Swinburne University of Technology

Centre for Sustainable Infrastructure

Performance of Anchors with Conbextra EP65 PLUS Epoxy grout in Concrete

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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 M12 and M24 all threads. These anchors were tested with Conbextra EP65 PLUS epoxy. An embedment depth of 100mm and hole diameter of 18mm was used for M12 anchor and an embedment depth of 200mm and hole diameter of 35mm was used for M24 anchors. Pullout test were carried out at 1 day and 3 days epoxy curing time. Slabs were cast by a local manufacturer with a 40MPa mix design, concrete cylinders compressive strength at 28days was in the range of 47.2 to 69.5MPa. In total 12 tests (3 for M12 anchor at 1 day epoxy curing, 3 for M24 anchor at 1 day epoxy curing, 3 for M12 anchor at 3-day epoxy curing and 3 for M24 anchor at 3-day epoxy curing) were conducted in the laboratory.

Majority of anchor failures were steel failures for M12 anchors and concrete cone failure for M24 anchors. There were two mixed mode failures (concrete cone and pullout) for M12 anchors.

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

Table 1: Summary of tests conducted for M12 and M24 anchors with Conbextra EP65 PLUS

Epoxy	Anchor Diameter (mm)	Embedment depth (mm)	Curing time	No. of tests	Average failure load (kN)	Failure Mode
Conbextra EP65 PLUS	12	100	1 day	3	68.8	2 mixed mode failure, 1 steel failure
Conbextra EP65 PLUS	12	100	3 days	3	70.9	All steel failure
Conbextra EP65 PLUS	24	200	1 day	3	315.8*	All concrete cone failure
Conbextra EP65 PLUS	24	200	3 days	3	341.1	1 concrete cone failure, 2 steel failure

*averaging over two different cylinder strengths

Note:

- *mixed mode failure = combined cone and pullout*

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1 Introduction

Swinburne University of Technology was commissioned by Parchem Pty Ltd to carry out testing of anchors with Conbextra EP65 PLUS epoxy to evaluate the tensile performance of bonded anchors. M12 and M24 anchors. An embedment depth of 100mm and hole diameter of 18mm was used for M12 anchor and an embedment depth of 200mm and hole diameter of 35mm was used for M24 anchors. Pullout tests were carried out at 1 day and 3 day of epoxy curing. 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 47.2MPa 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 EP65 PLUS epoxy

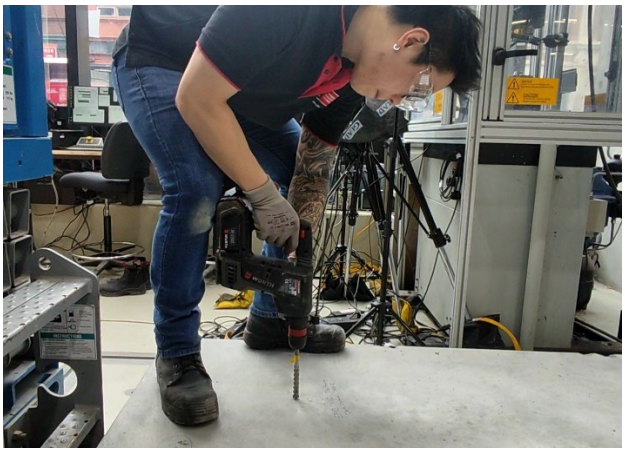
Figure 1 Slab and anchor for pullout test

2 Test specimen and setup

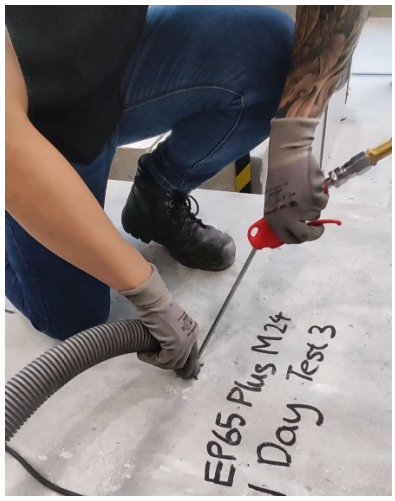
Concrete panels of 1400x2000x400mm (Figure 1) were cast with *VA402PA* mix design from a local supplier. Standard cylinders for each slab were tested in accordance with AS1012.9 to confirm the compressive strength.

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.

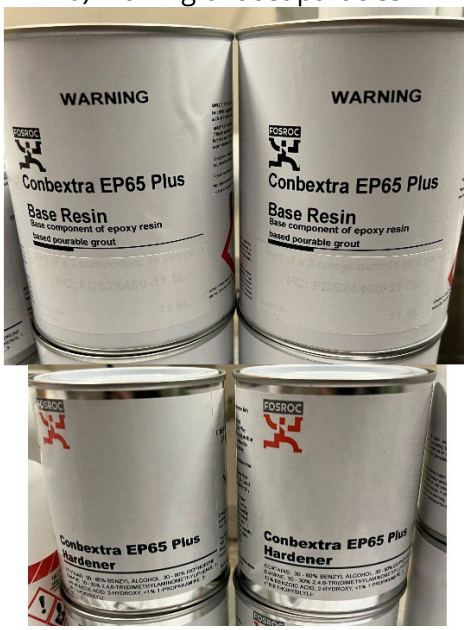


a) Drilling of hole



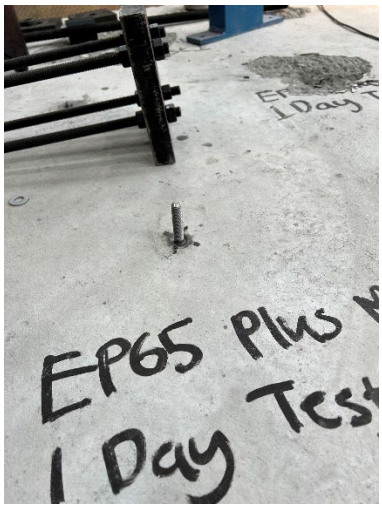
b) Blowing of dust particles

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.

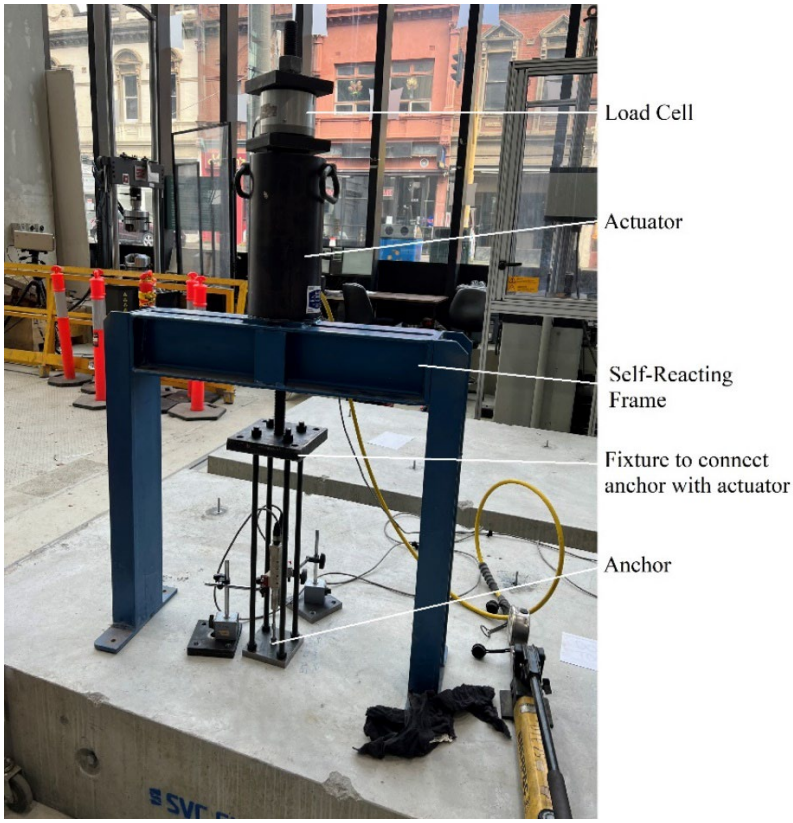


Figure 3: Test setup for pull-out test of headed anchors

3 Test results

The pull-out tests were performed at two curing ages of epoxy. For each test, the ultimate loads were recorded. The mean ultimate load was calculated for each test series and coefficient of variation (COV) was calculated for test series with at least 3 specimens. Table 2 and Table 3 show the summary of pullout tests of anchors. Three types of failure modes were observed during the test: concrete cone failure, steel failure and mixed mode failure.

Table 2 Summary of pull-out tests for M12 anchors with Conbextra EP65 PLUS.

Anchor Diameter (mm)	Hole Diameter (mm)	Embedment depth (mm)	Mean compressive strength (MPa)	Epoxy Curing Time	Failure Load (kN)	Failure Mode	Average Load (kN) and CoV (%)
12	18	100	69.5	1 day	66.7	Mixed Mode Failure	68.8, 5.0
12	18	100	69.5	1 day	67.0	Mixed Mode Failure	
12	18	100	69.5	1 day	72.8	Steel Failure	
12	18	100	67.5	3 days	71.1	Steel Failure	

12	18	100	67.5	3 days	70.5	Steel Failure	70.9, 0.6
12	18	100	67.5	3 days	71.3	Steel Failure	

Note: Mixed Mode Failure= Concrete cone with pullout failure

Table 3 Summary of pull-out tests for M24 anchors with Conbextra EP65 PLUS.

Anchor Diameter (mm)	Hole Diameter (mm)	Embedment depth (mm)	Mean compressive strength (MPa)	Epoxy Curing Time	Failure Load (kN)	Failure Mode	Average Load (kN) and CoV (%)
24	35	200	66.5	1 day	322.1	Concrete Cone Failure	315.8, 8.8
24	35	200	66.5	1 day	285.4	Concrete Cone Failure	
24	35	200	58.5	1 day	340.0	Concrete Cone Failure	
24	35	200	58.5	3 days	339.2	Concrete Cone Failure	341.1, 0.8
24	35	200	47.2	3 days	344.0	Steel Failure	
24	35	200	47.2	3 days	340.1	Steel Failure	

The failure loads were in the same range for all these failure modes. The COV from the tests conducted was in the range of 0.6-8.8%.

3.1 Typical failure modes

The failure modes observed for the M12 anchors with Conbextra EP65 PLUS were steel failure and mixed mode failure while for M24 anchors the failure modes were concrete cone failure and steel failure. In the mixed mode failure, a small 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) Concrete cone failure

c) Mixed mode failure

Figure 4: Typical failure modes

4 Conclusion

An experimental program was conducted at Swinburne University of Technology for pullout test of M12 and M24 anchors bonded with Conbextra EP65 PLUS epoxy grout in concrete. An embedment depth of 100mm and hole diameter of 18mm was used for M12 anchor and an embedment depth of 200mm and hole diameter of 35mm was used for M24 anchors. The pullout test were carried out at 1day and 3-day epoxy curing. The mean cylinder compressive strength of concrete slabs was in the range of 47.2 to 69.5MPa. In total 12 tests (3 for M12 anchor at 1 day epoxy curing, 3 for M24 anchor at 1 day epoxy curing, 3 for M12 anchor at 3 day epoxy curing and 3 for M24 anchor at 3 day epoxy curing) were conducted in the laboratory.

Steel failure and mixed mode failure were observed for M12 anchors whereas concrete cone failure and steel failure were observed for M24 anchors. Majority of anchor failures were steel failures for M12 anchor and concrete cone failure for M24 anchors. There were two mixed mode failures for M12 anchors.

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.