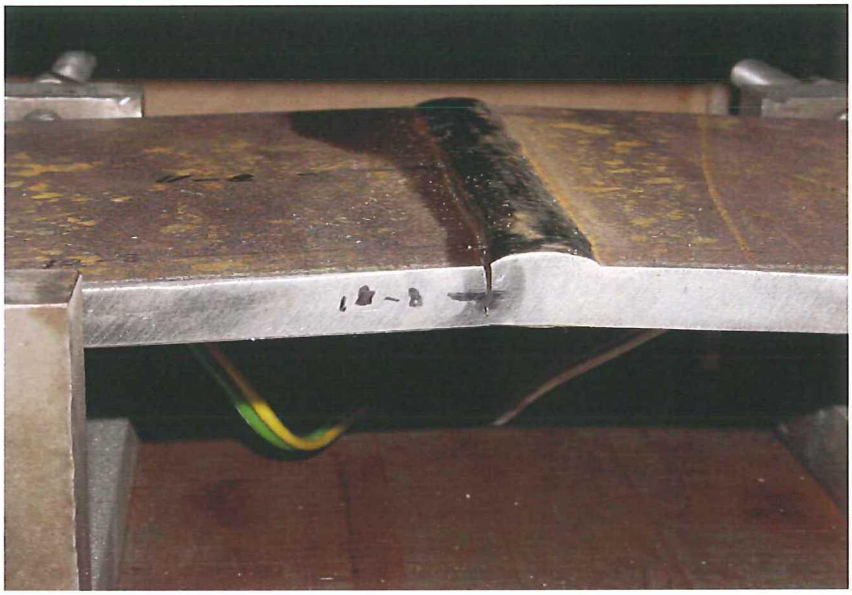
Stevin: 6-06-2

FATIGUE TESTS SUBMERGED ARC WELDED BRIDGE DECK REPAIR

August 2006

M.H. Kolstein



Delft University of Technology

Faculty of Civil Engineering and Geosciences
Structural and Building Engineering
Steel Structures

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PRINCIPAL:

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Contents page

1. INTRODUCTION

Before applying a renovation technique, cracks in the deck plate have to be repaired. With the submerged arc welding technique (De Jong, 2004) the weld is made in an automated way. The advantage of submerged arc welding is that the speed of execution is high; the welding thakes place only from the top of the deck plate, and the relatively limited welding shrinkage. Disadvantage is that due to the automated procedure only straight cracks can be repaired with this technique. Because there was only little experience with the submerged arc welding technique on fatigue cracked deck plates a research program was set up to develop this technique and establish the best repair parameters. This report focuses on the determination of the fatigue behaviour of a submerged arc welded bridge deck repair.

2. TEST SPECIMENS

The dimensions of the test specimens that have been sawed out of a larger plate is given in Figure 1. Due to the fact that the fatigue cracks in the existing bridge decks grow under an angle of approximately 70^0 the plates of the specimens have been shaped befor welding simulating this situation. The penetration depth of these submerged arc welded plates amounts 65% to 75%.

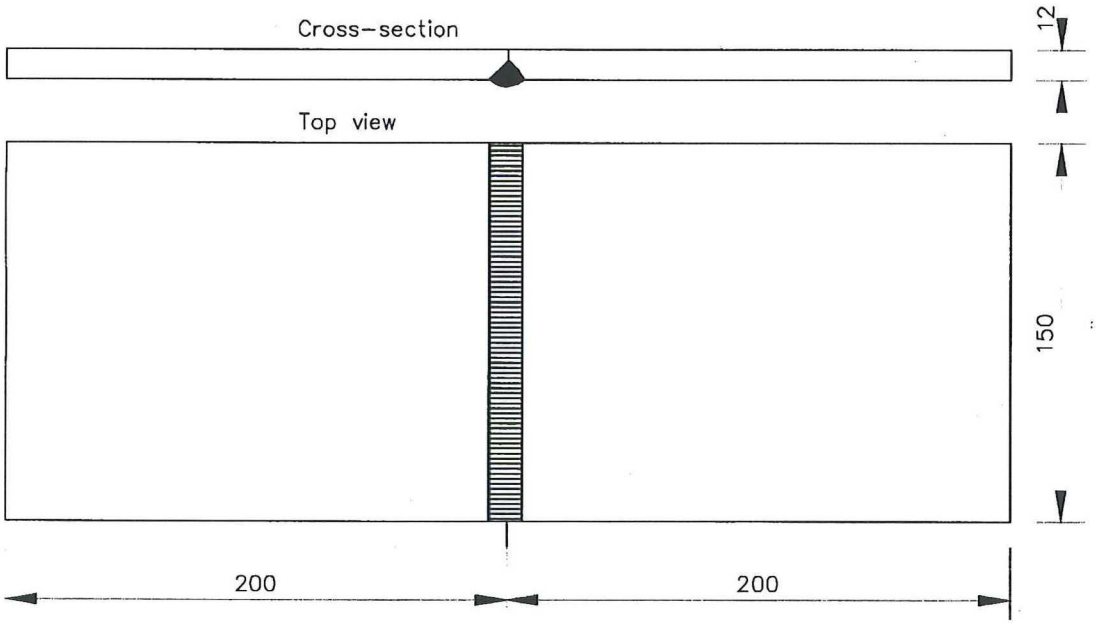


Figure 1. Dimensions of the test specimens

3. TEST SET-UP

The loading scheme is given in figure 2. Two strain gauges have been located on the steel plate. The plates are subjected to four point bending tests. The test specimens are positioned in the test machine in a way to generate compression at the side of the remaining inwelded part of the connection and tension at the top side of the submerged arc weld. This simulates more or less the situation in real bridges where mostly compression at the root of the weld is thought. Figure 3 shows the four point bending test set up. The load cycle is different for each specimen in order to enable the derivation of a fatigue detail classification. For testing 6 specimens are available.

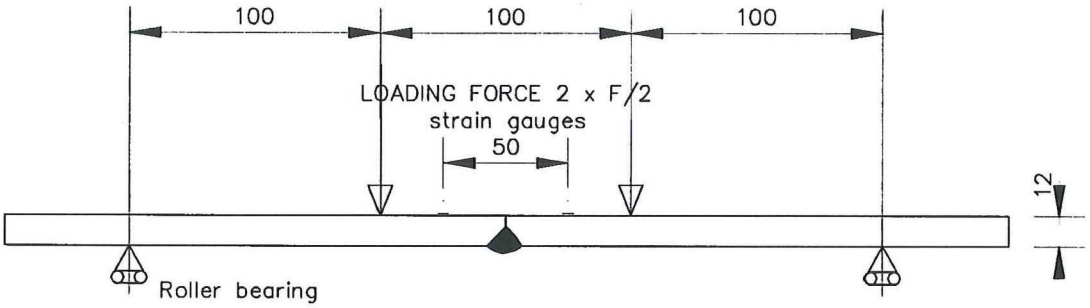


Figure 2. Loading scheme of the test specimens

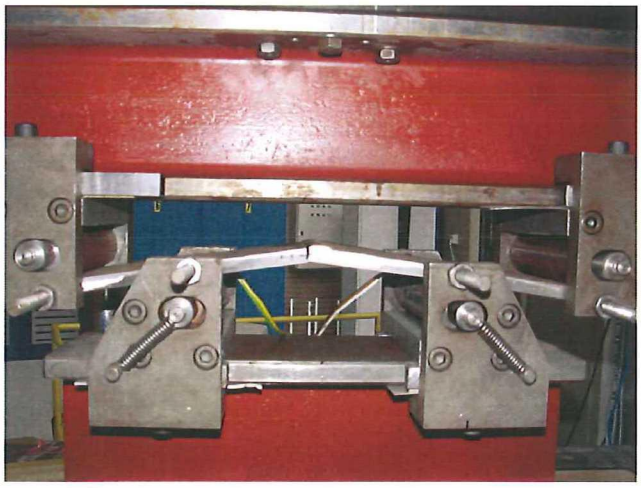


Figure 3. Four point bending test set up

4. MEASUREMENTS

During the tests the test loading (F01), the piston displacement of the actuator (S01) and both strain gauges have been measured continuously. Typical results are shown in figure 4 to figure 6.

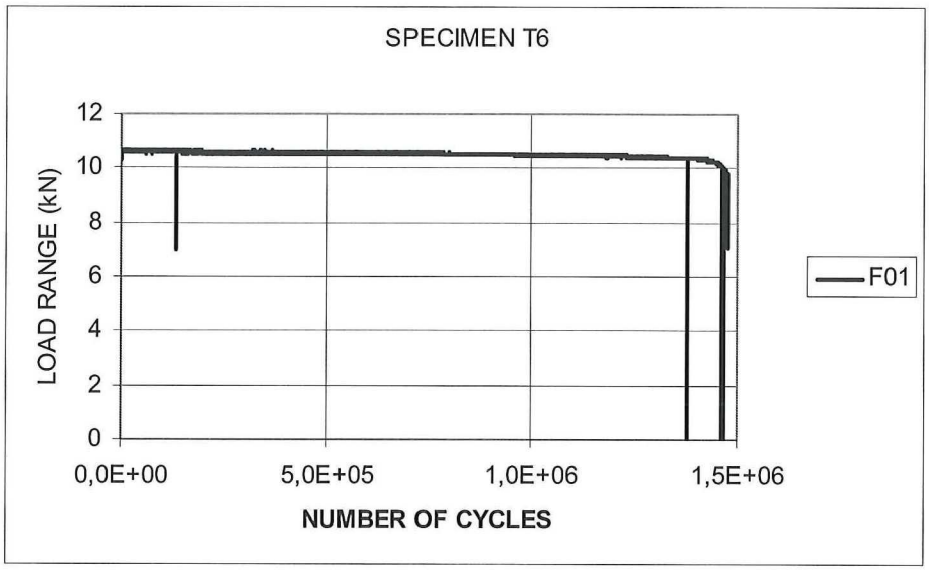


Figure 4. Measured load range during the fatigue test

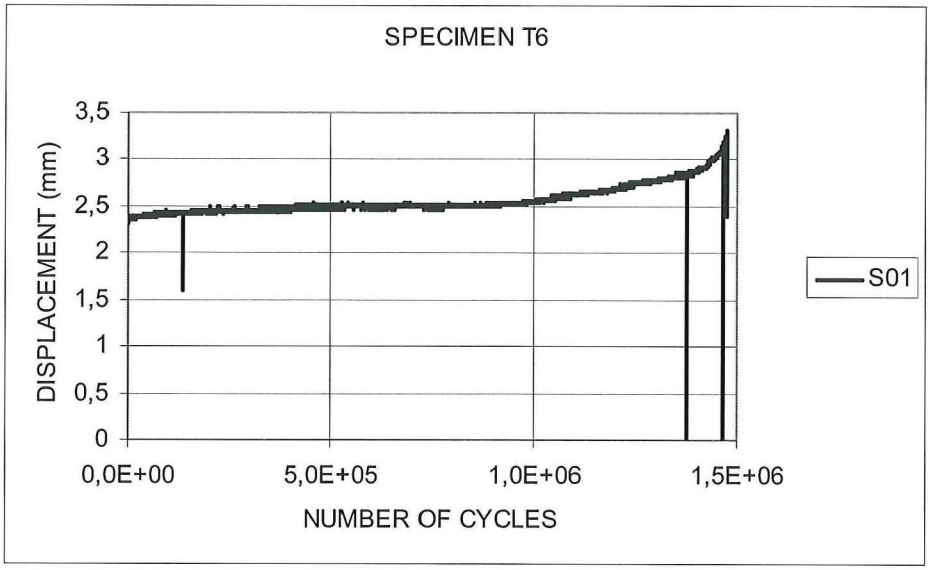


Figure 5. Measured displacement during the fatigue test

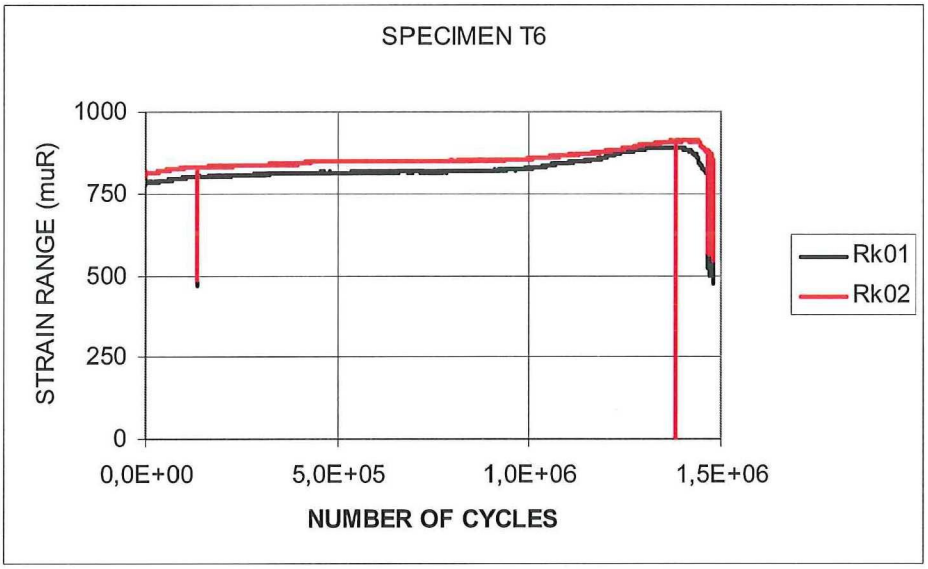


Figure 6. Measured strains during the fatigue test

5. TEST RESULTS

A review of the obtained test results is given in table 1. As shown 5 test specimens have been tested as planned. At a given load level five specimens failed after a certain number of cycles. Failure of the test specimens is defined as total failure of the welded joint. The determining crack initiated at the toe of the weld and growth trough the deck plate. In some specimens a crack initiated at the root of the weld but did not grow through the weld. One test specimen failed due to an unexpected error in the testing equipment. A typical crack starting at the weld toe is shown in figure 7. The graphs as mentioned in chapter 4 are gathered in the Annex I of this report.

TEST	F01 (kN)	S01 (mm)	Rk01 (muR)	Rk02(muR)	N_{tot} (cyc)	
T6	10.65	2.37	791	814	1.478.185	
T5	15.14	3.61	1180	1299	226.903	
T4	8.64	2.00	662	702	2.577.392	
T3	11.23	2.88	980	770	949.612	
T2	5.37	1.61	498	469	11.676.255	
T1	overloaded					

Table 1. Review of test results

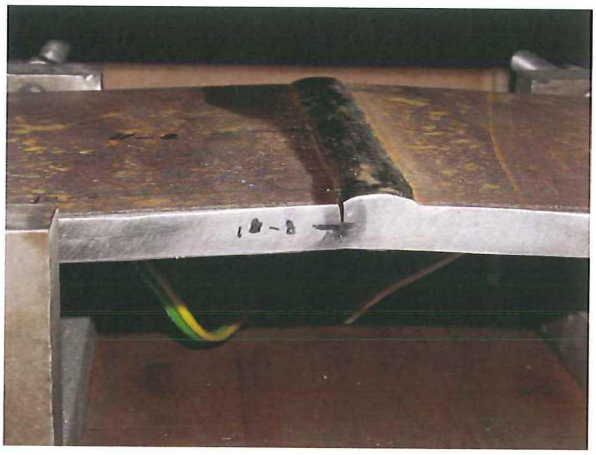
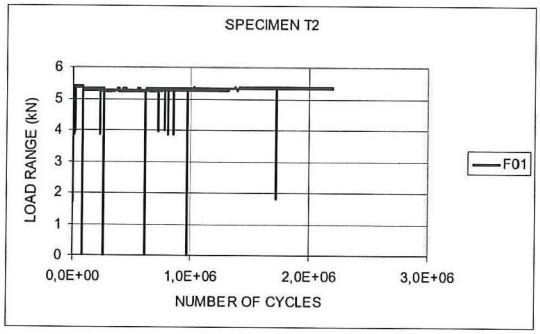
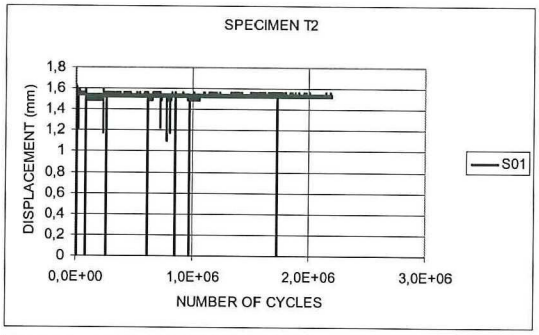


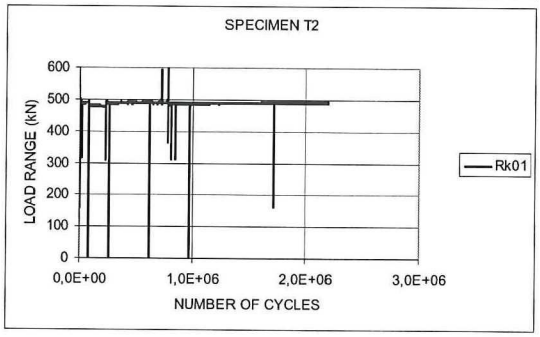
Figure 7. Typical fatigue crack at the weld toe

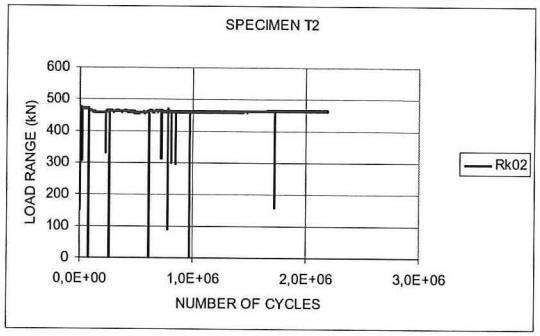
ANNEX I

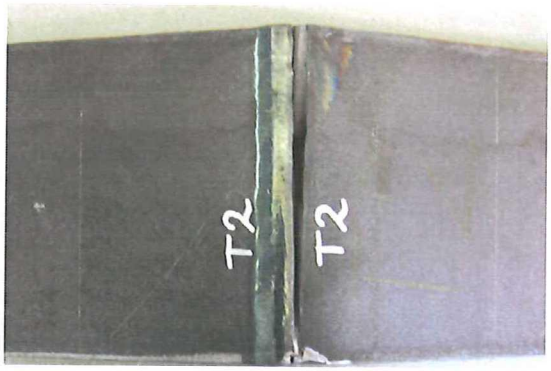
TEST T2



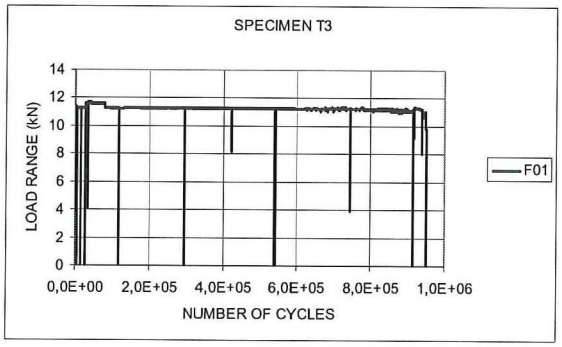


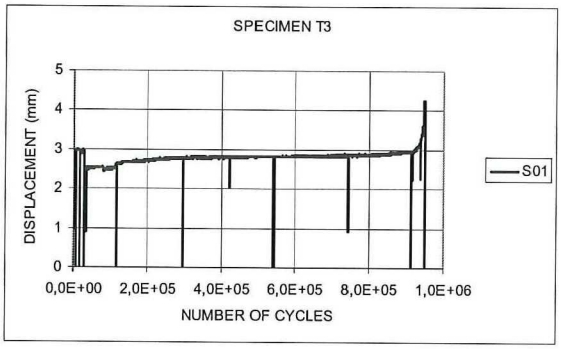


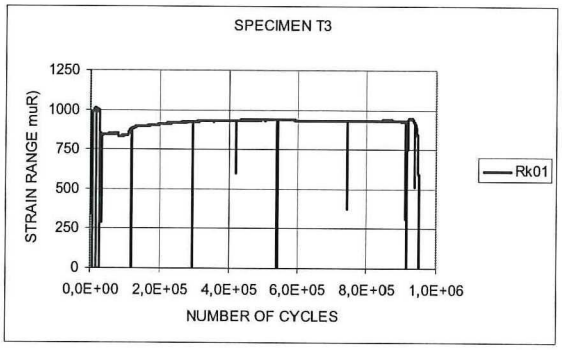


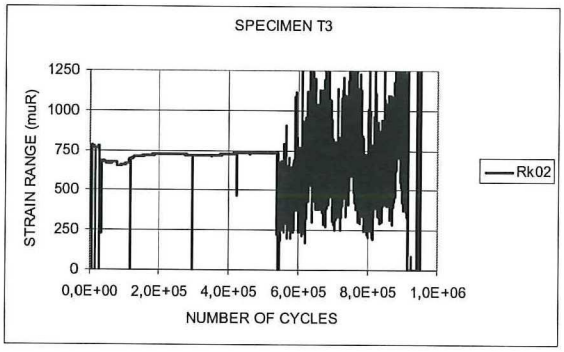


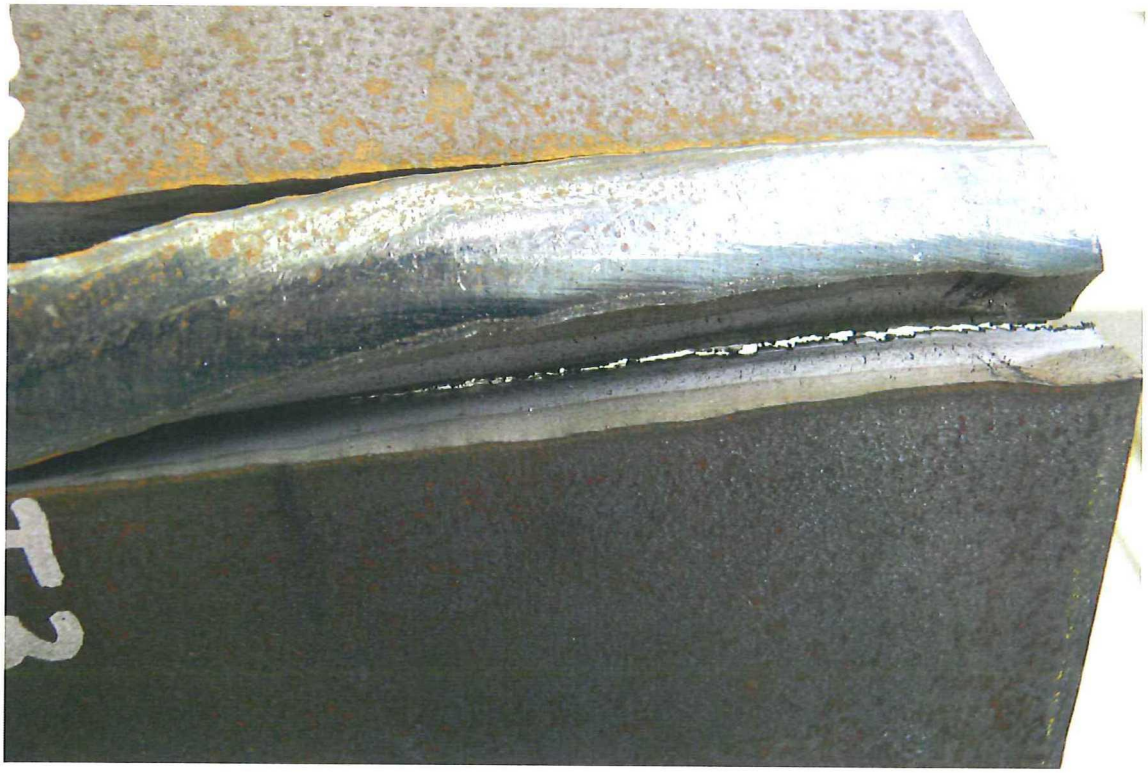
TEST T3


SPECIMEN T3
LOAD RANGE (kN)
14
12
10
8
6
4
2
0
0,0E+00 2,0E+05 4,0E+05 6,0E+05 8,0E+05 1,0E+06
NUMBER OF CYCLES
F01

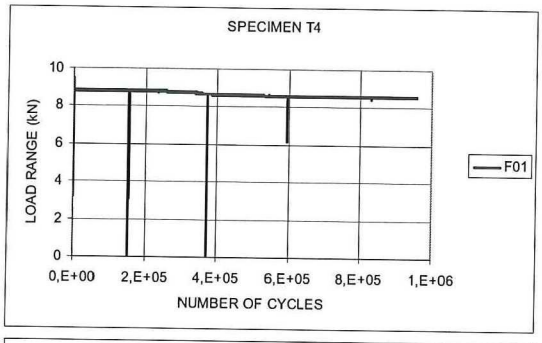

SPECIMEN T3
DISPLACEMENT (mm)
5
4
3
2
1
0
0,0E+00 2,0E+05 4,0E+05 6,0E+05 8,0E+05 1,0E+06
NUMBER OF CYCLES
S01

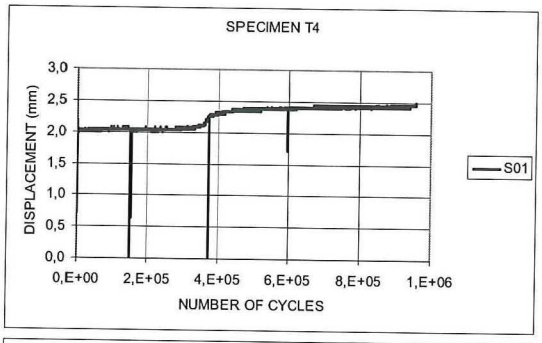

SPECIMEN T3
STRAIN RANGE (muR)
1250
1000
750
500
250
0
0,0E+00 2,0E+05 4,0E+05 6,0E+05 8,0E+05 1,0E+06
NUMBER OF CYCLES
Rk01

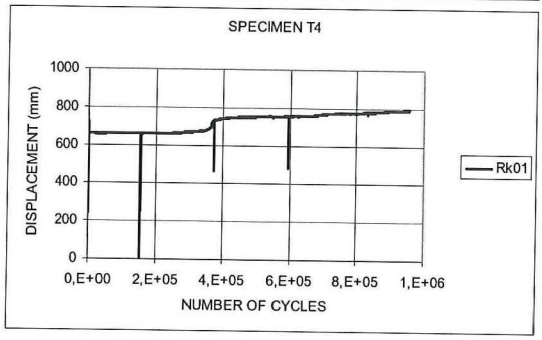

SPECIMEN T3
STRAIN RANGE (muR)
1250
1000
750
500
250
0
0,0E+00 2,0E+05 4,0E+05 6,0E+05 8,0E+05 1,0E+06
NUMBER OF CYCLES
Rk02

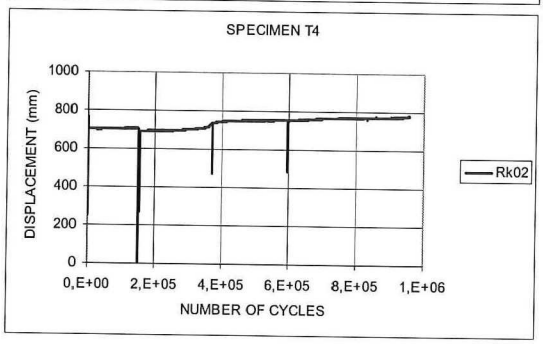


TEST T4

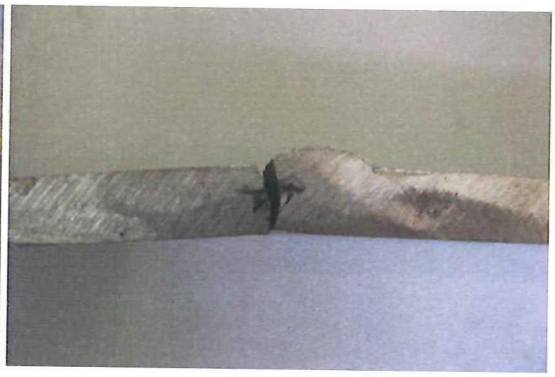

SPECIMEN T4
LOAD RANGE (kN)
10
8
6
4
2
0
0,E+00
2,E+05
4,E+05
6,E+05
8,E+05
1,E+06
NUMBER OF CYCLES
F01

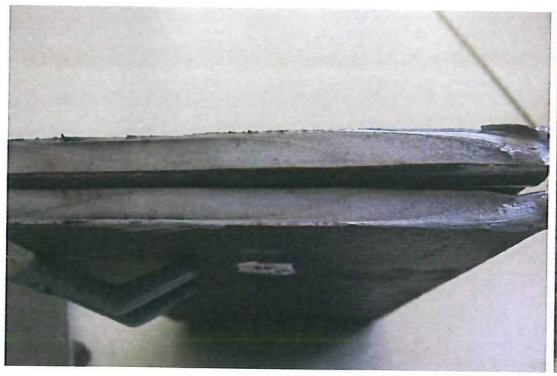

SPECIMEN T4
DISPLACEMENT (mm)
3,0
2,5
2,0
1,5
1,0
0,5
0,0
0,E+00
2,E+05
4,E+05
6,E+05
8,E+05
1,E+06
NUMBER OF CYCLES
S01

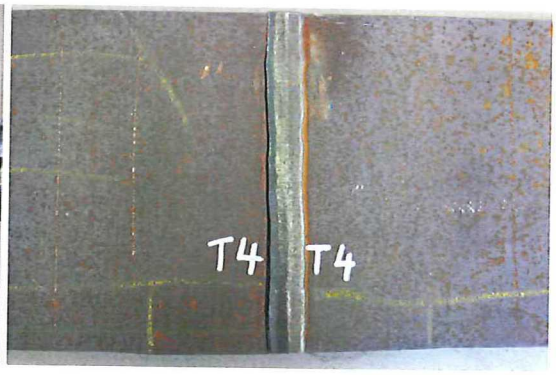

SPECIMEN T4
DISPLACEMENT (mm)
1000
800
600
400
200
0
0,E+00
2,E+05
4,E+05
6,E+05
8,E+05
1,E+06
NUMBER OF CYCLES
Rk01


SPECIMEN T4
DISPLACEMENT (mm)
1000
800
600
400
200
0
0,E+00
2,E+05
4,E+05
6,E+05
8,E+05
1,E+06
NUMBER OF CYCLES
Rk02

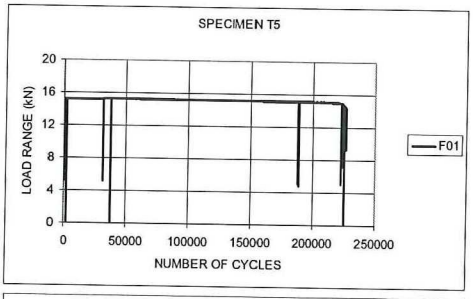

T4
T4

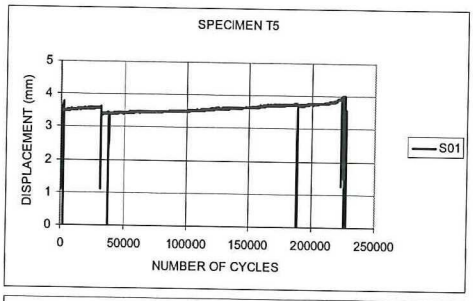


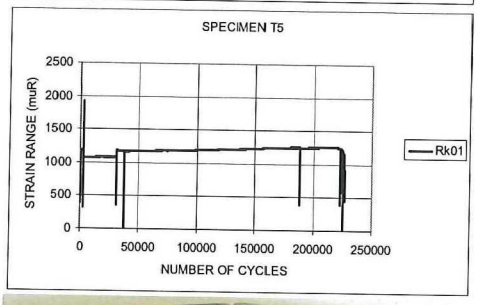


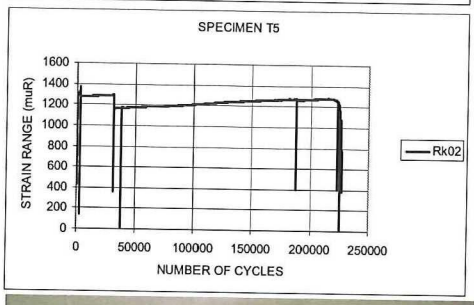

T4
T4

TEST T5


SPECIMEN T5
LOAD RANGE (kN)
NUMBER OF CYCLES
F01


SPECIMEN T5
DISPLACEMENT (mm)
NUMBER OF CYCLES
S01

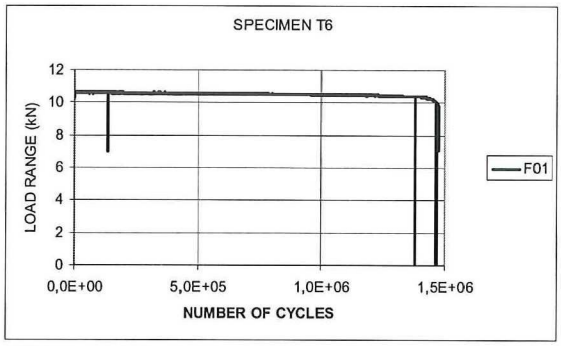

SPECIMEN T5
STRAIN RANGE (muR)
NUMBER OF CYCLES
Rk01

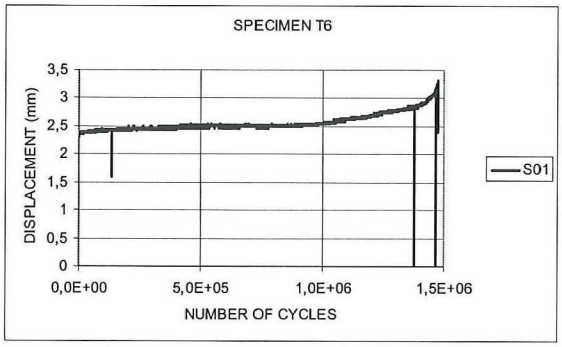

SPECIMEN T5
STRAIN RANGE (muR)
NUMBER OF CYCLES
Rk02

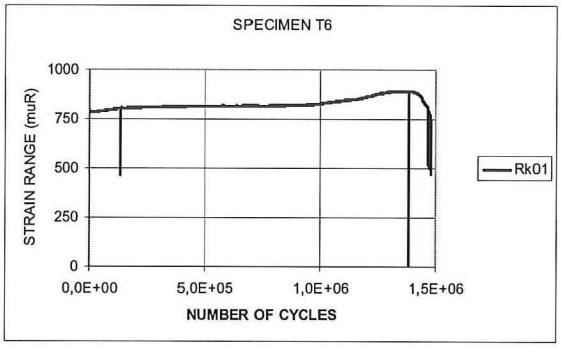

T5
T5

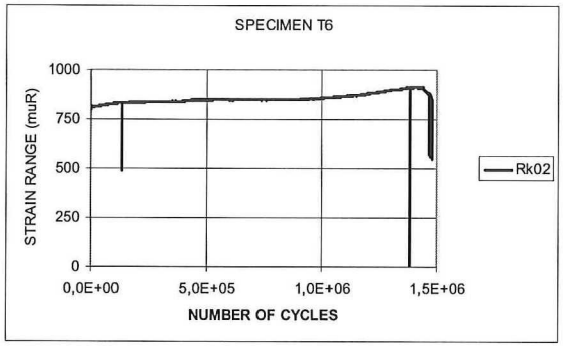

T5
T5

TEST T6


SPECIMEN T6
LOAD RANGE (kN)
12
10
8
6
4
2
0
0,0E+00
5,0E+05
1,0E+06
1,5E+06
NUMBER OF CYCLES
F01


SPECIMEN T6
DISPLACEMENT (mm)
3,5
3
2,5
2
1,5
1
0,5
0
0,0E+00
5,0E+05
1,0E+06
1,5E+06
NUMBER OF CYCLES
S01


SPECIMEN T6
STRAIN RANGE (muR)
1000
750
500
250
0
0,0E+00
5,0E+05
1,0E+06
1,5E+06
NUMBER OF CYCLES
Rk01


SPECIMEN T6
STRAIN RANGE (muR)
1000
750
500
250
0
0,0E+00
5,0E+05
1,0E+06
1,5E+06
NUMBER OF CYCLES
Rk02


T6 T6