Swinburne University of Technology

Centre for Sustainable Infrastructure

Performance of Anchors with Conbextra EP10 Epoxy grout in Concrete

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Report prepared for:

Parchem Pty Ltd

Testing conducted by:

Kelvin Liu and Prayush Rajbhandari

Report by:

Prayush Rajbhandari and Jessey Lee

Executive Summary

This report provides results from pull-out tests of bonded anchors in concrete conducted at Swinburne University of Technology, Smart Structures Laboratory in August 2023. Anchors tested were 8.8 grade M10 all threads. These anchors were tested with Conbextra EP10 epoxy with an embedment depth of 80mm and 100mm. A hole diameter of 15mm was used for embedment depth of 80mm and a hole diameter of 13mm and 15mm were used for an embedment depth of 100mm. Pullout test were carried out at 3 days curing of epoxy. Slabs were cast by a local manufacturer with a 40MPa mix design, concrete cylinders compressive strength at 28days was in the range of 67.5 to 69.5MPa.

In total 6 tests (2 for embedment depth of 80mm with 15mm hole diameter, 2 for embedment depth of 100mm with 15mm hole diameter and 2 for embedment depth of 100mm with 13mm hole diameter) were conducted in the laboratory. Five anchors failed with steel failures while only one anchor failed with mixed mode failure that is concrete cone with pullout.

The results for the tests conducted are summarised in Table 1.

Table 1: Summary of tests conducted for M10 with Conbextra EP10

Epoxy	Anchor Diameter (mm)	Embedment depth (mm)	Curing time	No. of tests	Average failure load (kN)	Failure Mode
Conbextra EP10	10	80	3 days	2	51.1	1 Steel failure, 1 Mixed mode failure
Conbextra EP10	10	100	3 days	4*	51.7 for 15mm dia hole, 50.1 for 13mm dia hole	All steel failure

*2 tests have a hole diameter of 15mm and 2 tests have hole diameter of 13mm

Note:

- *mixed mode failure = combined cone and pullout*

Table of Contents

1 Introduction

Swinburne University of Technology was commissioned by Parchem Pty Ltd to carry out testing of anchors with Conbextra EP10 epoxy to evaluate the tensile performance of bonded anchors. M10 anchors were tested with an embedment depth of 80mm and 100mm. A hole diameter of 15mm was used for embedment depth of 80mm and a hole diameter of 13mm and 15mm were used for an embedment depth of 100mm. The curing time for epoxy was 3 days. Slabs were cast by a local manufacturer with a 40MPa mix design. The mean cylinder (100 diameter x 200mm) compressive strength results of the concrete slabs ranged from 67.5MPa to 69.5MPa after 28 days. Figure 1 shows the slab and anchor used for testing.

The scope of work was:

(i) to assess the tensile behaviour of bonded anchors through pull-out testing.
(ii) to provide a report on the work completed.

The work was undertaken at the Swinburne University of Technology (SUT) in Hawthorn, Victoria.

a) Slab before installation of anchor

b) Anchor installed with ConbextraEP10 epoxy

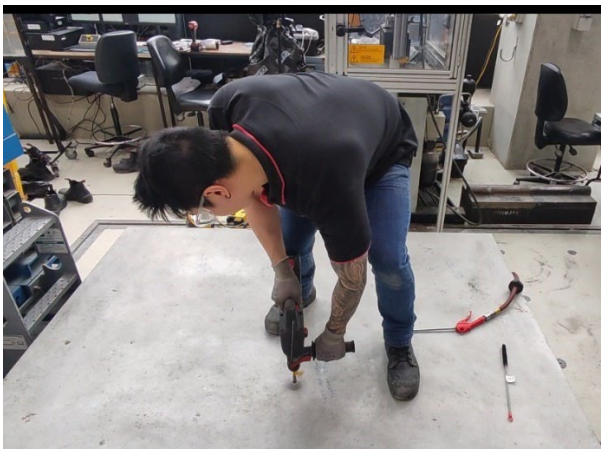
Figure 1 Slab and anchor for pullout test

2 Test specimen and setup

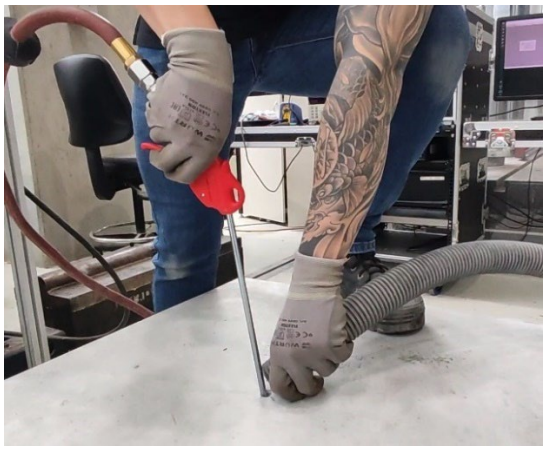
Concrete panels of 1400x2000x400mm (Figure 1) were cast with *VA402PA* mix design from a local supplier. Standard cylinders for each slab were tested in accordance with AS1012.9 to confirm the compressive strength.

The slabs were laid flat, and the location of anchors were marked. The holes were percussion drilled vertically into the concrete and the holes were cleaned by blowing with dry compressed air

followed by brushing and then again followed by blowing with compressed air. The components of epoxy i.e., the base and hardener were mixed using a spiral mixture for three minutes before application. The mixture was then filled into the holes to about 2/3rd of the hole depth. The anchor rod was gently rotated vertically down into the hole with a slow turning action. The excess epoxy exuding out of the hole was cleaned. Heat lamps were set near the anchors to maintain a curing temperature of approximately 23˚C. The installation process is shown in Figure 2.



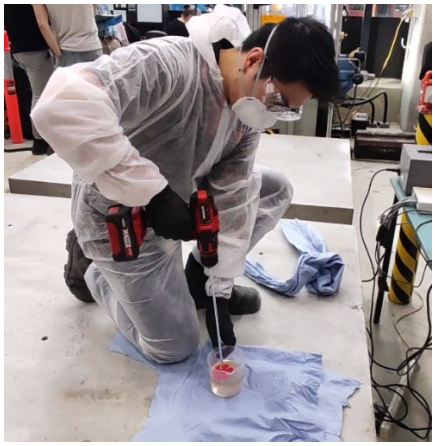
a) Drilling of hole



b) Blowing of dust particles

c) Brushing of hole

d) Base and hardener in separate container



e) Mixing of Base and Hardener

f) Anchor installed in concrete

g) Heat lamps to maintain curing temperature
Figure 2 Installation of anchor in concrete

The test arrangement consists of a hand jack, a self-reacting frame, load cell and a fixture to connect the anchor as shown in Figure 3. The load on the anchors were continuously monitored and recorded.

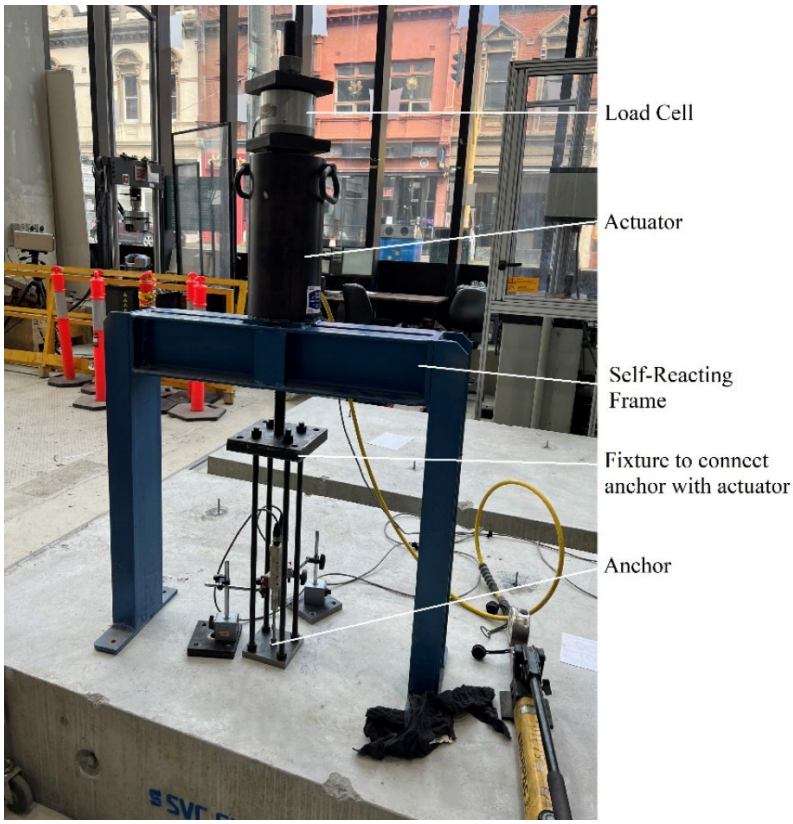


Figure 3: Test setup for pull-out test of headed anchors

3 Test results

The pull-out tests were performed at 3-day curing of epoxy. For each test, the ultimate loads were recorded. The mean ultimate load was calculated for each test series. Table 2 shows the summary of pullout tests of anchors. Two types of failure modes were observed during the test: steel failure and mixed mode failure.

Table 2 Summary of pull-out tests for M10 anchors with Conbextra EP10.

Anchor Diameter (mm)	Hole Diameter (mm)	Embedment depth (mm)	Mean compressive strength (MPa)	Epoxy Curing Time	Failure Load (kN)		Failure Mode	Average Experimental Load (kN)
10	15	80	69.5	3 days	52.3		Steel Failure	51.1
10	15	80	69.5	3 days	49.9		Mixed Mode Failure	
10	15	100	69.5	3 days	51.7		Steel Failure	51.7
10	15	100	67.5	3 days	51.7		Steel Failure	
10	13	100	67.5	3 days	49.2		Steel Failure	50.1
10	13	100	67.5	3 days	50.9		Steel Failure	

Note: Mixed Mode Failure=Concrete cone with pullout failure

Most of the failures that occurred were steel failure with only one that exhibited mixed mode failure. The failure loads were in the same range for all these failures.

3.1 Typical failure modes

The failure modes observed for the anchors in Conbextra EP10 were steel failure and mixed mode failure. In the mixed mode failure, a concrete cone was observed at the surface, while a pullout failure was observed at the bottom. Figure 4 shows the typical failure modes observed in the tests.

a) Steel failure b) Mixed mode failure

Figure 4: Typical failure modes

4 Conclusion

An experimental program was conducted at Swinburne University of Technology for pullout test of M10 anchors bonded with Conbextra EP10 epoxy grout in concrete. M10 anchors with a hole diameter of 15mm was used for embedment depth of 80mm and a hole diameter of 13mm and 15mm were used for an embedment depth of 100mm. The pullout tests were carried out at 3-day epoxy curing. The mean cylinder compressive strength of concrete slabs was in the range of 67.5 to 69.5MPa. In total 6 tests (2 for embedment depth of 80mm with 15mm hole diameter, 2 for embedment depth of 100mm with 15mm hole diameter and 2 for embedment depth of 100mm with 13mm hole diameter) were conducted in the laboratory.

Two types of failure modes were observed: steel failure and mixed mode failure. Five anchors failed with steel failures while only one anchor failed with mixed mode failure that is concrete cone with pullout.

5 References

Standard Australia AS 1012.9: Methods of testing concrete, Method 9: Compressive strength tests — Concrete, mortar and grout specimens, *Standards Australia*, 2014.

Standard Australia AS 5216: Design of post-installed and cast-in fastenings in concrete, *Standards Australia*, 2021.

Rolf Eligehausen, Rainer Mallée, John F. Silva, Anchorage in Concrete Construction, *Wiley*, 2006.