470	920	35.4	87.4	11.0	1738	201	201	106	105	750	468
8168	365	420	35.3	87.5	11.6	1763	201	202	103	100	660	476
8169	330	745	35.3	86.5	11.2	2020	201	201	138	136	1740	551
8177	360	680	35.2	87.7	11.4	1797	201	200	102	99	660	484
8207	595	640	35.3	87.4	10.8	1869	201	200	115	113	1080	504
8216	925		35.3	87.3	11.4	2084	201	201	123	116	1200	563
8223	345	835	35.2	87.4	11.1	2051	201	200	132	126	1500	555
8241	640	800	35.3	87.4	10.7	1717	200	201	114	110	780	464
8247	930		35.4	86.3	11.6	1930	201	200	113	113	1230	527
8281	745	805	35.5	88.1	11.4	1848	201	201	115	112	930	493
8294	570	275	35.3	87.1	11.3	1943	201	201	128	122	1470	526
8361	525	745	35.3	87.1	10.5	1911	201	203	103	93	600	518
8370	870	275	35.3	87.2	10.7	2106	201	201	141	136	1980	571
8373	775	920	35.3	87.4	10.2	1852	202	203	118	112	960	501
8417	560	925	35.2	88.3	10.5	2004	201	200	116	115	1080	538
8430	510	780	35.2	87.9	10.2	1888	201	200	117	113	930	508
average =			35.3	87.8	11.1	1884	201	201	111	107	960	508
st.dev. =			0.08	0.67	0.43	143	0.4	1.0	20.1	20.0	514	42
cov (%) =			0.24	0.77	3.88	7.6	0.2	0.5	18.1	18.7	53.5	8.3

DATA SUMMARY
250°C - 12kN

Specimen No.	Failure location	Failure location	Width	Depth	Meter MC	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
							Platen End	Platen End	Wood End	Wood End		
	(mm)	(mm)	(mm)	(mm)	(%)		(°C)	(°C)	(°C)	(°C)		
63	445	775	35.3	86.0	9.9	1954	252	251	197	190	2720	537
167	265	940	35.1	87.2	10.5	2012	251	250	202	190	2726	548
172	265	935	35.2	88.6	10.0	1796	251	251	197	195	2722	479
188	265	935	35.2	86.9	10.9	2167	251	251	191	184	2726	590
189	830	260	35.3	86.9	10.8	2120	251	251	196	193	2730	575
204	365	265	35.3	87.6	10.8	2049	251	251	194	188	2724	552
263	415	880	35.4	87.7	10.3	1753	251	251	197	193	2720	471
272	265	945	35.3	88.6	10.1	2203	252	251	187	180	2730	588
296	255	940	35.3	88.0	10.1	1973	251	251	189	188	2722	530
324	265	940	35.2	88.1	10.6	2054	251	251	189	187	2726	552
326	415	835	35.3	86.0	10.3	1937	251	250	183	181	2724	531
345	840	870	35.3	87.9	10.4	1924	251	250	198	188	2720	517
374	600	810	35.2	88.2	10.2	2066	251	250	196	191	2730	555
390	330	490	35.2	86.9	11.1	1903	251	251	191	187	2722	518
396	265	940	35.2	86.6	10.5	1876	252	251	195	190	2726	512
416	465	675	35.3	88.0	10.0	1891	251	250	196	191	2720	508
5002	560	755	35.4	87.8	9.9	1637	251	251	201	193	2716	439
5029	430	460	35.3	88.4	10.8	1661	251	251	210	203	2716	443
5048	690	265	35.3	87.3	10.1	1838	251	251	198	196	2716	497
5056	575	260	35.3	86.7	11.0	1841	251	251	203	190	2736	501
5064	330	760	35.3	87.5	9.9	1684	251	250	209	210	2718	454
5099	395		35.2	88.6	11.1	2034	251	250	191	188	2720	543
5114	505	845	35.1	87.5	10.1	1691	251	251	196	200	2714	459
5117	605	265	35.0	87.7	10.3	1808	251	251	192	188	2718	490
5121	480	710	35.1	86.8	10.3	1661	252	251	208	206	2714	454
5159	825	260	35.3	87.4	10.8	1801	251	251	214	207	2724	487
5215	420	745	35.2	88.3	10.3	1819	251	250	203	195	2714	488
5217	360	840	35.2	88.6	10.1	1553	251	251	215	196	2716	415
5254	355	460	35.2	87.8	9.4	1611	252	251	198	190	2714	434
5274	265	940	35.1	88.5	10.3	1840	251	251	206	201	2730	494
5307	405		35.3	87.9	10.7	1719	251	251	204	199	2722	462
5323	610	630	35.2	88.5	10.5	1762	251	251	188	185	2718	471
5324	490	850	35.5	86.9	10.1	1726	252	251	199	200	2720	467
5354	630	830	35.3	87.3	10.7	1740	251	251	198	197	2718	471
5394	560	865	35.4	87.7	10.4	1705	251	251	209	203	2716	458
5517	260	935	35.4	88.6	9.8	1813	251	251	204	202	2720	482
5539	595	265	35.3	86.7	10.3	2000	251	251	193	188	2722	545
8005	730	875	35.2	87.6	10.4	1868	251	251	198	190	2720	505
8021	600	265	35.4	88.1	10.1	1820	251	251	201	188	2722	487
8068	635	260	35.4	87.5	10.4	1862	251	251	195	190	2720	501
8086	265	940	35.3	87.4	10.6	2289	251	251	184	178	2734	618
8108			35.3	87.4	10.2	1844	251	251	196	193	2722	498
8109	580	600	35.3	87.0	11.1	1860	251	251	186	178	2716	504
8161	705	265	35.3	87.3	10.4	2085	251	250	192	198	2730	564
8190	845	260	35.2	87.2	10.3	1966	251	251	193	185	2726	534
8199	715	265	35.1	87.8	10.3	1954	251	251	191	188	2722	528
8202	485	670	35.3	85.4	10.4	1976	251	250	205	198	2732	546
8218	260	940	35.3	87.2	10.1	1743	251	251	193	192	2718	472
8239	265	940	35.3	87.3	10.1	1766	251	250	193	191	2718	478
8270	615	265	35.2	87.5	10.2	1912	251	250	196	191	2720	517
8292	745	845	35.3	86.9	10.5	1997	252	251	197	193	2720	543
8301	265	940	35.2	86.9	11.2	1885	251	251	189	182	2720	513
8311	820	940	35.3	86.5	10.1	2102	252	251	190	187	2724	574
8334	345	675	35.3	88.6	9.9	1787	251	250	196	187	2722	476
8344	765	265	35.3	86.6	10.4	1913	251	251	193	188	2730	522
8383	260	945	35.3	86.5	10.0	1848	251	251	200	192	2722	505
8396	850	265	35.4	88.1	10.7	1932	252	251	199	191	2720	516
8403	420	550	35.1	88.7	10.7	2016	251	251	192	188	2722	540
8407	310	860	35.2	88.4	10.4	1922	251	251	204	198	2722	515
8414	375	560	35.2	88.8	9.9	1870	252	251	207	198	2724	499
8437	430	265	35.2	88.1	10.2	1766	252	250	202	201	2718	475
average =			35.3	87.6	10.4	1878	251	251	197	192	2722	507
st.dev. =			0.1	0.7	0.4	152	0.2	0.2	7.1	7.0	5.1	41.7
cov (%) =			0.2	0.8	3.5	8.1	0.1	0.1	3.6	3.7	0.2	8.2

DATA SUMMARY
250°C - 25kN

Specimen No.	Failure location	Failure location	Width	Depth	Meter MC	Wt. (g)	Temperature				TTF (sec)	Density kg/m ³
							Platen End	Platen End	Wood End	Wood End		
	(mm)	(mm)	(mm)	(mm)	(%)		(°C)	(°C)	(°C)	(°C)		
39	400	265	35.4	87.2	10.7	2117	251	251	188	182	2708	572
85	530	770	35.2	86.5	10.3	1918	251	251	187	175	2550	525
90	420	600	35.4	88.1	11.2	2173	251	251	190	185	2714	581
92	340	375	35.2	87.2	11.2	1879	251	253	150	148	1110	510
97	315	615	35.3	87.8	11.1	2267	251	251	184	172	2716	609
98	270	940	35.4	87.8	11.0	2032	251	251	188	180	2710	545
111	345	555	35.2	87.4	10.7	2046	252	250	193	194	2710	554
163	475	870	35.2	88.1	11.3	2083	251	251	190	180	2716	559
176	265	940	35.3	87.5	11.5	2059	251	251	140	138	1680	555
317	265	940	35.2	87.9	10.9	1856	251	251	192	189	2710	501
341	505	680	35.2	88.1	11.0	1909	251	251	197	189	2714	513
353	425	720	35.2	87.9	11.1	1781	251	251	198	191	2712	480
360	530	850	35.8	87.2	10.8	1882	251	251	177	175	2490	502
361	265	940	35.2	87.2	11.7	1876	251	250	183	177	2712	509
362	630	265	35.7	88.5	10.9	2014	251	251	189	184	2712	531
430	265	940	35.2	87.4	11.4	1752	252	251	161	154	1890	475
436	590	760	35.3	88.8	10.5	1897	251	250	181	164	2010	505
438	770	265	35.3	87.5	11.2	1952	251	251	191	183	2712	526
5005	370	770	35.3	87.5	10.4	1677	249	251	156	149	1110	453
5044	430	495	35.5	87.8	11.1	1718	251	251	165	173	1710	459
5053	430	695	35.2	87.7	11.0	1775	252	251	141	131	870	479
5061	510	685	35.3	87.7	11.0	1830	251	253	121	118	630	493
5088	570	860	35.2	88.0	10.6	1925	251	251	165	159	1560	517
5104	340	540	35.3	88.6	10.4	1714	251	251	157	156	1200	457
5144	570	710	35.3	87.9	10.1	1900	249	250	148	141	1020	510
5150	420	500	35.3	88.5	10.6	1606	252	250	120	118	600	428
5157	680	865	35.4	87.4	10.9	1755	251	251	114	112	510	473
5162	560	605	35.2	87.1	10.7	1853	251	250	131	122	780	503
5180	385	630	35.2	88.0	10.7	1560	250	252	129	123	780	420
5235	525	940	35.2	88.2	10.4	1817	251	251	197	195	2710	487
5245	415	530	35.2	88.1	10.6	1839	252	251	143	141	900	495
5312	450	630	35.2	88.1	10.7	1650	251	251	134	118	810	443
5319	270	940	35.3	87.7	10.9	1677	251	251	165	154	1800	452
5365	680		35.2	88.8	11.0	1636	251	253	118	114	510	435
5379	335	520	35.2	88.3	10.8	1741	251	251	123	121	660	467
5409	345	855	35.3	88.4	11.6	1732	252	251	152	142	1440	463
5502	440	610	35.4	88.4	11.5	1829	251	253	130	126	900	487
5506	485	800	35.2	87.3	10.5	2003	251	251	193	186	2706	543
5512	360	405	34.1	88.1	10.1	1816	251	251	164	162	1320	505
5528	265	940	35.5	88.1	11.3	1958	251	251	163	166	1500	522
8055	640	805	35.4	87.4	10.8	2112	251	251	194	188	2714	570
8060	390	540	35.3	87.8	10.7	1878	251	251	159	157	1710	506
8077	380	405	35.3	88.2	10.5	1799	251	251	176	177	2040	482
8079	545	880	35.3	87.4	11.0	1864	251	251	131	129	720	503
8099	590	270	35.3	87.8	10.6	1983	251	251	163	168	1620	533
8102	460	645	35.4	87.6	10.9	1935	251	251	152	143	990	519
8128	420	680	35.1	87.4	10.5	1761	251	251	156	150	1080	479
8157	580	265	35.3	86.4	11.0	1731	251	250	141	135	990	474
8174	720		35.1	87.4	10.4	1953	251	251	145	142	930	530
8196	630	825	35.1	86.6	10.2	1898	251	251	194	186	2714	520
8197	265	940	35.2	87.7	10.2	1993	251	251	193	189	2714	538
8212	385	580	35.2	88.0	10.8	1842	251	251	156	161	1380	495
8225	755	265	35.3	87.6	10.9	1989	251	251	194	190	2710	536
8227	700	265	35.3	87.9	11.5	2210	251	251	179	171	2714	593
8254	270	930	35.2	87.5	11.0	2026	249	251	185	178	2708	548
8258	330	445	35.3	87.7	10.4	1947	251	251	191	195	2698	524
8263	265	940	35.2	87.3	9.6	2077	251	251	187	185	2716	563
8309	270	610	35.4	87.4	10.4	1973	251	251	159	158	1590	532
8331	375	575	35.3	87.5	10.7	1800	251	251	133	127	750	486
8395	585	785	35.1	87.5	10.7	1828	252	251	168	163	1890	496
8400	305	550	35.3	88.0	10.3	1688	251	251	156	153	1380	453
average =			35.3	87.7	10.8	1878	251	251	164	159	1773	507
st.dev. =			0.2	0.5	0.4	149	0.5	0.6	24.9	24.9	816.0	41.0
cov (%) =			0.6	0.6	3.8	8.0	0.2	0.2	15.2	15.6	46.0	8.1

DATA SUMMARY

150°C - No Load

Specimen No.	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density (kg/m ³)
					Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)		
8	35.2	88.0	10.6	1966	153	152	127	126	N/A	529
67	35.1	87.8	9.7	1928	153	152	141	136	N/A	522
68	35.1	87.2	9.5	1824	153	152	141	139	N/A	497
70	35.2	86.9	10.3	1895	152	152	28	28	N/A	516
114	35.3	87.7	10.1	2095	153	150	140	135	N/A	565
133	35.1	87.6	9.7	1764	152	151	141	138	N/A	478
178	35.2	87.9	10.2	2023	152	152	140	136	N/A	545
179	35.2	88.0	10.2	1984	153	152	138	135	N/A	533
198	35.3	87.1	10.8	2003	153	150	121	116	N/A	543
216	35.3	87.8	10.3	2128	153	152	128	125	N/A	573
229	35.2	88.4	10.1	1966	151	152	129	128	N/A	527
235	35.1	86.8	10.1	2084	153	152	123	120	N/A	570
237	35.0	87.7	9.8	1853	151	152	140	135	N/A	503
260	35.1	88.5	9.8	1791	153	152	132	136	N/A	481
289	35.1	88.4	10.2	1975	155	152	122	120	N/A	530
303	35.1	88.0	9.8	1868	151	152	139	135	N/A	504
315	35.2	88.2	10.0	2192	151	152	132	130	N/A	589
347	35.1	88.7	10.1	2017	151	150	145	143	N/A	539
363	35.2	88.7	10.0	1953	152	150	136	133	N/A	522
400	35.2	88.5	10.1	1804	149	152	137	135	N/A	482
418	35.2	87.9	10.2	2064	153	150	138	135	N/A	556
421	35.2	87.4	9.9	2052	153	152	131	128	N/A	555
5020	35.3	88.2	10.0	1666	152	150	124	120	N/A	445
5037	35.3	86.8	10.2	1837	155	150	123	119	N/A	499
5054	35.4	88.4	9.6	1909	153	152	138	136	N/A	508
5084	35.2	88.4	9.6	1908	153	152	149	148	N/A	511
5115	35.1	88.2	9.8	1750	153	152	142	136	N/A	472
5184	35.2	88.0	10.2	1737	153	152	139	137	N/A	467
5192	35.3	88.0	9.7	1780	151	152	141	136	N/A	478
5226	35.2	87.6	10.0	1803	153	151	137	127	N/A	487
5256	35.2	88.0	9.3	1601	151	150	139	131	N/A	431
5304	35.2	88.0	9.5	1644	153	152	137	131	N/A	443
5317	35.2	88.2	9.4	1718	152	150	140	136	N/A	462
5330	35.2	87.2	9.5	1707	151	152	138	138	N/A	463
5334	35.3	87.9	9.5	1627	153	152	136	134	N/A	438
5336	35.2	87.9	9.5	1563	153	150	140	136	N/A	421
5357	35.1	87.7	9.3	1730	152	152	140	137	N/A	468
5366	35.2	88.2	10.0	1668	151	151	132	130	N/A	448
5388	35.2	87.8	10.0	1687	152	152	133	136	N/A	455
8013	35.3	87.8	9.7	1840	153	152	141	137	N/A	495
8015	35.3	87.4	9.9	1851	151	152	136	137	N/A	500
8043	35.2	87.4	9.9	2163	151	152	127	123	N/A	586
8067	35.2	87.8	10.0	2035	150	152	139	137	N/A	549
8120	35.2	87.7	10.1	2290	154	152	141	137	N/A	618
8127	35.3	87.9	9.8	1753	154	150	138	138	N/A	472
8156	35.3	88.4	9.7	1949	153	152	139	136	N/A	521
8183	35.2	87.4	10.0	1865	153	152	134	130	N/A	506
8198	35.3	88.1	10.1	1791	151	152	139	131	N/A	480
8208	35.2	87.6	9.7	1820	153	152	140	138	N/A	492
8215	35.1	87.5	9.6	1928	152	152	126	125	N/A	523
8224	35.2	88.1	9.7	1756	152	152	125	121	N/A	472
8229	35.2	87.7	9.7	1866	154	152	136	136	N/A	504
8302	35.1	85.8	9.8	2001	153	152	128	124	N/A	553
8308	35.1	86.7	9.4	1935	153	152	128	126	N/A	530
8349	35.1	88.2	9.5	1809	150	150	132	131	N/A	487
8369	35.2	87.5	9.6	1886	150	152	140	132	N/A	510
8378	35.2	86.9	9.7	1842	151	150	140	134	N/A	502
8399	35.2	88.4	10.2	1702	151	152	130	132	N/A	455
8418	35.2	88.2	9.9	1890	154	152	132	128	N/A	508
8432	35.3	87.5	9.8	1913	153	152	139	135	N/A	516
8433	35.2	87.0	10.0	1877	153	152	123	123	N/A	511
average =	35.2	87.8	9.9	1874	152	152	133	130	N/A	506
st.dev. =	0.1	0.5	0.3	152	1.2	0.9	15.1	14.7	N/A	41.5
cov (%) =	0.2	0.6	3.1	8.09	0.8	0.6	11.4	11.3	N/A	8.2

DATA SUMMARY

200°C - No Load

Specimen No.	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density (kg/m ³)
					Platen End (°C)	Platen End (°C)	Wood End (°C)	Wood End (°C)		
4	35.3	87.7	10.5	1844	251	251	212	206	N/A	496
11	35.3	88.1	9.8	1865	251	250	203	200	N/A	500
47	35.4	85.3	10.8	2061	251	250	196	183	N/A	569
56	35.2	87.7	9.9	1911	252	251	196	192	N/A	516
108	35.4	86.8	9.7	1806	251	250	197	190	N/A	491
142	35.3	88.0	10.5	2014	251	250	190	182	N/A	540
152	35.2	87.1	10.7	2207	251	251	184	181	N/A	600
170	35.2	87.6	10.2	2077	251	250	191	185	N/A	562
215	35.1	88.6	10.6	1887	251	251	200	197	N/A	505
238	35.3	87.7	10.6	2106	251	251	194	189	N/A	568
241	35.3	86.5	11.1	1974	251	250	194	189	N/A	539
264	35.3	88.1	10.5	1946	251	251	197	189	N/A	522
270	35.1	87.1	10.7	1979	251	251	197	187	N/A	539
311	35.2	88.2	10.5	1810	251	251	201	193	N/A	486
318	35.2	87.8	10.8	2083	251	251	198	191	N/A	562
365	35.1	88.3	11.1	1976	251	251	191	181	N/A	531
379	35.2	87.7	10.4	2067	251	251	194	188	N/A	558
408	35.2	86.7	10.1	1987	251	251	194	190	N/A	543
410	35.2	88.5	11.1	1957	251	251	29	26	N/A	524
5067	35.2	88.5	10.5	1669	252	251	207	208	N/A	446
5078	35.2	87.4	9.8	1803	251	250	202	191	N/A	489
5110	35.1	87.5	10.0	1727	251	251	206	197	N/A	469
5133	35.2	87.7	9.6	1775	251	251	213	211	N/A	480
5138	35.2	87.5	9.3	1786	250	251	200	201	N/A	484
5163	35.3	87.6	10.0	1858	252	251	210	202	N/A	501
5178	35.1	88.2	10.1	1691	251	251	220	218	N/A	455
5194	35.3	88.0	10.0	1654	252	251	200	200	N/A	444
5196	35.3	87.9	9.6	1769	251	251	207	198	N/A	475
5225	35.1	87.8	10.5	1920	251	250	221	211	N/A	519
5258	35.2	87.8	9.7	1610	251	251	222	215	N/A	435
5271	35.1	85.7	9.7	1835	250	251	212	206	N/A	509
5278	35.2	87.6	9.7	1736	249	251	211	206	N/A	469
5280	35.3	88.3	9.7	1630	251	251	213	212	N/A	436
5325	35.2	88.6	9.8	1680	251	251	255	251	N/A	449
5340	35.2	87.7	10.0	1718	251	251	208	210	N/A	464
5352	35.4	87.1	10.4	1869	251	250	215	212	N/A	505
5367	35.2	86.7	10.0	1562	251	250	214	206	N/A	426
5391	35.2	87.7	9.9	1708	251	251	210	207	N/A	461
5411	35.2	87.2	9.9	1754	251	250	220	217	N/A	476
5419	35.3	87.0	10.0	1846	251	251	200	198	N/A	501
5509	35.3	87.2	9.9	2035	251	251	205	206	N/A	551
5525	35.3	87.4	9.5	1905	251	251	205	196	N/A	515
8009	35.1	87.4	9.7	1951	251	251	192	188	N/A	530
8010	35.3	86.9	9.8	1924	251	251	216	209	N/A	523
8024	35.3	87.8	10.7	2177	251	251	197	189	N/A	586
8089	35.2	87.5	10.2	2281	251	251	199	190	N/A	618
8129	35.3	87.6	10.3	1760	251	251	202	200	N/A	475
8159	35.2	87.7	9.9	1793	251	251	201	196	N/A	484
8167	35.1	88.3	10.2	1986	251	250	196	192	N/A	533
8179	35.2	87.2	9.7	1820	251	251	197	190	N/A	494
8186	35.2	87.9	9.7	1859	251	251	195	192	N/A	501
8194	35.3	88.3	9.5	1895	252	251	204	198	N/A	507
8205	35.4	87.3	10.1	1901	251	251	196	194	N/A	512
8231	35.3	87.8	10.0	2006	251	251	193	193	N/A	540
8315	35.3	87.3	9.8	1931	251	251	196	191	N/A	523
8327	35.4	87.1	11.0	1889	251	251	199	190	N/A	511
8401	35.2	88.3	10.4	1744	251	250	202	193	N/A	467
8402	35.2	86.7	10.2	1830	251	250	192	184	N/A	500
8419	35.2	88.0	10.1	1878	251	251	193	191	N/A	505
8428	35.2	88.2	10.3	2020	251	251	193	184	N/A	543
8434	35.3	88.4	10.9	2128	251	251	203	198	N/A	568
average =	35.2	87.6	10.2	1883	251	251	200	195	N/A	509
st.dev. =	0.1	0.6	0.4	152	0.4	0.2	24.8	24.9	N/A	41.7
cov (%) =	0.2	0.7	4.4	8.09	0.2	0.1	12.4	12.8	N/A	8.2

DATA SUMMARY

250°C - No Load

Specimen No.	Width (mm)	Depth (mm)	Meter MC (%)	Wt. (g)	Temperature				TTF (sec)	Density (kg/m ³)
					Platen End	Platen End	Wood End	Wood End		
					(°C)	(°C)	(°C)	(°C)		
2	35.2	87.5	10.3	2160	201	201	167	166	N/A	585
14	35.3	87.7	10.6	1895	201	202	152	148	N/A	511
20	35.1	87.2	9.7	1996	201	202	178	173	N/A	543
33	35.1	87.9	9.7	1882	201	200	174	174	N/A	508
127	35.2	87.6	9.8	1903	201	202	180	177	N/A	515
137	35.2	87.8	10.6	2206	201	203	153	152	N/A	594
141	35.2	87.1	9.7	1965	201	200	173	170	N/A	535
159	35.3	87.5	10.1	2098	201	202	175	173	N/A	566
162	35.1	88.5	10.6	1939	201	200	161	156	N/A	520
181	35.2	88.3	9.0	1873	201	202	174	169	N/A	503
191	35.2	86.8	9.8	1941	201	200	179	178	N/A	530
205	35.2	88.3	9.4	1940	201	200	161	156	N/A	521
209	35.3	88.7	10.0	1948	201	202	174	173	N/A	519
221	35.2	87.2	10.4	2278	201	202	167	170	N/A	619
283	35.3	87.7	9.9	2060	203	200	176	169	N/A	555
284	35.1	87.6	9.9	1996	201	201	173	168	N/A	541
325	35.2	87.2	10.4	2072	201	200	159	153	N/A	563
328	35.2	87.3	10.0	1913	203	200	175	171	N/A	519
389	35.1	88.0	10.1	1857	203	200	172	168	N/A	500
420	35.2	87.3	10.0	2034	201	202	176	170	N/A	552
424	35.3	87.3	10.1	1712	201	201	182	180	N/A	464
2052	35.2	87.6	10.8	2052	201	201	150	147	N/A	555
5014	35.2	87.7	9.4	1603	203	202	171	166	N/A	434
5058	35.3	87.8	9.7	1764	201	200	30	28	N/A	475
5075	35.3	87.4	9.9	1898	203	202	170	156	N/A	513
5081	35.3	88.2	8.9	1545	201	202	171	169	N/A	413
5119	35.2	86.7	9.7	1638	201	202	168	161	N/A	447
5120	35.2	88.4	9.9	1661	201	202	176	172	N/A	444
5122	35.1	88.4	10.5	1788	201	201	160	166	N/A	480
5160	35.3	87.8	9.6	1689	201	202	160	156	N/A	455
5181	35.2	88.1	9.5	1827	201	200	176	172	N/A	491
5199	35.3	87.8	9.6	1742	201	201	180	171	N/A	469
5216	35.1	87.5	9.6	1646	201	200	178	171	N/A	447
5222	35.2	86.2	10.1	1874	203	202	154	150	N/A	515
5238	35.3	87.4	9.9	1722	201	203	168	169	N/A	466
5247	35.2	87.3	9.7	1736	203	202	179	181	N/A	471
5299	35.1	88.2	9.6	1593	201	202	169	163	N/A	429
5326	35.3	86.3	9.8	1989	201	202	175	178	N/A	545
5345	35.2	87.5	10.9	1777	201	202	175	170	N/A	481
5346	35.2	87.9	9.7	1629	201	200	180	177	N/A	439
5349	35.1	87.7	10.1	1695	201	200	176	170	N/A	458
5359	35.3	87.0	9.6	1754	201	202	180	172	N/A	476
5378	35.3	87.5	9.6	1731	201	202	177	172	N/A	467
5380	35.3	87.3	9.9	1686	201	200	185	179	N/A	456
5511	35.3	86.8	10.3	1807	201	203	169	170	N/A	492
5531	35.3	88.2	9.9	1800	201	200	172	161	N/A	482
5534	35.1	87.5	10.1	1943	201	202	167	167	N/A	527
8002	35.2	86.9	9.6	1984	201	202	174	163	N/A	541
8030	34.9	86.8	9.8	1975	201	202	157	155	N/A	544
8048	35.2	87.1	9.3	2027	201	201	173	167	N/A	552
8078	35.1	87.4	9.8	1867	201	200	174	176	N/A	506
8166	35.2	87.3	10.2	1840	201	202	171	163	N/A	498
8252	35.1	86.8	10.1	1923	201	202	167	163	N/A	526
8296	35.1	86.8	9.7	1804	201	201	178	173	N/A	493
8322	35.2	87.9	9.7	1849	201	200	177	174	N/A	498
8323	35.1	87.0	9.9	1817	201	200	178	175	N/A	496
8360	35.0	87.5	10.1	1844	201	200	169	168	N/A	502
8366	35.2	87.8	10.1	2119	203	202	168	165	N/A	572
8368	35.2	87.3	10.3	1872	201	200	175	167	N/A	508
8381	35.1	88.7	9.4	1827	201	200	176	174	N/A	489
8427	35.1	88.1	9.4	1781	201	200	170	168	N/A	480
average =	35.2	87.5	9.9	1865	201	201	169	165	N/A	505
st.dev. =	0.1	0.6	0.4	157	0.8	0.9	19.7	19.6	N/A	43.3
cov (%) =	0.2	0.6	4.0	8.41	0.4	0.5	11.7	11.9	N/A	8.6

APPENDIX II

Source-code HTEposure

Program HTE Exposure

! This program calculates the time to failure (TTF)
! of a wood stud exposed to a constant elevated temp.
! and under constant load.

USE MSIMSLSS

IMPLICIT REAL*8 (A-H, O-Z)

DIMENSION T(1:70,1:30), H(1:70,1:30)
DIMENSION WMC(1:999), TRUEDENW(1:999)
DIMENSION SG2(1:999), TTF(1:999)

CHARACTER*72 TYPSTU, NOTTF
CHARACTER(4) SPECNO(1:999)
INTEGER ISEED, N, NSTUD
REAL SIGLNMN, SIGLNSD, SIGMA(1:999)
REAL*8 SIGMAMN, SIGMASD, TAMB, TEXP, LOAD, TIMEMN
REAL*8 DT, LSCC, STREN

! VARIABLES

! T(I,J): Temperature of node (I,J) in degrees Celsius
! H(I,J): Enthalpy at node (I,J)
! N NUMBER OF STUDS (SPECIMENS) TO BE HEATED
! NSTUD CHOICE IN SIZE OF STUD
! TYPSTU TYPE OF STUD (ALPHANUMERIC)
! XTHSTU ACTUAL THICKNESS OF THE STUD in X dir(mm)
! YTHSTU ACTUAL THICKNESS OF THE STUD in Y dir(mm)
! NODSTX NUMBER OF NODES IN STUD IN X DIRECTION
! NODSTY NUMBER OF NODES IN STUD IN Y DIRECTION
! DX DISTANCE BETWEEN NODES IN THE X DIRECTION
! DY DISTANCE BETWEEN NODES IN THE Y DIRECTION
! MIDCTRX center node in X
! MIDCTRY center node in Y
! CTRX1 center node - 1 in X
! CTRY1 center node - 1 in Y
! SIGMAMN MEAN OF SAMPLE OF STRENGTH
! SIGMASD STANDARD DEVIATION OF SAMPLE OF STRENGTH
! SIGLNSD STANDARD DEVIATION OF LN(SAMPLE STRENGTH)
! SIGLNMN MEAN OF LN(SAMPLE STRENGTH)
! ISEED SEED FOR RANDOM NUMBER GENERATION
! SIGMA(L) INITIAL STRENGTH OF WOOD STUD L (ASSUMING A
! LOGNORMAL DISTRIBUTION)
! STREN STRENGTH OF STUD AT TIME, TIME
! LSCC Load stud can carry at reduced strength at time, TIME(kN)
! TAMB AMBIENT TEMPERATURE (Celsius)
! TEXP TEMPERATURE OF EXPOSURE IN CELSIUS
! LOAD COMPRESSION LOAD APPLIED TO STUD (kN)
! TIMEMN TOTAL TIME OF THE ANALYSIS IN MINUTES
! TIMESL TOTAL TIME OF THE ANALYSIS IN SECONDS
! DT DURATION OF EACH TIME STEP (sec.)

```

!   NT ..... NUMBER OF TIME STEPS
!   SPECNO(L) ... NUMBER OF TEST SPECIMEN FROM WOOD STUD EXPERIMENT
!   WMC(L) ..... MOISTURE CONTENT OF WOOD STUD L (decimal fraction)
!   TRUEDENW(L).. TRUE DENSITY OF THE WOOD OF STUD L (Mass/Vol.) (kg/m**3)
!                   BOTH AT SPECIFIED MC)
!   SG2(L) ..... SPECIFIC GRAVITY OF WOOD OF STUD L (VOLUME AT SPECIFIED
!                   MOISTURE CONTENT) - CALCULATED FROM WMC(L)
!                   AND TRUEDENW(L)
!   TIMIN ..... TIME DURING ANALYSIS (min.)
!   TIME ..... TIME DURING ANALYSIS (sec.)
!   TTF(L) ..... Time To Failure of stud (sec.)

```

```

!   SUBPROGRAMS

```

```

!   HT(T,H,DX,DY,DT,MIDCTRX,MIDCTRY,WMC,TRUEDENW,TAMB,TEXP,THERMWD)
!   .....DETERMINES CROSS-SECTIONAL TEMPERATURES
!                   OF WOOD STUD
!   STRENGTH(SIGMA,LSCC,T,DX,DY,MIDCTRX,MIDCTRY)
!   .....DETERMINES STRENGTH REDUCTION OF WOOD
!                   STUD

```

```

INTERFACE

```

```

      SUBROUTINE HT(T,H,DX,DY,DT,MIDCTRX,MIDCTRY,WMC,TRUEDENW,TAMB,TEXP
, THERMWD)

```

```

      IMPLICIT REAL*8 (A-H, O-Z)
      DIMENSION T(1:70,1:30), H(1:70,1:30)
      REAL*8 DT, TAMB, TEXP
      END SUBROUTINE HT

```

```

      SUBROUTINE STRENGTH(SIGMA,LSCC,T,DX,DY,MIDCTRX,MIDCTRY)
      IMPLICIT REAL*8 (A-H, O-Z)
      DIMENSION T(1:70,1:30)
      REAL SIGMA
      REAL*8 LSCC
      END SUBROUTINE STRENGTH

```

```

END INTERFACE

```

```

! *****
!   INPUT DATA SECTION
! *****

```

```

!   THIS PART READS INFORMATION FROM THE DATA FILE CONTAINING VALUES THAT
!   AFFECT ALL SPECIMENS TO BE "TESTED"

```

```

      OPEN (UNIT = 4 , FILE = 'TEST.DAT', STATUS = 'UNKNOWN')

```

```

      READ(4,802) N, NSTUD, SIGMAMN, SIGMASD, TAMB, TEXP, LOAD, TIME MN,
DT

```

```

      802   FORMAT(1X,I3,/,1X,I1,/,1X,F8.4,/,1X,F8.4,/,1X,F8.2,/,1X,F8.2,/,1X,
F8.2,/,1X,F8.4,/,1X,F8.4)

```

```

CLOSE(4)

!   THIS PART READS INFORMATION FROM THE FILE OF MOISTURE CONTENT AND
!   DENSITY OF EXPERIMENTAL SPECIMENS

OPEN (UNIT = 5 , FILE = 'WMC RHO.DAT', STATUS = 'UNKNOWN')

DO 90 L = 1,N

      READ(5,1002) SPECNO(L), WMC(L), TRUEDENW(L)
      SG2(L) = TRUEDENW(L)/(1000*(1+WMC(L)))
90    CONTINUE

1002   FORMAT(A4,\,1X,F5.3,\,1X,F8.3)

CLOSE(5)

!   THIS PART OPENS FILES THAT WILL RECEIVE OUTPUT
OPEN (UNIT = 7 , FILE = 'CENTERPT.dat' , STATUS = 'UNKNOWN')
OPEN (UNIT = 8 , FILE = 'TTF.dat' , STATUS = 'UNKNOWN')
OPEN (UNIT = 9 , FILE = 'STRENGTH.dat', STATUS = 'UNKNOWN')

!   =====
!   CALCULATION OF SOME STUD PROPERTIES
!   =====

!   GENERATION OF INITIAL STRENGTHS FOR ALL STUDS FROM LOGNORMAL
!   DISTRIBUTION OF STRENGTH WITH:
!   MEAN = SIGMAMN, AND STANDARD DEVIATION = SIGMASD

SIGLNSD = SQRT(LOG(1 + (SIGMASD**2/SIGMAMN**2)))
SIGLNMN = LOG(SIGMAMN) - SIGLNSD/2

ISEED = 5230478 !0 means that seed is generated from internal clock,
                ! and therefore is different for every run

CALL RNSET(ISEED)
CALL RNLNL(N,SIGLNMN,SIGLNSD,SIGMA)

!   DETERMINATION OF WHICH KIND OF STUDS WILL BE USED
!   (DEFAULT = nominal 2" X 4")

IF (NSTUD .EQ. 2) THEN
  TYPSTU = 'nominal 2" X 6"'
  NODSTX = 55                                !- must be an odd number
  NODSTY = 15                                !/
  XTHSTU = 139.700D0                          !mm
  YTHSTU = 38.00D0                            !mm
ELSE
  TYPSTU = 'nominal 2" X 4"'

```

```

      NODSTX = 35                !- must be an odd number
      NODSTY = 15                !/
      XTHSTU = 87.700D0         !mm
      YTHSTU = 35.20D0         !mm

      ENDIF

      MIDCTRX = ((NODSTX-1)/2) +1  !node at centre in X-direction
      MIDCTRY = ((NODSTY-1)/2) +1  !node at centre in Y-direction
      CTRX1 = MIDCTRX-1
      CTRY1 = MIDCTRY-1

      ! DETERMINATION OF THE STEP SIZE IN THE X & Y DIRECTIONS
      ! (DISTANCE BETWEEN NODES)
      DX = XTHSTU/(NODSTX-1)/1000  !metres
      DY = YTHSTU/(NODSTY-1)/1000  !metres

      ! THIS PART DEFINES THE TIME PARTITIONING
      TIMESC = TIMEMN * 60.000D0
      NT = TIMESC / DT

      ! *****
      ! ***** S T U D   L O O P   S T A R T *****
      ! *****

      DO 100 L = 1,N

      ! THIS PART INITIALIZES ALL REMAINING VARIABLES REQUIRED TO BE
      ! RESET FOR EACH STUD

      LSCC = 0.0D0      ! kN
      TIME = 0.0D0      ! seconds
      TIMIN = TIME / 60.0D0  ! for minutes
      TTF(L) = 0.0D0      ! seconds

      DO 1 I = 1,MIDCTRX
        DO 2 J = 1,MIDCTRY
          T(I,J) = TAMB
          H(I,J) = 0.00D0
        2 CONTINUE
      1 CONTINUE

      ! THERMAL CONDUCTIVITY OF WOOD AT ROOM TEMPERATURE

      THERMWD = SG2(L) * ( 0.200D0 + 0.0404D0 * WMC(L)) + 0.0238

      ! WRITES THE CENTER TEMPERATURE FOR THE STUD TO A DATA FILE

      WRITE(7,901) SPECNO(L), TIME
      WRITE(7,800) T(MIDCTRX,MIDCTRY)

      ! WRITES THE STRENGTH FOR THE STUD TO A DATA FILE

```

```

        WRITE(9,901) SPECNO(L), TIME
        WRITE(9,800) SIGMA(L)

800    FORMAT (1X,F7.2)
901    FORMAT (1X,A4,1X,F7.2,\)

!    FIRST TIMESTEP

        TIME = TIME + DT

!*****T I M E   L O O P   S T A R T *****

        DO 3 K = 1, NT                                !TIME LOOP

            CALL HT(T,H,DX,DY,DT,MIDCTRX,MIDCTRY,WMC(L),TRUEDENW(L),TAMB,TEXP
,THERMWD)

            CALL STRENGTH(SIGMA(L),LSCC,T,DX,DY,MIDCTRX,MIDCTRY)

            STREN = LSCC * 1000.0D0 / (XTHSTU * YTHSTU)

            R = MOD(TIME,15.0)

            IF (R .EQ. 0.0) then

!    WRITES CENTER TEMPERATURE FOR THE STUD TO A DATA FILE
                WRITE(7,901) SPECNO(L), TIME
                WRITE(7,800) T(MIDCTRX,MIDCTRY)

!    WRITES THE STRENGTH FOR THE STUD TO A DATA FILE
                WRITE(9,901) SPECNO(L), TIME
                WRITE(9,800) STREN

                ENDIF

!    NEW TIME

                IF (LSCC .GE. LOAD) then

                    TIME = TIME + DT
                    TIMIN = TIME / 60.0D0

                ELSE                                !(LSCC > LOAD - i.e stud can no longer support load)

                    TTF(L) = TIME
                    WRITE(8,1010) SPECNO(L), SIGMA(L), WMC(L), TRUEDENW(L), TTF(L)
                    !EXIT TIME LOOP AND GO ON TO NEXT STUD
                    EXIT

                ENDIF

1010    FORMAT (1X,A4,\,1X,F8.1,\,1X,F8.3,\,1X,F8.3,\,1X,F8.1)

```



```

!      END OF K(time) LOOP

      3      CONTINUE

!*****T I M E   L O O P   E N D *****

      IF (TTF(L) .EQ. 0.0D0) then

          NOTTF = 'STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED'
          WRITE(8,1020) SPECNO(L), SIGMA(L), WMC(L), TRUEDENW(L), NOTTF

      ENDIF

1020  FORMAT (1X,A4,\,1X,F8.1,\,1X,F8.3,\,1X,F8.3,\1X,A50)

100  CONTINUE

!*****S T U D   L O O P   E N D S *****
!*****

      CLOSE(7)      !CENTERPTS.dat
      CLOSE(8)      !TTF.dat
      CLOSE(9)      !STRENGTH.dat

      END

```

```

      SUBROUTINE HT(T,H,DX,DY,DT,MIDCTRX,MIDCTRY,
*              WMC,TRUEDENW,TAMB,TEXP,THERMWD)

*!This subroutine has been modified substantially from the program WALL2D
*!to calculate the cross-sectional temps. of 1/4 of a wood stud
*!exposed to a constant temp. on all 4 sides.

*!NOTE: assumption is that wood specimen will be immediately at the
*!exposure temp. at its surface, and heated internally by conduction.

      IMPLICIT REAL*8 (A-H, O-Z)
      REAL*8 T(1:70,1:30), H(1:70,1:30)

*!      T:      Temperature array for cross-section in degrees Celsius
*!      H:      Enthalpy array for cross-section
*!      DX ..... DISTANCE BETWEEN NODES IN THE X DIRECTION
*!      DY ..... DISTANCE BETWEEN NODES IN THE Y DIRECTION
*!      DT ..... DURATION OF EACH TIME STEP
*!      MIDCTRX ..... center node in X
*!      MIDCTRY ..... center node in Y
*!      WMC ..... MOISTURE CONTENT OF THE WOOD STUD (decimal fraction)
*!      TRUEDENW .... TRUE DENSITY OF THE WOOD (MASS/VOLUME (kg/m**3)
*!                   BOTH AT SPECIFIED MC)
*!      TAMB ..... AMBIENT TEMPERATURE (Celsius)
*!      TEXP ..... TEMPERATURE OF EXPOSURE IN CELSIUS
*!      THERMWD ..... THERMAL CONDUCTIVITY OF WOOD AT AMBIENT TEMP.

*!      SUBPROGRAMS

*!      TEMPW(WMC,H,TAMB) ..... DETERMINES ELEMENT'S TEMPERATURE
*!                               FOR WOOD
*!      THERMW(TEMP,THERMWD) ..... THERMAL CONDUCTIVITY OF WOOD OR
*!                               CHAR

*!      VARIABLES

*!      CONDD ..... CONDUCTION WITH ELEMENT I + 1
*!      CONDU ..... CONDUCTION WITH ELEMENT I - 1
*!      CONDR ..... CONDUCTION WITH ELEMENT J + 1
*!      CONDL ..... CONDUCTION WITH ELEMENT J - 1
*!      HTERM ..... TERMS MULTIPLYING THE ENTHALPY IN ENERGY BALANCE
*!      TOTTERM ..... INCREASE IN ENTHALPY

*!      (IP(I),J) ... ELEMENT I + 1
*!      (IM(I),J) ... ELEMENT I - 1
*!      (I,JP(J)) ... ELEMENT J + 1
*!      (I,JM(J)) ... ELEMENT J - 1

*****
*****      L O O P   S T A R T      *****
*****

```

```

DO 4 I = 1,MIDCTRX
DO 5 J = 1,MIDCTRY

  IF (I .EQ. 1) then      !WOOD FACING EXPOSURE - CORNER(J=1),
                          !Y CENTERLINE EDGE (J=MIDCTRY), AND
                          !(TOP) EDGE (J NOT EQUAL TO 1 OR MIDCTRY)

    T(I,J) = TEXP          !ASSUMES WOOD SURFACE HEATS IMMEDIATELY
                          !  TO EXPOSURE TEMPERATURE

  ELSEIF (I .EQ. MIDCTRX) then

    IF (J .EQ. 1) then    !WOOD FACING EXPOSURE -
                          !X CENTERLINE EDGE

      T(I,J) = TEXP        !ASSUMES WOOD SURFACE HEATS IMMEDIATELY
                          !  TO EXPOSURE TEMPERATURE

    ELSEIF (J .EQ. MIDCTRY) then

      !***WOOD CENTRE - MEETING OF X/Y CENTERLINES***

      CONDU = 4.0D0*(-DY / 2.0D0 * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(IM(I),J),THERMWD)))/2.0D0 *
*      (T(I,J)-T(IM(I),J)) / DX)
      CONDL = 4.0D0*(-DX / 2.0D0 * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(I,JM(J)),THERMWD)))/2.0D0 *
*      (T(I,J)-T(I,JM(J))) / DY)

      HTERMW = DX*DY*TRUEDENW/DT

      TOTTERM = (CONDU + CONDL)/HTERMW

      H(I,J) = H(I,J) + TOTTERM

    ELSE                  !J DOES NOT EQUAL 1 OR MIDCTRY

      !*** WOOD ALONG X CENTERLINE ***

      CONDR = 2.0D0*(-DX / 2.0D0 * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(I,JP(J)),THERMWD)))/2.0D0 *
*      (T(I,J)-T(I,JP(J))) / DY)
      CONDU = 2.0D0*(-DY * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(IM(I),J),THERMWD)))/2.0D0 *
*      (T(I,J)-T(IM(I),J)) / DX)
      CONDL = 2.0D0*(-DX / 2.0D0 * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(I,JM(J)),THERMWD)))/2.0D0
*      * (T(I,J) - T(I,JM(J))) / DY)

      HTERM = DX * DY * TRUEDENW / DT

      TOTTERM = (CONDR + CONDU + CONDL) / HTERM

```

```

      H(I,J) = H(I,J) + TOTTERM

ENDIF

ELSE                                     !I DOES NOT EQUAL 1 OR MIDCTRX

IF (J .EQ. 1) then                      !WOOD FACING EXPOSURE - (LEFT) EDGE

      T(I,J) = TEXP                     !ASSUMES WOOD SURFACE HEATS
                                      ! IMMEDIATELY TO EXPOSURE
                                      ! TEMPERATURE

ELSEIF (J .EQ. MIDCTRY) then

      !*** WOOD ALONG Y CENTERLINE ***

      CONDD = 2.0D0*(-DY / 2.0D0 * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(IP(I),J),THERMWD))/2.0D0 *
*      (T(I,J)-T(IP(I),J)) / DX)
      CONDU = 2.0D0*(-DY / 2.0D0 * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(IM(I),J),THERMWD))/2.0D0 *
*      (T(I,J)-T(IM(I),J)) / DX)
      CONDL = 2.0D0*(-DX * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(I,JM(J)),THERMWD))/2.0D0
*      * (T(I,J) - T(I,JM(J))) / DY)

      HTERM = DX * DY * TRUEDENW / DT

      TOTTERM = (CONDD + CONDU + CONDL) / HTERM

      H(I,J) = H(I,J) + TOTTERM

ELSE                                     !J DOES NOT EQUAL 1 OR MIDCTRY

      !*** WOOD STUD BULK ***

      CONDD = -DY * (THERMW(T(I,J),THERMWD)+
*      THERMW(T(IP(I),J),THERMWD))/2.0D0 *
*      (T(I,J) - T(IP(I),J)) / DX
      CONDU = -DY * (THERMW(T(I,J),THERMWD)+
*      THERMW(T(IM(I),J),THERMWD))/2.0D0 *
*      (T(I,J) - T(IM(I),J)) / DX
      CONDR = -DX * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(I,JP(J)),THERMWD))/2.0D0
*      * (T(I,J) - T(I,JP(J))) / DY
      CONDL = -DX * (THERMW(T(I,J),THERMWD) +
*      THERMW(T(I,JM(J)),THERMWD))/2.0D0
*      * (T(I,J) - T(I,JM(J))) / DY

      HTERM = DX * DY * TRUEDENW / DT

      TOTTERM = (CONDD + CONDU + CONDR + CONDL) / HTERM

```

```

        H(I,J) = H(I,J) + TOTTERM

        ENDIF

    ENDIF

*!      THIS PART CALCULATES NEW TEMPERATURES

        IF (I .GT. 1) THEN
            IF (J .GT. 1) THEN
                T(I,J) = TEMPW(WMC,H(I,J),TAMB)
            ENDIF
        ENDIF

*!      End of J loop

        5    CONTINUE

*!      End of I loop

        4    CONTINUE

*****
***** L O O P   E N D *****
*****

        END

        INTEGER FUNCTION IM(I)
        IM = I - 1
        END

        INTEGER FUNCTION IP(I)
        IP = I + 1
        END

        INTEGER FUNCTION JM(J)
        JM = J - 1
        END

        INTEGER FUNCTION JP(J)
        JP = J + 1
        END

        SUBROUTINE CP(X,F)
        IMPLICIT REAL*8 (A-H, O-Z)
        F = DSQRT(1.0D0+X*X) - X
        RETURN
        END

```

```

      REAL*8 FUNCTION TEMPW(XM, H, TAMB)

      *!  SUBPROGRAM BASED ON THEORETICAL ANALYSIS TO COMPUTE THE TEMPERATURE,
      *!  IN DEGREES C, AT CERTAIN POINTS WITHIN WOOD.

      IMPLICIT REAL*8 (A-H, O-Z)

      *!  XM: Moisture content of wood
      *!  H: Enthalpy in KJ/Kg
      *!  HXXX: Enthalpy at XXX temperature

      H = H / 1.0D+03

      *!  FW : Mass fraction of water in wood
      *!  FD : Mass fraction of dry wood

      FW = XM / (1.0D0 + XM)
      FD = 1.0D0 / (1.0D0 + XM)

      CV = 2.10D0          !kJ/(kg*C)
      *!  CV = 0.0D0

      *!  This indicates the range over which MC is vapourized
      *!  (from 100 to 100+deltaT C)

      deltaT = 70.0D0          !degrees Celcius (deltaT<100)

      *!  SLOPE AND INTERCEPT FOR PHASE-DOWN

      SPH = -(FW * CV + FD * 1.260D0) / 150.0D0
      BPH = 1.950D0 * FD + CV * FW

      *!  HEAT OF PYROLYSIS (KJ/KG)

      *!  HPYR = 0.0D0
      *!  HPYR = 370.0D0
      *!  HPYR = 200.0D0

      H100 = FD * (2.1D-03*(1.0D+04-TAMB**2)+1.11D0*(100.0D0 - TAMB)) +
      *      FW * 4.2D0 * (100.0D0 - TAMB)

      *!  HdeltaT represents H(100+deltaT)
      HdeltaT = H100 +
      *      FD * ( 2.1D-03 * ( (100.0D0+deltaT)**2 - 100.0D0**2 )
      *              + 1.11D0 * ( (100.0D0+deltaT) - 100.0D0 ) )
      *      + FW * 2.89D03
      *!  *      + FW * 2.26D03
      *      + FW * 4.2D0 / deltaT * ((100.0D0-deltaT)*((100.0D0+deltaT)
      *      - 100.0D0) - ((100.0D0+deltaT)**2 - 100.0D0**2)/2.0D0)
      *      + FW * CV / deltaT * (100.0D0*(100.0D0-(100.0D0+deltaT))
      *      +((100.0D0+deltaT)**2 - 100.0D0**2)/2.0D0)

      H200 = HdeltaT

```

```

*          + FD * ( 2.1D-03 * (200.0D0**2 - (100.0D0+deltaT)**2)
*          + 1.11D0 * (200.0D0 - (100.0D0+deltaT)))
*          + FW * CV * (200.0D0 - (100.0D0+deltaT))

H350 = H200 + FD * HPYR + BPH * 150.0D0 + SPH/2.0D0 * 150.0D0**2

IF (H.le.H100) THEN

    AX1 = FD * 2.1D-03
    BX1 = FD * 1.11D0 + FW * 4.2D0
    CX1 = -H - FD * (2.1D-03 * TAMB**2 + 1.11D0 * TAMB)
*          - FW * 4.2D0 * TAMB

    TEMPW=(-BX1 +(BX1**2 - 4.0D0 * AX1 * CX1)**0.5) / (2.0D0 * AX1)

ELSEIF (H.gt.H100.and.H.le.HdeltaT) THEN

    AX2 = FD * 2.1D-03 - FW * (4.20D0 - CV) / (2.0D0*deltaT)
    BX2 = FD * 1.11D0 + FW * 2.89D03 / deltaT
*          + FW * 4.20D0/deltaT*(100.0D0-deltaT)
*          - FW*CV/deltaT*100.0D0
*!      BX2 = FD * 1.11D0 + FW * 2.26D03 / 20.0D0 + FW * 4.2D0
*!      *          + FW * 2.1D0 * 5.0D0
    CX2 = H100 - H - FD * 2.1D-03 * 100.0D0**2
*          - FD * 1.11D0 * 100.0D0
*          - FW * 2.89D03 / deltaT * 100.0D0
*!      *          - FW * 2.26D03 / 20.0D0 * 100.0D0
*          + FW * 4.20D0 * 100.0D0
*          + FW * 100.0D0**2/(2.0D0*deltaT)*(CV - 4.20D0)

    TEMPW=(-BX2 +(BX2**2 - 4.0D0 * AX2 * CX2)**0.5) / (2.0D0 * AX2)

ELSEIF (H.GT.HdeltaT.AND.H.LE.H200) THEN

    AX3 = FD * 2.1D-03
    BX3 = FD * 1.11D0 + FW * CV
    CX3 = HdeltaT - H - FD * 2.1D-03 * (100.0D0+deltaT)**2
*          - FD * 1.11D0 * (100.0D0+deltaT)
*          - FW * CV * (100.0D0+deltaT)

    TEMPW=(-BX3 +(BX3**2 - 4.0D0 * AX3 * CX3)**0.5) / (2.0D0 * AX3)

ELSEIF (H .GT. H200 .AND. H .LE. H350) THEN

    AX4 = SPH / 2.0D0
    BX4 = FD * HPYR / 150.0D0 + BPH - 200.0D0 * SPH
    CX4 = H200 - H - 200.0D0 * FD * HPYR / 150.0D0
*          - 200.0D0 * BPH + SPH/2.0D0 * 200.0D0**2

    TEMPW=(-BX4 +(BX4**2 - 4.0D0 * AX4 * CX4)**0.5) / (2.0D0 * AX4)

ELSE

```

```
TEMPW = 350.0D0 + (H - H350) / (FD * 0.690D0)
```

```
ENDIF
```

```
H = H * 1.0D+03
```

```
RETURN
```

```
END
```



```

      REAL*8 FUNCTION THERMW(TEMP,THERMWD)

*C  FUNCTION TO CALCULATE THE THERMAL CONDUCTIVITY OF WOOD.

      IMPLICIT REAL*8 (A-H,O-Z)

      XK1 = THERMWD

      XK2 = 0.178D0*0.90D0

      XK3 = 0.085D0*0.90D0

      XK4 = (0.160D0 - XK3) / 1073.150D0**3 * 0.90D0

*C  FIRST SLOPE AND FIRST INTERCEPT

      S1 = (XK2 - XK1) / (200.0D0 - 0.0D0)
      B1 = XK1

*C  SECOND SLOPE AND SECOND INTERCEPT

      S2 = (XK3 - XK2) / (350.0D0 - 200.0D0)
      B2 = XK2 - S2 * 200.0D0

100  CONTINUE
      IF (TEMP .LE. 200.0D0) THEN
         THERMW = (B1 + S1 * TEMP)

      ELSEIF (TEMP .GT. 200.0D0 .AND. TEMP .LE. 350.0D0) THEN
         FT = (TEMP - 200.0D0) / 150.0D0
         THERMW = ((B2 + S2 * TEMP) + FT * XK4 * (TEMP + 273.150D0)**3)

      ELSE
         THERMW = (XK3 + XK4 * (TEMP + 273.150D0)**3)

      ENDIF

      RETURN

      END

```

```

      SUBROUTINE STRENGTH(SIGMA,LSCC,T,DX,DY,MIDCTRX,MIDCTRY)

      *!This subroutine calculates the degraded load-carrying capacity of a
      *!wood stud exposed to elevated temperature

      *!Note: It is assumed that full load sharing occurs btw elements -
      *! i.e. when one element has reached its full capacity, the additional
      *!      load is taken up by other elements until their capacities are
      *!      also reached.

      IMPLICIT REAL*8 (A-H, O-Z)

      *!      S(I,J):      Strength of element surrounding node (I,J) in MPa
      *!      LECC(I,J):  "Load element can carry" surrounding node (I,J) (kN)

      REAL*8 T(1:70,1:30), S(1:70,1:30), LECC(1:70,1:30)
      REAL*8 LSCC
      REAL SIGMA

      *!      SIGMA ..... Initial Strength of stud (MPa)
      *!      LSCC ..... "Load stud can carry" (kN)
      *!      T ..... Temperature array T(I,J) for cross-section in
      *!                      degrees Celsius
      *!      DX ..... DISTANCE BETWEEN NODES IN THE X DIRECTION (m)
      *!      DY ..... DISTANCE BETWEEN NODES IN THE Y DIRECTION (m)
      *!      MIDCTRX ..... center node in X
      *!      MIDCTRY ..... center node in Y
      *!      P ..... Percent of initial strength remaining (%)

      LSCC = 0.0D0          !NEED TO RESET FOR EACH TIME IMCREMENT,
                           !    SO IS NOT CUMULATIVE OVER TIME!

      DO 20 I = 1,MIDCTRX
        DO 30 J = 1,MIDCTRY

      *!=====
      *!      Strength reduction models
      *!      -----

      !      P = 105.0D0 - 0.25D0 * T(I,J)      !1. Kollman, 1940

      !      P = 106.0D0 - 0.29D0 * T(I,J)      !3. Knudson & Schniewind, 1975

      !      P = 72.0D0 - 0.20D0 * T(I,J)       !4. Rykov, 1980

      !      P = 111.4D0 - 0.57D0 * T(I,J)      !6. Hosser, et al. 1994

      *!*****
      !      2. Schaffer (1971)

      !      IF (T(I,J) .GE. 25.0D0 .AND. T(I,J) .LE. 68.88D0) THEN

      !      P = 102.8D0 - 0.1139D0 * T(I,J)

```

```

!      ELSEIF (T(I,J) .GT. 68.88D0 .AND. T(I,J) .LE. 154.81D0) THEN
!
!      P = 126.10D0 - 0.4509D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 154.81D0 .AND. T(I,J) .LE. 203.19D0) THEN
!
!      P = 80.25D0 - 0.155D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 203.19D0 .AND. T(I,J) .LE. 342.38D0) THEN
!
!      P = 119.9D0 - 0.3502D0 * T(I,J)
!
!      ENDIF

```

```

*! *****

```

```

!      5. Schaffer et al. (1986)

```

```

!      IF (T(I,J) .GE. 25.0D0 .AND. T(I,J) .LE. 25.5D0) THEN
!
!      P = 620.0D0 - 20.8D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 25.5D0 .AND. T(I,J) .LE. 39.7D0) THEN
!
!      P = 149.9D0 - 2.366D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 39.7D0 .AND. T(I,J) .LE. 59.9D0) THEN
!
!      P = 78.01D0 - 0.5545D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 59.9D0 .AND. T(I,J) .LE. 105.7D0) THEN
!
!      P = 55.26D0 - 0.1747D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 105.7D0 .AND. T(I,J) .LE. 162.9D0) THEN
!
!      P = -19.38D0 + 0.5315D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 162.9D0 .AND. T(I,J) .LE. 235.5D0) THEN
!
!      P = 124.6D0 - 0.3526D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 235.5D0 .AND. T(I,J) .LE. 256.1D0) THEN
!
!      P = 206.2D0 - 0.699D0 * T(I,J)
!
!      ENDIF

```

```

*! *****

```

```

!      7. YOUNG AND CLANCY (2000)

```

```

!      IF (T(I,J) .GE. 20.0D0 .AND. T(I,J) .LE. 100.0D0) THEN

```

```

!      P = 115.0D0 - 0.75D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 100.0D0 .AND. T(I,J) .LE. 110.0D0) THEN
!
!      P = -760.0D0 + 8.0D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 110.0D0 .AND. T(I,J) .LE. 200.0D0) THEN
!
!      P = 168.9D0 - 0.44D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 200.0D0 .AND. T(I,J) .LE. 300.0D0) THEN
!
!      P = 240.0D0 - 0.80D0 * T(I,J)
!
!      ENDIF
*!*****
!      8. Konig & Walleij
!
!      IF (T(I,J) .GE. 20.0D0 .AND. T(I,J) .LT. 100.0D0) THEN
!
!      P = 118.75D0 - 0.9375D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GE. 100.0D0 .AND. T(I,J) .LE. 300.0D0) THEN
!
!      P = 37.5D0 - 0.125D0 * T(I,J)
!
!      ENDIF
*!*****
!      9. Proposed Model
!
!      IF (T(I,J) .GE. 20.0D0 .AND. T(I,J) .LE. 100.0D0) THEN
!
!      P = 115.0D0 - 0.75D0 * T(I,J)
!
!      ELSEIF (T(I,J) .GT. 100.0D0 .AND. T(I,J) .LE. 250.0D0) THEN
!
!      P = 60.0D0 - 0.20D0 * T(I,J)
!
!      ENDIF
*!=====
!
!      IF (P .GE. 0.0D0) then
!
!      S(I,J) = SIGMA * P/100
!
!      IF (I .EQ. 1) then
!
!      IF (J .EQ. 1) then
!
!      LECC(I,J) = S(I,J) * DY/2.0D0 * DX/2.0D0 * 1000

```

```

ELSEIF (J .EQ. MIDCTRY) then
    LECC(I,J) = S(I,J) * DY/2.0D0 * DX/2.0D0 * 1000
ELSE      !(J is not 1 or MIDCTRY)
    LECC(I,J) = S(I,J) * DY * DX/2.0D0 * 1000
ENDIF

ELSEIF (I .EQ. MIDCTRX) then
    IF (J .EQ. 1) then
        LECC(I,J) = S(I,J) * DY/2.0D0 * DX/2.0D0 * 1000
    ELSEIF (J .EQ. MIDCTRY) then
        LECC(I,J) = S(I,J) * DY/2.0D0 * DX/2.0D0 * 1000
    ELSE      !(J is not 1 or MIDCTRY)
        LECC(I,J) = S(I,J) * DY * DX/2.0D0 * 1000
    ENDIF
ELSE      !(I is not 1 or MIDCTRX)
    IF (J .EQ. 1) then
        LECC(I,J) = S(I,J) * DY/2.0D0 * DX * 1000
    ELSEIF (J .EQ. MIDCTRY) then
        LECC(I,J) = S(I,J) * DY/2.0D0 * DX * 1000
    ELSE      !(J is not 1 or MIDCTRY)
        LECC(I,J) = S(I,J) * DY * DX * 1000
    ENDIF
ENDIF

ELSE
    S(I,J) = 0.0D0
ENDIF

*!      THIS PART CALCULATES ACCUMULATED TOTAL LOAD STUD CAN CARRY
*!      FOR THIS TIME STEP

```

```
        LSCC = LSCC + LECC(I,J)

*!      End of J loop

30      CONTINUE

*!      End of I loop

20      CONTINUE

        LSCC = LSCC * 4.0D0  !stud can carry 4X the LSCC calculated above
                           !because (I,J) is only for 1/4 of stud
                           !(Mirrored along X- and Y-cntrlns of stud)

END
```

APPENDIX III
Sample input data file entitled "Test.dat"

61	-N:number of studs (specimens) to be analyzed
1	-NSTUD:choice of size of stud
43.9188	-SIGMAMN: mean of sample of strengths (MPa)
8.1305	-SIGMASD: standard deviation of sample of strengths
25.00	-TAMB: ambient temperature (degrees Celsius)
250.00	-TEXP: exposure temperature (degrees Celsius)
12.00	-LOAD: compression load to be applied to stud (kN)
120.0000	-TIMEMN: total time of analysis (min)
5.0000	-DT: duration of each time step (seconds)

APPENDIX IV
Sample input data file entitled "WMCRHO.dat"

0014	0.101	490.706
0058	0.104	557.393
0124	0.100	558.486
0131	0.104	560.617
0148	0.105	597.310
0160	0.104	571.635
0173	0.102	505.387
0251	0.101	484.790
0268	0.106	522.785
0277	0.105	502.577
0344	0.103	536.853
0355	0.108	517.469
0375	0.111	527.573
0398	0.104	542.417
0414	0.104	538.348
0417	0.103	597.033
5003	0.099	515.254
5022	0.105	519.745
5034	0.103	444.041
5038	0.099	475.741
5086	0.102	471.071
5105	0.103	494.362
5137	0.092	458.999
5143	0.106	505.896
5182	0.102	485.495
5188	0.103	462.005
5211	0.099	449.877
5234	0.101	494.151
5241	0.097	509.916
5255	0.103	482.074
5272	0.104	470.886
5288	0.101	415.348
5295	0.102	485.552
5301	0.099	444.967
5318	0.098	508.364
5329	0.104	456.418
5333	0.098	433.854
5337	0.100	456.802
5351	0.098	468.373
5399	0.096	561.778
5412	0.102	472.022
5415	0.097	576.003
5524	0.102	546.250
5535	0.107	516.208
8032	0.105	514.640
8041	0.097	512.916
8062	0.097	479.953
8154	0.101	583.487
8191	0.099	497.625
8237	0.099	535.529
8266	0.099	509.873
8300	0.105	536.444
8303	0.102	548.116

8305	0.100	489.175
8320	0.097	500.757
8326	0.097	504.783
8335	0.101	524.140
8341	0.098	460.884
8376	0.097	540.157
8410	0.094	474.647
8438	0.101	522.266

APPENDIX V
Tabulated output from HTE exposure using
Schaffer *et al.* (1986) compression-strength reduction model

Schaffer *et al.* (1986)

150°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
14	36.4	0.101	491	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
58	45.1	0.104	557	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
124	35.8	0.1	558	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
131	41.3	0.104	561	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
148	39.7	0.105	597	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
160	37.4	0.104	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
173	56.6	0.102	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
251	47.1	0.101	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
268	50.8	0.106	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
277	41	0.105	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
344	45.4	0.103	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
355	44.7	0.108	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
375	49.6	0.111	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
398	46.8	0.104	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
414	30.9	0.104	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
417	50.8	0.103	597	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5003	38.2	0.099	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5022	42.6	0.105	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5034	57.9	0.103	444	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5038	34.8	0.099	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5086	33.7	0.102	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5105	45.7	0.103	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5137	43.5	0.092	459	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5143	41.2	0.106	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5182	39.6	0.102	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5188	35.1	0.103	462	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5211	38.5	0.099	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5234	49.6	0.101	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5241	34.9	0.097	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5255	29.5	0.103	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5272	34.9	0.104	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5288	59.3	0.101	415	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5295	45.8	0.102	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5301	36.4	0.099	445	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5318	52.2	0.098	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5329	41.6	0.104	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5333	51.6	0.098	434	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5337	29.8	0.1	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5351	41	0.098	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5399	59.6	0.096	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5412	40	0.102	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5415	39.9	0.097	576	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5524	49	0.102	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5535	39.4	0.107	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8032	39.1	0.105	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8041	29.7	0.097	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8062	39.5	0.097	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8154	33.9	0.101	583	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8191	40.3	0.099	498	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8237	31.1	0.099	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8266	32.6	0.099	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8300	34.2	0.105	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8303	33.2	0.102	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8305	39.3	0.1	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8320	44.5	0.097	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8326	40	0.097	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8335	42.7	0.101	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8341	31.7	0.098	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8376	34.3	0.097	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8410	40.4	0.094	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8438	34.7	0.101	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Schaffer *et al.* (1986)

150°C - 50 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
5	37.8	0.099	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
42	52.6	0.106	596	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
46	37.4	0.108	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
62	36	0.104	554	275
84	44.2	0.102	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
88	36.2	0.1	512	280
112	48.6	0.1	552	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
161	51.2	0.106	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
201	28.7	0.108	565	85
231	41.5	0.106	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
330	31.4	0.106	568	125
413	45.1	0.102	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
426	40.4	0.103	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
434	44.4	0.109	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5018	49.3	0.104	431	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5082	45.7	0.104	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5093	42.6	0.106	491	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5118	47	0.103	459	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5136	40.6	0.104	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5173	40.9	0.1	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5179	33	0.103	495	140
5191	31.9	0.104	485	120
5212	36.7	0.105	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5228	43.6	0.102	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5246	35.2	0.103	461	195
5257	41.7	0.107	469	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5259	36.5	0.097	450	290
5260	48.6	0.102	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5285	30.2	0.1	486	90
5289	34.2	0.101	478	160
5294	42.6	0.109	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5303	40.2	0.106	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5342	40.6	0.101	439	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5373	45.8	0.104	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5387	52.7	0.105	420	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5395	38.6	0.097	560	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5397	30.7	0.098	444	95
5529	31.4	0.098	528	115
5532	34.8	0.103	507	190
8012	40.4	0.102	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8019	49.8	0.103	521	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8052	38.4	0.109	613	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8074	46.6	0.099	466	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8104	36.8	0.105	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8118	36.4	0.097	484	285
8139	35.7	0.099	510	240
8142	27.9	0.097	508	70
8162	37.7	0.102	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8164	38.6	0.101	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8173	35.5	0.098	504	225
8193	51.5	0.103	534	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8200	37.3	0.1	544	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8220	37.3	0.1	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8253	41.5	0.103	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8265	36.7	0.097	527	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8268	62.1	0.099	496	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8276	26.9	0.098	497	55
8298	53.9	0.096	586	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8333	42.8	0.095	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8352	36.2	0.095	489	270
8422	27.8	0.097	519	70

Schaffer *et al.* (1986)

200°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
37	27.4	0.098	547	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
38	38.7	0.097	591	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
48	46.7	0.099	560	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
116	45.5	0.102	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
126	29.6	0.099	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
135	44.2	0.103	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
145	46.3	0.102	534	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
150	52	0.116	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
164	48.8	0.109	589	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
185	61.6	0.113	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
225	37.3	0.118	578	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
256	43.2	0.11	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
261	37.1	0.109	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
281	49.2	0.112	559	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
306	42.3	0.104	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
312	36.3	0.112	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
316	44.8	0.107	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
366	32	0.113	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
377	44.2	0.113	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
378	32.8	0.105	519	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
427	45.7	0.116	500	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5055	46.3	0.104	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5060	34.5	0.113	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5111	47.7	0.107	470	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5123	35.6	0.109	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5124	41.7	0.113	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5166	50.3	0.103	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5171	52.1	0.109	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5239	29.7	0.104	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5251	30.5	0.104	442	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5269	33.2	0.11	443	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5281	30.2	0.108	453	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5306	50.9	0.099	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5310	51.2	0.103	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5328	36.8	0.113	434	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5343	30.1	0.1	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5368	47.1	0.11	413	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5404	40.1	0.1	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5413	36.3	0.122	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5417	39.6	0.11	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8014	42.4	0.101	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8037	54.9	0.103	574	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8047	48	0.114	606	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8054	40.9	0.107	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8070	40.2	0.107	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8071	34.5	0.103	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8072	46.5	0.1	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8091	38.5	0.106	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8095	36.2	0.096	460	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8116	37.6	0.096	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8160	41.9	0.107	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8201	32.6	0.097	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8204	58.5	0.103	491	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8250	32.3	0.097	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8255	31.4	0.108	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8299	37.4	0.113	504	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8347	49.6	0.107	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8372	29.4	0.102	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8377	36.1	0.101	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8393	33.5	0.108	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8443	31.1	0.104	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Schaffer *et al.* (1986)

200°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
21	36.3	0.108	616	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
23	47.2	0.11	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
80	43.2	0.114	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
94	39.7	0.113	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
140	41.7	0.112	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
174	47.1	0.112	488	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
175	37.3	0.118	539	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
227	36	0.106	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
230	46.6	0.115	561	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
286	42.8	0.114	509	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
287	33.2	0.113	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
351	38.6	0.117	521	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
386	42.6	0.107	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
406	34.6	0.109	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
407	38.8	0.112	612	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
425	50.9	0.114	527	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5019	41.4	0.108	451	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5028	40.5	0.108	470	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5125	31.6	0.113	491	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5148	49.4	0.111	483	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5205	39.7	0.112	434	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5209	34.3	0.111	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5221	45.9	0.112	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5291	42.4	0.109	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5296	38.6	0.111	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5311	33.9	0.11	448	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5320	40.4	0.105	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5356	69.1	0.099	416	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5375	46.2	0.12	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5376	42.7	0.113	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5385	42.2	0.11	439	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5401	44.4	0.12	492	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5523	46.9	0.116	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5530	40.8	0.12	554	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8035	41.9	0.108	509	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8049	37.8	0.114	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8058	37.7	0.115	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8065	39.5	0.111	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8066	30.7	0.111	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8080	51.3	0.112	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8096	45.2	0.115	444	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8097	44.3	0.112	586	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8135	38.7	0.112	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8151	40.1	0.111	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8163	38.7	0.106	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8165	50.2	0.11	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8168	31.9	0.116	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8169	41.8	0.112	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8177	32.7	0.114	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8207	48.2	0.108	504	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8216	36.2	0.114	563	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8223	44.3	0.111	555	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8241	30.6	0.107	464	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8247	32.3	0.116	527	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8281	29	0.114	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8294	38.1	0.113	526	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8361	52.8	0.105	518	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8370	46.4	0.107	571	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8373	37.8	0.102	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8417	53.9	0.105	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8430	26.4	0.102	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Schaffer *et al.* (1986)

250°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
39	27.7	0.107	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
85	51.4	0.103	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
90	41.6	0.112	581	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
92	38.8	0.112	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
97	33.7	0.111	609	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
98	42.8	0.11	545	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
111	40.4	0.107	554	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
163	43	0.113	559	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
176	47.7	0.115	555	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
317	50.7	0.109	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
341	49	0.11	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
353	42.4	0.111	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
360	52.3	0.108	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
361	41.4	0.117	509	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
362	41.8	0.109	531	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
430	38.4	0.114	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
436	33.3	0.105	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
438	38.6	0.112	526	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5005	47.7	0.104	453	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5044	37.7	0.111	459	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5053	52.5	0.11	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5061	33.6	0.11	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5088	52.9	0.106	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5104	57.2	0.104	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5144	34.8	0.101	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5150	41.8	0.106	428	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5157	43.3	0.109	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5162	35.8	0.107	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5180	44.7	0.107	420	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5235	39.1	0.104	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5245	47	0.106	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5312	35.2	0.107	443	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5319	40.2	0.109	452	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5365	31.5	0.11	435	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5379	36	0.108	467	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5409	35.1	0.116	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5502	30.4	0.115	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5506	40.4	0.105	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5512	38.5	0.101	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5528	57.4	0.113	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8055	37.1	0.108	570	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8060	38.3	0.107	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8077	68.1	0.105	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8079	45.6	0.11	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8099	27.4	0.106	533	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8102	54.1	0.109	519	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8128	42.3	0.105	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8157	33.7	0.11	474	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8174	33.3	0.104	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8196	43.6	0.102	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8197	30.6	0.102	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8212	43.5	0.108	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8225	46.4	0.109	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8227	43.1	0.115	593	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8254	35.6	0.11	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8258	38.6	0.104	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8263	45.3	0.096	563	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8309	49.6	0.104	532	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8331	43.6	0.107	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8395	38.4	0.107	496	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8400	39.7	0.103	453	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

APPENDIX VI
Tabulated output from HTExposure using
Rykov (1980) compression-strength reduction model

Rykov (1980)

150°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
14	55.6	0.101	491	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
58	49.4	0.104	557	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
124	43.7	0.1	558	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
131	34.8	0.104	561	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
148	46.8	0.105	597	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
160	54.6	0.104	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
173	39.9	0.102	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
251	40.9	0.101	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
268	41.5	0.106	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
277	55.8	0.105	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
344	36.6	0.103	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
355	35.5	0.108	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
375	41.1	0.111	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
398	42.3	0.104	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
414	39.1	0.104	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
417	39.3	0.103	597	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5003	33	0.099	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5022	41.2	0.105	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5034	41.4	0.103	444	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5038	39.8	0.099	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5086	26.3	0.102	471	1345
5105	34.5	0.103	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5137	54.1	0.092	459	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5143	32.6	0.106	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5182	44	0.102	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5188	36.6	0.103	462	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5211	52.1	0.099	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5234	48.5	0.101	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5241	53	0.097	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5255	49.7	0.103	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5272	38.7	0.104	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5288	39	0.101	415	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5295	35.4	0.102	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5301	28.9	0.099	445	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5318	39	0.098	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5329	29.7	0.104	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5333	34.2	0.098	434	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5337	44.9	0.1	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5351	40.3	0.098	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5399	49.7	0.096	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5412	34.5	0.102	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5415	45.6	0.097	576	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5524	28.3	0.102	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5535	43.1	0.107	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8032	34.6	0.105	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8041	40.1	0.097	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8062	50.6	0.097	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8154	38.5	0.101	583	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8191	39	0.099	498	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8237	28.5	0.099	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8266	45.4	0.099	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8300	36.1	0.105	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8303	42.8	0.102	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8305	45.1	0.1	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8320	35	0.097	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8326	34.3	0.097	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8335	32.6	0.101	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8341	33.7	0.098	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8376	48.9	0.097	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8410	39.9	0.094	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8438	36.5	0.101	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Rykov (1980)

150°C - 50 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
5	39.6	0.099	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
42	42.2	0.106	596	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
46	42.5	0.108	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
62	42.4	0.104	554	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
84	39.2	0.102	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
88	37.7	0.1	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
112	30.1	0.1	552	235
161	37.3	0.106	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
201	42.7	0.108	565	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
231	40.8	0.106	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
330	44.7	0.106	568	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
413	46.6	0.102	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
426	48.5	0.103	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
434	41.1	0.109	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5018	45.5	0.104	431	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5082	47.9	0.104	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5093	35.4	0.106	491	1380
5118	43.2	0.103	459	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5136	65.6	0.104	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5173	35	0.1	506	1180
5179	40.5	0.103	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5191	27.8	0.104	485	75
5212	43.9	0.105	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5228	42.4	0.102	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5246	45.9	0.103	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5257	38.7	0.107	469	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5259	41.2	0.097	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5260	43	0.102	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5285	46.8	0.1	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5289	40.3	0.101	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5294	40.2	0.109	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5303	42.6	0.106	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5342	39.5	0.101	439	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5373	53	0.104	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5387	36.3	0.105	420	1655
5395	35.9	0.097	560	1765
5397	44	0.098	444	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5529	34.1	0.098	528	845
5532	42.1	0.103	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8012	28.5	0.102	502	115
8019	44.6	0.103	521	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8052	37	0.109	613	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8074	32.5	0.099	466	425
8104	42.7	0.105	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8118	46.3	0.097	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8139	36.8	0.099	510	2315
8142	39.5	0.097	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8162	41.7	0.102	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8164	30.4	0.101	528	250
8173	56.8	0.098	504	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8193	36	0.103	534	1845
8200	35.4	0.1	544	1485
8220	56.9	0.1	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8253	45.6	0.103	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8265	37.2	0.097	527	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8268	39.8	0.099	496	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8276	42.9	0.098	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8298	35.8	0.096	586	1745
8333	41.6	0.095	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8352	49.9	0.095	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8422	63.7	0.097	519	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Rykov (1980)

200°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
37	33.5	0.098	547	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
38	26.4	0.097	591	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
48	40.8	0.099	560	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
116	34.4	0.102	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
126	43.1	0.099	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
135	34.1	0.103	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
145	45.2	0.102	534	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
150	44.4	0.116	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
164	38.2	0.109	589	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
185	31	0.113	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
225	38.7	0.118	578	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
256	40.4	0.11	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
261	43.4	0.109	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
281	43.2	0.112	559	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
306	49.3	0.104	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
312	45.1	0.112	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
316	55.8	0.107	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
366	42.4	0.113	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
377	29.6	0.113	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
378	55.2	0.105	519	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
427	40.2	0.116	500	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5055	33.6	0.104	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5060	34	0.113	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5111	51.3	0.107	470	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5123	45.7	0.109	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5124	34.9	0.113	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5166	51	0.103	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5171	34.2	0.109	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5239	41	0.104	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5251	44.3	0.104	442	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5269	47.9	0.11	443	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5281	39.6	0.108	453	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5306	40.8	0.099	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5310	47.4	0.103	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5328	34.3	0.113	434	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5343	39.2	0.1	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5368	38	0.11	413	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5404	33.5	0.1	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5413	46	0.122	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5417	42.7	0.11	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8014	34.6	0.101	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8037	41.3	0.103	574	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8047	32.3	0.114	606	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8054	29.7	0.107	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8070	45.3	0.107	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8071	46.9	0.103	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8072	39.9	0.1	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8091	45.2	0.106	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8095	45.1	0.096	460	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8116	42.6	0.096	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8160	61.6	0.107	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8201	41.2	0.097	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8204	50.8	0.103	491	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8250	45.7	0.097	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8255	40.7	0.108	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8299	52.4	0.113	504	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8347	40.2	0.107	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8372	60.2	0.102	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8377	48.5	0.101	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8393	45.6	0.108	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8443	35.7	0.104	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Rykov (1980)

200°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
21	43	0.108	616	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
23	50	0.11	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
80	35.6	0.114	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
94	41.8	0.113	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
140	37.5	0.112	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
174	44.6	0.112	488	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
175	41.1	0.118	539	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
227	44.5	0.106	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
230	47.7	0.115	561	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
286	49.6	0.114	509	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
287	35.1	0.113	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
351	40.9	0.117	521	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
386	46.3	0.107	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
406	53.6	0.109	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
407	45	0.112	612	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
425	46.6	0.114	527	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5019	36.5	0.108	451	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5028	32.7	0.108	470	1685
5125	36.4	0.113	491	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5148	31.2	0.111	483	1360
5205	45.9	0.112	434	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5209	34.5	0.111	471	2250
5221	27.2	0.112	493	530
5291	41.2	0.109	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5296	41.1	0.111	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5311	40.1	0.11	448	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5320	50	0.105	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5356	39.9	0.099	416	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5375	37.5	0.12	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5376	39.7	0.113	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5385	45.5	0.11	439	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5401	34.1	0.12	492	2325
5523	30.6	0.116	507	1295
5530	49.3	0.12	554	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8035	43.1	0.108	509	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8049	52.1	0.114	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8058	45.4	0.115	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8065	39.6	0.111	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8066	45	0.111	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8080	41.8	0.112	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8096	36.8	0.115	444	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8097	24.9	0.112	586	330
8135	37.7	0.112	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8151	32.7	0.111	513	1880
8163	52.3	0.106	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8165	47.9	0.11	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8168	36.9	0.116	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8169	32	0.112	551	1780
8177	33	0.114	484	1895
8207	33.3	0.108	504	1985
8216	40.5	0.114	563	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8223	36.1	0.111	555	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8241	49.9	0.107	464	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8247	43.5	0.116	527	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8281	43.4	0.114	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8294	39	0.113	526	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8361	38.7	0.105	518	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8370	43.2	0.107	571	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8373	43.3	0.102	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8417	33.2	0.105	538	2050
8430	49.8	0.102	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Rykov (1980)

250°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
39	41.2	0.107	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
85	44.2	0.103	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
90	41.7	0.112	581	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
92	38.3	0.112	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
97	41.5	0.111	609	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
98	26.9	0.11	545	1565
111	73.2	0.107	554	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
163	45.8	0.113	559	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
176	40.6	0.115	555	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
317	32.9	0.109	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
341	34.2	0.11	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
353	38.6	0.111	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
360	38	0.108	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
361	41.1	0.117	509	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
362	51.9	0.109	531	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
430	57.6	0.114	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
436	38.3	0.105	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
438	49.1	0.112	526	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5005	40	0.104	453	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5044	42.5	0.111	459	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5053	41.9	0.11	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5061	39	0.11	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5088	33.4	0.106	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5104	36.7	0.104	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5144	32.3	0.101	510	2515
5150	29.8	0.106	428	1540
5157	52.6	0.109	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5162	32.7	0.107	503	2665
5180	42.3	0.107	420	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5235	33.2	0.104	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5245	44.2	0.106	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5312	41.5	0.107	443	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5319	51.7	0.109	452	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5365	29.8	0.11	435	1605
5379	51.6	0.108	467	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5409	32.4	0.116	463	2380
5502	40.8	0.115	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5506	34.8	0.105	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5512	34.5	0.101	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5528	24	0.113	522	1065
8055	40.5	0.108	570	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8060	32.3	0.107	506	2555
8077	40.7	0.105	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8079	45.9	0.11	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8099	48.4	0.106	533	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8102	33	0.109	519	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8128	43.9	0.105	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8157	33	0.11	474	2620
8174	23.3	0.104	530	925
8196	44.8	0.102	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8197	38.1	0.102	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8212	43.8	0.108	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8225	36	0.109	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8227	34.3	0.115	593	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8254	30.5	0.11	548	2230
8258	37.9	0.104	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8263	40.2	0.096	563	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8309	47.3	0.104	532	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8331	62.8	0.107	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8395	43.7	0.107	496	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8400	38.8	0.103	453	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

APPENDIX VII
Tabulated output from HTEposure using
Hosser *et al.* (1994) compression-strength reduction model

Hosser et al (1994)

75°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
28	40	0.094	483	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
55	38.3	0.098	500	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
71	41.7	0.093	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
155	35	0.099	534	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
168	36.1	0.093	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
246	41.6	0.099	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
258	34.6	0.096	544	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
288	35.7	0.094	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
300	34.9	0.095	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
332	52.5	0.096	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
342	47.4	0.092	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
349	37.6	0.095	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
357	32.7	0.093	519	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
369	36.7	0.096	496	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
376	29.6	0.094	599	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
382	69.7	0.098	585	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
401	37.4	0.096	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
412	49.7	0.095	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
1900	54.3	0.096	547	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5083	44.1	0.094	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5092	28.4	0.096	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5100	40.5	0.094	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5108	37.2	0.093	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5147	28.7	0.09	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5149	34.9	0.088	452	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5175	42.9	0.095	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5177	41.8	0.089	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5244	41.8	0.098	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5262	34.4	0.096	441	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5282	47.8	0.091	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5283	39	0.091	398	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5335	36.1	0.089	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5348	41.5	0.09	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5384	41.5	0.092	425	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5402	35.7	0.09	446	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5519	35.5	0.091	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5533	34.4	0.091	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8003	31.4	0.092	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8007	54.7	0.094	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8057	43.1	0.09	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8073	41	0.091	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8083	37.5	0.092	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8107	37.3	0.092	577	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8115	31.8	0.099	460	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8181	35.5	0.093	415	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8187	38.9	0.089	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8264	47.6	0.089	488	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8275	42.5	0.101	573	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8289	40.9	0.091	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8297	37.3	0.096	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8317	28.1	0.087	567	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8337	49.6	0.088	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8338	51.3	0.092	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8340	27.7	0.094	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8343	47	0.089	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8359	61.1	0.094	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8392	35.7	0.09	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8411	44.4	0.092	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8416	38.5	0.093	535	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8429	42.8	0.09	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8436	44.5	0.089	518	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Hosser et al (1994)

75°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
7	40.1	0.099	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
13	45.1	0.095	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
29	38.9	0.091	521	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
83	46.6	0.094	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
121	40.1	0.093	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
192	30.8	0.1	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
200	36.2	0.098	545	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
224	48.3	0.094	492	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
228	32.8	0.093	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
244	40.4	0.096	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
249	54.2	0.093	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
255	45.7	0.1	547	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
267	40.7	0.099	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
271	34.3	0.097	595	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
319	40.5	0.097	558	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
338	40.5	0.096	595	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
359	52.6	0.099	567	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
404	42.3	0.097	533	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
422	58.9	0.095	566	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
423	29.5	0.098	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
428	54.3	0.096	541	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5008	35.9	0.093	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5009	31.4	0.1	467	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5047	37.8	0.101	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5065	41.1	0.097	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5069	35.7	0.095	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5073	48.2	0.096	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5077	37.5	0.097	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5126	57.8	0.094	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5214	37.5	0.093	416	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5223	56.4	0.094	469	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5240	37.6	0.096	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5293	37.2	0.099	454	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5338	49.2	0.093	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5362	46.6	0.097	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5364	41.9	0.093	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5381	60.2	0.092	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5386	36	0.094	446	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5389	37.9	0.093	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5393	42.5	0.095	435	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5400	38.5	0.088	430	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5504	40.6	0.1	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5510	29.2	0.093	560	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5541	33.7	0.094	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8018	45.6	0.096	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8022	30.6	0.097	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8023	41.2	0.092	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8027	36.4	0.093	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8029	42.3	0.092	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8050	33.3	0.097	569	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8075	45.7	0.092	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8145	41.3	0.101	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8176	43.1	0.095	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8228	49	0.098	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8313	43.2	0.095	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8339	29.1	0.094	504	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8342	44.5	0.1	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8382	31.2	0.096	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8425	47.5	0.091	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8431	29.1	0.095	464	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8439	27	0.091	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Hosser et al (1994)

75°C - 50 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
44	30.1	0.094	567	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
50	26.3	0.096	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
74	47.8	0.094	518	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
78	47.6	0.103	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
110	38.7	0.095	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
118	50.8	0.095	532	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
120	37.7	0.097	407	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
169	36.9	0.099	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
184	42.9	0.1	596	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
232R	32.4	0.104	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
259	43.1	0.097	535	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
266	45	0.094	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
273	52.3	0.098	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
279	38.6	0.096	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
293	56.7	0.095	564	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
294	42.2	0.105	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
297	45	0.095	541	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
302	42.5	0.102	555	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
321	44.2	0.099	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
364	34.6	0.106	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
385	40.7	0.096	500	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
399	29.5	0.095	527	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
402	36.7	0.099	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5004	45.5	0.097	440	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5011	42.7	0.099	488	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5026	32.1	0.096	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5042	36.4	0.092	441	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5057	37.7	0.102	436	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5066	46.7	0.099	412	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5068	47.9	0.098	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5079	37.9	0.095	465	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5080	49.8	0.091	429	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5102	34.1	0.098	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5134	35.6	0.101	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5145	33	0.102	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5156	31.2	0.094	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5203	30.3	0.096	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5236	39.2	0.098	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5297	35.5	0.095	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5341	38.2	0.094	467	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5355	32.3	0.1	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5383	53.9	0.095	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5406	40.4	0.092	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5508	37.2	0.102	470	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8028	61.3	0.098	584	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8031	36.7	0.098	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8069	39.8	0.095	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8090	33.4	0.095	605	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8094	38.7	0.1	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8213	41	0.103	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8219	33.8	0.095	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8230	56.1	0.097	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8279	29	0.099	573	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8287	30.8	0.098	569	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8310	39.4	0.097	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8312	37.9	0.095	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8351	41.8	0.1	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8355	33.1	0.095	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8356	37	0.097	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8391	35.8	0.095	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Hosser et al (1994)

150°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
3	32.1	0.097	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
12	38.6	0.108	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
17	46.3	0.102	594	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
19	38.5	0.103	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
45	41.8	0.105	531	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
64	48.2	0.1	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
66	38.2	0.101	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
81	43.1	0.097	615	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
89	38.1	0.097	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
125	42.9	0.097	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
129	51.1	0.099	609	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
136	46.9	0.102	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
199	46.3	0.099	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
223	51.4	0.101	509	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
291	50.7	0.104	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
298	49.7	0.104	557	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
299	43.6	0.103	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
322	43.3	0.102	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
339	59.6	0.106	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
411	45.4	0.108	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
415	48.7	0.103	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
439	37.5	0.108	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5032	35.1	0.103	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5071	31.7	0.102	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5074	40.8	0.112	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5091	33.5	0.097	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5106	34.5	0.099	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5135	39.9	0.115	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5151	52.8	0.1	428	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5154	42.1	0.103	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5164	52	0.103	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5186	33.6	0.102	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5189	32.2	0.098	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5190	30.4	0.103	438	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5249	38.3	0.099	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5267	34.3	0.102	414	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5286	32.3	0.103	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5290	39.5	0.1	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5298	46.7	0.112	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5300	38.1	0.106	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5331	55.5	0.1	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5515	38.6	0.11	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5520	40.8	0.101	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5538	41.7	0.102	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8001	43.7	0.102	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8082	38.9	0.099	570	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8137	35	0.098	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8138	47.8	0.105	462	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8144	35.5	0.102	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8178	35.4	0.1	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8242	33.9	0.101	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8273	32.3	0.105	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8277	53.3	0.101	563	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8307	45.6	0.106	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8316	37.3	0.098	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8319	46.9	0.102	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8330	38.2	0.101	474	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8348	46.7	0.091	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8406	33.8	0.1	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8424	41.1	0.097	483	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Hosser et al. (1994)

150°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
14	38.4	0.101	491	2415
58	34.5	0.104	557	1855
124	41.8	0.1	558	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
131	49.2	0.104	561	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
148	32.3	0.105	597	1545
160	36.3	0.104	572	2270
173	60.3	0.102	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
251	45.5	0.101	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
268	34.5	0.106	523	1780
277	32.8	0.105	503	1410
344	37.9	0.103	537	2505
355	36.7	0.108	517	2220
375	32.8	0.111	528	1520
398	47.7	0.104	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
414	33.6	0.104	538	1625
417	37.8	0.103	597	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5003	27.2	0.099	515	640
5022	40	0.105	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5034	42.4	0.103	444	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5038	50.3	0.099	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5086	47.4	0.102	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5105	35.2	0.103	494	1780
5137	34.5	0.092	459	1450
5143	34.8	0.106	506	1775
5182	38.4	0.102	485	2405
5188	32.2	0.103	462	1205
5211	41.8	0.099	450	3110
5234	55.7	0.101	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5241	37.4	0.097	510	2220
5255	35.1	0.103	482	1735
5272	27.3	0.104	471	610
5288	49.6	0.101	415	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5295	43	0.102	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5301	29.2	0.099	445	765
5318	42.8	0.098	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5329	51	0.104	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5333	33	0.098	434	1220
5337	35.7	0.1	457	1725
5351	48.4	0.098	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5399	46.7	0.096	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5412	45	0.102	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5415	47.7	0.097	576	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5524	37.3	0.102	546	2395
5535	39.1	0.107	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8032	34.4	0.105	515	1715
8041	37.2	0.097	513	2175
8062	39	0.097	480	2445
8154	34.3	0.101	583	1850
8191	45.9	0.099	498	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8237	37.3	0.099	536	2315
8266	31.7	0.099	510	1210
8300	37.9	0.105	536	2555
8303	55.7	0.102	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8305	30.6	0.1	489	1015
8320	35.6	0.097	501	1820
8326	41.4	0.097	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8335	42.2	0.101	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8341	40.3	0.098	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8376	38.4	0.097	540	2560
8410	47.4	0.094	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8438	61.4	0.101	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Hosser et al (1994)

150°C - 50 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
5	52.1	0.099	516	2535
42	41.4	0.106	596	1250
46	36.8	0.108	549	705
62	42.8	0.104	554	1325
84	36.2	0.102	542	645
88	34	0.1	512	490
112	26.8	0.1	552	220
161	35.1	0.106	562	600
201	36.7	0.108	565	720
231	44.7	0.106	543	1560
330	38.7	0.106	568	890
413	37.5	0.102	516	705
426	57.7	0.103	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
434	35.9	0.109	517	615
5018	32.5	0.104	431	365
5082	37.2	0.104	455	615
5093	38.1	0.106	491	735
5118	42.6	0.103	459	1110
5136	40.1	0.104	495	920
5173	48.5	0.1	506	1920
5179	46.7	0.103	495	1675
5191	49.3	0.104	485	2020
5212	53	0.105	458	2510
5228	27.1	0.102	471	200
5246	51.9	0.103	461	2315
5257	37.9	0.107	469	690
5259	38.3	0.097	450	670
5260	30.7	0.102	468	320
5285	37.3	0.1	486	650
5289	36.3	0.101	478	580
5294	32.4	0.109	463	390
5303	36.4	0.106	493	615
5342	31.7	0.101	439	340
5373	50.1	0.104	480	2120
5387	36	0.105	420	510
5395	39.5	0.097	560	930
5397	31.7	0.098	444	340
5529	45.3	0.098	528	1545
5532	36.3	0.103	507	615
8012	40.4	0.102	502	960
8019	42.3	0.103	521	1200
8052	38.1	0.109	613	890
8074	44.2	0.099	466	1270
8104	49.8	0.105	507	2175
8118	29.2	0.097	484	275
8139	43.9	0.099	510	1335
8142	32.6	0.097	508	415
8162	37.5	0.102	536	730
8164	43	0.101	528	1285
8173	40.6	0.098	504	955
8193	42.4	0.103	534	1230
8200	39.4	0.1	544	915
8220	30.9	0.1	471	330
8253	54.2	0.103	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8265	37.4	0.097	527	690
8268	39.7	0.099	496	870
8276	39.2	0.098	497	820
8298	42.4	0.096	586	1295
8333	25.4	0.095	516	165
8352	35.7	0.095	489	545
8422	54	0.097	519	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Hosser et al (1994)

200°C - 12 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
9	34.6	0.11	481	1730
18	45.6	0.114	574	2415
22	33	0.108	522	1800
34	34.2	0.111	501	1795
77	36.5	0.104	511	1830
122	38.3	0.108	462	1735
130	34.1	0.109	512	1810
149	54.5	0.114	533	2410
186	40.1	0.111	520	2035
187	51.6	0.112	517	2270
193	44.2	0.11	502	2045
196	44.3	0.11	572	2330
202	48.5	0.111	544	2315
210	52.1	0.111	474	2075
226	48.4	0.11	498	2105
242	40.5	0.106	601	2290
262	41.7	0.115	463	1885
307	44.2	0.111	542	2220
313	43.9	0.113	521	2150
367	46.8	0.111	558	2340
372	48	0.111	552	2340
394	36.4	0.108	523	1915
440	42.1	0.111	492	1970
5001	49.8	0.112	440	1900
5024	39.1	0.11	451	1735
5033	30.2	0.11	535	1760
5046	50.9	0.11	433	1865
5070	44.2	0.112	468	1925
5076	36.5	0.111	473	1760
5090	40.4	0.112	485	1915
5098	54.1	0.11	493	2180
5127	45.8	0.102	499	1975
5131	44.3	0.107	473	1900
5141	37.3	0.112	476	1805
5227	40.9	0.118	427	1750
5250	32.6	0.107	451	1535
5358	39.6	0.113	492	1935
5382	47	0.108	447	1845
5513	36.5	0.109	484	1785
5526	26.6	0.113	489	1490
8033	36.1	0.112	562	2085
8045	38.2	0.111	493	1880
8046	40.1	0.109	601	2315
8053	40	0.112	505	1990
8061	40.1	0.111	539	2110
8103	33.4	0.117	591	2145
8110	28	0.112	517	1630
8134	35.1	0.113	479	1765
8136	48.4	0.112	474	2030
8171	35.9	0.114	447	1675
8210	65	0.105	506	2310
8251	49.5	0.114	544	2370
8267	42.8	0.111	523	2110
8288	48.8	0.106	459	1910
8290	42.8	0.112	487	1980
8291	36.4	0.119	498	1930
8321	31.7	0.108	553	1855
8367	45	0.106	517	2080
8388	52.5	0.117	512	2320
8444	32.1	0.109	548	1865
8445	28.4	0.111	531	1680

Hosser et al. (1994)

200°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
37	33.9	0.098	547	910
38	42.8	0.097	591	1300
48	46.6	0.099	560	1360
116	47.8	0.102	512	1295
126	46.7	0.099	562	1365
135	42.7	0.103	537	1220
145	38	0.102	534	1055
150	39.1	0.116	499	1100
164	25.3	0.109	589	615
185	35.3	0.113	516	985
225	42.7	0.118	578	1415
256	34.3	0.11	540	975
261	27.7	0.109	551	695
281	30.2	0.112	559	835
306	46.9	0.104	485	1225
312	40.4	0.112	529	1185
316	39.4	0.107	525	1115
366	42	0.113	543	1280
377	32.1	0.113	506	840
378	32	0.105	519	820
427	38.9	0.116	500	1095
5055	32.7	0.104	468	765
5060	47.4	0.113	471	1260
5111	41.2	0.107	470	1050
5123	46.7	0.109	506	1305
5124	36	0.113	517	1010
5166	58.1	0.103	457	1370
5171	57.3	0.109	487	1490
5239	54	0.104	478	1360
5251	43.3	0.104	442	1030
5269	38.7	0.11	443	940
5281	28.5	0.108	453	600
5306	40.7	0.099	450	955
5310	48.3	0.103	543	1395
5328	35.4	0.113	434	830
5343	50.7	0.1	502	1325
5368	45.6	0.11	413	1045
5404	48.6	0.1	482	1225
5413	32.5	0.122	493	870
5417	35	0.11	506	940
8014	38.3	0.101	502	1000
8037	42.9	0.103	574	1310
8047	40.9	0.114	606	1385
8054	38.3	0.107	490	1010
8070	31.3	0.107	501	775
8071	30.3	0.103	477	690
8072	45.9	0.1	514	1240
8091	46.7	0.106	475	1205
8095	46.3	0.096	460	1095
8116	54.1	0.096	455	1240
8160	35.7	0.107	520	975
8201	39.9	0.097	536	1095
8204	30.7	0.103	491	725
8250	32.6	0.097	510	800
8255	45.7	0.108	528	1325
8299	43.7	0.113	504	1240
8347	42	0.107	513	1175
8372	34.9	0.102	473	840
8377	31.7	0.101	543	830
8393	49	0.108	477	1280
8443	41	0.104	507	1110

Hosser et al (1994)

200°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
21	38.6	0.108	616	680
23	38.7	0.11	575	650
80	37.6	0.114	499	545
94	33.6	0.113	528	460
140	38.9	0.112	525	605
174	30	0.112	488	340
175	31.3	0.118	539	415
227	37.3	0.106	512	530
230	33.9	0.115	561	500
286	39.2	0.114	509	600
287	52.2	0.113	548	1040
351	50.5	0.117	521	965
386	32.7	0.107	551	445
406	35.3	0.109	525	495
407	30.9	0.112	612	445
425	43.1	0.114	527	750
5019	52	0.108	451	835
5028	47	0.108	470	750
5125	28.1	0.113	491	300
5148	34.6	0.111	483	445
5205	32.7	0.112	434	360
5209	26	0.111	471	235
5221	42.2	0.112	493	665
5291	49	0.109	461	790
5296	39.3	0.111	475	560
5311	30.9	0.11	448	330
5320	57.5	0.105	458	950
5356	29.2	0.099	416	260
5375	40.8	0.12	468	615
5376	31.2	0.113	494	370
5385	29.7	0.11	439	295
5401	43.7	0.12	492	735
5523	47.1	0.116	507	845
5530	49.4	0.12	554	1005
8035	40.7	0.108	509	630
8049	33.4	0.114	538	465
8058	37.9	0.115	479	535
8065	52.2	0.111	522	980
8066	47.4	0.111	503	825
8080	40	0.112	490	595
8096	31.7	0.115	444	350
8097	33	0.112	586	485
8135	31.4	0.112	530	405
8151	41.2	0.111	513	660
8163	44.3	0.106	513	735
8165	43.9	0.11	468	675
8168	32.3	0.116	476	390
8169	39.9	0.112	551	665
8177	35.6	0.114	484	475
8207	49.4	0.108	504	870
8216	56.7	0.114	563	1195
8223	46.8	0.111	555	890
8241	45.6	0.107	464	700
8247	37.6	0.116	527	575
8281	40	0.114	493	605
8294	32.9	0.113	526	440
8361	47.4	0.105	518	820
8370	35.9	0.107	571	550
8373	36.2	0.102	501	480
8417	46.7	0.105	538	835
8430	39.3	0.102	508	570

Hosser et al (1994)

250°C - 12 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
63	39.1	0.099	537	1065
167	39.1	0.105	548	1120
172	44.6	0.1	479	1015
188	45.6	0.109	590	1325
189	33	0.108	575	1090
204	46.3	0.108	552	1240
263	40.2	0.103	471	965
272	45.9	0.101	588	1270
296	32.1	0.101	530	950
324	46.1	0.106	552	1230
326	37.2	0.103	531	1050
345	50.5	0.104	517	1180
374	43	0.102	555	1170
390	36.9	0.111	518	1060
396	51.7	0.105	512	1185
416	35.5	0.1	508	960
5002	37.9	0.099	439	850
5029	58.4	0.108	443	1085
5048	43.2	0.101	497	1045
5056	43.7	0.11	501	1110
5064	37.2	0.099	454	875
5099	33.6	0.111	543	1055
5114	35.2	0.101	459	865
5117	49.8	0.103	490	1105
5121	47.1	0.103	454	1000
5159	31.2	0.108	487	890
5215	54.1	0.103	488	1135
5217	41	0.101	415	845
5254	42.7	0.094	434	870
5274	32.4	0.103	494	900
5307	33.3	0.107	462	875
5323	46.9	0.105	471	1045
5324	41.9	0.101	467	965
5354	45.6	0.107	471	1045
5394	30.6	0.104	458	810
5517	49.7	0.098	482	1055
5539	49.2	0.103	545	1225
8005	34.3	0.104	505	955
8021	42	0.101	487	1010
8068	42.1	0.104	501	1055
8086	34.5	0.106	618	1190
8108	37.3	0.102	498	980
8109	41.3	0.111	504	1090
8161	62.3	0.104	564	1390
8190	34.3	0.103	534	1010
8199	51.2	0.103	528	1205
8202	32.1	0.104	546	995
8218	31.3	0.101	472	830
8239	38.5	0.101	478	950
8270	50	0.102	517	1165
8292	45.6	0.105	543	1195
8301	43.8	0.112	513	1150
8311	39.9	0.101	574	1165
8334	48	0.099	476	1035
8344	38.6	0.104	522	1055
8383	34.6	0.1	505	940
8396	45	0.107	516	1140
8403	48.8	0.107	540	1235
8407	35.8	0.104	515	1000
8414	39.8	0.099	499	995
8437	33.9	0.102	475	880

Hosser et al. (1994)

250°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
39	29.4	0.107	572	470
85	45.1	0.103	525	710
90	46.2	0.112	581	840
92	39.9	0.112	510	635
97	34.2	0.111	609	630
98	49.8	0.11	545	830
111	49.7	0.107	554	830
163	38.7	0.113	559	675
176	41.8	0.115	555	735
317	43.1	0.109	501	665
341	39.3	0.11	513	625
353	59.9	0.111	480	845
360	36.1	0.108	502	550
361	30.8	0.117	509	470
362	36.5	0.109	531	590
430	36.9	0.114	475	545
436	41.8	0.105	505	640
438	39.6	0.112	526	650
5005	36.9	0.104	453	495
5044	51.2	0.111	459	720
5053	51.7	0.11	479	755
5061	32.3	0.11	493	470
5088	37.4	0.106	517	585
5104	39.3	0.104	457	535
5144	43.3	0.101	510	655
5150	26.2	0.106	428	300
5157	57.7	0.109	473	805
5162	49	0.107	503	745
5180	49.1	0.107	420	620
5235	42.6	0.104	487	625
5245	32.7	0.106	495	470
5312	35.5	0.107	443	470
5319	44.1	0.109	452	615
5365	25.5	0.11	435	295
5379	27.5	0.108	467	355
5409	37.7	0.116	463	550
5502	57.9	0.115	487	855
5506	37	0.105	543	605
5512	34.1	0.101	505	495
5528	42.5	0.113	522	700
8055	44.3	0.108	570	775
8060	49.6	0.107	506	755
8077	30.9	0.105	482	425
8079	37.3	0.11	503	575
8099	22.9	0.106	533	300
8102	35.7	0.109	519	565
8128	30.4	0.105	479	410
8157	49.2	0.11	474	715
8174	33.3	0.104	530	515
8196	42.6	0.102	520	665
8197	44	0.102	538	705
8212	40	0.108	495	610
8225	40.5	0.109	536	670
8227	25.7	0.115	593	415
8254	39.1	0.11	548	665
8258	35.9	0.104	524	555
8263	43.5	0.096	563	710
8309	45.1	0.104	532	720
8331	38	0.107	486	560
8395	24.1	0.107	496	305
8400	47.1	0.103	453	635

APPENDIX VIII
Tabulated output from HTEposure using
König & Walleij (1986) compression-strength reduction model

Konig & Walleij (2000)

75°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
28	42.8	0.094	483	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
55	36	0.098	500	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
71	35.9	0.093	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
155	45.4	0.099	534	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
168	37.3	0.093	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
246	43.7	0.099	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
258	33.9	0.096	544	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
288	38.4	0.094	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
300	25.5	0.095	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
332	40.6	0.096	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
342	43.1	0.092	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
349	33.7	0.095	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
357	30.2	0.093	519	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
369	32	0.096	496	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
376	36.2	0.094	599	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
382	35.6	0.098	585	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
401	46.4	0.096	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
412	53.1	0.095	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
1900	38.2	0.096	547	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5083	57.6	0.094	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5092	31.4	0.096	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5100	36.1	0.094	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5108	43.7	0.093	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5147	44.2	0.09	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5149	44.5	0.088	452	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5175	43.7	0.095	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5177	36	0.089	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5244	39.6	0.098	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5262	41.2	0.096	441	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5282	32.2	0.091	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5283	38.8	0.091	398	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5335	54.7	0.089	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5348	42.6	0.09	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5384	46.7	0.092	425	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5402	45.6	0.09	446	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5519	40	0.091	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5533	29.4	0.091	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8003	41.5	0.092	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8007	30.8	0.094	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8057	29.2	0.09	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8073	38.9	0.091	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8083	51	0.092	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8107	37.4	0.092	577	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8115	31.2	0.099	460	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8181	47.3	0.093	415	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8187	29	0.089	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8264	54	0.089	488	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8275	41.8	0.101	573	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8289	47	0.091	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8297	33.8	0.096	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8317	59.1	0.087	567	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8337	39.5	0.088	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8338	31.7	0.092	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8340	43.5	0.094	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8343	30	0.089	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8359	41.3	0.094	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8392	35.3	0.09	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8411	33.8	0.092	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8416	40.1	0.093	535	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8429	46.1	0.09	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8436	41	0.089	518	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Konig & Walleij (2000)

75°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
7	52	0.099	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
13	28.9	0.095	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
29	30.8	0.091	521	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
83	48.9	0.094	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
121	47.2	0.093	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
192	30.6	0.1	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
200	29.1	0.098	545	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
224	43.3	0.094	492	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
228	43.4	0.093	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
244	32.3	0.096	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
249	39.3	0.093	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
255	56.5	0.1	547	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
267	28	0.099	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
271	40.9	0.097	595	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
319	40.8	0.097	558	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
338	38.4	0.096	595	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
359	39.1	0.099	567	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
404	26.2	0.097	533	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
422	35.7	0.095	566	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
423	38.4	0.098	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
428	47.6	0.096	541	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5008	38.1	0.093	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5009	36.1	0.1	467	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5047	39.9	0.101	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5065	39.4	0.097	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5069	44.1	0.095	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5073	59.3	0.096	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5077	39.6	0.097	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5126	33	0.094	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5214	36.5	0.093	416	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5223	66.6	0.094	469	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5240	44.6	0.096	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5293	30.3	0.099	454	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5338	28.1	0.093	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5362	45.2	0.097	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5364	52.6	0.093	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5381	30.9	0.092	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5386	43	0.094	446	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5389	53.3	0.093	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5393	34.4	0.095	435	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5400	43	0.088	430	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5504	33.7	0.1	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5510	42.4	0.093	560	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5541	42.3	0.094	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8018	46.4	0.096	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8022	40.8	0.097	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8023	37.5	0.092	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8027	32.6	0.093	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8029	38.1	0.092	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8050	57.5	0.097	569	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8075	40.6	0.092	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8145	28.2	0.101	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8176	45.8	0.095	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8228	30.3	0.098	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8313	42.6	0.095	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8339	41.9	0.094	504	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8342	22.1	0.1	505	835
8382	37.7	0.096	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8425	37.4	0.091	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8431	43.9	0.095	464	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8439	43.5	0.091	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Konig & Walleij (2000)
75°C - 50 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
44	47	0.094	567	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
50	46.1	0.096	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
74	36.1	0.094	518	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
78	44.3	0.103	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
110	48.3	0.095	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
118	33.1	0.095	532	2130
120	43.5	0.097	407	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
169	46	0.099	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
184	37.7	0.1	596	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
232R	37.1	0.104	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
259	48	0.097	535	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
266	44.3	0.094	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
273	29.8	0.098	493	800
279	35.1	0.096	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
293	48.3	0.095	564	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
294	25.2	0.105	512	350
297	49.8	0.095	541	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
302	33.8	0.102	555	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
321	35.8	0.099	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
364	42.4	0.106	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
385	35.8	0.096	500	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
399	37.5	0.095	527	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
402	42.1	0.099	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5004	27.5	0.097	440	485
5011	55.4	0.099	488	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5026	35.1	0.096	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5042	43.6	0.092	441	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5057	45.9	0.102	436	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5066	37.8	0.099	412	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5068	38.5	0.098	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5079	55.2	0.095	465	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5080	47.7	0.091	429	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5102	42.2	0.098	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5134	42	0.101	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5145	49.8	0.102	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5156	42.2	0.094	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5203	40	0.096	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5236	36.9	0.098	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5297	40.3	0.095	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5341	47.6	0.094	467	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5355	45.6	0.1	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5383	39	0.095	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5406	50.3	0.092	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5508	45.5	0.102	470	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8028	45.3	0.098	584	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8031	44.4	0.098	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8069	30	0.095	461	785
8090	36.9	0.095	605	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8094	64.3	0.1	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8213	40.7	0.103	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8219	36.8	0.095	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8230	43.8	0.097	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8279	42.6	0.099	573	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8287	48.8	0.098	569	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8310	30.1	0.097	455	795
8312	45.2	0.095	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8351	34.7	0.1	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8355	53.3	0.095	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8356	44.3	0.097	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8391	46.1	0.095	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Konig & Walleij (2000)

150°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
3	47.5	0.097	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
12	37.8	0.108	485	1180
17	36.6	0.102	594	975
19	29.4	0.103	524	470
45	30.3	0.105	531	510
64	63.8	0.1	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
66	42.4	0.101	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
81	45.8	0.097	615	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
89	30.9	0.097	514	500
125	44.3	0.097	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
129	48.4	0.099	609	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
136	44.4	0.102	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
199	36.1	0.099	516	745
223	37.5	0.101	509	1080
291	35	0.104	551	705
298	27.8	0.104	557	450
299	38.2	0.103	499	1295
322	34.5	0.102	515	640
339	41.9	0.106	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
411	32.3	0.108	514	560
415	50.1	0.103	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
439	55.5	0.108	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5032	31.5	0.103	528	540
5071	61.8	0.102	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5074	41.8	0.112	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5091	49.1	0.097	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5106	32.3	0.099	455	490
5135	40.4	0.115	471	2365
5151	39.3	0.1	428	1475
5154	37.7	0.103	485	1110
5164	40.9	0.103	473	2535
5186	44.7	0.102	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5189	38.8	0.098	468	1395
5190	38.1	0.103	438	1125
5249	44.5	0.099	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5267	43.5	0.102	414	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5286	28.6	0.103	484	420
5290	34.3	0.1	495	605
5298	40.6	0.112	455	2385
5300	39.9	0.106	523	2145
5331	46.5	0.1	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5515	44	0.11	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5520	42	0.101	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5538	31.9	0.102	508	535
8001	43.3	0.102	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8082	36.2	0.099	570	825
8137	66.8	0.098	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8138	53.6	0.105	462	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8144	35	0.102	549	700
8178	46.9	0.1	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8242	34.7	0.101	494	620
8273	41.6	0.105	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8277	51.6	0.101	563	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8307	40	0.106	490	2065
8316	66.5	0.098	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8319	48.9	0.102	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8330	38.7	0.101	474	1425
8348	45.4	0.091	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8406	40.7	0.1	549	2650
8424	42.8	0.097	483	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Konig & Walleij (2000)
150°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
14	36.6	0.101	491	335
58	36.9	0.104	557	380
124	41.1	0.1	558	450
131	59.6	0.104	561	2470
148	40	0.105	597	460
160	36.9	0.104	572	385
173	40.7	0.102	505	410
251	35.8	0.101	485	320
268	42.2	0.106	523	450
277	49.6	0.105	503	585
344	28.5	0.103	537	225
355	36.7	0.108	517	360
375	40.3	0.111	528	430
398	33.1	0.104	542	305
414	42.7	0.104	538	465
417	43	0.103	597	510
5003	32.6	0.099	515	280
5022	50.3	0.105	520	625
5034	36	0.103	444	300
5038	36.9	0.099	476	330
5086	33.6	0.102	471	280
5105	45.4	0.103	494	485
5137	36.2	0.092	459	300
5143	48.9	0.106	506	575
5182	33.1	0.102	485	280
5188	40.3	0.103	462	375
5211	42.7	0.099	450	395
5234	22.1	0.101	494	110
5241	36.3	0.097	510	335
5255	30.4	0.103	482	235
5272	36.5	0.104	471	325
5288	45.3	0.101	415	415
5295	45.4	0.102	486	475
5301	41	0.099	445	365
5318	50.9	0.098	508	615
5329	34.6	0.104	456	290
5333	38.8	0.098	434	330
5337	46.6	0.1	457	470
5351	47.3	0.098	468	495
5399	51.2	0.096	562	680
5412	46.1	0.102	472	480
5415	32.4	0.097	576	300
5524	43.6	0.102	546	490
5535	26.6	0.107	516	190
8032	45	0.105	515	495
8041	36.1	0.097	513	335
8062	49.1	0.097	480	540
8154	43.5	0.101	583	510
8191	35.4	0.099	498	320
8237	55.2	0.099	536	1065
8266	46.2	0.099	510	510
8300	54.4	0.105	536	945
8303	41	0.102	548	440
8305	29.9	0.1	489	225
8320	36.6	0.097	501	335
8326	38.7	0.097	505	370
8335	36.2	0.101	524	345
8341	47.8	0.098	461	495
8376	37.8	0.097	540	380
8410	43.3	0.094	475	420
8438	34.7	0.101	522	320

Konig & Walleij (2000)
150°C - 50 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
14	36.6	0.101	491	185
58	36.9	0.104	557	210
124	41.1	0.1	558	260
131	59.6	0.104	561	510
148	40	0.105	597	265
160	36.9	0.104	572	215
173	40.7	0.102	505	240
251	35.8	0.101	485	175
268	42.2	0.106	523	265
277	49.6	0.105	503	345
344	28.5	0.103	537	100
355	36.7	0.108	517	200
375	40.3	0.111	528	250
398	33.1	0.104	542	160
414	42.7	0.104	538	275
417	43	0.103	597	305
5003	32.6	0.099	515	145
5022	50.3	0.105	520	365
5034	36	0.103	444	165
5038	36.9	0.099	476	185
5086	33.6	0.102	471	150
5105	45.4	0.103	494	290
5137	36.2	0.092	459	165
5143	48.9	0.106	506	340
5182	33.1	0.102	485	145
5188	40.3	0.103	462	215
5211	42.7	0.099	450	235
5234	22.1	0.101	494	25
5241	36.3	0.097	510	185
5255	30.4	0.103	482	115
5272	36.5	0.104	471	180
5288	45.3	0.101	415	250
5295	45.4	0.102	486	285
5301	41	0.099	445	215
5318	50.9	0.098	508	360
5329	34.6	0.104	456	155
5333	38.8	0.098	434	185
5337	46.6	0.1	457	285
5351	47.3	0.098	468	295
5399	51.2	0.096	562	390
5412	46.1	0.102	472	285
5415	32.4	0.097	576	155
5524	43.6	0.102	546	290
5535	26.6	0.107	516	70
8032	45	0.105	515	295
8041	36.1	0.097	513	185
3062	49.1	0.097	480	320
8154	43.5	0.101	583	305
8191	35.4	0.099	498	175
8237	55.2	0.099	536	425
8266	46.2	0.099	510	305
8300	54.4	0.105	536	425
8303	41	0.102	548	260
8305	29.9	0.1	489	110
8320	36.6	0.097	501	185
8326	38.7	0.097	505	210
8335	36.2	0.101	524	190
8341	47.8	0.098	461	295
8376	37.8	0.097	540	215
8410	43.3	0.094	475	250
8438	34.7	0.101	522	175

Konig & Walleij (2000)

200°C - 12 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
9	48.9	0.11	481	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
18	40.9	0.114	574	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
22	32.7	0.108	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
34	41.5	0.111	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
77	36.4	0.104	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
122	27.9	0.108	462	2290
130	48.4	0.109	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
149	28	0.114	533	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
186	33.7	0.111	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
187	31.3	0.112	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
193	36.7	0.11	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
196	43.4	0.11	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
202	34.5	0.111	544	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
210	40.3	0.111	474	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
226	36.8	0.11	498	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
242	32	0.106	601	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
262	38	0.115	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
307	33.2	0.111	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
313	42.3	0.113	521	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
367	38.7	0.111	558	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
372	50.4	0.111	552	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
394	39.4	0.108	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
440	39	0.111	492	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5001	48.8	0.112	440	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5024	36.3	0.11	451	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5033	44.3	0.11	535	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5046	71.2	0.11	433	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5070	44.2	0.112	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5076	34.8	0.111	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5090	36.9	0.112	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5098	33.5	0.11	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5127	33.2	0.102	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5131	32.3	0.107	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5141	32.2	0.112	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5227	43.9	0.118	427	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5250	58.8	0.107	451	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5358	46.3	0.113	492	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5382	42.4	0.108	447	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5513	44.2	0.109	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5526	33.7	0.113	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8033	42.6	0.112	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8045	53.1	0.111	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8046	42.4	0.109	601	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8053	38.5	0.112	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8061	36.3	0.111	539	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8103	40.1	0.117	591	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8110	43.2	0.112	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8134	38.1	0.113	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8136	44	0.112	474	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8171	36.8	0.114	447	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8210	54.8	0.105	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8251	28.8	0.114	544	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8267	38.3	0.111	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8288	29.1	0.106	459	2510
8290	39.9	0.112	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8291	38.9	0.119	498	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8321	41.7	0.108	553	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8367	31.6	0.106	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8388	43.7	0.117	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8444	39.5	0.109	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8445	39.5	0.111	531	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Konig & Walleij (2000)

200°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
14	36.6	0.101	490.706	420
58	36.9	0.104	557.393	480
124	41.1	0.1	558.486	620
131	59.6	0.104	560.617	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
148	40	0.105	597.31	
160	36.9	0.104	571.635	
173	40.7	0.102	505.387	
251	35.8	0.101	484.79	
268	42.2	0.106	522.785	
277	49.6	0.105	502.577	
344	28.5	0.103	536.853	
355	36.7	0.108	517.469	
375	40.3	0.111	527.573	
398	33.1	0.104	542.417	
414	42.7	0.104	538.348	
417	43	0.103	597.033	
5003	32.6	0.099	515.254	
5022	50.3	0.105	519.745	
5034	36	0.103	444.041	
5038	36.9	0.099	475.741	
5086	33.6	0.102	471.071	355
5105	45.4	0.103	494.362	945
5137	36.2	0.092	458.999	375
5143	48.9	0.106	505.896	1365
5182	33.1	0.102	485.495	355
5188	40.3	0.103	462.005	485
5211	42.7	0.099	449.877	620
5234	22.1	0.101	494.151	195
5241	36.3	0.097	509.916	425
5255	30.4	0.103	482.074	315
5272	36.5	0.104	470.886	405
5288	45.3	0.101	415.348	780
5295	45.4	0.102	485.552	920
5301	41	0.099	444.967	490
5318	50.9	0.098	508.364	1530
5329	34.6	0.104	456.418	360
5333	38.8	0.098	433.854	410
5337	46.6	0.1	456.802	965
5351	47.3	0.098	468.373	1055
5399	51.2	0.096	561.778	1715
5412	46.1	0.102	472.022	965
5415	32.4	0.097	576.003	395
5524	43.6	0.102	546.25	850
5535	26.6	0.107	516.208	275
8032	45	0.105	514.64	950
8041	36.1	0.097	512.916	420
8062	49.1	0.097	479.953	1250
8154	43.5	0.101	583.487	890
8191	35.4	0.099	497.625	400
8237	55.2	0.099	535.529	2170
8266	46.2	0.099	509.873	1035
8300	54.4	0.105	536.444	2145
8303	41	0.102	548.116	605
8305	29.9	0.1	489.175	310
8320	36.6	0.097	500.757	420
8326	38.7	0.097	504.783	470
8335	36.2	0.101	524.14	440
8341	47.8	0.098	460.884	1080
8376	37.8	0.097	540.157	480
8410	43.3	0.094	474.647	680
8438	34.7	0.101	522.266	405

Konig & Walleij (2000)

200°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
14	36.6	0.101	491	230
58	36.9	0.104	557	265
124	41.1	0.1	558	310
131	59.6	0.104	561	585
148	40	0.105	597	320
160	36.9	0.104	572	270
173	40.7	0.102	505	280
251	35.8	0.101	485	220
268	42.2	0.106	523	310
277	49.6	0.105	503	380
344	28.5	0.103	537	160
355	36.7	0.108	517	250
375	40.3	0.111	528	295
398	33.1	0.104	542	220
414	42.7	0.104	538	325
417	43	0.103	597	355
5003	32.6	0.099	515	200
5022	50.3	0.105	520	400
5034	36	0.103	444	210
5038	36.9	0.099	476	230
5086	33.6	0.102	471	195
5105	45.4	0.103	494	325
5137	36.2	0.092	459	210
5143	48.9	0.106	506	375
5182	33.1	0.102	485	195
5188	40.3	0.103	462	260
5211	42.7	0.099	450	270
5234	22.1	0.101	494	75
5241	36.3	0.097	510	235
5255	30.4	0.103	482	170
5272	36.5	0.104	471	225
5288	45.3	0.101	415	275
5295	45.4	0.102	486	320
5301	41	0.099	445	250
5318	50.9	0.098	508	385
5329	34.6	0.104	456	200
5333	38.8	0.098	434	225
5337	46.6	0.1	457	315
5351	47.3	0.098	468	325
5399	51.2	0.096	562	425
5412	46.1	0.102	472	320
5415	32.4	0.097	576	215
5524	43.6	0.102	546	335
5535	26.6	0.107	516	135
8032	45	0.105	515	335
8041	36.1	0.097	513	235
8062	49.1	0.097	480	350
8154	43.5	0.101	583	350
8191	35.4	0.099	498	220
8237	55.2	0.099	536	465
8266	46.2	0.099	510	340
8300	54.4	0.105	536	465
8303	41	0.102	548	305
8305	29.9	0.1	489	165
8320	36.6	0.097	501	235
8326	38.7	0.097	505	255
8335	36.2	0.101	524	240
8341	47.8	0.098	461	325
8376	37.8	0.097	540	260
8410	43.3	0.094	475	285
8438	34.7	0.101	522	225

Konig & Walleij (2000)

250°C - 12 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
63	47.1	0.099	537	2595
167	37.6	0.105	548	1765
172	34.7	0.1	479	1335
188	46.1	0.109	590	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
189	44.4	0.108	575	2525
204	43	0.108	552	2255
263	39.6	0.103	471	1605
272	36.1	0.101	588	1760
296	41.3	0.101	530	1945
324	31.7	0.106	552	1365
326	37.5	0.103	531	1690
345	45.8	0.104	517	2375
374	42.3	0.102	555	2150
390	46.3	0.111	518	2485
396	38.2	0.105	512	1680
416	28.2	0.1	508	935
5002	39.8	0.099	439	1470
5029	40.7	0.108	443	1600
5048	47.9	0.101	497	2495
5056	54.6	0.11	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5064	38.2	0.099	454	1435
5099	48.7	0.111	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5114	31	0.101	459	1045
5117	34.7	0.103	490	1385
5121	41.2	0.103	454	1645
5159	28.3	0.108	487	945
5215	32.3	0.103	488	1220
5217	45	0.101	415	1775
5254	45.1	0.094	434	1665
5274	41	0.103	494	1795
5307	33.9	0.107	462	1280
5323	42.7	0.105	471	1855
5324	28.2	0.101	467	860
5354	32.4	0.107	471	1205
5394	49.2	0.104	458	2440
5517	45.9	0.098	482	2165
5539	48.5	0.103	545	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8005	56.4	0.104	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8021	48.9	0.101	487	2560
8068	39.5	0.104	501	1715
8086	31.7	0.106	618	1525
8108	30.2	0.102	498	1090
8109	47.4	0.111	504	2540
8161	37.4	0.104	564	1800
8190	38.9	0.103	534	1785
8199	33.3	0.103	528	1400
8202	45.8	0.104	546	2515
8218	27.9	0.101	472	845
8239	40.3	0.101	478	1660
8270	37	0.102	517	1610
8292	42.3	0.105	543	2120
8301	31.7	0.112	513	1300
8311	32.3	0.101	574	1430
8334	34.6	0.099	476	1310
8344	45.9	0.104	522	2405
8383	33.4	0.1	505	1320
8396	49.4	0.107	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8403	55.9	0.107	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8407	46.1	0.104	515	2400
8414	46.7	0.099	499	2350
8437	45.3	0.102	475	2105

Konig & Walleij (2000)
250°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
14	36.6	0.101	491	315
58	36.9	0.104	557	360
124	41.1	0.1	558	415
131	59.6	0.104	561	1095
148	40	0.105	597	430
160	36.9	0.104	572	370
173	40.7	0.102	505	375
251	35.8	0.101	485	300
268	42.2	0.106	523	415
277	49.6	0.105	503	590
344	28.5	0.103	537	255
355	36.7	0.108	517	340
375	40.3	0.111	528	400
398	33.1	0.104	542	310
414	42.7	0.104	538	425
417	43	0.103	597	470
5003	32.6	0.099	515	285
5022	50.3	0.105	520	635
5034	36	0.103	444	280
5038	36.9	0.099	476	310
5086	33.6	0.102	471	275
5105	45.4	0.103	494	435
5137	36.2	0.092	459	280
5143	48.9	0.106	506	570
5182	33.1	0.102	485	280
5188	40.3	0.103	462	340
5211	42.7	0.099	450	355
5234	22.1	0.101	494	160
5241	36.3	0.097	510	320
5255	30.4	0.103	482	250
5272	36.5	0.104	471	305
5288	45.3	0.101	415	365
5295	45.4	0.102	486	425
5301	41	0.099	445	330
5318	50.9	0.098	508	625
5329	34.6	0.104	456	280
5333	38.8	0.098	434	300
5337	46.6	0.1	457	420
5351	47.3	0.098	468	450
5399	51.2	0.096	562	700
5412	46.1	0.102	472	430
5415	32.4	0.097	576	310
5524	43.6	0.102	546	445
5535	26.6	0.107	516	225
8032	45	0.105	515	450
8041	36.1	0.097	513	315
8062	49.1	0.097	480	520
8154	43.5	0.101	583	465
8191	35.4	0.099	498	305
8237	55.2	0.099	536	840
8266	46.2	0.099	510	460
8300	54.4	0.105	536	835
8303	41	0.102	548	410
8305	29.9	0.1	489	245
8320	36.6	0.097	501	315
8326	38.7	0.097	505	345
8335	36.2	0.101	524	330
8341	47.8	0.098	461	455
8376	37.8	0.097	540	355
8410	43.3	0.094	475	370
8438	34.7	0.101	522	310

APPENDIX IX
Tabulated output from HTE exposure using
new proposed compression-strength reduction model

Proposed Model
75°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
28	43	0.094	483	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
55	39.5	0.098	500	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
71	37.9	0.093	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
155	35.5	0.099	534	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
168	27.8	0.093	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
246	32.1	0.099	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
258	52.1	0.096	544	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
288	44.1	0.094	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
300	32.6	0.095	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
332	31.2	0.096	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
342	34.6	0.092	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
349	39	0.095	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
357	29	0.093	519	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
369	46	0.096	496	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
376	38.7	0.094	599	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
382	39.1	0.098	585	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
401	41.4	0.096	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
412	41.4	0.095	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
1900	37	0.096	547	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5083	41.6	0.094	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5092	37.4	0.096	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5100	42	0.094	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5108	27.8	0.093	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5147	38.6	0.09	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5149	40.6	0.088	452	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5175	35.9	0.095	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5177	41.9	0.089	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5244	49.8	0.098	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5262	37.5	0.096	441	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5282	39.4	0.091	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5283	39.1	0.091	398	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5335	38.4	0.089	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5348	42.7	0.09	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5384	33.4	0.092	425	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5402	48.9	0.09	446	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5519	47.5	0.091	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5533	40	0.091	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8003	37.1	0.092	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8007	47.2	0.094	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8057	38.8	0.09	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8073	41.4	0.091	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8083	46.6	0.092	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8107	43.3	0.092	577	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8115	33	0.099	460	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8181	37.3	0.093	415	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8187	37	0.089	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8264	29.5	0.089	488	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8275	44.9	0.101	573	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8289	40.9	0.091	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8297	28.3	0.096	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8317	36	0.087	567	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8337	48.6	0.088	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8338	40.1	0.092	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8340	53.7	0.094	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8343	44	0.089	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8359	38.7	0.094	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8392	35.3	0.09	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8411	29	0.092	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8416	33.6	0.093	535	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8429	34.9	0.09	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8436	39.8	0.089	518	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Proposed Model

75°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
7	53	0.099	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
13	38.9	0.095	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
29	30.9	0.091	521	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
83	38.8	0.094	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
121	45.4	0.093	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
192	31.4	0.1	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
200	34.1	0.098	545	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
224	26.1	0.094	492	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
228	30.1	0.093	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
244	30	0.096	529	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
249	42.9	0.093	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
255	51.6	0.1	547	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
267	36.3	0.099	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
271	30.9	0.097	595	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
319	38.8	0.097	558	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
338	41.8	0.096	595	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
359	38.6	0.099	567	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
404	38	0.097	533	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
422	44.8	0.095	566	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
423	52.4	0.098	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
428	43.7	0.096	541	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5008	24.2	0.093	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5009	30.2	0.1	467	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5047	41.7	0.101	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5065	36.5	0.097	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5069	50.1	0.095	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5073	40.6	0.096	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5077	40.9	0.097	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5126	43.4	0.094	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5214	43.6	0.093	416	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5223	34.7	0.094	469	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5240	38.6	0.096	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5293	34.2	0.099	454	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5338	55.2	0.093	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5362	39.1	0.097	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5364	50.4	0.093	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5381	39.4	0.092	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5386	34.2	0.094	446	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5389	41.7	0.093	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5393	45.5	0.095	435	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5400	39.4	0.088	430	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5504	43.3	0.1	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5510	37.7	0.093	560	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5541	32.8	0.094	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8018	47.1	0.096	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8022	36.5	0.097	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8023	47.3	0.092	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8027	49.5	0.093	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8029	36	0.092	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8050	31.8	0.097	569	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8075	33.9	0.092	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8145	35.2	0.101	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8176	33.6	0.095	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8228	36.9	0.098	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8313	32.5	0.095	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8339	39.2	0.094	504	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8342	28.7	0.1	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8382	43.7	0.096	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8425	34.4	0.091	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8431	47.7	0.095	464	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8439	36.3	0.091	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Proposed Model

75°C - 50 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
44	39.9	0.094	567	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
50	31.1	0.096	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
74	38	0.094	518	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
78	32.1	0.103	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
110	51	0.095	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
118	42.6	0.095	532	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
120	35.6	0.097	407	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
169	34.5	0.099	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
184	36	0.1	596	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
232R	34.8	0.104	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
259	45.5	0.097	535	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
266	34.9	0.094	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
273	42.3	0.098	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
279	32.6	0.096	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
293	30.9	0.095	564	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
294	38.7	0.105	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
297	52.2	0.095	541	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
302	47.9	0.102	555	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
321	45	0.099	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
364	36.3	0.106	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
385	29.2	0.096	500	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
399	50.3	0.095	527	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
402	39.2	0.099	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5004	43.3	0.097	440	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5011	42.5	0.099	488	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5026	41.4	0.096	449	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5042	36.3	0.092	441	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5057	43.1	0.102	436	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5066	37.9	0.099	412	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5068	34	0.098	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5079	34.1	0.095	465	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5080	37.5	0.091	429	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5102	35.3	0.098	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5134	40.5	0.101	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5145	35.9	0.102	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5156	48.8	0.094	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5203	43.1	0.096	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5236	32.9	0.098	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5297	36.2	0.095	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5341	41.6	0.094	467	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5355	40.9	0.1	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5383	27.6	0.095	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5406	40.9	0.092	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5508	40.8	0.102	470	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8028	36.1	0.098	584	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8031	41	0.098	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8069	44.9	0.095	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8090	44.6	0.095	605	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8094	34.2	0.1	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8213	30.3	0.103	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8219	43	0.095	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8230	47.9	0.097	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8279	37.6	0.099	573	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8287	28.4	0.098	569	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8310	47.7	0.097	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8312	54.1	0.095	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8351	36.9	0.1	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8355	54.7	0.095	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8356	32.7	0.097	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8391	49	0.095	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Proposed Model
150°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
3	53.6	0.097	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
12	29.7	0.108	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
17	46.7	0.102	594	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
19	37.9	0.103	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
45	57	0.105	531	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
64	24.5	0.1	562	1885
66	33.3	0.101	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
81	34.1	0.097	615	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
89	48.4	0.097	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
125	45.9	0.097	538	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
129	47.3	0.099	609	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
136	28	0.102	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
199	49.9	0.099	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
223	38.2	0.101	509	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
291	43.7	0.104	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
298	23.6	0.104	557	1310
299	51.5	0.103	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
322	33.1	0.102	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
339	45.6	0.106	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
411	35.6	0.108	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
415	41	0.103	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
439	34.9	0.108	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5032	49.3	0.103	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5071	59.8	0.102	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5074	47.8	0.112	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5091	39	0.097	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5106	44.2	0.099	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5135	33.3	0.115	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5151	43	0.1	428	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5154	44.5	0.103	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5164	37.2	0.103	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5186	37.8	0.102	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5189	51.4	0.098	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5190	29.8	0.103	438	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5249	44.7	0.099	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5267	60.2	0.102	414	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5286	40.8	0.103	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5290	29.4	0.1	495	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5298	39.2	0.112	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5300	49.5	0.106	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5331	38.1	0.1	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5515	38.1	0.11	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5520	45.5	0.101	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5538	32.2	0.102	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8001	42.1	0.102	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8082	48	0.099	570	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8137	46.3	0.098	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8138	28.2	0.105	462	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8144	38.5	0.102	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8178	38.4	0.1	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8242	34	0.101	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8273	38.4	0.105	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8277	47.1	0.101	563	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8307	31.3	0.106	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8316	35.3	0.098	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8319	43.6	0.102	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8330	39.5	0.101	474	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8348	36.3	0.091	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8406	41.8	0.1	549	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8424	38.8	0.097	483	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Proposed Model

150°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
14	52.7	0.101	491	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
58	35	0.104	557	1320
124	37.9	0.1	558	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
131	40.7	0.104	561	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
148	27.1	0.105	597	415
160	45.5	0.104	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
173	59.9	0.102	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
251	32.7	0.101	485	625
268	58.7	0.106	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
277	42.9	0.105	503	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
344	44.4	0.103	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
355	37.5	0.108	517	2535
375	46.7	0.111	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
398	26.7	0.104	542	365
414	36	0.104	538	1695
417	33.3	0.103	597	825
5003	42.1	0.099	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5022	39.4	0.105	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5034	39.8	0.103	444	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5038	53.4	0.099	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5086	35.5	0.102	471	1285
5105	42.1	0.103	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5137	50	0.092	459	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5143	39.7	0.106	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5182	50.4	0.102	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5188	60.1	0.103	462	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5211	35.8	0.099	450	1345
5234	36.9	0.101	494	1990
5241	42.2	0.097	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5255	44.3	0.103	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5272	43.8	0.104	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5288	50.7	0.101	415	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5295	41.7	0.102	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5301	41.1	0.099	445	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5318	35.4	0.098	508	1335
5329	42.2	0.104	456	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5333	33.3	0.098	434	615
5337	38.8	0.1	457	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5351	40.4	0.098	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5399	47.4	0.096	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5412	43	0.102	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5415	30.3	0.097	576	540
5524	30.4	0.102	546	530
5535	34.2	0.107	516	990
8032	33.7	0.105	515	820
8041	53.6	0.097	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8062	54.7	0.097	480	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8154	38.9	0.101	583	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8191	34.8	0.099	498	1085
8237	38.8	0.099	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8266	54.7	0.099	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8300	50.2	0.105	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8303	39.8	0.102	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8305	42	0.1	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8320	37.9	0.097	501	2595
8326	51.5	0.097	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8335	38.1	0.101	524	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8341	46.9	0.098	461	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8376	31.9	0.097	540	605
8410	44.8	0.094	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8438	40	0.101	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Proposed Model

150°C - 50 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
5	46.4	0.099	516	980
42	34.1	0.106	596	340
46	39.9	0.108	549	495
62	56.3	0.104	554	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
84	37.5	0.102	542	405
88	51.1	0.1	512	2625
112	35.5	0.1	552	350
161	41.9	0.106	562	585
201	50.6	0.108	565	2690
231	36.8	0.106	543	390
330	36.9	0.106	568	405
413	40.5	0.102	516	485
426	35.1	0.103	536	335
434	39.9	0.109	517	475
5018	40.8	0.104	431	425
5082	39.1	0.104	455	395
5093	38.5	0.106	491	405
5118	37.5	0.103	459	355
5136	29.3	0.104	495	180
5173	32.8	0.1	506	260
5179	40.4	0.103	495	465
5191	41	0.104	485	480
5212	38.4	0.105	458	380
5228	37.7	0.102	471	365
5246	41.6	0.103	461	480
5257	43.1	0.107	469	555
5259	38	0.097	450	355
5260	24.9	0.102	468	85
5285	61.2	0.1	486	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5289	40.2	0.101	478	440
5294	41.8	0.109	463	500
5303	41.3	0.106	493	500
5342	48.1	0.101	439	1250
5373	47.3	0.104	480	1155
5387	36.9	0.105	420	315
5395	51.2	0.097	560	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5397	34.5	0.098	444	270
5529	45.5	0.098	528	800
5532	37.3	0.103	507	380
8012	39.5	0.102	502	440
8019	32.6	0.103	521	265
8052	46.8	0.109	613	1300
8074	39.3	0.099	466	400
8104	47.3	0.105	507	1210
8118	44.6	0.097	484	645
8139	32.3	0.099	510	245
8142	41.5	0.097	508	510
8162	38.4	0.102	536	430
8164	35.5	0.101	528	340
8173	37.2	0.098	504	370
8193	34.5	0.103	534	315
8200	31.4	0.1	544	240
8220	43.3	0.1	471	555
8253	66.7	0.103	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8265	39.6	0.097	527	450
8268	42.4	0.099	496	540
8276	42.7	0.098	497	550
8298	39.4	0.096	586	485
8333	43	0.095	516	575
8352	37.3	0.095	489	360
8422	32.6	0.097	519	255

Proposed Model
200°C - 12 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
9	50	0.11	481	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
18	33.9	0.114	574	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
22	39.1	0.108	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
34	49.5	0.111	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
77	36.9	0.104	511	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
122	48.2	0.108	462	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
130	40.1	0.109	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
149	39.6	0.114	533	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
186	37.1	0.111	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
187	43.5	0.112	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
193	33.1	0.11	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
196	35.1	0.11	572	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
202	32.7	0.111	544	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
210	36.9	0.111	474	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
226	33.9	0.11	498	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
242	38.9	0.106	601	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
262	42.5	0.115	463	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
307	41.5	0.111	542	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
313	42.7	0.113	521	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
367	27.6	0.111	558	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
372	30.3	0.111	552	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
394	41.5	0.108	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
440	42.6	0.111	492	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5001	32.9	0.112	440	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5024	39.6	0.11	451	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5033	44.1	0.11	535	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5046	33.2	0.11	433	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5070	36.2	0.112	468	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5076	47.1	0.111	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5090	46.6	0.112	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5098	39.2	0.11	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5127	43	0.102	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5131	43.9	0.107	473	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5141	40.6	0.112	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5227	58.7	0.118	427	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5250	37	0.107	451	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5358	37.2	0.113	492	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5382	26.8	0.108	447	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5513	48.9	0.109	484	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5526	49	0.113	489	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8033	46.5	0.112	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8045	38.5	0.111	493	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8046	39.5	0.109	601	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8053	47.6	0.112	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8061	50.6	0.111	539	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8103	49.9	0.117	591	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8110	44.6	0.112	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8134	34.4	0.113	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8136	34.5	0.112	474	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8171	35.5	0.114	447	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8210	33.8	0.105	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8251	37.4	0.114	544	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8267	31.1	0.111	523	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8288	33.4	0.106	459	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8290	29.8	0.112	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8291	47.7	0.119	498	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8321	28.9	0.108	553	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8367	43.8	0.106	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8388	36.5	0.117	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8444	47.9	0.109	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8445	34.6	0.111	531	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Proposed Model
200°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
37	48.2	0.098	547	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
38	29.9	0.097	591	1370
48	43.5	0.099	560	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
116	43.1	0.102	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
126	45.5	0.099	562	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
135	45.4	0.103	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
145	52.2	0.102	534	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
150	34.2	0.116	499	2165
164	48.3	0.109	589	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
185	38.5	0.113	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
225	42.1	0.118	578	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
256	62.3	0.11	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
261	42.8	0.109	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
281	28.4	0.112	559	1125
306	38.3	0.104	485	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
312	35.5	0.112	529	2515
316	45.7	0.107	525	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
366	45.1	0.113	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
377	30.9	0.113	506	1480
378	29.4	0.105	519	1185
427	38.1	0.116	500	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5055	33	0.104	468	1680
5060	45.1	0.113	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5111	35.3	0.107	470	2145
5123	46.7	0.109	506	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5124	42.5	0.113	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5166	28.5	0.103	457	895
5171	34.9	0.109	487	2170
5239	46.9	0.104	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5251	45.9	0.104	442	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5269	38	0.11	443	2495
5281	49.9	0.108	453	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5306	40.5	0.099	450	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5310	49.9	0.103	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5328	36.1	0.113	434	2170
5343	37.6	0.1	502	2615
5368	34.6	0.11	413	1795
5404	39.7	0.1	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5413	26.5	0.122	493	730
5417	36.8	0.11	506	2635
8014	52.1	0.101	502	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8037	52.5	0.103	574	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8047	46.4	0.114	606	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8054	38.7	0.107	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8070	28.8	0.107	501	1050
8071	39	0.103	477	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8072	42.6	0.1	514	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8091	40.8	0.106	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8095	31.9	0.096	460	1385
8116	41.4	0.096	455	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8160	50.1	0.107	520	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8201	52.5	0.097	536	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8204	38.5	0.103	491	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8250	44.5	0.097	510	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8255	38.2	0.108	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8299	45.9	0.113	504	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8347	42.3	0.107	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8372	36.5	0.102	473	2310
8377	57.5	0.101	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8393	30.5	0.108	477	1295
8443	53.8	0.104	507	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Proposed Model

200°C - 37 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
21	48.6	0.108	616	2195
23	54.4	0.11	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
80	59.2	0.114	499	
94	45.8	0.113	528	1560
140	29.6	0.112	525	305
174	34.1	0.112	488	400
175	39.5	0.118	539	815
227	39.7	0.106	512	755
230	34.6	0.115	561	475
286	41.4	0.114	509	960
287	44.1	0.113	548	1375
351	46.2	0.117	521	1620
386	44.8	0.107	551	1440
406	29.5	0.109	525	300
407	51.4	0.112	612	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
425	30.9	0.114	527	
5019	35	0.108	451	395
5028	40.2	0.108	470	745
5125	51.9	0.113	491	2265
5148	34	0.111	483	395
5205	45.9	0.112	434	1280
5209	38.7	0.111	471	610
5221	32.3	0.112	493	355
5291	42.8	0.109	461	995
5296	34	0.111	475	385
5311	53	0.11	448	2165
5320	33.4	0.105	458	350
5356	29	0.099	416	225
5375	47.1	0.12	468	1595
5376	39.9	0.113	494	770
5385	30.5	0.11	439	280
5401	39.5	0.12	492	750
5523	41.8	0.116	507	1020
5530	40.9	0.12	554	1005
8035	40.9	0.108	509	875
8049	40.4	0.114	538	890
8058	30	0.115	479	295
8065	51.8	0.111	522	2365
8066	48.4	0.111	503	1815
8080	41.8	0.112	490	955
8096	41.3	0.115	444	835
8097	51.8	0.112	586	2680
8135	31.5	0.112	530	360
8151	33.3	0.111	513	395
8163	40.8	0.106	513	865
8165	37.7	0.11	468	525
8168	48.8	0.116	476	1810
8169	56.3	0.112	551	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8177	33.1	0.114	484	
8207	33.8	0.108	504	400
8216	29.3	0.114	563	320
8223	34.9	0.111	555	475
8241	36.4	0.107	464	450
8247	49.1	0.116	527	2055
8281	43.2	0.114	493	1140
8294	41.8	0.113	526	1030
8361	41.7	0.105	518	965
8370	32.6	0.107	571	405
8373	44.3	0.102	501	1220
8417	32.9	0.105	538	395
8430	40.1	0.102	508	765

Proposed Model
250°C - 12 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
63	59.3	0.099	537	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
167	40.3	0.105	548	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
172	36.5	0.1	479	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
188	44.7	0.109	590	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
189	39.1	0.108	575	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
204	32.4	0.108	552	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
263	35.8	0.103	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
272	35.6	0.101	588	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
296	40.5	0.101	530	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
324	37.7	0.106	552	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
326	59.1	0.103	531	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
345	37.2	0.104	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
374	53.4	0.102	555	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
390	38.7	0.111	518	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
396	52.6	0.105	512	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
416	41.5	0.1	508	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5002	42.1	0.099	439	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5029	38.3	0.108	443	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5048	60.2	0.101	497	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5056	36.5	0.11	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5064	32	0.099	454	2625
5099	42.1	0.111	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5114	30.3	0.101	459	2350
5117	47.3	0.103	490	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5121	30.6	0.103	454	2385
5159	50.3	0.108	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5215	24.8	0.103	488	1670
5217	42.2	0.101	415	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5254	35	0.094	434	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5274	57.1	0.103	494	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5307	47.1	0.107	462	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5323	35.2	0.105	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5324	30.2	0.101	467	2365
5354	34.7	0.107	471	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5394	42.5	0.104	458	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5517	38.5	0.098	482	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
5539	41	0.103	545	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8005	29	0.104	505	2375
8021	39.4	0.101	487	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8068	49.5	0.104	501	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8086	32.7	0.106	618	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8108	45.5	0.102	498	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8109	32.8	0.111	504	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8161	47	0.104	564	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8190	31.4	0.103	534	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8199	43.9	0.103	528	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8202	48.7	0.104	546	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8218	47.3	0.101	472	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8239	52.8	0.101	478	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8270	37.2	0.102	517	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8292	32.9	0.105	543	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8301	46.3	0.112	513	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8311	47.5	0.101	574	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8334	50.9	0.099	476	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8344	44.1	0.104	522	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8383	34.7	0.1	505	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8396	37.3	0.107	516	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8403	33.6	0.107	540	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8407	49.4	0.104	515	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8414	51.3	0.099	499	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED
8437	38	0.102	475	STUD HAS NOT FAILED IN EXPOSURE TIME SPECIFIED

Proposed Model
250°C - 25 kN

Specimen Number	Initial Strength (MPa)	Moisture Content	Density (kg/m ³)	Failure Time (s)
39	41.9	0.107	572	1460
85	45.6	0.103	525	1510
90	43.8	0.112	581	1640
92	31	0.112	510	615
97	44.5	0.111	609	1755
98	30.5	0.11	545	620
111	41	0.107	554	1355
163	42.8	0.113	559	1520
176	46.6	0.115	555	1750
317	38	0.109	501	1045
341	32	0.11	513	680
353	35.4	0.111	480	855
360	36.1	0.108	502	930
361	42.8	0.117	509	1410
362	47.3	0.109	531	1665
430	42.1	0.114	475	1255
436	58.1	0.105	505	2190
438	55.3	0.112	526	2125
5005	31.2	0.104	453	535
5044	35	0.111	459	790
5053	39	0.11	479	1060
5061	41	0.11	493	1215
5088	31.2	0.106	517	625
5104	32.8	0.104	457	635
5144	55.3	0.101	510	1970
5150	40.4	0.106	428	995
5157	28.4	0.109	473	420
5162	39.6	0.107	503	1145
5180	45.1	0.107	420	1195
5235	42.6	0.104	487	1250
5245	41.3	0.106	495	1215
5312	33.9	0.107	443	685
5319	36	0.109	452	825
5365	43.1	0.11	435	1170
5379	51.1	0.108	467	1600
5409	41.5	0.116	463	1195
5502	45	0.115	487	1445
5506	53	0.105	543	1970
5512	39.9	0.101	505	1130
5528	32.8	0.113	522	755
8055	38.3	0.108	570	1210
8060	55.4	0.107	506	2005
8077	46.8	0.105	482	1450
8079	38.4	0.11	503	1080
8099	38.3	0.106	533	1120
8102	41.7	0.109	519	1320
8128	49.8	0.105	479	1570
8157	37.8	0.11	474	980
8174	37.6	0.104	530	1055
8196	54.8	0.102	520	1985
8197	57.8	0.102	538	2300
8212	32	0.108	495	655
8225	31.1	0.109	536	650
8227	41.4	0.115	593	1535
8254	25.7	0.11	548	390
8258	49.5	0.104	524	1705
8263	37.7	0.096	563	1085
8309	59.6	0.104	532	2445
8331	42.1	0.107	486	1240
8395	49.3	0.107	496	1620
8400	27.5	0.103	453	365