CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 61-100

INVESTIGATION INTO THE CAUSE OF FAILURE OF A BACK BOLT FOR STEEL SHEET PILING

by

R.D. McDONALD & W.A. MORGAN

PHYSICAL METALLURGY DIVISION

COPY NO. 7

SEPTEMBER 13, 1961

Mines Branch Investigation Report IR 61-100

INVESTIGATION INTO THE CAUSE OF FAILURE OF A BACK BOLT FOR STEEL SHEET PILING

by

R. D. McDonald* and W. A. Morgan**

SUMMARY OF RESULTS

The investigation has shown that the bolt fractured in a brittle manner at the root of the thread. No material defects were evident and it was concluded that failure resulted primarily from a suddenly applied overload. Such failures would be abetted by a stress concentration at the root of the thread, and possibly by some increase in notch sensitivity caused by a thin layer of cold worked metal in that region.

*Senior Scientific Officer and **Head, Ferrous Metals Section, Physical Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

INTRODUCTION

Under a covering letter of August 4, 1961, File Q 29-19, a sample of a broken $1\frac{1}{2}$ in. back bolt was received from National Harbours Board, Ottawa. This bolt had been removed from a sheet pile water assembly after it had fractured.

It was stated that the bolt material had been purchased in accordance with Specification CSA G-40.2 and that the Department of Public Works had reported that the material met the "physical test" requirements.

It was further stated in the covering letter that "all samples (of broken bolts) examined here have the same appearance in the break with no elongation of the bolt shank."

Visual Examination

A photograph of the surface of the fracture is shown in Figure 1. It is a brittle type of fracture, having its origin at the root of the thread.

Figure 1. Surface of Fracture in a Bolt from Steel Sheet Piling.

Brittle fracture with origin at the three o'clock position.

Microscopic Examination

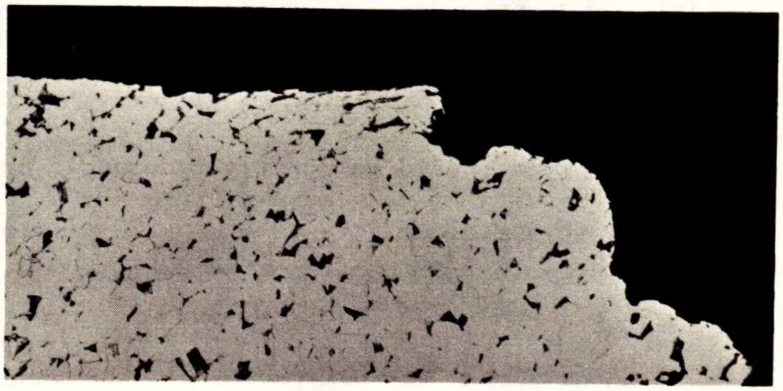
A microscopic examination of threads adjacent to the origin of the fracture revealed areas of cold worked metal up to 0.002 in. thick on thread surfaces, (Figures 2 and 3). These areas were not continuous, apparently as a result of corrosion and scaling. The depth of scaling, or corrosion attack, in many areas appeared limited to the depth of the worked metal. However, the corrosion appeared to be general with no severe pitting.

A cold worked area was observed at the root of the thread at the location where the fracture originated.

The microstructure was typical of a normalized steel or a hot rolled steel which had been finished at a low temperature. It appeared likely that some of the cold work occurred during threading and some due to heavy torquing during installation of the bolts.

Etched in 2% nital X100

Figure 2. Cold Work on Surface of Thread



Etched in 2% nital X100

Figure 3. Cold Work on the Same Thread as in Figure 2 but Located at the Origin of the Fracture.

SUMMARY AND CONCLUSION

It has been stated that the bolt material met the requirements of C.S.A. Specification G-40.2. Brittle fractures have occurred in these bolts in service, possibly when suddenly increased loads resulted when fill had been built up inside the piling structure. These bolts serve as holding bolts and therefore do not require high initial torquing. Also, in this service any additional load will be additive to the initial torquing stresses.

Cold work evident at the root of the thread would tend to increase the notch sensitivity of the material. It is concluded that, initially, high torquing loads have been chiefly responsible for the failures when combined with the additional suddenly applied loads during back filling. In the presence of a severe notch and some cold work, brittle fracture could be anticipated.

Failures of this type should be greatly reduced if initial torquing stresses are held to a minimum.

RDM:WAM:ac