Resin injected bolted connections: A step towards achieving slip-resistant joints in FRP bridge engineering

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Outline

- Introduction
- Experimental arrangement
- Injection bolts
- Test results
- Concluding remarks

Introduction

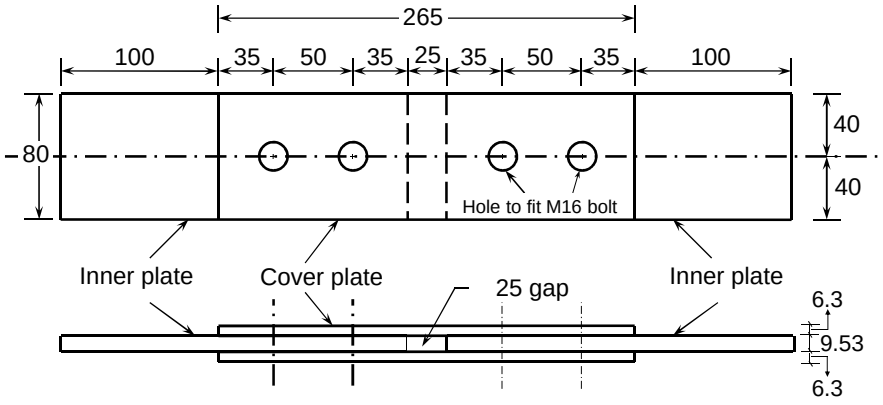
- Fatigue and slip resistance are critical to bridges.
- In steel bridges, the conventional way to achieve slip resistance is to use rivets, fitted bolts or HSFG bolts.
- In FRP bridges:
  - Hot riveting is unsuitable due to lack of labour and equipment.
  - Fitted bolts are expensive and not a practical solution.
  - FRP can loose tightening over lifetime due to creep relaxation and HSFG bolts cannot be relied upon.
- Injection bolts offer slip, fatigue and shock resistant connections.
- They can be used as an alternative to fitted bolts, rivets or preloaded HSFG bolts.

Introduction

1. Quality control tests
   - Injection assembly with perspex to check passage of resin.
   - Static load test to check curing of resin – slip not more than 0.15 mm.
2. Static creep test
   - Test for determination of design bearing resistance of the resin – creep should be less than 0.3 mm during lifetime.
3. Fatigue test
   - Bearing resistance from creep test is used to establish bearing stress ranges.
   - If total slip between the inner and outer plates is more than 0.3 mm, the fatigue life is at its end.

Experimental arrangement

Note: Both inner and outer plates are of pultruded FRP material



Double lap shear bolted connection specimens as per Annex G of BS EN 1090-2* (dimensions in mm).

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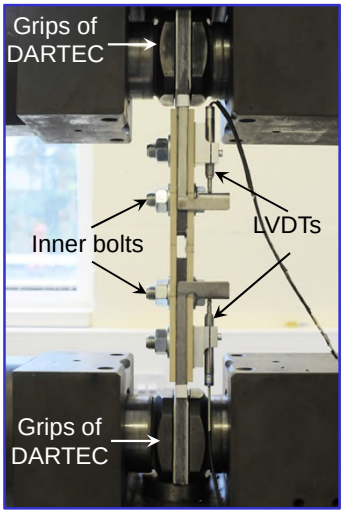
*BS EN 1090-2:2008. Execution of steel structures and aluminium structures Part 2: Technical requirements for the execution of steel structures, British Standards Institution, United Kingdom, 2008

Experimental arrangement

Details of four test specimens.

	Test	Bolt	Bolt hole	Resin
Standard bolts	Test 1	M16	18 mm	---
	Test 2	M16	16 mm	---
Resin injected bolts	Test 3	M16	18 mm	RenGel SW404
	Test 4	M16	18 mm	Sikadur-30

Note : Bolts tightened to a bolt torque of 88 N.m, using tension formula given in Smith et al*.



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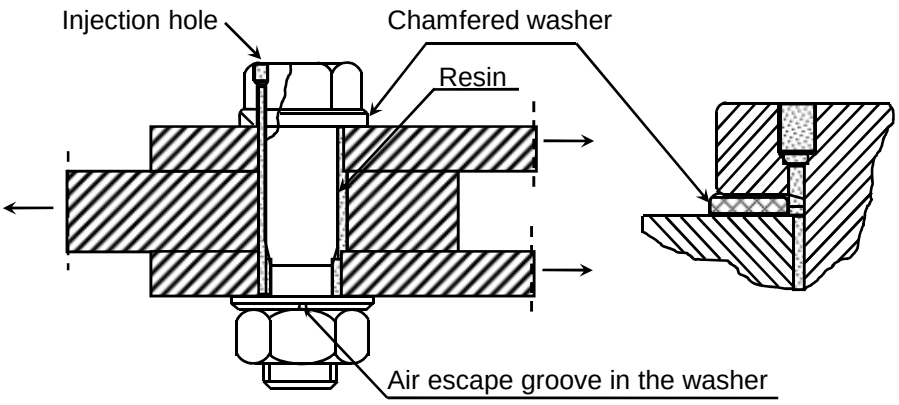
*Smith, P. A., Ashby, M. F. and Pascoe, K. J. Modelling clamp-up effects in composite bolted joints. Journal of Composite Materials, 1987; 21(10): pp 878-897.

Injection bolts

Note : There is a standard procedure to produce hexagon injection bolts in ECCS 79* and BS EN 1090-2:2008.



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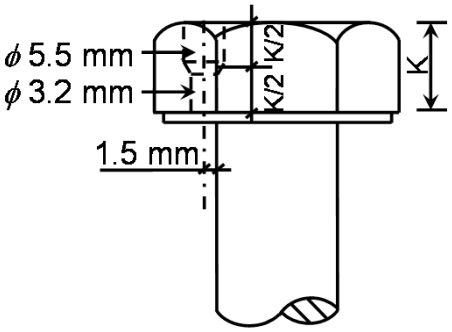
*European Convention for Constructional Steelwork (ECCS). *European Recommendations for bolted connections with injection bolts*. ECCS Publication No. 79, 1994.

Injection bolts – Preparation of bolts and washers

Annex K: Hexagon Injection bolts of BS EN 1090-2:2008.



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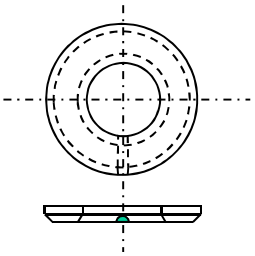
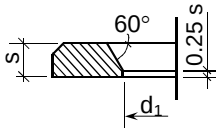
Injection bolts – Preparation of bolts and washers

Bottom washer

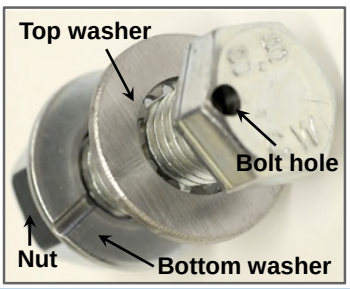


Top washer

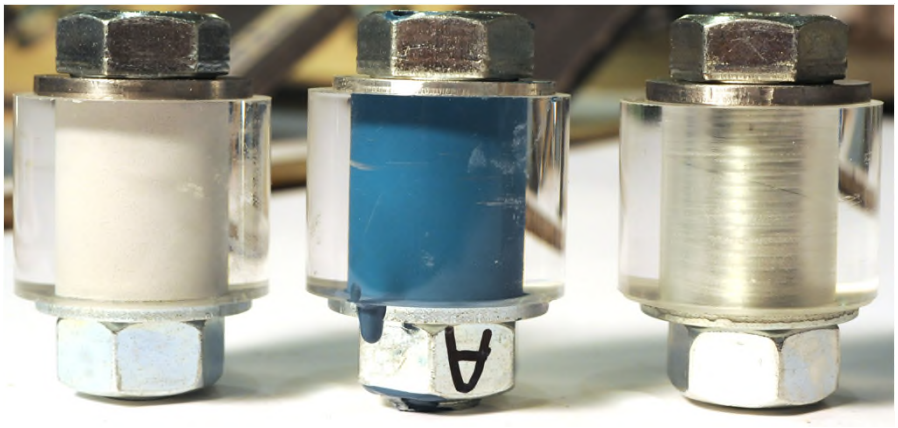


Injection bolts – Preparation of bolts and washers

Standard | EN 1090 | 6 under cuts | 12 under cuts



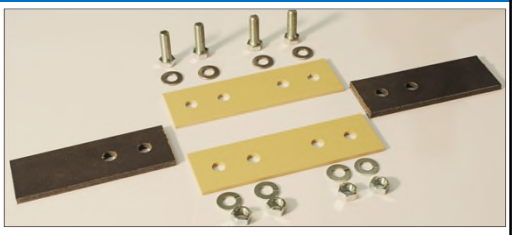
Injection bolts – Trial injection procedure



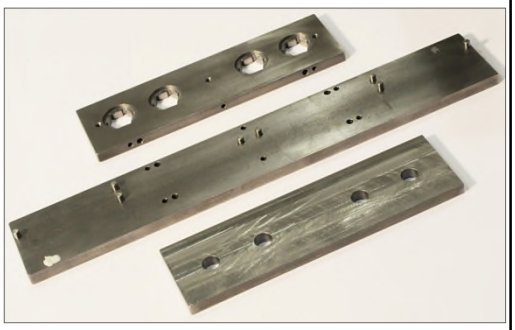
Sikadur-30 RenGel SW404 Empty perspex

Injection bolts – Assembling and resin injection

Unassembled specimen

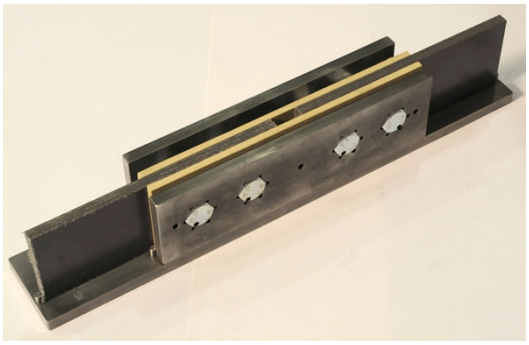


Bolt centreline location jig



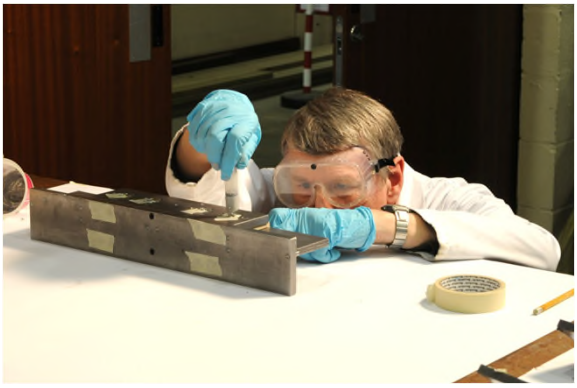
Injection bolts – Assembling and resin injection

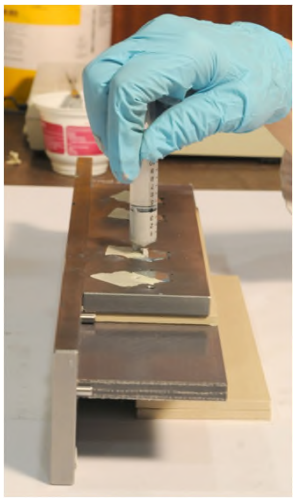
Test specimen



Test specimen in location jig

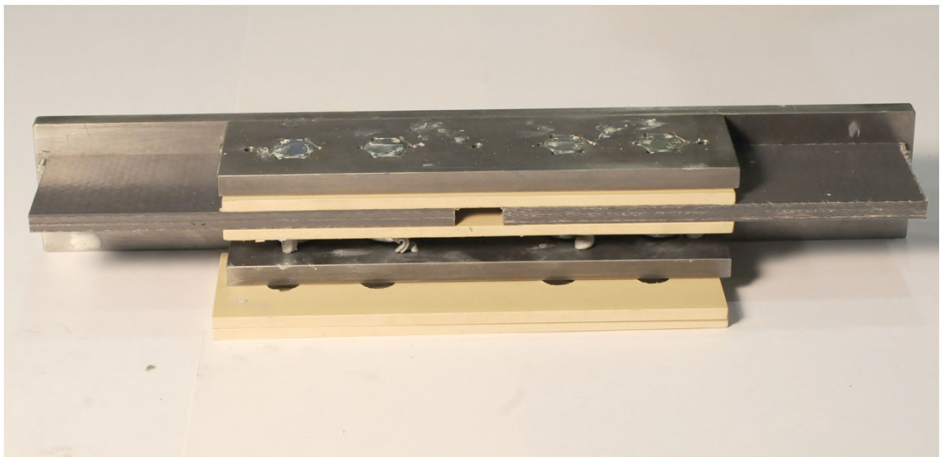
Injection bolts – Assembling and resin injection





Resin injection process

Injection bolts – Assembling and resin injection



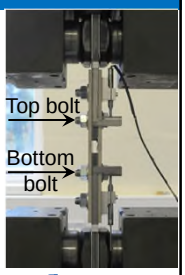
Test specimen in location jig after resin injection

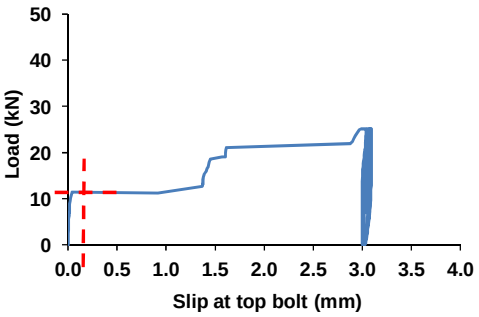
Injection bolts – Assembling and resin injection

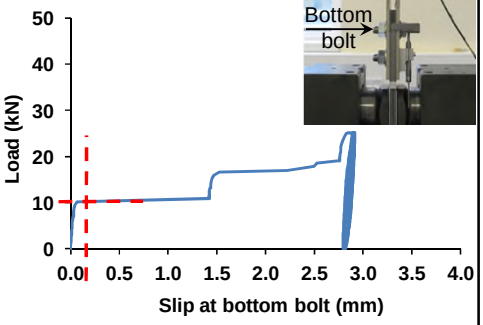
Resin injected test specimen ready to be tested

Test results – Test 1: No resin and clearance hole

Note: Static slip resistance is the load corresponding to a slip of 0.15 mm in load-slip curve (indicated by dashed line)

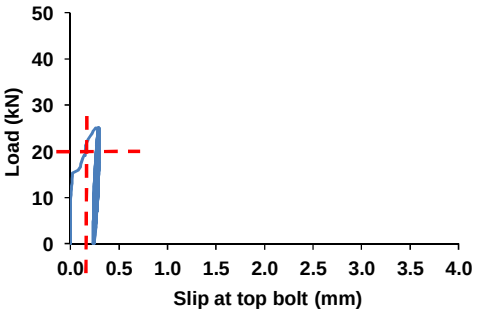


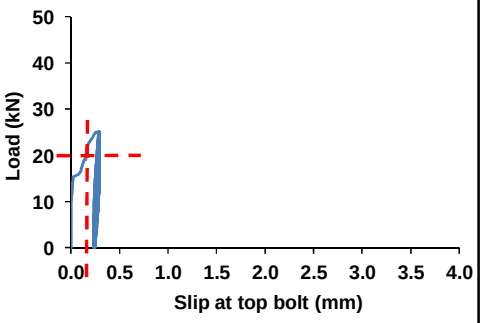




Specimen with M16 bolts, 18 mm holes and no resin

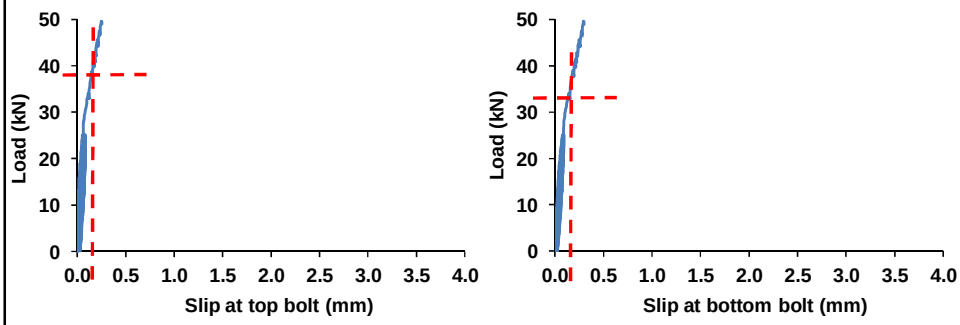
Test results – Test 2: No resin and no clearance





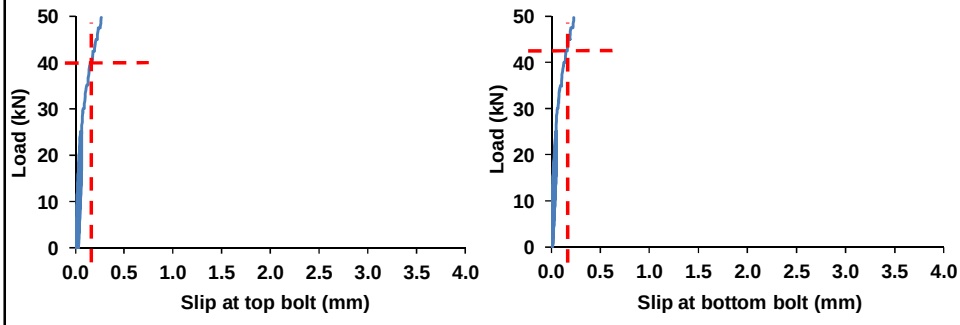
Specimen with M16 bolts, 16 mm holes and no resin

Test results – Test 3: RenGel SW404+HY2404 resin



Specimen with M16 bolts, 18 mm holes and RenGel SW404+HY2404 resin

Test results – Test 4: Sikadur-30 resin



Specimen with M16 bolts, 18 mm holes and Sikadur-30 resin

Concluding remarks

- Resins RenGel SW404+HY2404 and Sikadur-30 were used.
- The resin injected bolts showed slip resistance.
- The new top washer ensured smooth filling of resin.
- Design bearing resistance of resin will be determined from static creep tests.
- This property will be used to establish bearing stress range in a fatigue test.
- Injection bolts look promising to provide slip and fatigue resistant connections in FRP bridges.

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