EpconG5

High-Strength Epoxy Adhesive

Ramset™

CONTENTS

Epcon G5 -- High Strength Epoxy

You don't have to waste your valuable time waiting for longer cure times or waste money disposing of dried up nozzles. The Epcon G5 is the solution to your problem.

The epoxy resin and hardener are thoroughly and evenly mixed as they are dispensed from the dual cartridge through a static mixing nozzle, directly into the anchor hole.

With an extended working time (15 minutes) and a full cure in less than 2 hours, your crew can work more efficiently saving you time and money.

Advantages

HIGH PERFORMANCE EPOXY: Shallower embedment depth required

FIRE RESISTANT STRUCTURES: Tested up to 4 hours FRP by Warrington (BS 476 Part 20)

EXTENDED WORKING TIME: 15-minute nozzle life at 20°C, 2-hour cure time at 20°C

COST SAVINGS: Less delay of work, Less nozzles used

LOW SHRINKAGE: Suitable for cored and oversized holes

NON-OFFENSIVE ODOR: Virtually odorless, can be used indoors

WATER INSENSITIVITY: Works in damp holes and underwater applications

Specifications

EPOXY CHEMICAL:

- Two component, 100% solids (containing no solvents), non-sag paste, insensitive to moisture, grey in colour
- Meets ASTM C881-99, Type IV, Grade 3 with the exception of gel time
- Shrinkage during cure per ASTM D2566: 0.00004 in./in
- Compressive strength, ASTM D695: 71 MPa minimum
- Heat Deflection Temperature: 62 C minimum
- Water solubility: None
- Shelf Life: Best if used within 18 months

PACKAGING:

- Disposable, self-contained 650mL cartridge system capable of despensing both epoxy components in the proper mixing ratio.
- Epoxy components dispensed through a static mixing nozzle that thoroughly mixes the material and places the epoxy at the base of the pre-drilled hole.
- Cartridge markings: Include manufacturer's name, batch number and best-used-by date, mix ratio by volume, ANSI hazard classification, and appropriate ANSI handling precautions.

1. Drill a hole with a Ramset Power Tool and Drill Bit to the required hole diameter and depth as indicated in the Ramset Design Guide.

2. Remove initial debris caused by the drilling action with a hand blower or air compressor.

3. Use a wire brush to dislodge excess debris on the surrounding surface of the hole.

4. Repeat steps 2 and 3

5. Remove the cap of the Ramset Epcon G5 cartridge and attach the static mixer provided.

6. Put the Ramset Epcon G5 cartridge into the hand dispenser tool.

7. Dispense the chemical initial mix until the colour is consistent.

8. Pump the chemical into the hole until it is half-filled.

9. Insert the rebar/stud into the hole in a twisting motion to ensure that the rebar/stud is fully coated with the chemical.

METHOD STATEMENT FOR NON-DESTRUCTIVE TENSILE TEST ON RAMSET EPCON G5 CHEMICAL WITH REBARS INSTALLED

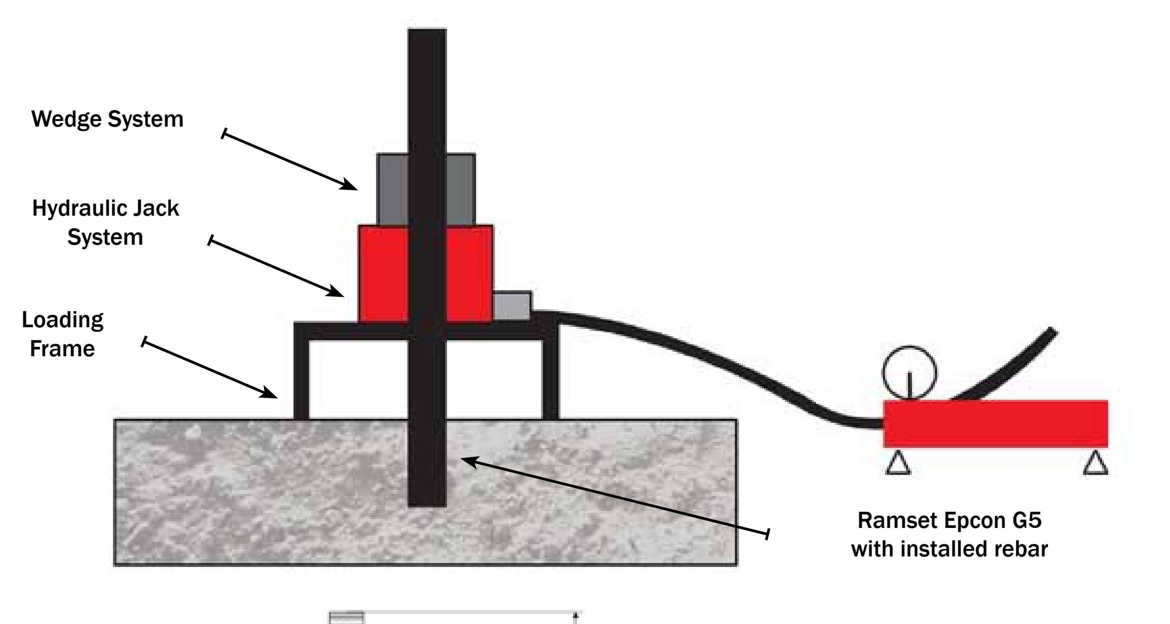
1. Prior to carrying out the test, the test equipment (Hydraulic Jack System with calibration certification attached) must be setup in position according to BS5080 Part 1.

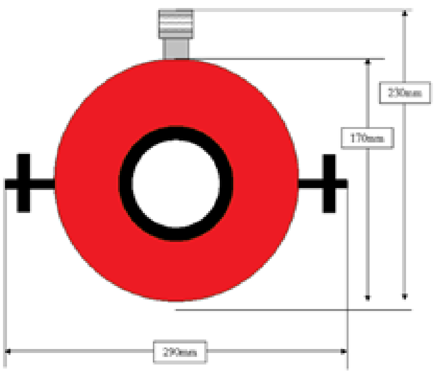
2. The loading frame is placed through the rebar and sits directly on the base concrete. The appropriate type of hydraulic jack is mounted on top of the loading frame and wedged in place with a corresponding wedge system to engage the rebar tightly at the end of the setup before applying the load.

3. A central load is applied gradually by means of the hydraulic jack system, via a hollow piston cylinder onto the wedges to create a reaction force equaling to a tensile pull-out effect, up to the required design test load.

4. The load achieved is indicated in the calibrated pressure gauge, usually expressed in KiloNewtons (kN) for ease of load determination. During or at the end of the loading, the achieved load and the mode of failure, if any, are recorded in the field test record form. The recorded field test record form shall be acknowledged by all parties present, namely the tester, the contractor and the consultant and shall form part of the final test report to be submitted to the contractor for filing purpose.

TEST SETUP (N.T.S.)





** For different diameters of anchors, the dimensions of the hollow jack may vary*

DIMENSION OF HOLLOW JACK

RED HEAD® CONCRETE ANCHORING SYSTEMS

G5 MATERIAL SAFETY DATA SHEET

Product Name: G5 Epoxy Adhesive **Date Prepared:** July, 2007

Description: Part A: Epoxy Resin **Part B:** Amine Hardener

General Use: Chemical anchor used for commercial construction.

Manufacturer: ITW Red Head · 2171 Executive Drive, Suite 100 · Addison, IL 60101

Emergency Number: 1-800-424-9300

Ingredients and Exposure Limits

Ingredients	CAS Number	TLV:	PEL:	STEL
Part A: Bisphenol A Epoxy Resin	25068-38-6	NE	NE	NE
Part B: Amine Blend	*	NE	NE	NE

* An asterisk indicates a substance whose identity is a trade secret of our supplier

Abbreviations: TLV = ACGIH Threshold Limit Value PEL = OSHA Permissible Exposure STEL = Short Term Exposure Limit NA = Not Applicable NE = None Established

Physical Properties

	Part A: Beige Paste	**Part B:** Gray Paste
Specific Gravity	= 1.2 g/cm³ (at 20° C)	= 1.7 g/cm³ (at 20° C)
Boiling Point	= > 400° F	= > 212° F
Water Solubility	None	None

Safe Handling Procedures

Handling and Storing Precautions: For professional use only. Keep away from children. Avoid contact with the eyes and skin. Wash after using and before eating or smoking. Avoid breathing vapors. Use only as directed; avoid uncontrolled mixing with other materials, esp. polymerizable or combustible materials.

Storage: For maximum shelf life, store in a cool dry area between 40° F and 80° F. Do not store above 110° F

Spill Procedures: Collect with an absorbent material and place in a container for proper disposal. For large spills, transfer to salvage vessels, and dispose of according to state, local and Federal regulations. Flush area with water to remove residue.

Personal Protection

Ventilation: Use in well ventilated areas.

Eye Protection: Wear safety glasses with side shields.

Skin Protection: Impermeable (neoprene or rubber) gloves are recommended.

Respiratory Protection: None normally required. Where ventilation is inadequate to control vapors, use a NIOSH/OSHA approved respirator with organic vapor cartridges. Do not enter confined spaces without an appropriate air supplied respirator.

Health Information

Part A: Eye and skin irritant. Possible skin sensitizer. May be irritating to eyes, skin, nose and throat.

Part B: Corrosive. May cause eye and skin burns. Vapors may be irritating. May cause burns if swallowed.

Routes of Exposure: Contact. Inhalation.

Medical Conditions Aggravated by Exposure: Eye, skin and respiratory conditions.

Carcinogenicity: No ingredients are classified as carcinogens by IARC, NTP or OSHA

Hazard Categories: Immediate health hazard; delayed health hazard

First Aid Measures

Eyes: Flush immediately with water for at least 15 minutes. Seek medical advice.

Skin: Wash immediately with soap and water. Launder contaminated clothing before reuse.

Inhalation: If symptoms occur, move to fresh air. Call a physician if symptoms persist.

Ingestion: Rinse mouth and then drink large quantities of water. Don't give anything by mouth to an unconscious person. Seek medical attention. Do not induce vomiting unless directed by a physician.

Other: Referral to a physician is recommended if there is any question about the seriousness of the exposure.

RED HEAD® CONCRETE ANCHORING SYSTEMS

G5 MATERIAL SAFETY DATA SHEET

Stability and Reactivity

Stability: Stable
Hazardous Polymerization: Will not occur.
Incompatibility: Strong acids and oxidizing agents.
Decomposition Products: Thermal decomposition can yield COx, NOx, water and carbon.
Conditions to Avoid: Avoid elevated temperatures which may shorten the shelf-life of this product.

Fire and Explosion Hazard Information

Flash point: > 212° F
Flammable Limits: Not applicable
Extinguishing Media: CO^2, Dry Chemical, Foam, and Water Spray.
Special Fire Fighting Procedures: Use self-contained breathing apparatus.
Unusual Fire and Explosion Hazards: Thermal decomposition products can be formed including carbon monoxide, sulfur and nitrogen oxide and other fumes and vapors.
Material will not burn unless pre-heated. Do not enter confined space without full bunker gear. Firefighters should use self-contained breathing apparatus and protective clothing.

Federal Regulatory Status

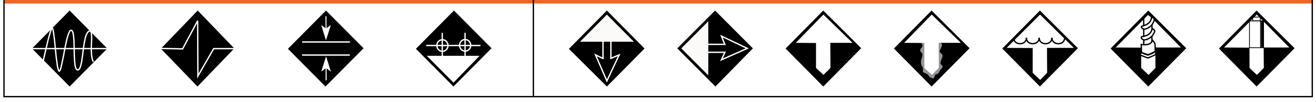
Regulatory Information
Hazard Communication: This MSDS has been prepared in accordance with the federal OSHA Hazard Communication Standard 29 CFR 1910.1200.
HMIS Codes: Health 3, Flammability 1, Reactivity 0, PPE B
DOT Shipping Name: Consumer commodity, ORM-D
UN#: 2735
Hazard Class: 8 Corrosives
Emergency Response Guide #153
TSCA Inventory Status: Chemical components are listed on TSCA inventory or are exempt as impurities.
SARA Title III, Section 313: This product contains an Amine Blend which is subject to reporting under Section 313 or SARA Title III (40 CFR Part 372).
EPA Waste Code(s): Not regulated by EPA as a hazardous waste.
Waste Disposal Methods: If this material becomes a waste, it would not be hazardous waste by RCRA criteria (40CFR261). Dispose according to federal, state and local regulations.

Canadian Regulations: WHMIS hazard class: D2B.
Canadian EPA: All ingredients are listed on the DSL or are exempt as impurities.

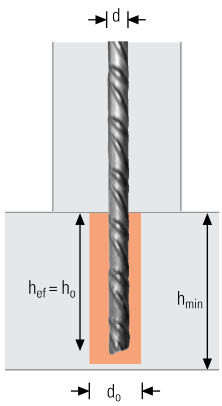
The information and recommendations in this document are based on the best information available to us at the time of preparation. We make no other warranty, expressed or implied, as to its correctness or completeness, or as to the results or reliance of this document.

REBAR (FE460)

Performance	Installation



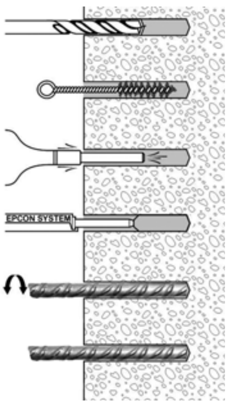
ICC-ES EVALUATION REPORT



MATERIAL

Grade 460 steel

INSTALLATION



Technical Data

EPCON G5		T8	T10	T12	T13	T16	T20	T25	T28	T32	T40
Dowel depth (mm)	$h_{ef,min}$	80	90	110	110	125	170	210	270	300	400
Ø bar (mm)	d	8	10	12	13	16	20	25	28	32	40
Ø drill bit (mm)	d_o	12	13	15	16	20	25	30	35	40	50
Drill depth (mm)	h_o	80	90	110	110	125	170	210	270	300	400
Min thick of base material (mm)	h_{min}	100	113	138	138	156	213	263	338	375	500
Ramset power tool code		DD544	DD544	DD544	DD544	DD565	DD565	DD565	DD565	DD576	DD576
Drill bit type-size		R3 PLUS-12	R3 PLUS-13	R3 PLUS-16	R3 PLUS-16	R3 MAX-20	R3 MAX-25	R3 MAX-30	R3 MAX-35	R3 MAX-40	R3 MAX-50

EPCON G5 Two part cartridge, 100% epoxy resin - vol. 650ml

Anchor Mechanical Properties

Rebar FE460	T8	T10	T12	T13	T16	T20	T25	T28	T32	T40
f_{yk} (N/mm2) Yield strength	460	460	460	460	460	460	460	460	460	460
A_s (mm2) Stressed cross-section	50.3	78.6	113.1	132.7	201.1	314.2	490.9	615.8	804.4	1,256.8
$N_{Rk,s}$ (kN) Charactierstic Yield	23.1	36.1	52.0	61.1	92.5	144.5	225.8	283.3	370.0	578.1
$N_{Rd,s}$ (kN) Design Yield	20.1	31.4	45.2	53.1	80.4	125.7	196.4	246.3	321.7	502.7

Setting Time before applying load

Ambient temperature (°C)	Max time for installation (min)	Waiting time before applying load (hr)
32°C	8.5	2
27°C	12	2
20°C	15	2
16°C	18	3
10°C	21	6

Chemical Resistance of EPCON G5 Anchor

Chemical substances	Resistance	Chemical substances	Resistance
Xylene	1	Toluene	2
Gasoline	1	10% Nitric Acid	2
20% Caustic NaOH (Sodium Hydroxide)	1	8.5% Ammonium Hydroxide	2
Fresh water	1	5% Bleach	3
Salt Water	1	Acetone	3
10% Sulfuric Acid (H2 SO4)	2	Glacial Acetic Acid	3
3.5% Hydrochloric Acid (HCL)	2	Methanol	3
9% Phosphoric Acid	2	Methylene Chloride	3

1 = High resistance (Anchors could be submerged in these materials)
2 = Medium resistance (Anchors could be temporary submerged due to splash or spill)
3 = Low resistance (Anchors should be limited to splash and spill followed by immediate cleanup)

REBAR (FE460)

Number of Anchors per cartridge

Rebar diameter	10	12	13	16	20	25	28	32	40
Drilling Ø (mm)	13	15	16	20	25	30	35	40	50
Drilling depth (mm)	90	110	110	125	170	210	270	300	400
No. of anchors per cartridge									
EPCON G5 (650ml)	108.8	66.9	58.8	33.1	15.6	8.8	5.0	3.4	1.7

Ultimate Loads ($N_{Ru,m}$, $V_{Ru,m}$) / Characteristic Loads (N_{Rk}, V_{Rk}) in kN

TENSILE @ Concrete strength 30 N/mm²

Rebar size	T8	T10	T12	T13	T16
h_{ef} (mm)	80	90	110	110	125
$N_{Ru,m}$ (kN)	25.0	39.0	56.2	65.9	99.9
N_{Rk} (kN)	23.1	36.1	52.0	61.1	92.5

Rebar size	T20	T25	T28	T32	T40
h_{ef} (mm)	170	210	270	300	400
$N_{Ru,m}$ (kN)	156.1	243.9	305.9	399.6	624.4
N_{Rk} (kN)	144.5	225.8	283.3	370.0	578.1

SHEAR @ Concrete strength 30 N/mm²

Rebar size	T8	T10	T12	T13	T20
$V_{Ru,m}$ (kN)	15.0	23.4	33.7	39.6	59.9
V_{Rk} (kN)	13.9	21.7	31.2	36.6	55.5

Rebar size	T20	T25	T28	T32	T40
$V_{Ru,m}$ (kN)	93.7	146.3	183.6	239.8	374.6
V_{Rk} (kN)	86.7	135.5	170.0	222.0	346.9

Design Loads (N_{Rd}, V_{Rd}) for one anchor without edge or spacing influence in kN

$$N_{Rd} = \frac{N_{Rk}}{\gamma_{Ms,N}}$$

$$V_{Rd} = \frac{V_{Rk}}{\gamma_{Ms,V}}$$

TENSILE @ Concrete strength 30 N/mm²

Rebar size	T8	T10	T12	T13	T16
h_{ef} (mm)	80	110	110	110	125
N_{Rd} (kN)	15.4	24.1	34.7	40.7	61.7

Rebar size	T20	T25	T28	T32	T40
h_{ef} (mm)	170	210	270	300	400
N_{Rd} (kN)	96.4	150.6	188.9	246.7	385.4

$\gamma_{Ms,N}$ = 1.5 *(steel failure)*

SHEAR @ Concrete strength 30 N/mm²

Rebar size	T8	T10	T12	T13	T16
V_{Rd} (kN)	11.1	17.3	25.0	29.3	44.4

Rebar size	T25	T25	T28	T32	T40
V_{Rd} (kN)	69.4	108.4	136.0	177.6	277.5

$\gamma_{Ms,V}$ = 1.25

Recommended Loads (N_{rec}, V_{rec}) for one anchor without edge or spacing influence in kN

$$N_{rec} = \frac{N_{Rk}}{\gamma_{Ms,N} \cdot \gamma_F}$$

$$V_{rec} = \frac{V_{Rk}}{\gamma_{Ms,V} \cdot \gamma_F}$$

TENSILE @ Concrete strength 30 N/mm²

Rebar size	T8	T10	T12	T13	T16
h_{ef} (mm)	80	90	110	110	125
N_{rec} (kN)	11.0	17.2	24.8	29.1	44.0

Rebar size	T20	T25	T28	T32	T40
h_{ef} (mm)	170	210	270	300	400
N_{rec} (kN)	68.8	107.5	134.9	176.2	275.3

γ_F = 1.4

$\gamma_{Ms,N}$ = 1.5 *(steel failure)*

SHEAR @ Concrete strength 30 N/mm²

Rebar size	T8	T10	T12	T13	T16
V_{rec} (kN)	7.9	12.4	17.8	20.9	31.7

Rebar size	T20	T25	T28	T32	T40
V_{rec} (kN)	49.6	77.4	97.1	126.9	198.2

γ_F = 1.4

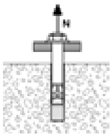
$\gamma_{Ms,V}$ = 1.25

steel failure

REBAR (FE460)

RAMSET CC-Method

TENSILE in kN



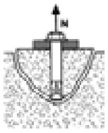
Pull-out resistance
Concrete strength C25/30

$N_{Rd,p} = N^0_{Rd,p} \cdot f_B \cdot f_T$

$N^0_{Rd,p}$ Rebar size	Design pull-out resistance T8	T10	T12	T13	T16
h_{ef} (mm)	80	90	110	110	125
$N^0_{Rd,p}$ (kN)	14.8	20.8	30.5	33.0	46.2

$N^0_{Rd,p}$ Rebar size	Design pull-out resistance T20	T25	T28	T32	T40
h_{ef} (mm)	170	210	270	300	400
$N^0_{Rd,p}$ (kN)	78.5	121.2	174.5	188.1	278.8

$\gamma_{Mc,N} = 1.8$



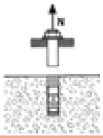
Concrete cone resistance
Concrete strength C25/30

$N_{Rd,c} = N^0_{Rd,c} \cdot f_B \cdot f_T \cdot \Psi_s \cdot \Psi_{c,N}$

$N^0_{Rd,c}$ Rebar size	Design cone resistance T8	T10	T12	T13	T16
h_{ef} (mm)	80	90	110	110	125
$N^0_{Rd,c}$ (kN)	26.3	31.4	42.5	42.5	51.4

$N^0_{Rd,c}$ Rebar size	Design cone resistance T20	T25	T28	T32	T40
h_{ef} (mm)	170	210	270	300	400
$N^0_{Rd,c}$ (kN)	81.6	112.0	163.3	191.3	294.5

$\gamma_{Mc,N} = 1.5$



Steel resistance

$N_{Rd,s}$ Rebar size	Steel design tensile resistance T8	T10	T12	T13	T16
$N_{Rd,s}$ (kN)	15.4	24.1	34.7	40.7	61.7

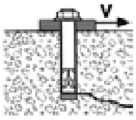
$N_{Rd,s}$ Rebar size	Steel design tensile resistance T20	T25	T28	T32	T40
$N_{Rd,s}$ (kN)	96.4	150.6	188.9	246.7	385.4

$\gamma_{Ms,N} = 1.5$

$N_{Rd} = \min (N_{Rd,p} \, ; N_{Rd,c} \, ; N_{Rd,s})$

$\beta N = N_{Sd} / N_{Rd} \leq 1$

SHEAR in kN



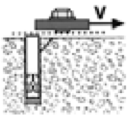
Concrete edge resistance
Concrete strength C25/30

$V_{Rd,c} = V^0_{Rd,c} \cdot f_B \cdot f_{\beta,V} \cdot \Psi_{s\text{-}c,V}$

$V^0_{Rd,c}$ Rebar size	Design concrete edge resistance at a minimum edge distance (c_{min}) T8	T10	T12	T13	T16
h_{ef} (mm)	80	90	110	110	125
c_{min}	40	45	55	55	63
s_{min}	40	45	55	55	63
$V^0_{Rd,c}$ (kN)	2.6	3.4	5.1	5.2	6.9

$V^0_{Rd,c}$ Rebar size	Design concrete edge resistance at a minimum edge distance (c_{min}) T20	T25	T28	T32	T40
h_{ef} (mm)	170	210	270	300	400
c_{min}	85	105	135	150	200
s_{min}	85	105	135	150	200
$V^0_{Rd,c}$ (kN)	12.4	18.9	30.0	37.4	65.2

$\gamma_{Mc,V} = 1.5$

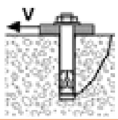


Steel resistance

$V_{Rd,s}$ Rebar size	Steel design shear resistance T8	T10	T12	T13	T16
$V_{Rd,s}$ (kN)	11.1	17.3	25.0	29.3	44.4

$V_{Rd,s}$ Rebar size	Steel design shear resistance T20	T25	T28	T32	T40
$V_{Rd,s}$ (kN)	69.4	108.4	136.0	177.6	277.5

$\gamma_{Ms,V} = 1.25$



Concrete pry-out failure
Concrete Strength C25/30

$V_{Rd,cp} = V^0_{Rd,cp} \cdot f_B \cdot \Psi_s \cdot \Psi_{c,N}$

$V^0_{Rd,cp}$ Rebar size	Design pry-out resistance T8	T10	T12	T13	T16
$V^0_{Rd,cp}$ (kN)	52.7	62.9	84.9	84.9	102.9

$V^0_{Rd,cp}$ Rebar size	Design pry-out resistance T20	T25	T28	T32	T40
$V^0_{Rd,cp}$ (kN)	163.2	224.0	326.6	382.5	588.9

$\gamma_{Mc,V} = 1.5$

$V_{Rd} = \min (V_{Rd,c} \, ; V_{Rd,s} \, ; V_{Rd,cp})$

$\beta V = V_{Sd} / V_{Rd} \leq 1$

$\beta N + \beta V \leq 1.2$

f_B INFLUENCE OF CONCRETE

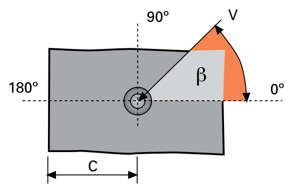
Concrete Grade	f_B	Concrete Grade	f_B
C16/20	0.81	C35/45	1.21
C20/25	0.90	C40/50	1.28
C25/30	1.00	C45/55	1.34
C30/37	1.10	C50/60	1.40

f_T INFLUENCE OF EMBEDMENT DEPTH

$$f_T = \frac{h_{act}}{h_{ef}}$$

$f_{\beta,V}$ INFLUENCE OF SHEAR LOADING DIRECTION

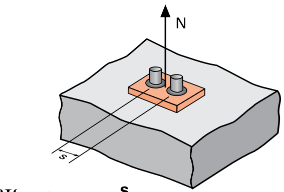
Angle β [°]	$f_{\beta,V}$
0~50	1.0
60	1.1
70	1.2
80	1.5
90~180	2.0



REBAR (FE460)

RAMSET CC-Method

Ψ_s INFLUENCE OF SPACING FOR CONCRETE



$\Psi_s = 0.5 + \frac{s}{4h_{ef}}$

$s < s_{cr,N}$

$s_{min} = 0.5h_{ef}$

$s_{cr,N} = 2h_{ef}$

Ψ_s must be used for each spacing influenced the anchors group

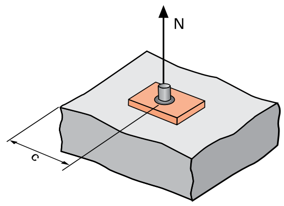
Spacing, s — Reduction Factor Ψ_s — Cracked / Non-cracked concrete

Spacing, s	T8	T10	T12	T13	T16
40	0.63				
45	0.64	0.63			
55	0.67	0.65	0.63	0.63	
65	0.70	0.68	0.65	0.65	0.63
85	0.77	0.74	0.69	0.69	0.67
105	0.83	0.79	0.74	0.74	0.71
140	0.94	0.89	0.82	0.82	0.78
160	1.00	0.94	0.86	0.86	0.82
180		1.00	0.91	0.91	0.86
220			1.00	1.00	0.94
250					1.00

Spacing, s — Reduction Factor Ψ_s — Cracked / Non-cracked concrete

Spacing, s	T20	T25	T28	T32	T40
85	0.63				
105	0.65	0.63			
140	0.71	0.67	0.63		
160	0.74	0.69	0.65	0.63	
210	0.81	0.75	0.69	0.68	0.63
250	0.87	0.80	0.73	0.71	0.66
300	0.94	0.86	0.78	0.75	0.69
350	1.00	0.92	0.82	0.79	0.72
420		1.00	0.89	0.85	0.76
540			1.00	0.95	0.84
600				1.00	0.88
700					0.94
800					1.00

$\Psi_{c,N}$ INFLUENCE OF EDGE FOR CONCRETE



$\Psi_{c,N} = 0.275 + 0.725 \cdot \frac{c}{h_{ef}}$

$c < c_{cr,N}$

$c_{min} = 0.5h_{ef}$

$c_{cr,N} = h_{ef}$

$\Psi_{c,N}$ must be used for each distance influenced the anchors group

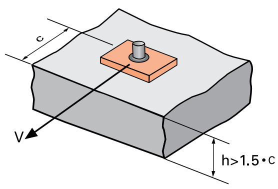
Edge, c — Reduction Factor $\Psi_{c,N}$ — Cracked / Non-cracked concrete

Edge, c	T8	T10	T12	T13	T16
40	0.63				
45	0.68	0.63			
55	0.77	0.71	0.63	0.63	
63	0.84	0.78	0.69	0.69	
80	1.00	0.91	0.80	0.80	
85		0.95	0.83	0.83	0.63
90		1.00	0.86	0.86	0.65
110			1.00	1.00	0.74
125					0.80
170					1.00

Edge, c — Reduction Factor $\Psi_{c,N}$ — Cracked / Non-cracked concrete

Edge, c	T20	T25	T28	T32	T40
85	0.63				
105	0.72	0.63			
135	0.85	0.74	0.63		
150	0.91	0.79	0.67	0.63	
170	1.00	0.86	0.73	0.68	
200		0.96	0.81	0.75	0.63
210		1.00	0.83	0.78	0.65
270			1.00	0.92	0.76
300				1.00	0.81
400					1.00

$\Psi_{s\text{-}c,V}$ INFLUENCED OF SPACING AND EDGE DISTANCE FOR CONCRETE EDGE RESISTANCE IN SHEAR LOAD

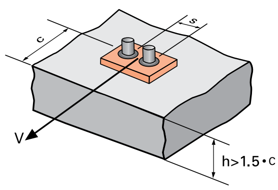


$\Psi_{s\text{-}c,V} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$

FOR SINGLE ANCHOR FASTENING

Reduction Factor $\Psi_{s\text{-}c,V}$ — Cracked / Non-cracked concrete

$\frac{c}{c_{min}}$	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2
$\Psi_{s\text{-}c,V}$	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72

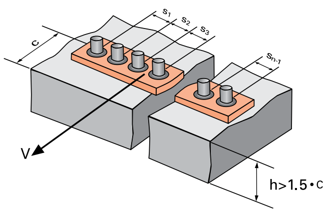


$\Psi_{s\text{-}c,V} = \frac{3c + s}{6c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$

FOR 2 ANCHORS FASTENING

Reduction Factor $\Psi_{s\text{-}c,V}$ — Cracked / Non-cracked concrete

$\frac{s}{c_{min}}$ \ $\frac{c}{c_{min}}$	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.12	2.38	2.63	2.90	3.18	3.46
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65



FOR OTHER CASE OF FASTENINGS

$\Psi_{s\text{-}c,V} = \frac{3c + s_1 + s_2 + s_3 + ... + s_{n-1}}{3nc_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$

REBAR (FE460)

Installation in G30 Reinforced Concrete

Design Embedment Depth $L_{b,rqd}$ and Design Tensile Load Table N_{Rd}

Rebar Ø (mm)	10	12	13	16	20	25	28	32	40
Hole Ø (mm)	13-14	15-16	16-18	20-22	25-28	30-32	35-38	40-42	50-52
Design Yield, N_{Rd} (kN)	31.4	45.2	53.1	80.4	125.7	196.4	246.3	321.7	502.7
$L_{b,rqd}$ (mm)	140	165	180	220	275	340	385	515	725
n = $L_{b,rqd}$ / Rebar Ø	14	14	14	14	14	14	14	17	19
L_b (mm)	N_{Rd} (kN)								
100	23.1								
110	25.4								
120	27.7	33.2							
125	28.9	34.6							
130	30.0	36.0	39.0						
140	31.4	38.8	42.9						
145		40.2	43.5						
160		44.3	48.0	59.1					
165		45.2	49.5	61.0					
180			53.1	66.5					
190				70.2					
200				73.9	92.4				
205				75.7	94.7				
220				80.4	101.6				
250					115.4	144.3			
255					117.8	147.2			
275					125.7	158.7			
280						161.6	181.0		
315						181.8	203.6		
320						184.7	206.9	200.6	
340						196.4	219.8	213.2	
360							232.7	225.7	
385							246.3	241.4	
395								247.6	
400								250.8	278.8
440								275.9	306.7
485								304.1	338.1
515								321.7	359.0
570									397.4
595									414.8
650									453.1
725									502.7

Safety Factor for bond γ_B = 1.8
Safety Factor for Concrete $\gamma_{Mc,N}$ = 1.5
Safety Factor for Steel $\gamma_{Ms,N}$ = 1.15
Tensile development length L_b using Epcon G5:
where the $F_{Rd} \leq N_{Rd,s}$:

$$L_b = \left(\frac{L_{b,rqd}}{f_B}\right) \cdot \left(\frac{F_{Rd}}{N_{Rd,s}}\right)$$

f_B INFLUENCE OF CONCRETE

Concrete Grade	f_B	Concrete Grade	f_B
C16/20	0.81	C35/45	1.21
C20/25	0.90	C40/50	1.28
C25/30	1.00	C45/55	1.34
C30/37	1.10	C50/60	1.40

Note: For splitting and splice calculation, please refer to ITW Technical Engineers.

REBAR (FE460)

INSTALLATION IN G40 REINFORCED CONCRETE

Design embedment depth $L_{b,rqd}$ and Design Tensile Load Table N_{Rd}

Rebar Ø (mm)	10	12	13	16	20	25	28	32	40
Hole Ø (mm)	13-14	15-16	16-18	20-22	25-28	30-32	35-38	40-42	50-52
Design Yield, $N_{Rd,s}$ (kN)	31.4	45.2	53.1	80.4	125.7	196.3	246.3	321.7	502.7
$L_{b,rqd}$ (mm)	125	145	160	200	250	300	340	455	640
$n=L_{b,rqd}$/Rebar Ø	13	13	13	13	13	12	13	15	16
L_b (mm)	kN								
90	23.1								
100	25.4								
105	27.7								
110	28.9	34.6							
115	30.0	36.0	39.0						
125	31.4	38.8	42.0						
130		40.2	43.5						
140		44.3	48.0	59.1					
145		45.2	49.5	61.0					
160			53.1	66.5					
170				70.2					
175				73.9	92.4				
180				75.7	94.7				
200				80.4	101.6				
220					115.4	144.3			
225					117.8	147.2			
250					125.7	158.7			
245						161.6			
235						173.2			
275						181.8	203.6		
280						184.7	206.9		
300						196.3	219.8	213.2	
320							232.7	225.7	
340							246.3	241.4	
350								247.6	
355								250.8	
390								275.9	
425								304.1	338.1
455								321.7	359.0
500									397.4
525									414.8
570									453.1
640									502.7

Safety Factor for Bond $\gamma_B = 1.8$
Safety Factor for Concrete $\gamma_{Mc,N} = 1.5$
Safety Factor for Steel $\gamma_{Ms,N} = 1.15$
Min Edge Distance is based on 30mm concrete cover

Tensile development length L_b using Epcon G5:
where the $F_{Rd} \leq N_{Rd,s}$:

$$L_b = \frac{L_{b,rqd}}{f_B} \bullet \frac{F_{Rd}}{N_{Rd,s}}$$

f_B **INFLUENCE OF CONCRETE**

Concrete Grade	f_B	Concrete Grade	f_B
C16/20	0.81	C35/45	1.21
C20/25	0.90	C40/50	1.28
C25/30	1.00	C45/55	1.34
C30/37	1.10	C50/60	1.40

REBAR (FE460)

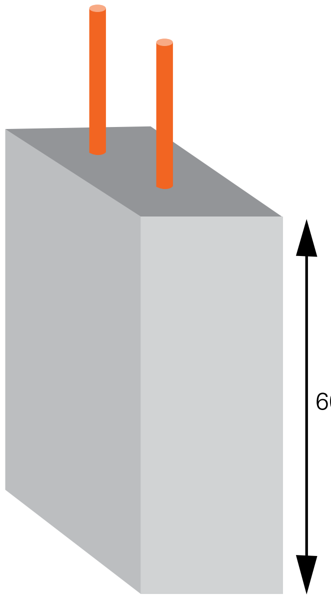
Installation in Reinforced Concrete

EXAMPLE 1:

The design action effect which causes tension in the starter bar is:

N = 650kN/m run

Strip footing details:
Concrete grade = 25N/mm^2
Structure Thickness = 600mm
Concrete cover = 50mm



Load case induced in starter bar = 650kN/m run

Consider design of 460N/mm^2 grade reinforcement bar

To satisfy Strength Limit State Design Criteria,

therefore,

$$N \leq A_s \cdot \frac{f_{yk}}{\gamma_{Ms}}$$

$$650{,}000(N) \leq A_s \cdot (460 \div 1.15)$$

$$A_s \geq 1{,}624mm^2$$

Using 4T25 reinforcing bar @ 300mm c/c = 1,963.6mm^2 > 1,624mm^2

Installing T25 with Epcon G5:

$$L_b = \left(\frac{L_{b,rqd}}{f_B}\right) \cdot \left(\frac{F_{Rd}}{N_{Rd,s}}\right)$$

L_b = (340mm ÷ 0.9) x (162.5kN ÷ 196.3kN)

L_b = 312.7mm.......say 315mm

EXAMPLE 2:

where the existing structure is 380mm deep and concrete cover remains 50mm:

hole depth = 330mm
design tensile capacity for T25 @ 300mm embedment depth = 173.1kN x 0.9 = 155.7kN
650kN = n x 155.7kN
n = 650kN / 155.7kN = 4.17 ~ 5 (round to nearest number)

Use 5T25 reinforcing bar @ 225mm c/c = 2,454.5mm^2 > 1,624mm^2

REBAR (FE460)

Rebar Connection Design as per EN 1992-1-1

General points

The design of rebar connections and determination of the internal section forces to be transferred in the construction joint shall be in keeping with the EN 1992-1-1.

Verfication of immediate local force transfer to the concrete has been provided.

Verification of the transfer of the loads to the anchored to the building component must be provided.

Connection joint

In case of a connection being made between new and existing concrete where the surface layer of the existing concrete is carbonated, the layer should be removed in the area of the new reinforcing bar (with a diameter d_s + 60mm) prior to the installation of the new bar. The forgoing may be neglected if building components are new and not carbonated.

To prevent damage of the concrete during drilling, the following requirements has to be met:

- Minimum concrete cover:
  $c_{min} = 30 + 0.06l_v \geq 2d_s$ (mm) for hammer drilled holes
  where l_v = actual embedment depth

- Minimum distances between 2 rebars:
  $s = 40mm \geq 4d_s$

- Minimum embedment:
  $l_{b,min} = 1.5 \cdot \max(0.3.L_{bd}\ ;\ 10Ø;\ 100mm)$

Furthermore, the minimum concrete cover according to EN 1992-1-1 SS 4.4.1.2 nust be observed.

REBAR (FE460)

Rebar Application Under ETA Rule - Intended Use

Overlap Joint

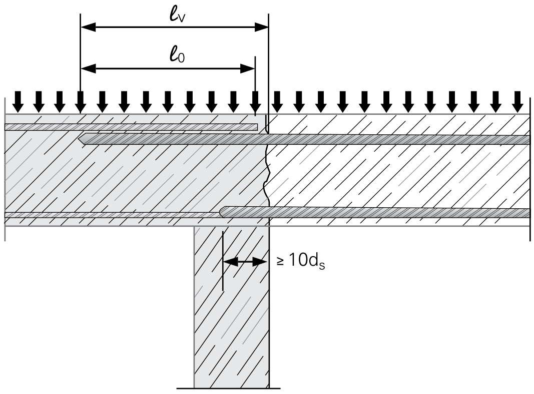


Figure 1.1: Overlap joint for rebar connections of slabs and beams.

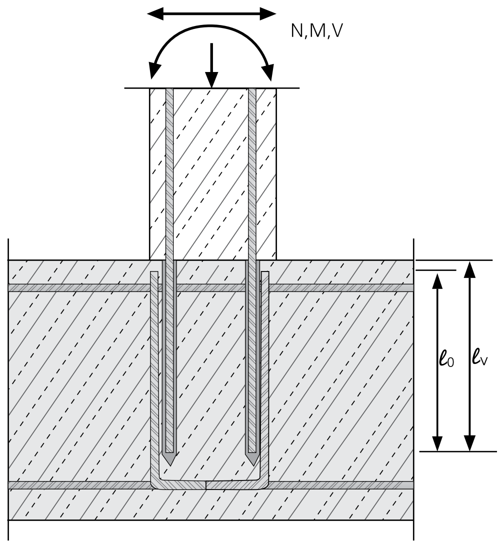


Figure 1.2: Overlap joint at a foundation of a column or wall where the rebars are stressed in tension

Anchoring Bar

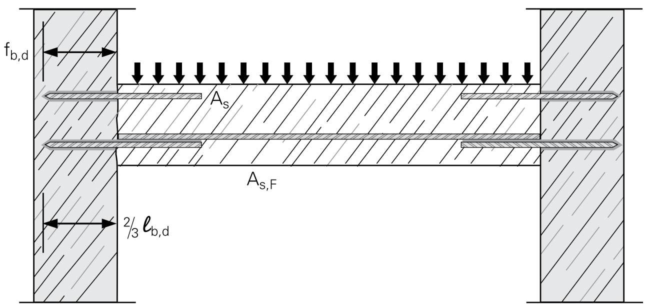


Figure 1.3: End anchoring of slabs or beams design as simply supported.

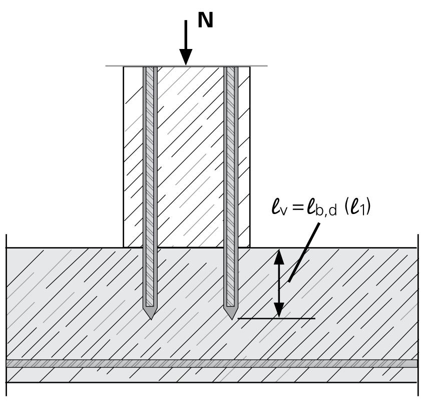


Figure 1.4: Rebar connection for components stressed primarily in compression. The rebars are stressed in compression.

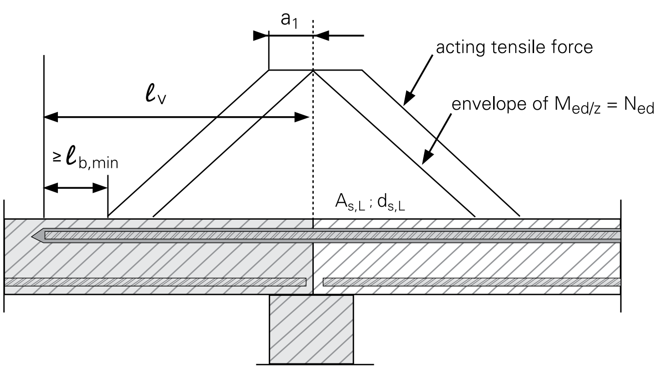
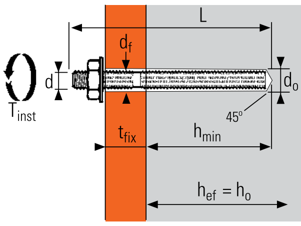


Figure 1.5: Anchoring of reinforcement to cover the line of acting tensile force.

ZINC COATED ANCHOR STUD(G5.8) / CHEMSET™

Performance	Material	Installation

ICC-ES EVALUATION REPORT



Technical Data

EPCON G5 with Chemset Stud	Anchor depth (mm)	Max thick of fixture (mm)	Drill depth (mm)	Thick of base material (mm)	Ø Thread (mm)	Ø Drill bit (mm)	Total anchor length (mm)	Tighten torque (Nm)	Chemset stud code	Ramset power tool code	Drill bit type-size
	$h_{ef,min}$	t_{fix}	h_o	h_{min}	d	d_o	L	T_{inst}			
M8	80	15	80	100	8	10	110	10	CS08110	DD527	R3 PLUS-10
M10	90	20	90	115	10	12	130	20	CS10130	DD527	R3 PLUS-12
M12	110	25	110	140	12	14	160	30	CS12160	DD527	R3 PLUS-14
M16	125	35	125	160	16	18	190	60	CS16190	DD544	R3 PLUS-18
M20	170	65	170	215	20	25	260	120	CS20260	DD565	R3 MAX-25
M24	210	63	210	270	24	28	300	200	CS24300	DD565	R3 MAX-28
M30	280	70	280	350	30	35	380	400	CS30380	DD565	R3 MAX-35

EPOXY G5 Two part cartridge, 100% epoxy resin - vol. 650ml

MATERIAL

Stud / Chemset™:
Grade 5.8

Hexagonal Nut:
Grade 6 or 8

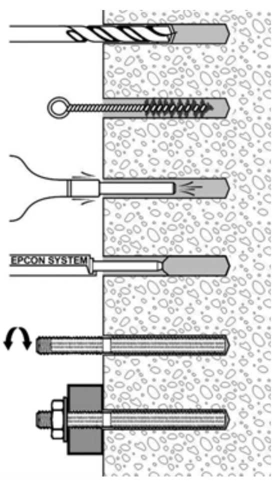
Washer:
Steel

Coating:
Zinc Coated 5µm

Anchor Mechanical Properties

CARBON STEEL Grade 5.8	M8	M10	M12	M16	M20	M24	M30
f_{uk} (N/mm2) Min. tensile strength	540	540	540	520	520	520	520
f_{yk} (N/mm2) Yield strength	430	430	430	420	420	420	420
A_s (mm2) Stressed cross-section	36.6	58	84.3	157	245	353	522.8
W_{el} (mm3) Elastic section modulus	31.2	62.3	109.2	277.5	540.9	935.5	1,686.0
$M^0_{Rk,s}$ (Nm) Characteristic bending moment	20.2	40.4	70.7	173.1	337.5	583.8	1,052.1
M (Nm) Recommended bending moment	16.2	32.3	56.6	138.5	270.0	467.0	841.7

INSTALLATION



Setting Time before applying load

Ambient temperature (°C)	Max time for installation (min)	Waiting time before applying load (hr)
32°C	8.5	2
27°C	12	2
20°C	15	2
16°C	18	3
10°C	21	6

Chemical Resistance of EPCON G5 Anchor

Chemical substances	Resistance	Chemical substances	Resistance
Xylene	1	Toluene	2
Gasoline	1	10% Nitric Acid	2
20% Caustic NaOH (Sodium Hydroxide)	1	8.5% Ammonium Hydroxide	2
Fresh Water	1	5% Bleach	3
Salt Water	1	Acetone	3
10% Sulfuric Acid (H2 SO4)	2	Glacial Acetic Acid	3
3.5% Hydrochloric Acid (HCL)	2	Methanol	3
9% Phosphoric Acid	2	Methylene Chloride	3

1 = High resistance (Anchors could be submerged in these materials)
2 = Medium resistance (Anchors could be temporary submerged due to splash or spill)
3 = Low resistance (Anchors should be limited to splash and spill followed by immediate cleanup)

ZINC COATED ANCHOR STUD(G5.8) / CHEMSET™

Number of Anchors per cartridge

Stud diameter	**8**	**10**	**12**	**16**	**20**	**24**	**30**
Drilling Ø (mm)	10	12	14	18	25	28	35
Drilling depth (mm)	80	90	110	125	170	210	280
No. of anchors per cartridge							
EPCON G5 (650ml)	206.9	127.7	76.8	40.9	15.6	10.1	4.8

Ultimate Loads ($N_{Ru,m}$, $V_{Ru,m}$) / Characteristic Loads (N_{Rk}, V_{Rk}) in kN

TENSILE @ Concrete strength 30 N/mm²

Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M30**
h_{ef} (mm)	80	90	110	125	170	210	280
$N_{Ru,m}$ (kN)	21.3	33.8	49.2	88.2	137.6	198.2	293.6
N_{Rk} (kN)	19.8	31.3	45.5	81.6	127.4	183.6	271.9

SHEAR @ Concrete strength 30 N/mm²

Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M30**
$V_{Ru,m}$ (kN)	12.8	20.3	29.5	52.9	82.6	118.9	176.2
V_{Rk} (kN)	11.9	18.8	27.3	49.0	76.4	110.1	163.1

Design Loads (N_{Rd}, V_{Rd}) for one anchor without edge or spacing influence in kN

$$N_{Rd} = \frac{N_{Rk}}{\gamma_{Ms,N}}$$

$$V_{Rd} = \frac{V_{Rk}}{\gamma_{Ms,V}}$$

TENSILE @ Concrete strength 30 N/mm²

Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M30**
h_{ef} (mm)	80	90	110	125	170	210	280
N_{Rd} (kN)	13.2	20.9	30.3	54.4	84.9	122.4	181.2

$\gamma_{Ms,N} = 1.5$ *(steel failure)*

SHEAR @ Concrete strength 30 N/mm²

Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M30**
V_{Rd} (kN)	9.5	15.0	21.9	39.2	61.2	88.1	130.5

$\gamma_{Ms,V} = 1.25$

Recommended Loads (N_{rec}, V_{rec}) for one anchor without edge or spacing influence in kN

$$N_{rec} = \frac{N_{Rk}}{\gamma_{Ms,N} \cdot \gamma_F}$$

$$V_{rec} = \frac{V_{Rk}}{\gamma_{Ms,V} \cdot \gamma_F}$$

TENSILE @ Concrete strength 30 N/mm²

Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M30**
h_{ef} (mm)	80	90	110	125	170	210	280
N_{rec} (kN)	9.4	14.9	21.7	38.9	60.7	87.4	129.5

$\gamma_F = 1.4$

$\gamma_{Ms,N} = 1.5$ *(steel failure)*

SHEAR @ Concrete strength 30 N/mm²

Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M30**
V_{rec} (kN)	6.8	10.7	15.6	28.0	43.7	62.9	93.2

$\gamma_F = 1.4$

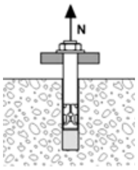
$\gamma_{Ms,V} = 1.25$

steel failure

ZINC COATED ANCHOR STUD(G5.8) / CHEMSET™

RAMSET CC-Method

TENSILE in kN

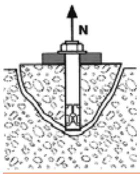


Pull-out resistance
Concrete strength C25/30

$N_{Rd,p} = N^0_{Rd,p} \cdot f_B \cdot f_T$

$N^0_{Rd,p}$	Design pull-out resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
h_{ef}	80	90	110	125	170	210	280
$N^0_{Rd,p}$ (kN)	15.3	26.7	33.8	45.5	59.1	90.1	150.1

$\gamma_{Mc,N} = 1.8$

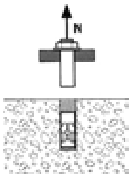


Concrete cone resistance
Concrete strength C25/30

$N_{Rd,c} = N^0_{Rd,c} \cdot f_B \cdot f_T \cdot \Psi_s \cdot \Psi_{c,N}$

$N^0_{Rd,c}$	Design cone resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
h_{ef} (mm)	80	90	110	125	170	210	280
$N^0_{Rd,c}$ (kN)	26.3	31.4	42.5	51.4	81.6	112.0	172.5

$\gamma_{Mc,N} = 1.5$

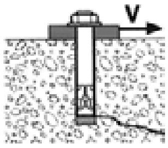


Steel resistance

$N_{Rd,s}$	Steel design tensile resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
$N_{Rd,s}$ (kN)	13.2	20.9	30.3	54.4	84.9	122.4	181.2

$\gamma_{Ms,N} = 1.5$

SHEAR in kN

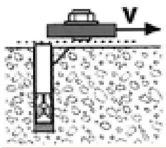


Concrete edge resistance
Concrete strength C25/30

$V_{Rd,c} = V^0_{Rd,c} \cdot f_B \cdot f_{\beta,V} \cdot \Psi_{s\text{-}c,V}$

$V^0_{Rd,c}$	Design concrete edge resistance at a minimum edge distance (c_{min})						
Anchor size	M8	M10	M12	M16	M20	M24	M30
h_{ef} (mm)	80	90	110	125	170	210	280
c_{min}	40	45	55	65	85	105	140
s_{min}	40	45	55	65	85	105	140
$V^0_{Rd,c}$ (kN)	2.6	3.4	5.1	7.3	12.4	18.7	32.6

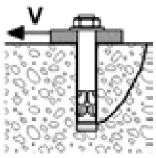
$\gamma_{Mc,V} = 1.5$



Steel resistance

$V_{Rd,s}$	Steel design shear resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
$V_{Rd,s}$ (kN)	9.5	15.0	21.9	39.2	61.2	88.1	130.5

$\gamma_{Ms,V} = 1.25$



Concrete pry-out failure
Concrete Strength C25/30

$V_{Rd,cp} = V^0_{Rd,cp} \cdot f_B \cdot \Psi_s \cdot \Psi_{c,N}$

$V^0_{Rd,cp}$	Design pry-out resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
$V^0_{Rd,cp}$ (kN)	52.7	62.9	84.9	102.9	163.2	224.0	344.9

$\gamma_{Mc,V} = 1.5$

$N_{Rd} = \min(N_{Rd,p}\,;\,N_{Rd,c}\,;\,N_{Rd,s})$
$\beta N = N_{Sd} / N_{Rd} \leq 1$

$V_{Rd} = \min(V_{Rd,c}\,;\,V_{Rd,s}\,;\,V_{Rd,cp})$
$\beta V = V_{Sd} / V_{Rd} \leq 1$

$\beta N + \beta V \leq 1.2$

f_B INFLUENCE OF CONCRETE

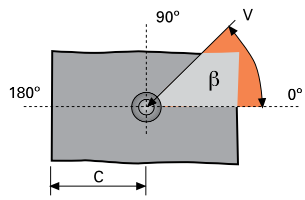
Concrete Grade	f_B	Concrete Grade	f_B
C16/20	0.81	C35/45	1.21
C20/25	0.90	C40/50	1.28
C25/30	1.00	C45/55	1.34
C30/37	1.10	C50/60	1.40

f_T INFLUENCE OF EMBEDMENT DEPTH

$$f_T = \frac{h_{act}}{h_{ef}}$$

$f_{\beta,V}$ INFLUENCE OF SHEAR LOADING DIRECTION

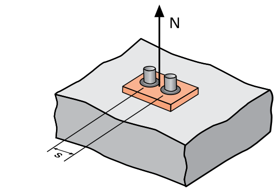
Angle β [°]	$f_{\beta,V}$
0~50	1.0
60	1.1
70	1.2
80	1.5
90~180	2.0



ZINC COATED ANCHOR STUD(G5.8) / CHEMSET™

RAMSET CC-Method

Ψ_s INFLUENCE OF SPACING FOR CONCRETE



$$\Psi_s = 0.5 + \frac{s}{4h_{ef}}$$

$s < s_{cr,N}$

$s_{min} = 0.5h_{ef}$

$s_{cr,N} = 2h_{ef}$

Ψ_s must be used for each spacing influenced the anchors group

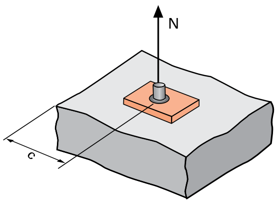
Spacing, s — Reduction Factor Ψ_s — Cracked / Non-cracked concrete

	M8	M10	M12	M16
40	0.63			
45	0.64	0.63		
55	0.67	0.65	0.63	
65	0.70	0.68	0.65	0.63
85	0.77	0.74	0.69	0.67
105	0.83	0.79	0.74	0.71
140	0.94	0.89	0.82	0.78
160	1.00	0.94	0.86	0.82
180		1.00	0.91	0.86
220			1.00	0.94
250				1.00

Spacing, s — Reduction Factor Ψ_s — Cracked / Non-cracked concrete

	M20	M24	M30
85	0.63		
105	0.65	0.63	
140	0.71	0.67	0.63
160	0.74	0.69	0.64
180	0.76	0.71	0.66
220	0.82	0.76	0.70
250	0.87	0.80	0.72
300	0.94	0.86	0.77
340	1.00	0.90	0.80
370		0.94	0.83
420		1.00	0.88
560			1.00

$\Psi_{c,N}$ INFLUENCE OF EDGE FOR CONCRETE



$$\Psi_{c,N} = 0.275 + 0.725 \cdot \frac{c}{h_{ef}}$$

$c < c_{cr,N}$

$c_{min} = 0.5h_{ef}$

$c_{cr,N} = h_{ef}$

$\Psi_{c,N}$ must be used for each distance influenced the anchors group

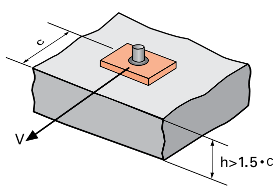
Edge, c — Reduction Factor $\Psi_{c,N}$ — Cracked / Non-cracked concrete

	M8	M10	M12	M16
40	0.63			
45	0.68	0.63		
55	0.77	0.71	0.63	
65	0.86	0.79	0.70	0.65
80	1.00	0.91	0.80	0.73
90		1.00	0.86	0.79
110			1.00	0.91
125				1.00

Edge, c — Reduction Factor $\Psi_{c,N}$ — Cracked / Non-cracked concrete

	M20	M24	M30
85	0.63		
105	0.72	0.63	
120	0.78	0.68	
140	0.87	0.75	0.63
170	1.00	0.86	0.71
210		1.00	0.81
250			0.92
280			1.00

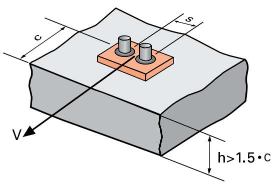
$\Psi_{s\text{-}c,V}$ INFLUENCED OF SPACING AND EDGE DISTANCE FOR CONCRETE EDGE RESISTANCE IN SHEAR LOAD



$$\Psi_{s\text{-}c,V} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

FOR SINGLE ANCHOR FASTENING — Reduction Factor $\Psi_{s\text{-}c,V}$ — Cracked / Non-cracked concrete

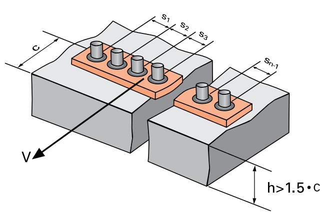
$\frac{c}{c_{min}}$	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2
$\Psi_{s\text{-}c,V}$	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72



$$\Psi_{s\text{-}c,V} = \frac{3c + s}{6c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

FOR 2 ANCHORS FASTENING — Reduction Factor $\Psi_{s\text{-}c,V}$ — Cracked / Non-cracked concrete

$\frac{s}{c_{min}}$ \ $\frac{c}{c_{min}}$	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.12	2.38	2.63	2.90	3.18	3.46
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65



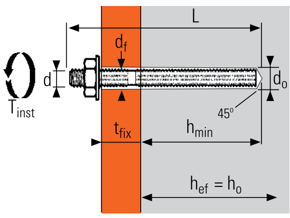
FOR OTHER CASE OF FASTENINGS

$$\Psi_{s\text{-}c,V} = \frac{3c + s_1 + s_2 + s_3 + \dots + s_{n-1}}{3nc_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

ZINC COATED ANCHOR STUD(G8.8) / CHEMSET™

Performance	Material	Installation
	Zn	

ICC-ES EVALUATION REPORT



MATERIAL

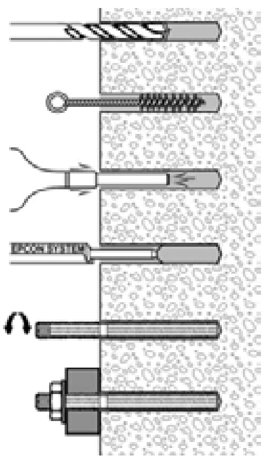
Stud / Chemset™ :
Grade 8.8

Hexagonal Nut:
Grade 8 or 10

Washer:
Steel

Coating:
Zinc Coated 5µm

INSTALLATION



Technical Data

EPCON G5	Anchor depth (mm)	Max thick of fixture (mm)	Drill depth (mm)	Thick of base material (mm)	Ø Thread (mm)	Ø Drill bit (mm)	Total anchor length (mm)	Tighten torque (Nm)	Ramset power tool code	Drill bit type-size
	$h_{ef,min}$	t_{fix}	h_o	h_{min}	d	d_o	L	T_{inst}		
M8	80	15	80	100	8	10	110	10	DD527	R3 PLUS-10
M10	90	20	90	115	10	12	130	20	DD527	R3 PLUS-12
M12	110	25	110	140	12	14	160	30	DD527	R3 PLUS-14
M16	125	35	125	160	16	18	190	60	DD544	R3 PLUS-18
M20	170	65	170	215	20	25	260	120	DD565	R3 MAX-25
M24	210	63	210	270	24	28	300	200	DD565	R3 MAX-28
M27	240	60	240	300	27	30	340	300	DD565	R3 MAX-30
M30	280	70	280	350	30	35	380	400	DD565	R3 MAX-35
M33	300	80	300	375	33	38	420	1200	DD565	R3 MAX-38
M36	330	90	330	413	36	40	460	1500	DD565	R3 MAX-40
M39	360	100	360	450	39	45	510	1800	DD565	R3 MAX-45

Anchor Mechanical Properties

CARBON STEEL Grade 8.8	M8	M10	M12	M16	M20	M24
f_{uk} (N/mm2) Min. tensile strength	800	800	800	800	800	800
f_{yk} (N/mm2) Yield strength	640	640	640	640	640	640
A_s (mm2) Stressed cross-section	36.6	58	84.3	157	245	353
W_{el} (mm3) Elastic section modulus	31.2	62.3	109.2	277.5	540.9	935.5
$M^0_{Rk,s}$ (Nm) Characteristic bending moment	30.0	59.8	104.8	266.4	519.3	898.1
M (Nm) Recommended bending moment	24.0	47.8	83.9	213.1	415.4	718.5

CARBON STEEL Grade 8.8	M27	M30	M33	M36	M39
f_{uk} (N/mm2) Min. tensile strength	800	800	800	800	800
f_{yk} (N/mm2) Yield strength	640	640	640	640	640
A_s (mm2) Stressed cross-section	427	522.8	647	759	913
W_{el} (mm3) Elastic section modulus	1,245.0	1,668.0	2,322.0	2,951.0	3,860.0
$M^0_{Rk,s}$ (Nm) Characteristic bending moment	1,195.2	1,601.3	2,229.1	2,833.0	3,705.6
M (Nm) Recommended bending moment	956.2	1,281.0	1,783.3	2,266.4	2,964.5

Setting Time before applying load

Ambient temperature (ºC)	Max time for installation (min)	Waiting time before applying load (hr)
32ºC	8.5	2
27ºC	12	2
20ºC	15	2
16ºC	18	3
10ºC	21	6

Chemical Resistance of EPCON G5 Anchor

Chemical substances	Resistance	Chemical substances	Resistance
Xylene	1	Toluene	2
Gasoline	1	10% Nitric Acid	2
20% Caustic NaOH (Sodium Hydroxide)	1	8.5% Ammonium Hydroxide	2
Fresh Water	1	5% Bleach	3
Salt Water	1	Acetone	3
10% Sulfuric Acid (H2 SO4)	2	Glacial Acetic Acid	3
3.5% Hydrochloric Acid (HCL)	2	Methanol	3
9% Phosphoric Acid	2	Methylene Chloride	3

1 = High resistance (Anchors could be submerged in these materials)
2 = Medium resistance (Anchors could be temporary submerged due to splash or spill)
3 = Low resistance (Anchors should be limited to splash and spill followed by immediate cleanup)

ZINC COATED ANCHOR STUD(G8.8) / CHEMSET™

Number of Anchors per cartridge

Stud diameter	8	10	12	16	20	24	27	30	33	36	39
Drilling Ø (mm)	10	12	14	18	25	28	30	35	38	35	45
Drilling depth (mm)	80	90	110	125	170	210	240	280	300	330	360
No. of anchors per cartridge											
EPCON G5 (650ml)	206.9	127.7	76.8	40.9	15.6	10.1	7.7	4.8	3.8	3.1	2.3

Ultimate Loads ($N_{Ru,m}$, $V_{Ru,m}$) / Characteristic Loads (N_{Rk}, V_{Rk}) in kN

TENSILE @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24
h_{ef} (mm)	80	90	110	125	170	210
$N_{Ru,m}$ (kN)	31.6	50.1	72.8	109.1	141.8	216.2
N_{Rk} (kN)	29.3	46.4	67.4	81.8	106.3	162.1

Anchor size	M27	M30	M33	M36	M39
h_{ef} (mm)	240	280	300	330	360
$N_{Ru,m}$ (kN)	264.7	360.3	419.1	485.3	595.6
N_{Rk} (kN)	198.5	270.2	314.3	364.0	446.7

SHEAR @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24
$V_{Ru,m}$ (kN)	19.0	30.1	43.7	81.4	127.0	183.0
V_{Rk} (kN)	17.6	27.8	40.5	75.4	117.6	169.4

Anchor size	M27	M30	M33	M36	M39
$V_{Ru,m}$ (kN)	221.4	271.0	335.4	393.5	473.3
V_{Rk} (kN)	205.0	250.9	310.6	364.3	438.2

Design Loads (N_{Rd}, V_{Rd}) for one anchor without edge or spacing influence in kN

$$N_{Rd} = \frac{N_{Rk}}{\gamma_{Mc,N}} \text{ or } \frac{N_{Rk}}{\gamma_{Ms,N}}$$

$$V_{Rd} = \frac{V_{Rk}}{\gamma_{Ms,V}}$$

TENSILE @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24
h_{ef} (mm)	80	90	110	125	170	210
N_{Rd} (kN)	19.5	30.9	45.0	45.5	59.1	90.1

Anchor size	M27	M30	M33	M36	M39
h_{ef} (mm)	240	280	300	330	360
N_{Rd} (kN)	110.3	150.1	174.6	202.2	248.2

$\gamma_{Mc,N}$ = 1.8

$\gamma_{Ms,N}$ = 1.5 *(steel failure)*

SHEAR @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24
V_{Rd} (kN)	14.1	22.3	32.4	60.3	94.1	135.6

Anchor size	M27	M30	M33	M36	M39
V_{Rd} (kN)	164.0	200.8	248.4	291.5	350.6

$\gamma_{Ms,V}$ = 1.25

Recommended Loads (N_{rec}, V_{rec}) for one anchor without edge or spacing influence in kN

$$N_{rec} = \frac{N_{Rk}}{\gamma_{Mc,N} \cdot \gamma_F} \text{ or } \frac{N_{Rk}}{\gamma_{Ms,N} \cdot \gamma_F}$$

$$V_{rec} = \frac{V_{Rk}}{\gamma_{Ms,V} \cdot \gamma_F}$$

TENSILE @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24
h_{ef} (mm)	80	90	110	125	170	210
N_{rec} (kN)	13.9	22.1	32.1	32.5	42.2	64.3

Anchor size	M27	M30	M33	M36	M39
h_{ef} (mm)	240	280	300	330	360
N_{rec} (kN)	78.8	107.2	124.7	144.4	177.3

γ_F = 1.4

$\gamma_{Mc,N}$ = 1.8

$\gamma_{Ms,N}$ = 1.5 *(steel failure)*

SHEAR @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24
V_{rec} (kN)	10.0	15.9	23.1	43.1	67.2	96.8

Anchor size	M27	M30	M33	M36	M39
V_{rec} (kN)	117.1	143.4	177.5	208.2	250.4

γ_F = 1.4

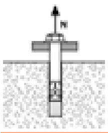
$\gamma_{Ms,V}$ = 1.25

steel failure (shaded cells)

ZINC COATED ANCHOR STUD(G8.8) / CHEMSET™

RAMSET CC-Method

TENSILE in kN



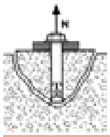
Pull-out resistance
Concrete strength C25/30

$N_{Rd,p} = N^0_{Rd,p} \cdot f_B \cdot f_T$

$N^0_{Rd,p}$	Design pull-out resistance					
Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**
h_{ef}	80	90	110	125	170	210
$N^0_{Rd,p}$ (kN)	15.3	26.7	33.8	45.5	59.1	90.1

$N^0_{Rd,p}$	Design pull-out resistance				
Anchor size	**M27**	**M30**	**M33**	**M36**	**M39**
h_{ef}	240	280	300	330	360
$N^0_{Rd,p}$ (kN)	110.3	150.1	174.6	202.2	248.2

$\gamma_{Mc,N} = 1.8$



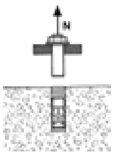
Concrete cone resistance
Concrete strength C25/30

$N_{Rd,c} = N^0_{Rd,c} \cdot f_B \cdot f_T \cdot \Psi_s \cdot \Psi_{c,N}$

$N^0_{Rd,c}$	Design cone resistance					
Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**
h_{ef} (mm)	80	90	110	125	170	210
$N^0_{Rd,c}$ (kN)	26.3	31.4	42.5	51.4	81.6	112.0

$N^0_{Rd,c}$	Design cone resistance				
Anchor size	**M27**	**M30**	**M33**	**M36**	**M39**
h_{ef} (mm)	240	280	300	330	360
$N^0_{Rd,c}$ (kN)	136.9	172.5	191.3	220.6	251.4

$\gamma_{Mc,N} = 1.5$



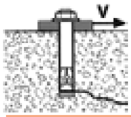
Steel resistance

$N_{Rd,s}$	Steel design tensile resistance					
Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**
$N_{Rd,s}$ (kN)	19.5	30.9	45.0	83.7	130.7	188.3

$N_{Rd,s}$	Steel design tensile resistance				
Anchor size	**M27**	**M30**	**M33**	**M36**	**M39**
$N_{Rd,s}$ (kN)	227.7	278.8	345.1	404.8	486.9

$\gamma_{Ms,N} = 1.5$

SHEAR in kN



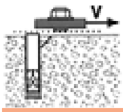
Concrete edge resistance
Concrete strength C25/30

$V_{Rd,c} = V^0_{Rd,c} \cdot f_B \cdot f_{\beta,V} \cdot \Psi_{s\text{-}c,V}$

$V^0_{Rd,c}$	Design concrete edge resistance at a minimum edge distance (c_{min})					
Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**
h_{ef} (mm)	80	90	110	125	170	210
c_{min}	40	45	55	65	85	105
s_{min}	40	45	55	65	85	105
$V^0_{Rd,c}$ (kN)	2.6	3.4	5.1	7.3	12.4	18.7

$V^0_{Rd,c}$	Design concrete edge resistance at a minimum edge distance (c_{min})				
Anchor size	**M27**	**M30**	**M33**	**M36**	**M39**
h_{ef} (mm)	240	280	300	330	360
c_{min}	120	140	150	165	180
s_{min}	120	140	150	165	180
$V^0_{Rd,c}$ (kN)	24.3	32.6	37.8	45.6	54.1

$\gamma_{Mc,V} = 1.5$

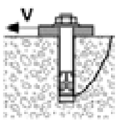


Steel resistance

$V_{Rd,s}$	Steel design shear resistance					
Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**
$V_{Rd,s}$ (kN)	14.1	22.3	32.4	60.3	94.1	135.6

$V_{Rd,s}$	Steel design shear resistance				
Anchor size	**M27**	**M30**	**M33**	**M36**	**M39**
$V_{Rd,s}$ (kN)	164.0	200.8	248.4	291.5	350.6

$\gamma_{Ms,V} = 1.25$



Concrete pry-out failure
Concrete Strength C25/30

$V_{Rd,cp} = V^0_{Rd,cp} \cdot f_B \cdot \Psi_s \cdot \Psi_{c,N}$

$V^0_{Rd,cp}$	Design pry-out resistance					
Anchor size	**M8**	**M10**	**M12**	**M16**	**M20**	**M24**
$V^0_{Rd,cp}$ (kN)	52.7	62.9	84.9	102.9	163.2	224.0

$V^0_{Rd,cp}$	Design pry-out resistance				
Anchor size	**M27**	**M30**	**M33**	**M36**	**M39**
$V^0_{Rd,cp}$ (kN)	273.7	344.9	382.5	441.3	502.8

$\gamma_{Mc,V} = 1.5$

$N_{Rd} = \min(N_{Rd,p}\,;\,N_{Rd,c}\,;\,N_{Rd,s})$
$\beta N = N_{Sd} / N_{Rd} \leq 1$

$V_{Rd} = \min(V_{Rd,c}\,;\,V_{Rd,s}\,;\,V_{Rd,cp})$
$\beta V = V_{Sd} / V_{Rd} \leq 1$

$\beta N + \beta V \leq 1.2$

f_B INFLUENCE OF CONCRETE

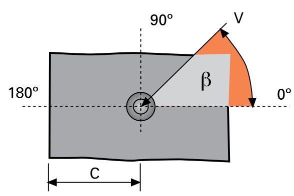
Concrete Grade	f_B	Concrete Grade	f_B
C16/20	0.81	C35/45	1.21
C20/25	0.90	C40/50	1.28
C25/30	1.00	C45/55	1.34
C30/37	1.10	C50/60	1.40

f_T INFLUENCE OF EMBEDMENT DEPTH

$$f_T = \frac{h_{act}}{h_{ef}}$$

$f_{\beta,V}$ INFLUENCE OF SHEAR LOADING DIRECTION

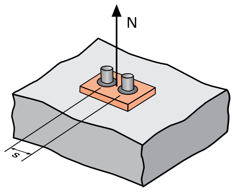
Angle β [°]	$f_{\beta,V}$
0~50	1.0
60	1.1
70	1.2
80	1.5
90~180	2.0



ZINC COATED ANCHOR STUD(G8.8) / CHEMSET™

RAMSET CC-Method

Ψ_s INFLUENCE OF SPACING FOR CONCRETE



$$\Psi_s = 0.5 + \frac{s}{4h_{ef}}$$

$s < s_{cr,N}$

$s_{min} = 0.5h_{ef}$

$s_{cr,N} = 2h_{ef}$

Ψ_s must be used for each spacing influenced the anchors group

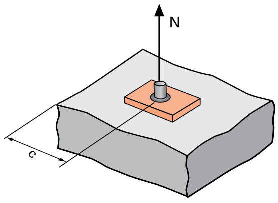
Reduction Factor Ψ_s – Cracked / Non-cracked concrete

Spacing, s	M8	M10	M12	M16	M20	M24
40	0.63					
45	0.64	0.63				
55	0.67	0.65	0.63			
65	0.70	0.68	0.65	0.63		
85	0.77	0.74	0.69	0.67	0.63	
105	0.83	0.79	0.74	0.71	0.65	0.63
140	0.94	0.89	0.82	0.78	0.71	0.67
160	1.00	0.94	0.86	0.82	0.74	0.69
180		1.00	0.91	0.86	0.76	0.71
220			1.00	0.94	0.82	0.76
250				1.00	0.87	0.80
340					1.00	0.90
420						1.00

Reduction Factor Ψ_s – Cracked / Non-cracked concrete

Spacing, s	M27	M30	M33	M36	M39
120	0.63				
140	0.65	0.63			
155	0.66	0.64	0.63		
165	0.67	0.65	0.64	0.63	
180	0.69	0.66	0.65	0.64	0.63
300	0.81	0.77	0.75	0.73	0.71
400	0.92	0.86	0.83	0.80	0.78
480	1.00	0.93	0.90	0.86	0.83
560		1.00	0.97	0.92	0.89
600			1.00	0.95	0.92
660				1.00	0.96
720					1.00

$\Psi_{c,N}$ INFLUENCE OF EDGE FOR CONCRETE



$$\Psi_{c,N} = 0.275 + 0.725 \cdot \frac{c}{h_{ef}}$$

$c < c_{cr,N}$

$c_{min} = 0.5h_{ef}$

$c_{cr,N} = h_{ef}$

$\Psi_{c,N}$ must be used for each distance influenced the anchors group

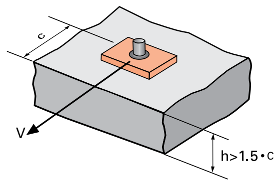
Reduction Factor $\Psi_{c,N}$ – Cracked / Non-cracked concrete

Edge, c	M8	M10	M12	M16	M20	M24
40	0.63					
45	0.68	0.63				
55	0.77	0.71	0.63			
63	0.84	0.78	0.69	0.64		
80	1.00	0.91	0.80	0.73		
85		0.95	0.83	0.76	0.63	
90		1.00	0.86	0.79	0.65	
105			0.96	0.88	0.72	0.63
110			1.00	0.91	0.74	0.65
125				1.00	0.80	0.70
150					0.91	0.79
170					1.00	0.86
210						1.00

Reduction Factor $\Psi_{c,N}$ – Cracked / Non-cracked concrete

Edge, c	M27	M30	M33	M36	M39
120	0.63				
140	0.69	0.63			
150	0.72	0.66	0.63		
165	0.77	0.70	0.67	0.63	
180	0.81	0.74	0.71	0.67	0.63
240	1.00	0.89	0.85	0.80	0.75
250		0.92	0.87	0.82	0.77
280		1.00	0.95	0.89	0.83
300			1.00	0.93	0.87
330				1.00	0.93
360					1.00

$\Psi_{s\text{-}c,V}$ INFLUENCED OF SPACING AND EDGE DISTANCE FOR CONCRETE EDGE RESISTANCE IN SHEAR LOAD

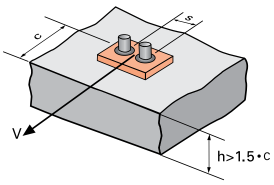


$$\Psi_{s\text{-}c,V} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

FOR SINGLE ANCHOR FASTENING

Reduction Factor $\Psi_{s\text{-}c,V}$ – Cracked / Non-cracked concrete

$\frac{c}{c_{min}}$	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2
$\Psi_{s\text{-}c,V}$	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72

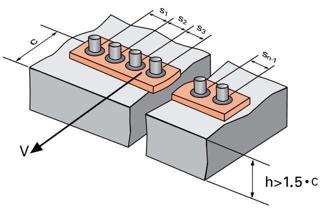


$$\Psi_{s\text{-}c,V} = \frac{3c + s}{6c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

FOR 2 ANCHORS FASTENING

Reduction Factor $\Psi_{s\text{-}c,V}$ – Cracked / Non-cracked concrete

$\frac{s}{c_{min}}$ \ $\frac{c}{c_{min}}$	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.12	2.38	2.63	2.90	3.18	3.46
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65

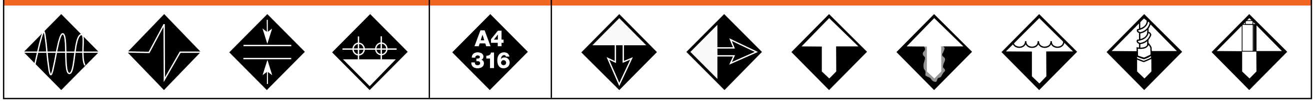


FOR OTHER CASE OF FASTENINGS

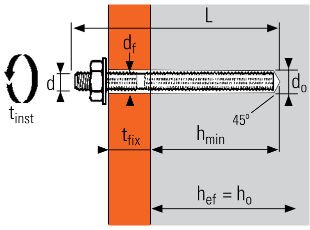
$$\Psi_{s\text{-}c,V} = \frac{3c + s_1 + s_2 + s_3 + ... + s_{n-1}}{3nc_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

STAINLESS STEEL ANCHOR STUD(SS316) / CHEMSET™

Performance	Material	Installation



ICC-ES EVALUATION REPORT



Technical Data

EPCON G5 with Chemset Stud SS	Anchor depth (mm) h_{ef}	Max thick of fixture (mm) t_{fix}	Drill depth (mm) h_o	Thick of base material (mm) h_{min}	Ø Thread (mm) d	Ø Drill bit (mm) d_o	Total anchor length (mm) L	Tighten torque (Nm) T_{inst}	Chemset stud code	Ramset power tool code	Drill bit type-size
M8	80	15	80	100	8	10	110	10	CS08110SS	DD527	R3 PLUS-10
M10	90	20	90	115	10	12	130	20	CS10130SS	DD527	R3 PLUS-12
M12	110	25	110	140	12	14	160	30	CS12160SS	DD527	R3 PLUS-14
M16	125	35	125	160	16	18	190	60	CS16190SS	DD544	R3 PLUS-18
M20	170	65	170	215	20	25	260	120	CS20260SS	DD565	R3 MAX-25
M24	210	63	210	270	24	28	300	200	CS24300SS	DD565	R3 MAX-28
M30	280	70	280	350	30	35	380	400	CS30380SS	DD565	R3 MAX-35

EPOXY G5 Two part cartridge, 100% epoxy resin - vol. 650ml

MATERIAL

Stud / Chemset™ :
SUS316

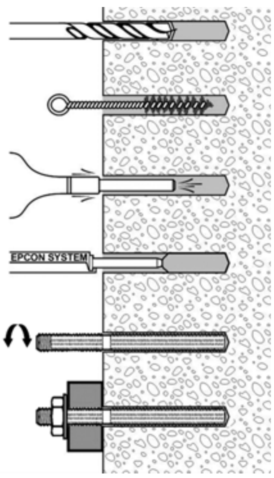
Hexagonal Nut:
SUS316

Washer:
SUS316

Anchor Mechanical Properties

STAINLESS STEEL SUS316	M8	M10	M12	M16	M20	M24	M30
f_{uk} (N/mm2) Min. tensile strength	650	650	650	650	650	650	500
f_{yk} (N/mm2) Yield strength	450	450	450	450	450	450	250
A_s (mm2) Stressed cross-section	36.6	58	84.3	157	245	353	522.8
W_{el} (mm3) Elastic section modulus	31.2	62.3	109.2	277.5	540.9	935.5	1,686.0
$M^0_{Rk,s}$ (Nm) Characteristic bending moment	24.4	48.6	85.2	216.4	421.9	729.7	1,011.6
M (Nm) Recommended bending moment	15.7	31.4	54.9	139.6	272.2	470.8	652.6

INSTALLATION



Setting Time before applying load

Ambient temperature (ºC)	Max time for installation (min)	Waiting time before applying load (hr)
32ºC	8.5	2
27ºC	12	2
20ºC	15	2
16ºC	18	3
10ºC	21	6

Chemical Resistance of EPCON G5 Anchor

Chemical substances	Resistance	Chemical substances	Resistance
Xylene	1	Toluene	2
Gasoline	1	10% Nitric Acid	2
20% Caustic NaOH (Sodium Hydroxide)	1	8.5% Ammonium Hydroxide	2
Fresh Water	1	5% Bleach	3
Salt Water	1	Acetone	3
10% Sulfuric Acid (H2 SO4)	2	Glacial Acetic Acid	3
3.5% Hydrochloric Acid (HCL)	2	Methanol	3
9% Phosphoric Acid	2	Methylene Chloride	3

1 = High resistance (Anchors could be submerged in these materials)

2 = Medium resistance (Anchors could be temporary submerged due to splash or spill)

3 = Low resistance (Anchors should be limited to splash and spill followed by immediate cleanup)

STAINLESS STEEL ANCHOR STUD(SS316) / CHEMSET™

Number of Sealings per cartridge

Stud diameter	8	10	12	16	20	24	30
Drilling Ø (mm)	10	12	14	18	25	28	35
Drilling depth (mm)	80	90	110	125	170	210	280
No. of anchors per cartridge							
EPCON G5 (650ml)	206.9	127.7	76.8	40.9	15.6	10.1	4.8

Ultimate Loads ($N_{Ru,m}$, $V_{Ru,m}$) / Characteristic Loads (N_{Rk}, V_{Rk}) in kN

TENSILE @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24	M30
h_{ef} (mm)	80	90	110	125	170	210	280
$N_{Ru,m}$ (kN)	25.7	40.7	59.2	110.2	141.8	216.2	360.3
N_{Rk} (kN)	23.8	37.7	54.8	102.1	106.3	162.1	270.2

SHEAR @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24	M30
$V_{Ru,m}$ (kN)	15.4	24.4	35.5	66.1	103.2	148.7	169.4
V_{Rk} (kN)	14.3	22.6	32.9	61.2	95.6	137.7	156.8

Design Loads (N_{Rd}, V_{Rd}) for one anchor without edge or spacing influence in kN

$$N_{Rd} = \frac{N_{Rk}}{\gamma_{Mc,N}} \quad \text{or} \quad \frac{N_{Rk}}{\gamma_{Ms,N}}$$

$$V_{Rd} = \frac{V_{Rk}}{\gamma_{Ms,V}}$$

TENSILE @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24	M30
h_{ef} (mm)	80	90	110	125	170	210	280
N_{Rd} (kN)	15.3	24.3	35.4	65.8	59.1	90.1	150.1

$\gamma_{Mc,N}$ = 1.8
$\gamma_{Ms,N}$ = 1.55 *(steel failure)*
$\gamma_{Mc,N}$ = 2.00 *(steel failure ≥ M30)*

SHEAR @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24	M30
V_{Rd} (kN)	9.2	14.6	21.2	39.5	61.6	88.8	78.4

$\gamma_{Ms,V}$ = 1.55 for M8 to M24
$\gamma_{Ms,V}$ = 2.00 for M30

Recommended Loads (N_{rec}, V_{rec}) for one anchor without edge or spacing influence in kN

$$N_{rec} = \frac{N_{Rk}}{\gamma_{Mc,N} \cdot \gamma_F} \quad \text{or} \quad \frac{N_{Rk}}{\gamma_{Ms,N} \cdot \gamma_F}$$

$$V_{rec} = \frac{V_{Rk}}{\gamma_{Ms,V} \cdot \gamma_F}$$

TENSILE @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24	M30
h_{ef} (mm)	80	90	110	125	170	210	280
N_{rec} (kN)	11.0	17.4	25.3	47.0	42.2	64.3	107.2

γ_F = 1.4
$\gamma_{Mc,N}$ = 1.8
$\gamma_{Ms,N}$ = 1.55 *(steel failure M8 - M24)*
$\gamma_{Mc,N}$ = 2.00 *(steel failure ≥ M30)*

SHEAR @ Concrete strength 30 N/mm²

Anchor size	M8	M10	M12	M16	M20	M24	M30
V_{rec} (kN)	6.6	10.4	15.2	28.2	44.0	63.4	56.0

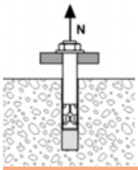
γ_F = 1.4
$\gamma_{Ms,V}$ = 1.55 for M8 to M24
$\gamma_{Ms,V}$ = 2.00 for M30

steel failure (shaded cells: $N_{Ru,m}$ and N_{Rk} for M8–M16)

STAINLESS STEEL ANCHOR STUD(SS316) / CHEMSET™

RAMSET CC-Method

TENSILE in kN

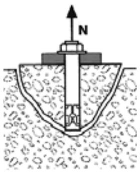


Pull-out resistance
Concrete strength C25/30

$N_{Rd,p} = N^0_{Rd,p} \cdot f_B \cdot f_T$

$N^0_{Rd,p}$	Design pull-out resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
h_{ef} (mm)	80	90	110	125	170	210	280
$N^0_{Rd,p}$ (kN)	15.3	26.7	33.8	45.5	59.1	90.1	150.1

$\gamma_{Mc,N} = 1.8$

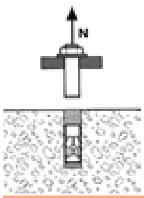


Concrete cone resistance
Concrete strength C25/30

$N_{Rd,c} = N^0_{Rd,c} \cdot f_B \cdot f_T \cdot \Psi_s \cdot \Psi_{c,N}$

$N^0_{Rd,p}$	Design cone resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
h_{ef} (mm)	80	90	110	125	170	210	280
$N^0_{Rd,c}$ (kN)	26.3	31.4	42.5	51.4	81.6	112.0	172.5

$\gamma_{Mc,N} = 1.5$

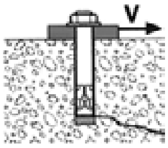


Steel resistance

$N_{Rd,s}$	Steel design tensile resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
$N_{Rd,s}$ (kN)	15.3	24.3	35.4	65.8	102.7	148.0	130.7

$\gamma_{Ms,N} = 1.55$ for M8 to M24
$\gamma_{Ms,N} = 2.00$ for M30

SHEAR in kN

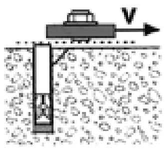


Concrete edge resistance
Concrete strength C25/30

$V_{Rd,c} = V^0_{Rd,c} \cdot f_B \cdot f_{\beta,V} \cdot \Psi_{s\text{-}c,V}$

$V^0_{Rd,c}$	Design concrete edge resistance at a minimum edge distance (c_{min})						
Anchor size	M8	M10	M12	M16	M20	M24	M30
h_{ef} (mm)	80	90	110	125	170	210	280
c_{min}	40	45	55	65	85	105	140
s_{min}	40	45	55	65	85	105	140
$V^0_{Rd,c}$ (kN)	2.6	3.4	5.1	7.3	12.4	18.7	32.6

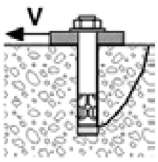
$\gamma_{Mc,V} = 1.5$



Steel resistance

$V_{Rd,s}$	Steel design shear resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
$V_{Rd,s}$ (kN)	9.2	14.6	21.2	39.5	61.6	88.8	78.4

$\gamma_{Ms,V} = 1.55$ for M8 to M24
$\gamma_{Ms,V} = 2.00$ for M30



Concrete pry-out failure
Concrete Strength C25/30

$V_{Rd,cp} = V^0_{Rd,cp} \cdot f_B \cdot \Psi_s \cdot \Psi_{c,N}$

$V^0_{Rd,cp}$	Design pry-out resistance						
Anchor size	M8	M10	M12	M16	M20	M24	M30
$V^0_{Rd,cp}$ (kN)	52.7	62.9	84.9	102.9	163.2	224.0	344.9

$\gamma_{Ms,V} = 1.5$

$N_{Rd} = \min(N_{Rd,p} ; N_{Rd,c} ; N_{Rd,s})$
$\beta N = N_{Sd} / N_{Rd} \leq 1$

$V_{Rd} = \min(V_{Rd,c} ; V_{Rd,s}; V_{Rd,cp})$
$\beta V = V_{Sd} / V_{Rd} \leq 1$

$\beta N + \beta V \leq 1.2$

f_B INFLUENCE OF CONCRETE

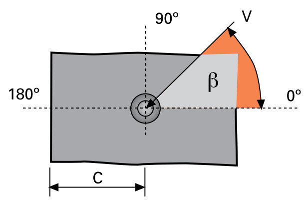
Concrete Grade	f_B	Concrete Grade	f_B
C16/20	0.81	C35/45	1.21
C20/25	0.90	C40/50	1.28
C25/30	1.00	C45/55	1.34
C30/37	1.10	C50/60	1.40

f_T INFLUENCE OF EMBEDMENT DEPTH

$$f_T = \frac{h_{act}}{h_{ef}}$$

$f_{\beta,V}$ INFLUENCE OF SHEAR LOADING DIRECTION

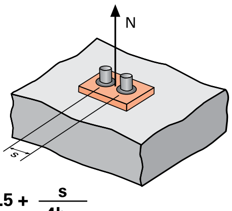
Angle β [°]	$f_{\beta,V}$
0~50	1.0
60	1.1
70	1.2
80	1.5
90~180	2.0



STAINLESS STEEL ANCHOR STUD(SS316) / CHEMSET™

RAMSET CC-Method

Ψ_s INFLUENCE OF SPACING FOR CONCRETE



$\Psi_s = 0.5 + \frac{s}{4h_{ef}}$

$s < s_{cr,N}$

$s_{min} = 0.5h_{ef}$

$s_{cr,N} = 2h_{ef}$

Ψ_s must be used for each spacing influenced the anchors group

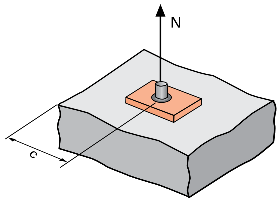
Spacing, s — Reduction Factor Ψ_s — Cracked / Non-cracked concrete

	M8	M10	M12	M16
40	0.63			
45	0.64	0.63		
55	0.67	0.65	0.63	
65	0.70	0.68	0.65	0.63
85	0.77	0.74	0.69	0.67
105	0.83	0.79	0.74	0.71
140	0.94	0.89	0.82	0.78
160	1.00	0.94	0.86	0.82
180		1.00	0.91	0.86
220			1.00	0.94
250				1.00

Spacing, s — Reduction Factor Ψ_s — Cracked / Non-cracked concrete

	M20	M24	M30
85	0.63		
105	0.65	0.63	
140	0.71	0.67	0.63
160	0.74	0.69	0.64
180	0.76	0.71	0.66
220	0.82	0.76	0.70
250	0.87	0.80	0.72
300	0.94	0.86	0.77
340	1.00	0.90	0.80
370		0.94	0.83
420		1.00	0.88
560			1.00

$\Psi_{c,N}$ INFLUENCE OF EDGE FOR CONCRETE



$\Psi_{c,N} = 0.275 + 0.725 \cdot \frac{c}{h_{ef}}$

$c < c_{cr,N}$

$c_{min} = 0.5h_{ef}$

$c_{cr,N} = h_{ef}$

$\Psi_{c,N}$ must be used for each distance influenced the anchors group

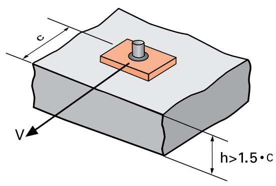
Edge, c — Reduction Factor $\Psi_{c,N}$ — Cracked / Non-cracked concrete

	M8	M10	M12	M16
40	0.63			
45	0.68	0.63		
55	0.77	0.71	0.63	
65	0.86	0.79	0.70	0.65
80	1.00	0.91	0.80	0.73
90		1.00	0.86	0.79
110			1.00	0.91
125				1.00

Edge, c — Reduction Factor $\Psi_{c,N}$ — Cracked / Non-cracked concrete

	M20	M24	M30
85	0.63		
105	0.72	0.63	
120	0.78	0.68	
140	0.87	0.75	0.63
170	1.00	0.86	0.71
210		1.00	0.81
250			0.92
280			1.00

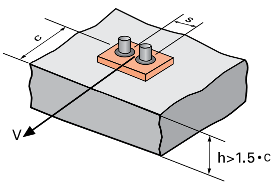
$\Psi_{s\text{-}c,V}$ INFLUENCED OF SPACING AND EDGE DISTANCE FOR CONCRETE EDGE RESISTANCE IN SHEAR LOAD



$\Psi_{s\text{-}c,V} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$

FOR SINGLE ANCHOR FASTENING — Reduction Factor $\Psi_{s\text{-}c,V}$ — Cracked / Non-cracked concrete

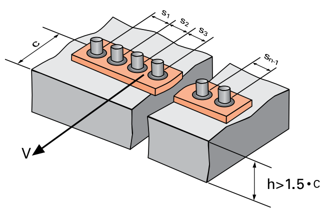
$\frac{c}{c_{min}}$	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2
$\Psi_{s\text{-}c,V}$	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72



$\Psi_{s\text{-}c,V} = \frac{3c + s}{6c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$

FOR 2 ANCHORS FASTENING — Reduction Factor $\Psi_{s\text{-}c,V}$ — Cracked / Non-cracked concrete

$\frac{s}{c_{min}}$ \ $\frac{c}{c_{min}}$	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.12	2.38	2.63	2.90	3.18	3.46
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65



FOR OTHER CASE OF FASTENINGS

$\Psi_{s\text{-}c,V} = \frac{3c + s_1 + s_2 + s_3 + ... + s_{n-1}}{3nc_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$

SETSCO SERVICES PTE LTD

SETSCO

18 Teban Gardens Crescent
Singapore 608925
Tel : (65) 6566 7777
Fax: (65) 6566 7718
Website: www.setsco.com
Business Reg. No. 196900269D

TEST REPORT

(This Report is issued subject to the terms & conditions set out below)

Our Ref: ST 8684/1 **Date :** 25th April 2011
Page :1 of 5

TENSILE PULL-OUT TEST ON VARIOUS SIZES OF REBARS INSTALLED INTO THE CONCRETE BLOCK WITH RAMSET EPCON G5 FOR THE PROPOSED MCE PROJECT C483

Prepared For:

ITW CONSTRUCTION PRODUCTS (SEA) PTE LTD
No.8, Kaki Bukit Road 2
#02-34, Ruby Warehouse Complex
Singapore 417841
Attn:- Mr Siang Peng Lam

Work Carried Out By :
Michael Gurusamy

Witnesses Of Test :
(1) Mr Aung (RJC)
(2) Mr Mark Lester Ramirez (Samsung)
(3) Mr Henry (Samsung)
(4) Mr Siang Peng Lam (ITW)

Report Prepared By :
How Yong Meng

ST 8684-1/hym

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ACCREDITED LABORATORY SAC-SINGLAS

"The results reported herein have been performed in accordance with the laboratory's terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme" LA-1994-0068-A, LA-1987-0001-B, LA-1993-0067-G, LA-1993-0051-C, LA-1998-0144-D, LA-2000-0181-F.

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CONTENT

APPENDICES

ANNEXES

Mike

SETSCO

ST 8684/1 Page 3 of 5

1.0 INTRODUCTION

SETSCO Services Pte Ltd (SETSCO) was engaged by M/s ITW Construction Products (SEA) Pte Ltd to conduct a Tensile pull-out test on rebars of sizes :- T13, T16, T20, T22, T25, T32 and T40 installed into the Grade 40 (as advised by the client) un-reinforced concrete blocks with Ramset Epcon G5 injection systems.

The above test was conducted on 19th and 21st April 2011 at Marina Coastal Expressway C483 project site located at Marina South.

2.0 OBJECTIVE

To determine the maximum force required to pull out the various sizes of Rebars installed with Ramset Epcon G5 chemical capsules into the Grade 40 concrete block and the corresponding mode of failure encountered.

3.0 DESCRIPTION OF TEST SPECIMENS AND PREPARATION

The test specimens for this exercise are as follows:-

- 3 nos of **T13** rebars installed with Ramset Epcon G5 injection system with embedment depth of 160mm,
- 3 nos of **T16** rebars installed with Ramset Epcon G5 injection system with embedment depth of 195mm,
- 3 nos of **T20** rebars installed with Ramset Epcon G5 injection system with embedment depth of 240mm,
- 3 nos of **T22** rebars installed with Ramset Epcon G5 injection system with embedment depth of 300mm,
- 3 nos of **T25** rebars installed with Ramset Epcon G5 injection system with embedment depth of 300mm,
- 3 nos of **T32** rebars installed with Ramset Epcon G5 injection system with embedment depth of 480mm,
- 3 nos of **T40** rebars installed with Ramset Epcon G5 injection system with embedment depth of 480mm.

Mike

All the above test specimens were installed into the Grade 40 (as advised by the client) concrete blocks and the method of installation are as in accordance to the proposed Method Statement for Rebars installation using Ramset Epcon G5 injection system, witnessed by the client's contractor and consultant. This method statement as provided by the client are as attached in the Appendix B while the technical specification of the injection system (Ramset Epcon G5) used are as presented in Appendix A.

All the rebars installed by the client themselves with the Ramset Epcon G5 are done one (01) day prior to the test date so that the injection system would have sufficient time to cure to attain their full strength.

4.0 TESTING PROCEDURE

The test was carried out adopted from **BS 5080 : Part 1 : 1993** where no displacement measurement was carried out during the course of loading. In addition, the size of the system supports (reaction frame) used is smaller than that recommended. In using such smaller support systems, the concrete around the installed rebars will be restraint when a load was applied onto the test specimens. (due to a opposite reaction force acting onto the reaction frame).

A detailed Method Statement of performing the above test are as attached in Appendix C while the calibration certificates of the test equipment used (hydraulic pump with jack and pressure gauges) are as presented in Appendix D.

Photographs showing the test specimens after test are as presented in the Annex.

Mike

SETSCO

ST 8684/1

5.0 RESULTS

Sample Ref	Fixing Type	Embedment depth** (mm)	Applied Load (kN)	Mean (kN)	Std Deviation	Observation(s)
T1	T13 rebars	160	79.1	77.0	3.6	Rebar fracture
T2			72.8			Concrete failure
T3			77.1			Rebar fracture
T4	T16 rebars	195	129.5	129.5	0.0	Rebar fracture
T5			129.5			Rebar fracture
T6			129.5			Rebar fracture
T7	T20 rebars	240	180.8	188.4	23.6	Rebar fracture
T8			169.5			Rebar fracture
T9			214.9			Rebar fracture
T10	T22 rebars	300	214.9	214.9	0	Rebar fracture
T11			214.9			Rebar fracture
T12			214.9			Rebar Fracture
T22	T25 rebars	300	283.0	290.6	6.6	Rebar fracture
T23			294.4			Rebar fracture
T24			294.4			Rebar fracture
T16	T32 rebars	455	510.2*	-	-	No failure
T17			510.2*			No failure
T18			510.2*			No failure
T19	T40 rebars	480	510.2*	-	-	No failure
T20			510.2*			No failure
T21			510.2*			No failure

Note:- '*' no further increase in loading is possible as the maximum capacity of the jack used had been reached.
'**' information provided by the client

Mike

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NSF Product and Service Listings

These NSF Official Listings are current as of **Thursday, July 19, 2012** at 12:15 a.m. Eastern Time. Please contact NSF International to confirm the status of any Listing, report errors, or make suggestions.

Alert: NSF is concerned about fraudulent downloading and manipulation of website text. Always confirm this information by clicking on the below link for the most accurate information:
http://www.nsf.org/Certified/PwsComponents/Listings.asp?Company=23610&Standard=061&

NSF/ANSI STANDARD 61
Drinking Water System Components - Health Effects

NOTE: Unless otherwise indicated for Materials, Certification is only for the Water Contact Material shown in the Listing. Click here for a list of Abbreviations used in these Listings.

ITW Red Head
2171 Executive Drive
Suite 100
Addison, IL 60101
United States
800-899-7890
630-694-4740
Visit this company's website

Facility : Elk Grove Village, IL

Joining and Sealing Materials

Trade Designation	Size	Water Contact Temp	Water Contact Material
Adhesives			
Epcon A7 Adhesive	[1]	CLD 23	ACR
Epcon C6 Epoxy[2]	[1]	CLD 23	EPOXY
Epcon G5	[1]	CLD 23	EPOXY

[1] Certified for use at a maximum surface area to volume ratio of 0.0005 sq. in./L in a tank.
[2] Only products bearing the NSF Mark are Certified.

Number of matching Manufacturers is 1
Number of matching Products is 3
Processing time was 0 seconds

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ITW Construction Products (SEA) Pte Ltd
8 Kaki Bukit Road 2, #02-34 Ruby Warehouse Complex
Singapore 417841

Dear Sir

APPLICATION FOR LISTING IN HDB'S MATERIALS LIST - STRUCTURAL PRODUCTS

We refer to your application dated 17 March 2011.

2. We have no objection for the following product to be listed in the Building & Infrastructure Department's internet website, **http://www.eptc.sg** under HDB's Materials List (ML): -

Section : Structural Products
Classification : Anchor Bolt (for G20 concrete & above)
Product : Medium Duty Mechanical Anchor
Brand / Model : Ramset, Trubolt M12x120

Section : Structural Products
Classification : Anchor Bolt (for G20 concrete & above)
Product : Heavy Duty Mechanical Anchor
Brand / Model : Ramset, Triga Z Type V, M12x130

Section : Structural Products
Classification : Anchor Bolt (for G20 concrete & above)
Product : Cartridge Injection Chemical Anchor
Brand / Model : Ramset Epcon G5, M12x160

Section : Structural Products
Classification : Anchor Bolt (for G20 concrete & above)
Product : Cartridge Injection Chemical Anchor
Brand / Model : Ramset Epcon G5 M10x130

3. The listing in HDB's ML is subject to the following conditions:

a) HDB reserves the right to review the performance and testing requirements at any time.
b) The listing in our ML does not relieve you the responsibility for the due performance of the product and compliance with HDB project specifications and drawings. Your product will be removed from the ML should we discover any lapse in quality standard or product performance.
c) None of the product's part, mixture, chemical constituents or brands name shall be altered. Any such alteration without prior acceptance by HDB will lead to automatic suspension of the product from the ML when discovered.
d) The supplier shall inform HDB if there is any change of the manufacturer or production plant location.
e) Name of HDB or contents of this letter must not be used or quoted in any forms of advertisement, brochure or publication of the product.
f) Your product may be subjected to site or factory sampling test. Following the product sampling by our officers, you are required to send the sample for laboratory testing. All testing cost incurred shall be borne by you. The test report can be submitted for renewal applications.

4. The listing for this product will expire on **31 May 2014**. Please apply for renewal of this listing 3 months before the expiry date.

5. Please contact Senior Technical Officer Mr. Wu Ser Luen at Tel No: 64902548 if you need any further information or clarification.

Yours faithfully

Tham Yew Cheong
Senior Executive Building Officer
Building & Infrastructure Department
Housing & Development Board

PROJECT	APPLICATION	CONTRACTOR
	TRANSPORTATION FACILITIES	
MRT A&A DSMRT545K0	Square Steel Hollow Section Fixing	OKH Construction
Circle Line C822	Starter bar – beams / slabs	Econ-NCC JV
Circle Line C823	Strut Fixing	Nishimatsu-LumChang JV
Circle Line C828	Bracket Fixing	Gin Lee Construction
Circle Line C853	Starter bar - slabs	Taisei Corporation
Circle Line C856	Starter bar – slabs	Sembawang E&C
Circle Line C8282	Starter bar – slabs	Chye Joo Construction
Downtown line C901	Starter bar – slabs	Hock Lian Seng
Downtown line C905	Starter bar - slabs	Shimizu
Downtown line C907	Starter bar - slabs	Wai Fong Construction
Downtown line C909	Starter bar - slabs	VSL
Downtown line C912	Starter bar - slabs	Lum Chang Building Contractors
Downtown line C929A	Starter bar - slabs	Nishimatsu
Downtown line C935	Starter bar - slabs	Leighton Offshore / John Holland
Downtown line 3 C923	Starter bar - slabs	Samsung C & T Corporation
Downtown line 3 C933	Starter bar - slabs	Penta Ocean Construction Co Ltd
Tuas MRT Extension	Starter bar	Shanghai Tunnel
Bridge Upgrading RD111	Starter bar – beams	Singapore Piling & Civil Engineering
Bridge Upgrading RD113	Starter bar – beams	Singapore Piling & Civil Engineering
Bridge Upgrading RD138	Starter bar – beams	Singapore Piling & Civil Engineering
Bridge Upgrading RD107	Starter bar – beams / slab	Chye Joo Construction
Bridge Widening RD104	Starter bar – beams / slab	Chye Joo Construction
RD145	Starter bar – beams	Chye Joo Construction
KPE C421	Starter bar – slabs	Sembcorp E&C
KPE C424	Starter bar – slabs	Taisei Corporation
KPE C425	Starter bar – slabs	Chan & Chan Construction
KPE C426	Starter bar - slabs	Chye Joo Construction
ER102	Starter bar	Sato Kogyo (S)
C114 Bridge Walkway	Covered walkway posts	Diethelm Singapore
BM101 Bridge Walkway	Covered walkway posts	Win Kiong Engineering Service
PPSE C3223A	Railings Fixings	United Central Engineering
Terminal 3	Railings Fixings	United Central Engineering
	GOVERNMENT BUILDINGS	
New Supreme Court	Starter bar - CBP Wall	Sato Kogyo (S)
Redevelopment of Singapore Museum	Starter bar - columns	Sato Kogyo (S)
Singapore Arts Centre	Starter bar - slabs	Sato Kogyo (S)
New Civil Service Club, Bukit Batok	Starter bar – beams	Lian Soon Construction
Law Enforcement Agency Singapore	Starter bar – CBP wall	Lian Soon Construction
		Tiong Seng Construction

PROJECT	APPLICATION	CONTRACTOR
	EDUCATION FACILITIES	
Yishun Secondary School	Starter bars – cantilever slabs	Lian Soon Construction
Nanyang Junior College	Starter bar	Quek Hock Seng Construction
Victoria School	Starter bar	Kay Lim Construction & Trading
Changkat Primary School	Starter bar	Kay Lim Construction & Trading
Saint Andrew Village A&A	Starter bar	SEF Construction
		China Construction (SP)
NTU School of Biological Science	Starter bar	China Construction (SP)
Raffles Junior College	Starter bar – cantilever staircase	Guan Ho Construction Co.
Eunos Primary School	Starter bar	Chiu Teng Construction
Dunman Secondary School	Starter bar	Chiu Teng Construction
NTU Teaching & Laboratory Facilities	Starter bar	Sato Kogyo (S)
SMU	Starter bar	Koon Seng Construction
Queenstown Secondary School	Starter bar	Quek Hock Seng Construction
Maha Bohdi School	Starter bar	Chiu Teng Enterprise BCEG JV
Australia International School	Starter bar – slab extension	G. James Singapore
Yong Loo Lin School of Medcine (NUS)		Lian Soon Construction
St. Andrew Autism Centre		Kian Hiap Construction
Prince Charles Primary School		Kwan Yong Construction Pte Ltd
Ngee Ann Polytechnic		Kwan Yong Construction Pte Ltd
SIT at Singapore Polytechnic		Koon Seng Construction Pte Ltd
Yale-NUS College		Ssangyong Engineering & Construction
Co Ltd		
	PUBLIC WATER FACILITIES	
Changi Water Reclamation Plant	Starter bar – Diaphragm Wall / slabs	LTH Engineering
		Sembcorp E&C
		Singapore Piling & Civil Engineering
Deep Tunnel System		Koh Brothers Construction
		Sembcorp E&C
New Water Pipeline	Pipeline Bracket Fixings	Toh Ban Seng Contractor
		HSC Pipeline Engineering

PROJECT	APPLICATION	CONTRACTOR
	RESIDENTIAL BUILDINGS	
Hamilton Scotts	Starter bar - beam / slabs	Yau Lee Construction
Compassvale View	Starter bar - beam / columns	Qingdao Construction
Fernvale Vista	Starter bar - beam / columns	Qingdao Construction
HDB Punggol C5A	Starter bar – slabs / pilecaps	Kay Lim Construction
HDB Sengkang N2C36		Kay Lim Construction
HDB Punggol W C7	Starter bar - beam	Kay Lim Construction
HDB Seng Kang N4C24		QingJian International
BTO at Punggol		Poh Cheong Concrete Product Pte. Ltd.
LUP42A	Starter bar – slab / wall	Hock Guan Cheong
Water Bay		QingJian International
Topiary		QingJian International
Caribbean	Bracket Fixing	Yodai Windows System Engineering
Saint Regis Hotels & Apartments	Starter bar – CBP wall / slabs / beams	Kajima-Tiong Seng JV
Riveria	Starter bar	Chip Eng Seng Contractors (1988)
Newton Suite	Starter bar	Kajima Overseas Asia
Admore Park	Starter bar – slabs	Shimizu Corporation
The Metz		Shimizu Corporation
Evelyn		Shimizu Corporation
RiverEdge	Starter bar – slabs	Tiong Seng Contractors
Hillview Regency		Poh Lian Construction
Paterson Residence	Starter bar – CBP wall	China Construction (SP)
One Amber	Starter bar - CBP Wall	China Construction (SP)
The Chuan	Starter bar – CBP wall	Low Keng Huat (S)
Orange Groove Condominium	Starter bar – CBP wall / slabs	Wee Hur Construction
La-Belle Townhouse		Wai Fong Construction
2rvg	Starter bar – CBP wall / slabs	Chiu Teng Enterprises
No.11 Astrid Hill		Daiya Engineering & Construction
Balestier Scenic Heights		Dbcorp Industries
Solitaire Condominium	Starter bar–retaining wall/slab/beam	Poh Lian Construction
Draycott Condominium	Starter slab – CBP wall	Tiong Seng Contractors
Nova 88 Condominium		Admin Construction
Nova 48 Condominium		Admin Construction
Halia Cluster Housing		GTMS Construction
Alexis Condominium	Starter slab – CBP wall	Kian Hiap Construction
D'Leedon Condominium	Starter bar	Woh Hup (Private) Ltd.
Leedon Heights	Starter bar	Woh Hup (Private) Ltd.
EuHabitat	Starter bar	Woh Hup (Private) Ltd.
YTL Westwood	Starter bar	YTL Construction (S) Pte. Ltd.
River Isle	Starter bar	NQC
A Treasure Trove	Starter bar	Sim Lian Construction Co. Pte. Ltd.
West Shore Residences	Starter bar	Ang Cheng Guan Construction Pte. Ltd.

PROJECT	APPLICATION	CONTRACTOR
	FACTORIES	
JTC Factory 161 Kallang Way		Interpo
Light Industrial Factory @ Jalan Kilang	Starter bar - CBP wall	V3 Construction
Micron (MSA 1.5 Project)		Sato Kogyo (S)
Project Eureka		Kajima Overseas Asia
Pan Tech Industrial Building		Win Kiong Engineering Service
Biopolis	Bracket fixing	InnoVision Façade
BTR Singapore	Adhesive for Anchor Bolts	Hiap Seng Engineering Ltd
Silo Plant at Jurong Port Road		YTL Construction (S) Pte. Ltd.
	COMMERCIAL OR MIXED DEVELOPMENT	
South Beach Mixed Development	Starter bar - beams	Hyundai E & C
		Doo Song Construction Co Ltd
Marina Bay Sands Integrated Resorts	Starter bar - CBP Wall/Slabs/Beams	Sato Kogyo (S)
		Sembawang E&C
		Shanghai Tunnel
		L & M Foundation
OG Complex A & A	Starter bars	Wing Tuck
One Raffles Quay	Starter bar – slabs / beams	Obayashi Corporation
		Gammon Skanska
Hilton Hotel	Temporary works	Hock Keng Heng
HSBC	Threaded studs for Temporary Works	Hock Keng Heng
Mercedes Showroom	Starter bar – beams / slabs	Gammon Skanska
Ginza Plaza A&A	Starter bar	Vigcon Construction
Somerset UOL Building	CBP Wall	Kajima Overseas Asia
Scotts Square		Shimizu Corporation
Paya Lebar Square	Starter bars	Low Kheng Huat (S)
UOB Centre	A & A	Gennal Industries
		TET Engineering & Metal Works
Bugis Junction	A & A	TET Engineering & Metal Works

PROJECT	APPLICATION	CONTRACTOR
	MARINE WORKS	
PSA Tanjong Pagar Reefer Wharf		Eng Lee Engineering
PSA Tanjong Pagar Slab Upgrading	Starter bar – slabs	United Specialist
PSA Brani Terminal	Starter bar – beams	United Specialist
Loyang Marine Base	Starter bar	DGS
Jurong Shipyard	Starter bar	Jurong Engineering
PSA Beam Strengthening	Starter bar – beams	Muhibbah Engineering (S'pore)
	OTHERS	
Sports Hub	Starter bar - slabs / beams	Dragages
Gardens by the Bay	Starter bar	
Pasir Ris Sports Hub	Starter bar - beams	Quek Hock Seng
Ng Teng Fong Hospital	Starter bar - beams	Penta Ocean
Merlion Park		Antara Koh
Mohd. Sultan Road Art Centre		Building Structural Inspection
Buddha Tooth Temple	Starter bar – CBP wall / beams	Sato Kogyo (S)
Singapore Flyers	Starter bar	Takenaka
Sentosa Cove Bus Terminal	Road kerb	Gammon
Art & Science Museum	Starter bar	Penta Ocean Corporation
SP Power Grid EW3		Nishimatsu Construction & KTC JV