Name: _____ Date: _____ Class: _____

Experimental Data Sets

Patched vs. Cracked Unpatched Fatigue Mean Life Data Sets

The following pages provide the experimental data from seven different research centers. See the project guidelines for details about the statistical analysis you will need to perform on the data sets.

All the specimens tested in the various research centers were one-quarter inch cold-rolled A36 steel bars. Holes were drilled and/or notches were cut to induce cracks or fractures; about half of them were patched on the induced fractures using CFRP bonded with epoxy.

All the specimens, patched and unpatched, were tested in hydraulic test systems (Figure 1) that were programmed to apply a constant force or stress periodically. A connected computer system records the testing process and the number of cycles at which the specimen breaks. This number is taken as the fatigue life of the specimen. Following are the data sets to be analyzed.

Figure 1. A servo hydraulic test system is used to apply constant and periodic forces on rigid objects such as steel bars. A connected computer system records the entire process until the tested element fails.

Image source: © 2015 A MTS Landmark® servo hydraulic test system, Structural Research Laboratory, Civil and Environmental Engineering Department, South Annex, University of Houston

Team member names:

Notes and team plans:

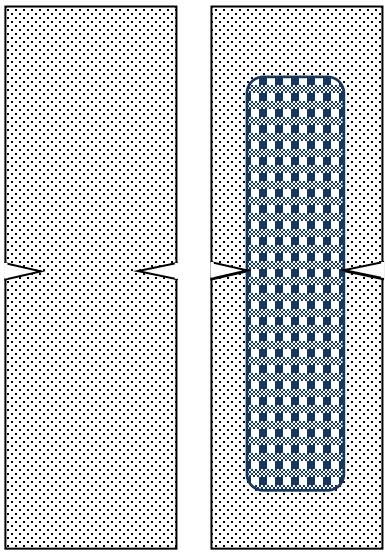
Department of Civil and Environmental Engineering, University of Massachusetts, MA, USA

Two different experimental setups were implemented. On a set of 33 specimens, two triangular notches at opposite edges were cut (22.5% of specimen's width) and unstressed CFRP patches were applied on 18 specimens (*Data Set* 1) on one side only. On a second set of 32 specimens, holes were drilled at the center plus two additional little cuts were made (22.5% of specimen's width). Unstressed CFRP patches covering the two little cuts were applied at both sides of 16 specimens.

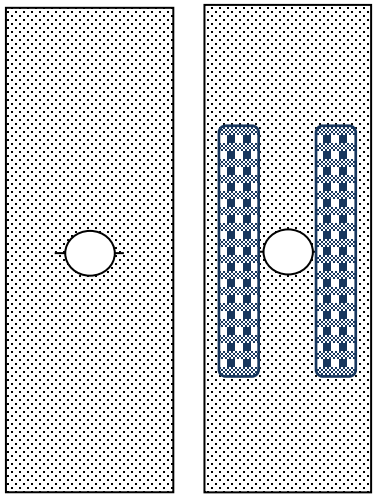
Stress applied on all specimens:
$\Delta\sigma =$ 80 MPa

Stress frequency:
$\Delta\sigma_{\omega} = 15$ Hz

Data Set 1
Unstressed patches on one side only

Patching Configuration	Fatigue Life (Cycles)	
	Unpatched	*Patched*
	198,140	159,747
	167,349	182,829
	114,189	192,075
	127,733	200,851
	154,586	212,374
	157,130	222,731
	186,956	223,045
	193,901	245,521
	194,960	254,856
	178,197	257,288
	205,253	265,487
	208,705	266,759
	212,164	323,509
	178,796	360,752
	123,215	377,575
		385,526
		392,902
		457,370

Data Set 2
Unstressed patches on both sides

Patching Configuration	Fatigue Life (Cycles)	
	Unpatched	*Patched*
	410,671	274,551
	283,173	366,104
	321,312	398,359
	363,126	452,973
	314,159	498,150
	355,113	617,712
	375,927	434,733
	391,929	433,360
	330,973	344,156
	367,413	530,470
	345,480	402,994
	339,783	467,906
	337,448	321,621
	295,788	549,137
	349,082	387,923
	369,377	465,744

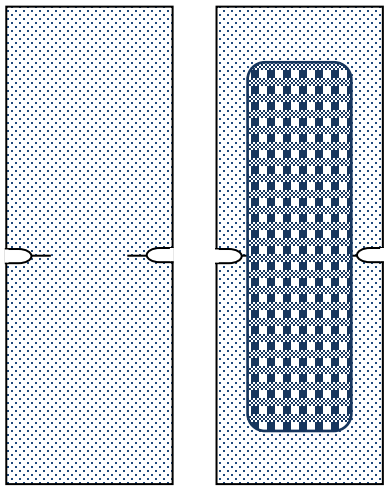
School of Civil Engineering, Southwest Jiaotong University, China
Institute for Rehabilitation of Buildings and Structures, University of Braunschweig, Germany

On 36 specimens, two circular notches at opposite edges were drilled and two little cuts were made (41% specimen's width). On 12 of the specimens (*Data Set* 3), unstressed CFRP patches were applied; on 12 specimens (*Data Set* 4), stressed patches were applied. Patches were applied on only one side of the specimens.

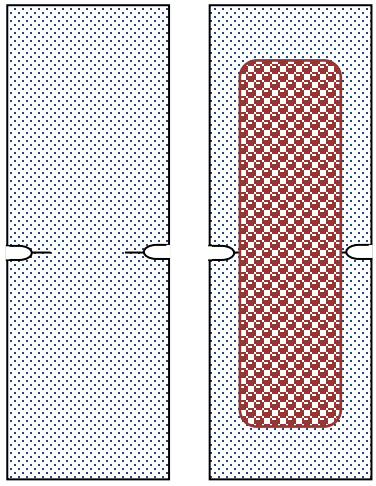
Stress applied on all specimens:
$\Delta\sigma = 117$ MPa

Stress frequency:
$\Delta\sigma_{\omega} = 25$ Hz

Data Set 3
Unstressed patches on one-side

Patching Configuration	**Fatigue Life (Cycles)**	
	Unpatched	*Patched*
	173,000	198,000
	189,000	209,000
	170,000	222,000
	160,000	228,000
	180,000	215,000
	161,000	218,000
	173,000	219,000
	171,000	225,000
	160,000	255,000
	148,000	243,000
	136,000	245,000
	163,000	235,000

Data Set 4
Stressed patches @ 1200 MPa on one-side

Patching Configuration	**Fatigue Life (Cycles)**	
	Unpatched	*Patched*
	173,000	544,000
	189,000	564,000
	170,000	474,000
	160,000	608,000
	180,000	551,000
	161,000	574,000
	173,000	580,000
	171,000	595,000
	160,000	639,000
	148,000	515,000
	136,000	499,000
	163,000	535,000

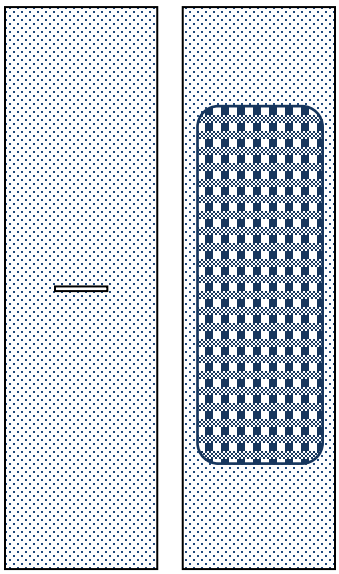
School of Naval Architecture and Marine Engineering, National Technical University of Athens, Greece

A set of 24 specimens having through thickness notches 60 mm long (30% of specimen's width) were tested. CFRP unstressed patches completely covering the notch were applied on 14 specimens, on one side only.

Stress applied on specimens:
$\Delta\sigma = 100$ MPa

Stress frequency:
$\Delta\sigma_{\omega} = 2$ Hz

Data Set 5
Unstressed patches

Patching Configuration	Fatigue Life (Cycles)	
	Unpatched	*Patched*
	38,035	63,385
	40,067	62,408
	38,865	47,053
	39,065	59,306
	39,211	59,560
	40,917	60,081
	41,375	55,383
	41,964	57,476
	39,680	60,664
	42,251	67,494
		69,789
		73,202
		77,682
		80,963

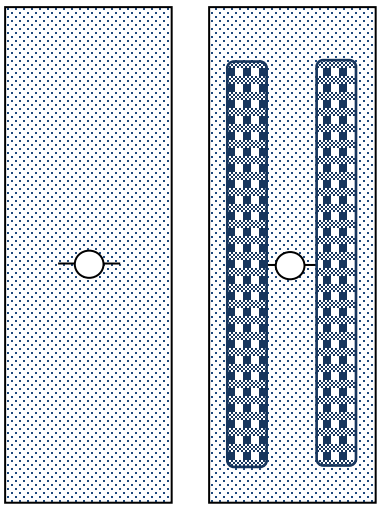
Department of Civil Engineering, Technical University of Denmark, Brovej, Denmark

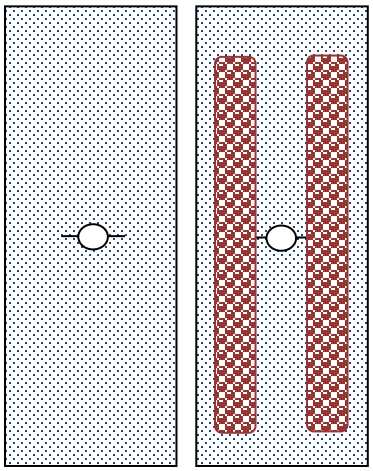
Two different experimental setups were used. At the center of 40 specimens, holes were drilled and two little notches were cut (17% of specimen's width). CFRP patches were applied at the tips of the notches. Stressed patches were used on 14 specimens and unstressed patches on other the 14 specimens. Specimens were patched on both sides.

Stress applied on all specimens:
$\Delta\sigma = 97.5$ MPa

Stress frequency:
$\Delta\sigma_{\omega} = 13.5$ Hz

Data Set 6
Unstressed patches on both sides

Patching Configuration	Fatigue Life (Cycles)	
	Unpatched	*Patched*
	470,000	1,150,000
	477,000	1,250,000
	456,000	1,470,000
	463,000	1,510,000
	469,000	1,760,000
	479,000	1,710,000
	474,000	1,401,000
	472,000	1,321,000
	478,000	1,380,000
	481,000	1,520,000
	467,000	1,200,000
	454,000	1,330,000
		1,380,000
		1,610,000

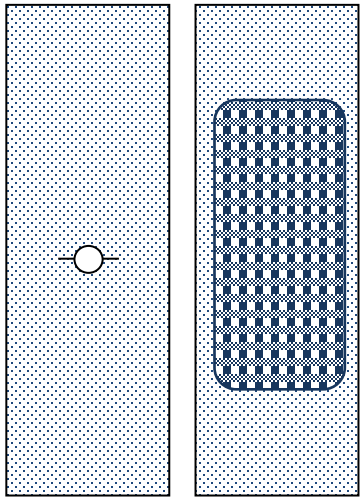
Data Set 7 Stressed patches @ 13.5 KN (Kilo-Newtons) on both sides.		
Patching Configuration	**Fatigue Life (Cycles)**	
	Unpatched	*Patched*
	470,000	3,780,000
	477,000	4,930,000
	456,000	15,980,000
	463,000	8,560,000
	469,000	10,500,000
	479,000	7,410,000
	474,000	6,070,000
	472,000	6,730,000
	478,000	8,340,000
	481,000	8,390,000
	467,000	7,990,000
	454,000	8,340,000

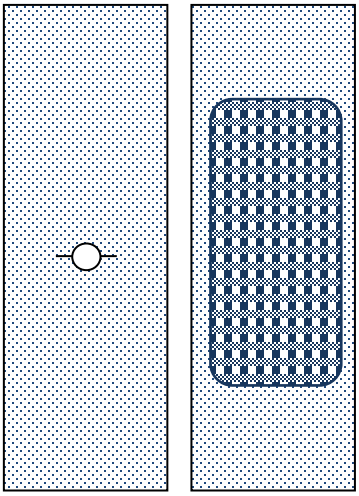
Department of Civil Engineering, Monash University, Clayton, Victoria, Australia

Two different experimental setups were used. At the center of 36 specimens, holes were drilled and two little notches were cut (13.3% of specimen's width). Unstressed CFRP patches covering holes and notches were applied on 24 specimens, 12 specimens were patched one side only (*Data Set* 8), and 12 specimens were patched on both sides (*Data Set* 9).

Stress applied on all specimens:
$\Delta\sigma = 135$ MPa

Stress frequency:
$\Delta\sigma_{\omega} = 30$ Hz

Data Set 8 One side patched. Unstressed patches		
Patching Configuration	**Fatigue Life (Cycles)**	
	Unpatched	*Patched*
	244,950	298,757
	238,333	339,823
	241,974	333,091
	240,825	345,684
	241,071	350,867
	238,881	390,034
	244,019	446,456
	242,554	478,351
	241,755	447,372
	241,474	346,657
	240,918	353,746
	242,944	350,757

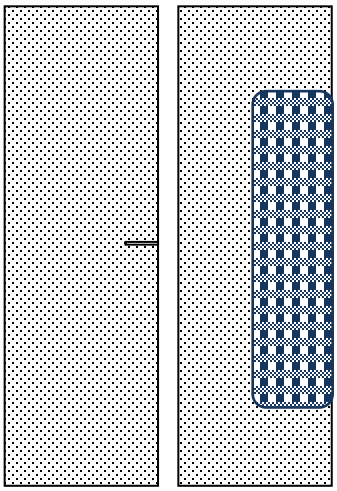
Data Set 9 Two sides patched; unstressed patches		
Patching Configuration	**Fatigue Life (Cycles)**	
	*Unpatched*	*Patched*
	244,950	542,353
	238,333	656,712
	241,974	1,135,592
	240,825	1,219,451
	241,071	1,604,008
	238,881	1,484,145
	244,019	1,920,000
	242,554	1,305,694
	241,755	1,723,519
	241,474	1,280,782
	240,918	953,603
	242,944	1,518,752

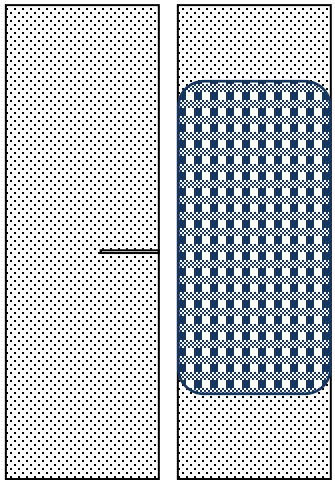
Department of Architecture, Built Environment and Construction Engineering, ABC Politecnico di Milano, Milan, Italy

Two different experimental setups were used. On 25 specimens, 6 mm long side notches were cut (12% of specimen's width); on the other 25 specimens, 15 mm long side notches were cut (30% of specimen's width). Unstressed CFRP patches were applied covering the notches only on one side of the specimen.

Stress applied on all specimens:
$\Delta\sigma = 90$ MPa

Stress frequency:
$\Delta\sigma_{\omega} = 18$ Hz

Data Set 10 Notch length: 6 mm. Patched half of specimen's width		
Patching Configuration	**Fatigue Life (Cycles)**	
	*Unpatched*	*Patched*
	196,714	58,400
	194,166	512,000
	187,214	565,000
	181,171	605,000
	191,649	344,838
	187,415	616,695
	199,561	409,475
	201,374	438,402
	204,627	301,521
	213,690	440,671
	206,273	448,455
		378,037
		499,095
		473,951

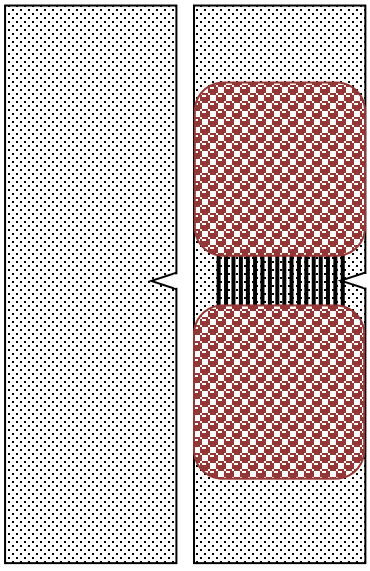
Data Set 11 Notch length: 15 mm. Patched all of specimen's width		
Patching Configuration	**Fatigue Life (Cycles)**	
	*Unpatched*	*Patched*
	29,264	66,800
	29,693	77,000
	29,533	81,184
	29,507	86,199
	30,961	91,132
	26,899	94,977
	30,357	103,457
	29,106	111,354
	29,294	114,627
	28,818	124,075
	28,472	129,331
		133,000
		151,504
		172,000

Department of Civil Engineering, Cullen College of Engineering, University of Houston, TX, USA

On 28 specimens were cut triangular side notches of 10 mm long (11.1% of specimen's width). Stressed CFRP-NiTiNB patches were applied on one side only. Nitinol-Niobium wires (NiTiNB = nickel-titanium-niobium) were used to pre-stress the patches.

Stress applied on all specimens:
$\Delta\sigma = 153$ MPa

Stress frequency:
$\Delta\sigma_{\omega} = 10$ Hz

Data Set 12 Stressed Patch @ 30 MPa – One side patching		
Patching Configuration	**Fatigue Life (Cycles)**	
	*Unpatched*	*Patched*
	48,172	960,000
	49,868	1,140,000
	44,265	840,000
	48,181	1,045,000
	48,622	1,078,000
	49,190	1,039,000
	48,454	956,000
	44,761	932,000
	45,337	1,108,000
	45,625	1,008,000
	49,525	980,000
	47,416	989,000
	46,243	880,000
	48,431	905,000