High Strength Bolts
A Primer for Structural Engineers
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Chapter 1
INTRODUCTION

1.1. Purpose and Scope

There are two principal types of fasteners used in contemporary fabricated steel structures—bolts and welds. Both are widely used, and sometimes both fastening types are used in the same connection. For many connections, it is common to use welds in the shop portion of the fabrication process and to use bolts in the field. Welding requires a significant amount of equipment, uses skilled operators, and its inspection is a relatively sophisticated procedure. On the other hand, bolts are a manufactured item, they are installed using simple equipment, and installation and inspection can be done by persons with only a relatively small amount of training.

Engineers who have the responsibility for structural design must be conversant with the behavior of both bolts and welds and must know how to design connections using these fastening elements. Design and specification of welds and their inspection methods generally involves selecting standardized techniques and acceptance criteria or soliciting the expertise of a specialist. On the other hand, design and specification of a bolted joint requires the structural engineer to select the type of fasteners, understand how they are to be used, and to set out acceptable methods of installation and inspection. Relatively speaking, then, a structural engineer must know more about high-strength bolts than about welds.

The purpose of this Primer is to provide the structural engineer with the information necessary to select suitable high-strength bolts, specify the methods of their installation and inspection, and to design connections that use this type of fastener. Bolts can be either common bolts (sometimes called ordinary or machine bolts) or high-strength bolts. Although both types will be described, emphasis will be placed on high-strength bolts. Because many riveted structures are still in use and often their adequacy must be verified, a short description of rivets is also provided.

1.2. Historical Notes

Rivets were the principal fastener used in the early days of iron and steel structures [1, 2]. They were a satisfactory solution generally, but the clamping force produced as the heated rivet shrank against the gripped material was both variable and uncertain as to magnitude. Thus, use of rivets as the fastener in joints where slip was to be prevented was problematic. Rivets in connections loaded such that tension was produced in the fastener also posed certain problems. Perhaps most important, however, the installation of rivets required more equipment and manpower than did the high-strength bolts that became available in a general way during the 1950's. This meant that it was more expensive to install a rivet than to install a high-strength bolt. Moreover, high-strength bolts offered certain advantages in strength and performance as compared with rivets.

Bolts made of mild steel had been used occasionally in the early days of steel and cast iron structures. The first suggestion that high-strength bolts could be used appears to have come from Batho and Bateman in a report made to the Steel Structures Committee of Scientific and Industrial Research of Great Britain [3] in 1934. Their finding was that bolts having a yield strength of at least 54 ksi could be pretensioned sufficiently to prevent slip of connected material. Other early research was done at the University of Illinois by Wilson and Thomas [4]. This study, directed toward the fatigue strength of riveted shear splices, showed that pretensioned high-strength bolted joints had a fatigue life at least as good as that of the riveted joints.

In 1947, the Research Council on Riveted and Bolted Structural Joints (RCRBSJ) was formed. This body was responsible for directing the research that ultimately led to the wide-spread acceptance of the high-strength bolt as the preferred mechanical fastener for fabricated structural steel. The Council continues today, and the organization is now known as the Research Council on Structural Connections (RCSC). The first specification for structural joints was issued by the RCRBSJ in 1951 [5].

At about the same time as this work was going on in North America, research studies and preparation of specifications started elsewhere, first in Germany and Britain, then in other European countries, in Japan, and elsewhere. Today, researchers in many countries of the world add to the knowledge base for structural joints made using high-strength bolts. Interested readers can find further information on these developments in References [6, 7, 8, 9].

1.3. Mechanical Fasteners

The mechanical fasteners most often used in structural steelwork are rivets and bolts. On occasion, other types of mechanical fasteners are used: generally, these are special forms of high-strength bolts. Rivets and bolts are used in drilled, punched, or flame-cut holes to fasten the parts to be connected. Pretension may be present in the fastener.