AN APPROXIMATE ELASTIC ANALYSIS OF W SHAPE BEAMS WITH REINFORCED RECTANGULAR WEB OPENINGS

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TABLE OF CONTENTS

INTRODUCTION

1. Problem Statement

In construction practice, when openings of some sort are cut in the web of a steel beam to accommodate the passage of utilities or to provide access to equipment, the beam may be weakened in the vicinity of the openings to the extent that reinforcing is required. Although the theory of elasticity provides some basis for estimating the stresses around an opening, it provides little basis for the practical design of reinforcement requirements. The purpose of the study described in this report was to develop an approximate, practical method for determining the amount of the necessary reinforcement at the web openings subjected to combined bending and shear.

The so-called Vierendeel method of analysis was used to calculate theoretical stresses around the holes. An A36 steel W12x45 beam with a 9"x6" rectangular web opening at middepth was used to illustrate the proposed method.

2. Purpose

The primary objectives of this report were:

a. To determine the amount of required reinforcement around rectangular openings in the webs of W shape members.

b. To determine the location of critical stress at the reinforced opening as limited by AISC allowable stresses and/or as limited by a yielding criterion using a proper factor of safety.

3. Scope

The study was limited to W shape steel beams having rectangular openings centered on the neutral axis of the members. However, the proposed method is applicable to any homogeneous and isotropic material within its elastic range. Only horizontal reinforcing bars welded to the web above and below the openings were considered. The horizontal reinforcing bars may be used on both sides or on only one side of the web without any changes in the design method.

LITERATURE REVIEW

In 1924 Timoshenko (17)* developed an approximate method of analysis for determining the stresses around the reinforcement in a circular hole in a uniform tension field; Sobreno and Gurney (6) continued this work independently in 1938. The David W. Taylor Model Test Basin (18) in Washington, D.C. in 1938 published results of an experimental study of various types of small openings reinforced in various ways. In 1949 Reissner and Morduchow (13) developed a method of analysis for the reinforcement of a circular hole for various types of loadings. Joseph and Brock (10) in 1950 developed a mathematical procedure for computing the effects of small circular openings in beams subjected to pure bending. In 1952, Heller (7) considered small circular openings (H/D less than 0.10) in beams subjected to both bending and shear. Later, in 1958, Heller (8) studied the case of square holes with H/D less than 0.25 in members subjected to axial loading only. In 1954 Mantle (11) studied reinforced circular openings with H/D less than 0.25 in a uniform tension field.

In 1958 Worley (19) studied the inelastic behavior of aluminum alloy I-beams with web cutouts unreinforced. His purpose was to determine the shape of the web section cutout that would result in the least reduction in the full plastic load carrying

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*Numbers in parentheses refer to corresponding items in " References ".