CHAPTER 1

INTRODUCTION

1.1 Historical Introduction

The most widely used and accepted theory for design of beams is the elastic theory, which is formulated on the basis that stresses remain linearly proportional to the accompanying strains, it also assumes that plane section of a beam remain plane during bending. When this theory is applied to the mechanics of wood, it predicts within certain limits the flexural behavior of beams of any cross-section, if the tensile strength is reduced by defects or other causes so that tensile failure occurs before the compression stress reaches the proportional limit value. In this case, the stress strain distribution at the critical section of the beam is linear even up to failure.

In clear wood, it is found that the proportional limit in bending as determined by standard bending test is much greater than determined by the compression test parallel to the grain. In fact, it usually exceeds the maximum crushing strength. A question remain wheather wood is actually stronger in compression when it is bent than when it is merely compressed. The compression failures in wood beams are often not prominent, sometimes being almost invisible. This has often led to the erroneous conclusion that tension failures occur before there is a compression failure. The modulus of rupture is then usually used for comparing the bending strength of different species. Since it is based on the maximum load.

However the linear stress-strain relation does not hold true within the failing range of the beam. The elastic theory then becomes inadequate to explain why wood beam of same species but different shape of cross-section posses different moduli of rupture. To account for the difference in shapes of wood beams, a "form factor" is applied to the modulus of rupture. The form factor is the ratio of the modulus of rupture of a wood beam of any cross-section to that of a standard 2 inch by 2 inch cross-section. Then the "Fiber Support Theory" was used to explain the modulus of rupture and form factor.

The theory of fiber support assumes that the minute fibers of the wood, which are more or less bound together, act as miniature Euler Columns when subjected to compression along their length. When stress is uniformly applied on all the fiber, little support is offered by one fiber to adjacent fibers; when the stress applied is non-uniform, as in bent beam, the fiber nearer the neutral axis, being less stressed, offer lateral support to the adjacent extreme fibers, and cause them to sustain higher stress. The theory accounts for the increase in compression strength in bending and conforms with the flexural behavior of wood beams in the failing range. Norris (9) reported that the fiber support theory can account for the lack of supporting wood under the compression flanges of I and box beams, but the fact that a circular cross-section beam has a form factor greater than unity is not explained.

A further application of the fiber support theory was investigated on very deep laminated beams. The investigation was based on the maximum crushing strength parallel to grain. The result showed that the decrease in modulus of rupture with increasing height of beam is greater than that obtained by the primer. The mathematical analysis of this study is reported by Freas and Selbo (6).

An analysis to prove the mathematical validity of the fiber support theory was conducted by Bechtel and Norris (3) by calculating the load deflection curve of a beam from the stress strain curve that were obtained from the compression test on the specimens matched to the beam. Norris stated that the fiber support theory should be abandoned.

In the elastic limit, the stress and strain variations in wood beam are linearly distributed. As the stress gradually increased beyond the proportional limit, the extreme fibers on the compression side start to yield plastically before the fibers on the tension side fail. This occurs because clear wood is usually much stronger in tension than in compression parallel to the grain. As a result a stress redistribution starts to occur. The neutral axis shifts downwards. This process is continues with an increase in the bending moment until tensile failure results; that is the reason bending strength is greater than compression strength. In fact, the compression failure in wood beams are often prominent, sometimes being almost invissible, which very often leads to the incorrect conclusion that tension failure occurs before compression failure.

The general equations for bending strength of beams under conditions of equilibrium are "Internal compression force, equal to the internal tension force, Internal moment equal to external moment."

It is seen that the reliability of a theoretical flexural analysis of wood beams at failure depends to the large extent on the accuracy to which the stress strain distribution can be determined. Bach and Bauman (2) proposed the first approximation for longitudinal stress distribution of wood beams by superimposing the stress strain curves obtained from tests of compression and tension specimens. Bechtel and Norris (3) assumed the same modulus of elasticity for tension and compression and simplified the longitudinal stress distribution. The validity of this theory was examined by Sawada (12).

In 1960, Brochard (4) found that the second degree parabola was the best approximation of the compression part of the stress strain curve obtained from test specimens. It is supported by Borislav D. Zakic (14) in 1973.

1.2 Purpose and Scope

Although wood beams are still widely used in construction. Even wood technology very much progress, the strength of timber can be closely predicted in the range by using, in limit of moisture content, seasoning wood instead of green wood. The defect of wood can be eliminated by using laminated wood beam instead of solid wood beam. The present design criteria are still based on elastic theory, the allowable strength must be divided by factor of safety 6 to the strength at proportional limit. The behavior of wood beam in the inelastic range has never been studied before in Thailand.

The purposes of this study are:

1) To investigate wheather the second degree parabola suggested by Borislav D. Zakic (14) can be applied for Thai wood beam.

2) To investigate the correlation between the ultimate load obtained by proposed theoretical method and those obtained by testing on Thai wood beam.

3) To determine a suitable coefficient that may be applied to flexural formula when using with Thai hard wood beam.

Three species of commercial timbers used in this investigation were selected on the basis of their general usage for structural purposes. Three of Thai well known woods : Teng (Shorea Obtusa), Dang (Xylia Kerrii) and Kiem (Cotylelobium Lanceolatum) were selected for this study. Two models of each species were tested as main beams. Bending test was carried out by a two point static loading system, thus excluding shear effects in the critical section. The longitudinal strains were measured by means of electrical strain gages.