WORK REPORT

FOUNDATION REPAIR
AND REGROUT
METALBOX BODYMAKER

CARNAUD METALBOX
SINGAPORE

Customer: CarnaudMetalbox Packaging Pte Ltd.

Location: 2-PC Plant, DWI Dept, Woodlands, Singapore.

Project: No 4 Bodymaker foundation repair & regrout

Equipment: Standun-Metalbox B3 Bodymaker operating at 200 to 300 cans per minute.

Work Period: Mobilization 22 December 1993
Completion 06 January 1994

1. Project Summary

1.1 Alpha Kogyo, the original ALPHATEC company, had regrouted hundreds of Standun bodymakers in Japan during the 1980s. When the writer came to Singapore, an approach was made to all aluminium can makers in the region, and CMB Singapore just happened to have an immediate problem.

1.2 Vibrations had reached such an extent that anchor bolts had broken, and the machine had been taken out of service. Oil penetration all around was severe, and the small amounts of epoxy grout which had been used to grout the footings could not stem the tide.

1.3 Alphatec Engineering Singapore offered a turn-key service to repair the foundation, remove all oil-soaked concrete and existing grout, replace all the anchor bolts, and align and regrout the machine. Sub-contract labour was employed for this project, but was supervised throughout by the writer.

1.4 Injection holes were drilled into the foundation, and rapidly showed that the depth of the block was not as imagined. However it did show the expected cold joints, indicating that the concrete had not been poured cintinuously. These cold joints were repaired by the pressure injection of ALPHATEC 300 adhesive.

1.5 Since the machine had been removed from its foundation, it was an easy job to attack the damaged concrete. The surprise was the extent to which the damage had gone down into the foundation, necessitating the removal of most of the depth in one area. Build-up of the deepest areas was done with non-shrink grout, which was then covered in layer of epoxy grout covering the entire foundation top.

1.6 The bodymaker was returned to the foundation, supported in place on ALPHAPAD hydraulically adjustable soleplates, and aligned. ALPHATEC 800 epoxy grout was poured to embed the footings properly.

2. Inspection & Existing Condition:

The following comments are based on a site inspection carried out in October 1993, and the execution of the foundation repair work itself in the above period.

2.1 The bodymaker, a B3 type unit manufactured in the UK by Metalbox under license to Standun Corp of the USA, was originally installed in 1979. Because of vibration and alignment problems, and broken anchor bolts, the machine had been taken out of service in early 1993, and removed from the foundation.

2.2 The effective foundation dimensions were estimated to be 2.95 x 1.2 x 1.2 m, giving an estimated total mass of approx 10,000 kg. This was judged to be a satisfactory size for the weight of the machine (approx 9,500 kg), and the power output of approx 90 kW. The construction drawings (for later models) suggested that the entire foundation consisted of a support foundation in the form of an open-topped box, with the inertia block mounted inside it, and supported by vibration damping pads on 5 sides. In fact, it was not possible to identify any vibration pad separation at the feed end of the machine, and a repair had apparently been carried out at some stage in the past, when the vibration pad was removed, and the concrete replaced.

2.3 Cold joints in the foundation were assumed at 2 levels, and this proved to be the case. They were found at 450 mm and 600 mm below floor level. These cold joints can occur from delays between concrete pours of as little as 30 minutes, if proper consolidation techniques are not employed.

2.4 An epoxy-based material had been used initially to install the machines, and was reported to be a Structoplast product. Judging from the appearance, the product is probably Ceemargrout, an aggregate-filled material with rather a low specification (ultimate compressive strength of no more than 74 N/mm^2), unsuitable (in the writer's opinion) for applications under critical production machinery. The foundation top was not otherwise sealed against oil ingress, or at least was not effectively sealed, since considerable oil penetration had taken place around and under the epoxy pads, and the underlying concrete was very badly deteriorated.

2.5 The Bodymaker had been mounted on a strange system of soleplates and jack screws, which appear to be designed with the idea of allowing compensation for the changes in alignment which the system assumes will take place! There are several specific points of interest:

2.5.1 The compensating jack screws are concentric with the anchor bolts. This is a rather nice engineering solution to the problem of where jack screws should be located, but means that when the anchor bolts are tightened - exerting a load which should be in the range of 9 to 16 tonnes - this load is transferred directly through the jack screw itself onto the soleplate. The soleplate diameter is 200 mm, and has an effective area of 307 cm^2. If the soleplate is stiff enough to transfer the anchor bolt load evenly onto the grout material, the 16 tonnes load translates into a stress on the grout of 52 kg/cm^2 or 5 MPa. This is a high figure, particularly in light of Lloyds recommendations to the Shipbuilding industry that epoxy chocks for machinery installation should not be loaded to more than 3.5 MPa, inclusive of the deadweight of the machine. Typically, the chocking compounds used have ultimate compressive strengths in the region of 150 MPa, rather more than Ceemargrout's 74 MPa.

2.5.2 The Bodymaker frame has footings at each anchor bolt location, but these are very small - 280 to 370 cm^2 each - and since the jack screw is used as the primary support, are not in contact with the grout, thus entirely superfluous. There is plenty of room on this frame to make provision for large footings - 500 to 600 cm^2 each - and to have thebolts centered within each footing. On the same subject, they should have rounded edges, rather than the sharp corners now employed.

2.5.3 For some strange reason, the anchor bolts are set at different lateral pitches. The drive end pitch is 936 mm, while the centre and feed end bolts are at 810 mm. The anchor bolts cored out from the foundation were very short, only 300 to 400 mm, and those at the feed end were shanked. Shanked bolts are quite common in some installations (many in the steel industry), but are quite pointless, since the loading can be properly distributed only over the straight section, so the bolt is effectively the length of that straight section.

2.5.4 The bolts were fully embedded into the concrete, and the grout. The tightening load was therefore concentrated in the upper few centimetres of the bolt length, and it was rapidly weakened by fatigue. This is the reason for the bolt failures seen.

2.6 The depth of the inertia block proved to be approx 0.75 m, when the first cores were drilled, giving an effective mass of 6,372 kg. This is small for a reciprocating machine, which requires approximately 100 kg per kW to properly damp out the energy transmitted. In addition, there was no sign of any vibration damping pads under the inertia block, but instead a layer of clay-like material. Drilling was not continued below 750 mm, so the thickness, or even the existence of the support foundation, has not been confirmed.

2.7 During the earlier repair of the foundation at the can feed end, a steel plate had been introduced, presumably with the intention of strengthening the whole structure. Unfortunately, the use of any additional steel within concrete in a machine foundation has the effect of weakening it, due to the increased number of interfaces between steel and concrete, the lack of bond at these interfaces, and the consequent ingress of oil. Oil degredation was found right down to 650 mm below floor level.

3. Work Carried Out:

3.1 **Foundation Repair:** The area of severe oil degradation at the feed end was chipped out down to 650 mm below floor level. A cement-based grout material, filled with crushed aggregate, was poured to approx 250 mm below FL. The foundation was further restored to a condition of integrity and improved stiffness by the Alpha Pressure Injection Method. 6 holes were drilled to a depth of 650 mm, and lengths of 32 mm ø high tensile strength rod (720 N/mm^2 proof yield) inserted. The top of the annular space around the bar was sealed by the overlay of epoxy grout, and an oil-tolerant epoxy adhesive, ALPHATEC 300, injected under high pressure to fill the separations, and any other voids, fissures and cracks in the structure. The rebar acts as a backbone for the encapsulating epoxy resin, allowing the full bond and shear strengths of the material to act on the concrete in the most effective manner. The effective mass of the foundation was increased by removal of the vibration damping pads around the sides, which, incidentally, were quite badly deteriorated by oil and impact. These pads extended only 300 mm down from floor level, and were therefore little more than decoration.

3.2 **Regrout:** The existing grout and underlying concrete to a depth of 250 mm was chipped out, and ALPHATEC 800 epoxy grout poured overall. The epoxy grout helps reinforce the top of the foundaton, since its tensile strength is many times that of concrete, and its resistance to oil is excellent. It also bonds to the surrounding support foundation, and helps raise the effective mass. The bodymaker was reinstalled on the foundation, and supported by ALPHAPAD soleplates. These hydraulically adjustable soleplates have a large bearing area of 555 cm^2 each, which lowers the stress on the grout to about half the original. The ALPHAPADs were used to align the bodymaker accurately, and were then grouted in place.

3.3 **Hold-Down Bolts:** At the same time as the HASP grout, the new anchor bolts were installed in the 650 mm deep diamond cored holes, and grouted in place. Approx 300 mm of the rod below the bodymaker base was isolated from contact with the grout by PE foam mat. The 1" rod has a yield strength of 720 N/mm^2, and an effective x-sectional area of 380 mm^2. The yield stress is therefore 273.6 kN. A fastening stress of 50% yield was chosen, or 137 kN. The torque to apply to achieve this fastening load is approx 680 N m, but, in the absence of an appropriately sized torque wrench, the actual torque applied was estimated by the site supervisor as being within ±20% of the calculated figure. The minimum bonded length was 400 mm, and using a bond strength of the grout material of 20 MPa, the resistance to pull-out will be in the order of 638 kN, or 4.6 times the fastening stress.

1.
93-12-22: Delivered materials and equipment to site, and started chipping out existing soleplates.

2.
Heavily oil-soaked concrete.

3.
The channel on the right hand side of the photo is the top of the vibration damping expansion joint..

4.
Chipping away the epoxy grout.

5.
The bond between the existing soleplates and the grout was very poor..

6.
Chipping at the feed end revealed the embedded steel plate, and a lot of oil-soaked concrete.

7.
93-12-23: The first core drilled revealed the thickness of the foundation, 750 mm, and the lack of vibration damping pads underneath. It also revealed the position of the cold joints.

8.
The cored holes were later used to position the new anchor bolts.

9.
93-12-29: chipping finally completed.

10.
93-12-30: 32 mm ø rod ws placed in the injection holes with injection and vent tubing attached.

11.
short lengths of PVC pipe were placed in position to re-establish the anchor bolt holes.

12.
cement grout was mixed....

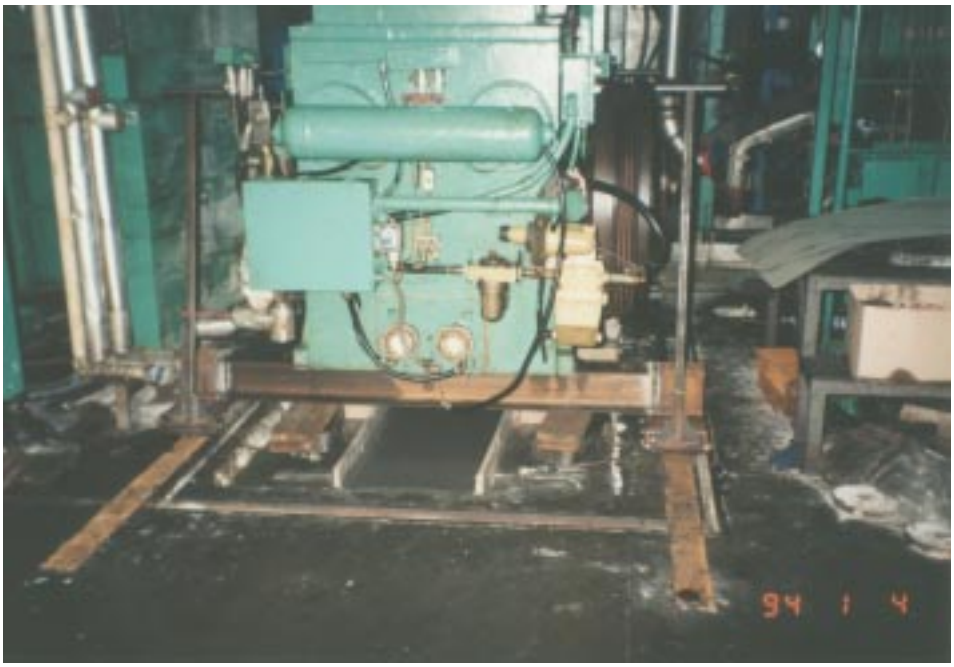
13.
...crushed stone aggregate added...

14.
...and the grout poured into the large excavation. The surface of the concrete had earlier been primed with epoxy resins.

15.
After the cement grout had set up, ALPHATEC 800 epoxy grout was mixed and poured overall to approx 60 mm below floor level. This pour also effectively selaed the injection holes, for pressure resistance of up to 300 bar. Injection was carried out on 31 December.

16.
94-01-03: The new anchor bolts, fabricated from high-ten fully threaded rod, were prepared for installation, with 300 mm of isolating PE foam attached.

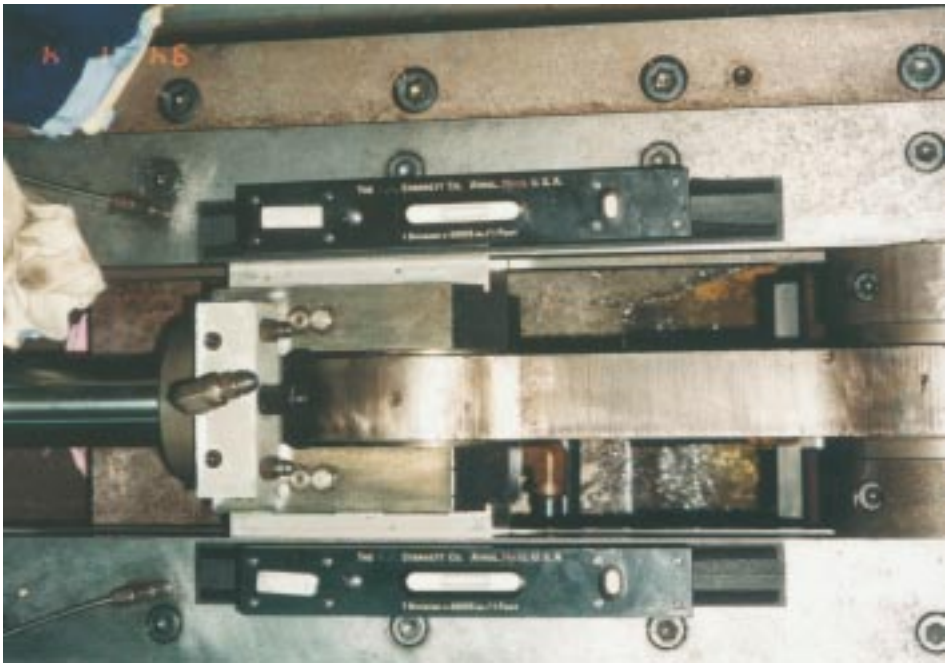
17.
Forms were set in place to contain the 2nd pour of epoxy grout, and the central area grout mixed and poured.



18.
94-01-04: The bodymaker was transported back onto the foundation...

19.
...and lowered onto the ALPHAPAD soleplates.

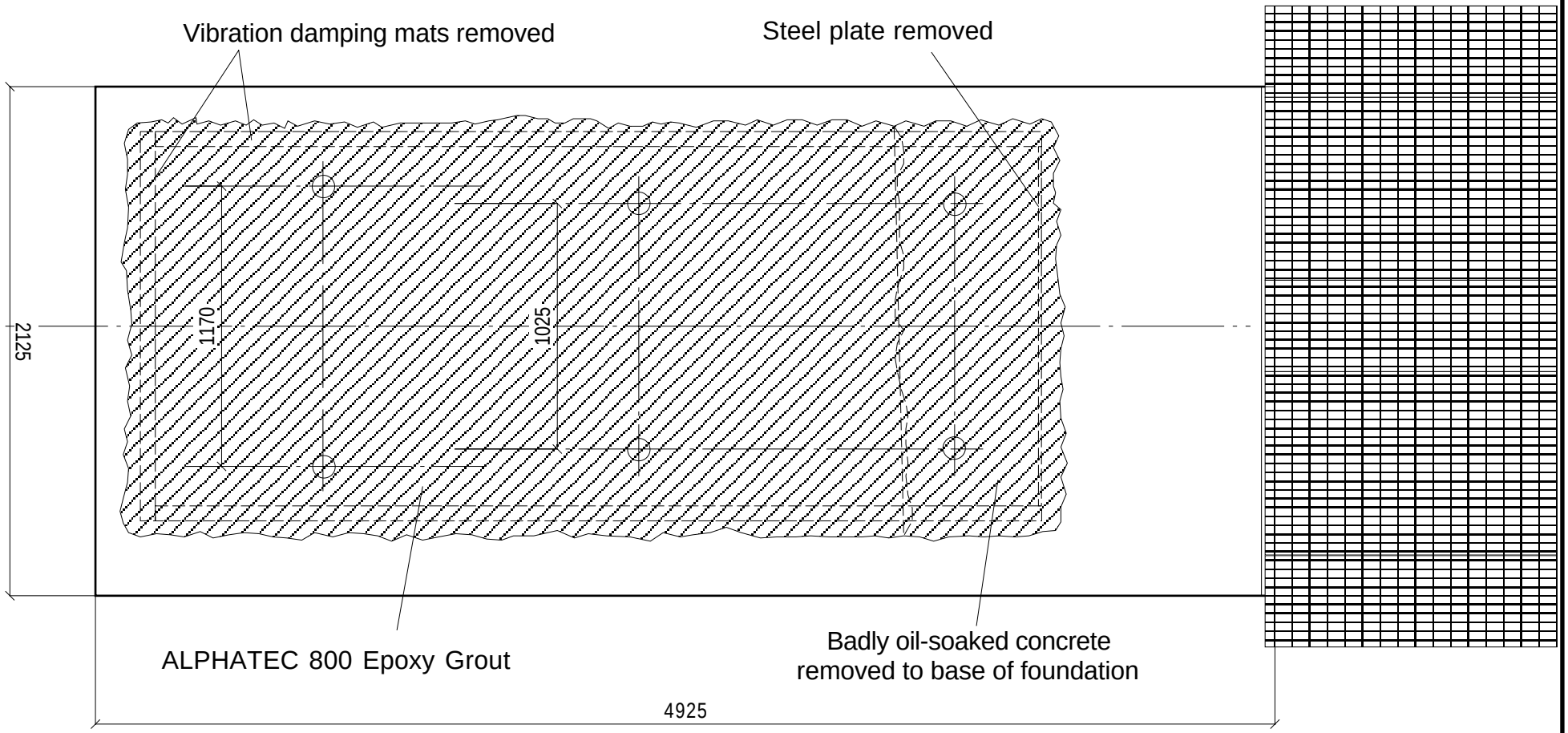
20.
The bodymaker was levelled....



21.
...and aligned with existing pipework, feed and output mechanisms.

22.
Epoxy grout was poured to embed the anchor bolts, and the ALPHAPAD soleplate.
94-01-06: Finally the anchor bolt nuts were torqued to 680 N.m, and the lock nuts tightened.

GD Goldsbro
Alphatec Engineering (Singapore) Pte Ltd
08 January 1994



Customer:	CarnaudMetalbox, No 4 Bodymaker.				
Location:	Woodlands, Singapore				
Project:	No 4 Bodymaker foundation repair & regrout (actual)				
Report No:	S-93-10064	Date:	94-02-08	Scale:	1:20

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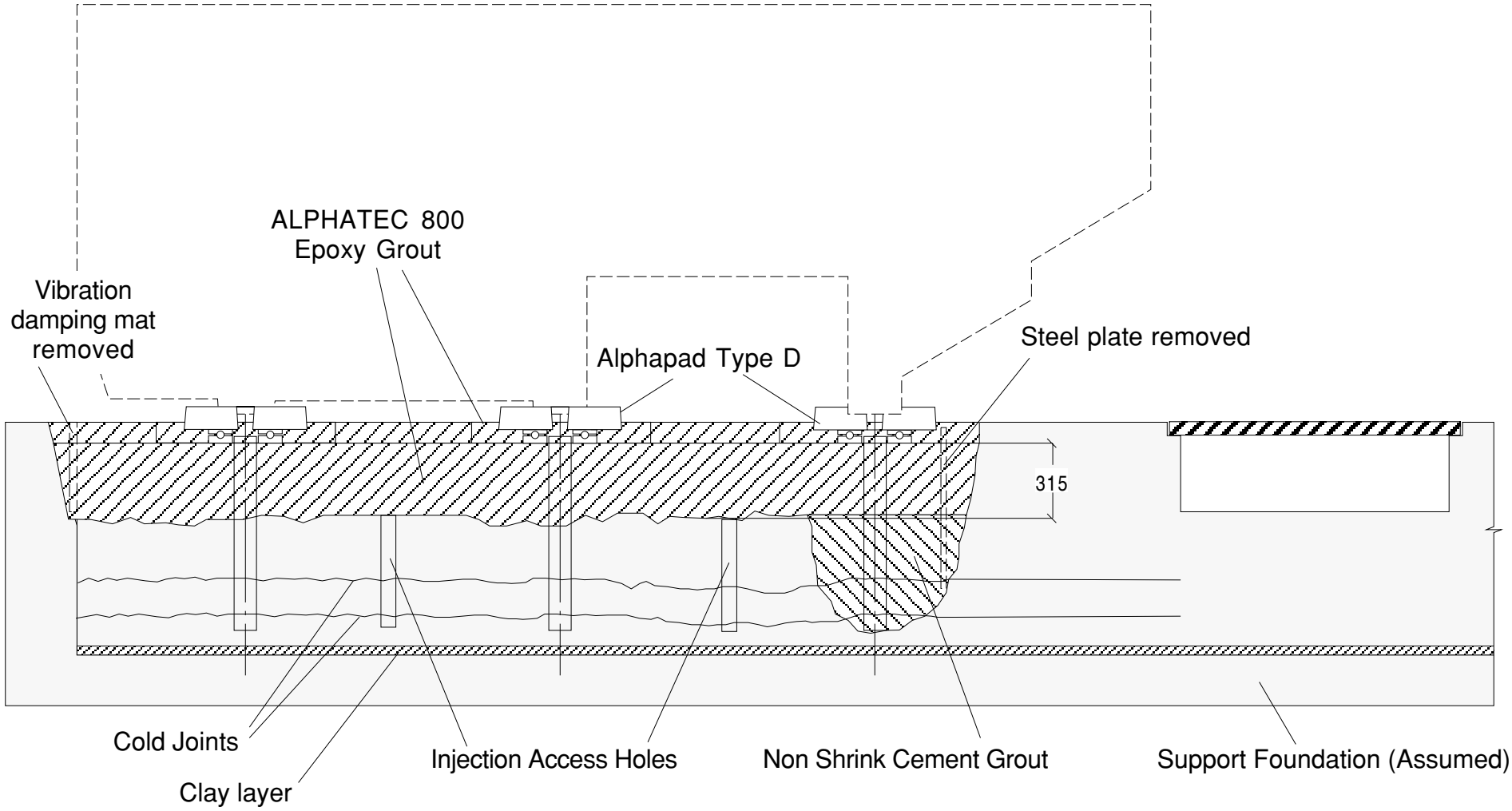
18 Pioneer Sector 1, Singapore 2262. Tel: (65)-862-5501 Fax: (65)-862-5128



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