KINGKRETE® We Create Future ACADEMY

CPD SEMINAR CPD-GA-PG-01

Precision Grouting: Base Plates, Machinery and Anchors

Load transfer, grout selection, detailing and anchoring for equipment foundations

1.0 LEU | AIA LU|HSW | 60 MIN | PRACTITIONER

RIBA core curriculum · Design, construction and technology



BEFORE WE START

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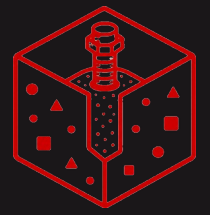
Questions about specific products or services are answered after the course, outside the time that earns credit.

Why this matters

A thin layer of grout carries the full weight and vibration of critical plant. When it fails, machines misalign, bolts loosen and production stops.

This seminar explains how grout transfers load, how cementitious and epoxy grouts behave and are tested, how to detail and place a grouting job so it achieves full bearing, and how to specify, install and verify bonded anchors and starter bars.

FOR Structural and mechanical engineers, specifiers, contractors and plant owners



CREDIT

1.0 LEU · AIA LU|HSW

RIBA TOPIC

Design, construction and technology

LEVEL

Practitioner

FORMAT

Live, in-office or self-paced

ASSESSMENT

10 questions, 80% to pass

LEARNING OBJECTIVES

By the end of this course you will be able to

01

Explain

how grout transfers load from base plates, bearings and machinery to the foundation, and how flow, bleed, volume change and effective bearing area decide success

HSW

02

Compare

cementitious and epoxy grouts and select between them by gap, load, vibration, temperature and chemical exposure

03

Design

the grouting detail, including gap and shoulder dimensions, formwork, head box, venting, expansion joints and placement method

HSW

04

Specify

anchoring of bolts and starter bars with resin or cementitious anchor grouts, including installation, curing and testing

HSW

AGENDA

How the next 60 minutes run

01	How grout carries the load	LO1	11 min
02	Cementitious grouts and testing	LO1, LO2	11 min
03	Epoxy grouts and grout selection	LO2	11 min
04	Designing the grouting detail	LO3	11 min
05	Anchoring bolts and starter bars	LO4	11 min
Q	Knowledge check and summary	LO1–LO4	5 min

01

MODULE 01 · 11 MIN · LO1

How grout carries the load

Load paths, bearing area and why a thin layer under a machine matters

What grout does under a base plate

Grout is the structural link between a steel base and its concrete foundation

01

Transfers load

Carries dead, live and dynamic loads from the plate into the foundation through uniform bearing

02

Fills an irregular gap

Bridges the rough, out-of-level concrete surface and the flat underside of the steel plate

03

Locks in alignment

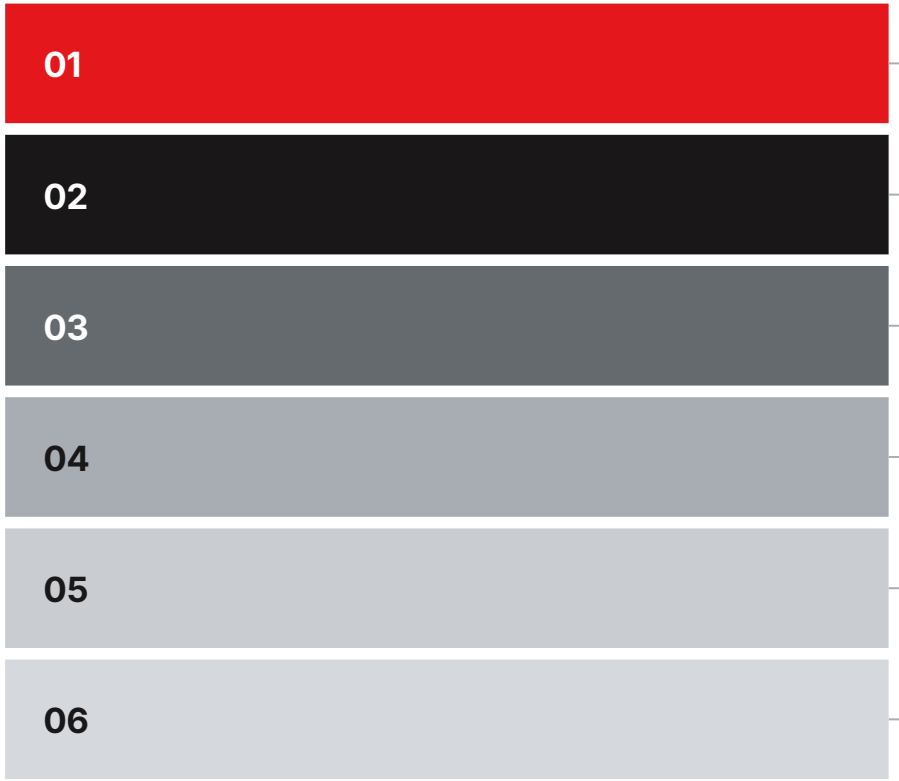
Fixes the level and position set on shims or jack screws so the machine stays true in service

04

Spreads dynamic load

Distributes vibration and impact over a wide area instead of a few hard contact points

Anatomy of a grouted machinery base



Machine frame or skid
Transmits static weight and dynamic forces from the equipment downward

Sole plate or base plate
Steel interface, levelled on shims or jack screws before grouting

Grout bed
Fills the gap in full contact: typically 25–100 mm cementitious, thinner for epoxy

Grout shoulder
Extends typically 50–100 mm past the plate edge to confine the bed and shed water

Prepared concrete surface
Laitance removed and sound aggregate exposed; clean, and wet or dry to suit the grout

Reinforced foundation
Block or mat sized for load and vibration, with anchor bolts cast in or drilled

Anchor bolts pass through every layer; their sleeves are kept free of grout to preserve bolt stretch length

Contact is what counts, not volume

≥ 95%

Typical target for effective bearing area under critical machinery

Zero

Bleed typically permitted for a non-shrink cementitious grout

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Effective bearing area is the share of the plate underside in true contact with hardened grout. Voids from trapped air, bleed or settlement concentrate stress on what remains.

Four properties that decide success

01	**Flow**	Grout must travel the full length of the gap and fill every corner before it stiffens
02	**Bleed**	Water rising to the plate leaves a weak layer and a void exactly where contact matters
03	**Volume change**	Settlement or shrinkage pulls grout away from the plate; controlled expansion closes it
04	**Effective bearing area**	The outcome of the first three: the share of the plate in full, sound contact

Point contact versus full bearing

Poor bearing

- Load concentrated on shims and high spots
- Plate flexes and misalignment develops over time
- Vibration amplified; anchor bolts lose preload
- Oil and water collect in voids and attack concrete

Full bearing

- Load spread across the whole plate area
- Plate stiffened by continuous support
- Vibration damped into the foundation mass
- Sealed interface protects the concrete below

KEY PRINCIPLE

Grout is structure

Grout is a structural component, not a filler. A grouting failure under rotating machinery shows up as vibration, misalignment and bearing damage long before anyone looks at the grout.



Loads the grout must resist

Load	Typical source	Consequence for the grout
Static dead load	Machine and skid self-weight	Uniform compressive bearing; stress usually modest
Bolt preload	Tensioning of anchor bolts	Locally high compression around each bolt
Dynamic and cyclic	Rotating unbalance, reciprocating forces	Fatigue, micro-cracking and creep under repeated stress
Thermal	Hot casings, process heat, sun	Differential movement, edge cracking and debonding
Impact	Crushers, presses, hammers	High local stress; needs full contact and toughness

Average bearing stress is often low; local, cyclic and thermal effects usually govern grout performance

Why does bleed water collecting under a base plate reduce grout performance?

A It raises the compressive strength at the top surface

B It leaves a weak layer and voids at the plate underside

C It makes the grout expand too much after hardening

D It speeds up setting so the grout cannot flow

Why does bleed water collecting under a base plate reduce grout performance?

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B. It leaves a weak layer and voids at the plate underside

C. It makes the grout expand too much after hardening

D. It speeds up setting so the grout cannot flow

WHY Bleed water rises and collects against the plate, leaving a porous, weak layer or a void exactly where full contact is needed.

02

MODULE 02 · 11 MIN · LO1, LO2

Cementitious grouts and testing

Non-shrink grades, consistency, volume change and hot-weather placing

Non-shrink grout grades by volume control

Grade	Volume control mechanism	Practical notes
Grade A	Pre-hardening: expansion while still plastic, e.g. gas generation	Offsets plastic settlement; sensitive to temperature and confinement
Grade B	Post-hardening: expansion after set, e.g. expansive cement	Needs restraint and moist curing to develop expansion
Grade C	Combination: both pre- and post-hardening control	Addresses both stages of volume change

ASTM C1107 covers packaged dry, hydraulic-cement non-shrink grout; specify grade, consistency and test ages

CONSISTENCY

Plastic, flowable and fluid grouts

ASTM C1107 recognises three consistencies; one grout may meet more than one at different water contents

01

Plastic

Stiff, mouldable mix; flow table typically 100–125%. Dry-pack or short, open placements

02

Flowable

Flow table typically 125–145%. General base plates with modest flow distances

03

Fluid

Flow cone efflux typically 20–30 s (ASTM C939). Long flow paths, tight gaps, congestion

04

Water is the variable

Consistency is set by water content within the stated range; never exceed the maximum

Testing a cementitious grout on site

01

Check materials

Confirm product, batch, shelf life, and powder and water temperatures

02

Mix as specified

Measured water, suitable paddle mixer and the full stated mixing time

03

Measure flow

Flow cone for fluid mixes; flow table for plastic and flowable mixes

04

Watch for bleed

Reject batches showing a water sheen, segregation or settled sand

05

Cast specimens

Make cubes or cylinders and cure them as the specification requires

06

Record results

Log temperatures, flow, times and pour location for traceability

Measuring volume change and bleed

01	**Early-age height change**	ASTM C827 tracks plastic expansion or settlement from mixing to final set
02	**Hardened height change**	ASTM C1090 measures height change of restrained specimens at later ages
03	**Bleed**	Fresh grout is checked for free water on the surface; non-shrink grouts should show none
04	**Read results in context**	Lab data assume set temperatures and restraint; site conditions can shift behaviour

Temperature controls working time

30–32 °C

Typical upper limit for mixed grout temperature at placement

24 h

Typical pre-soak of the foundation before cementitious grouting

Heat shortens working time, raises water demand and drives plastic shrinkage. In hot, arid regions such as the Middle East, plan the pour around temperature, not the clock.



Practical measures in hot climates

01

Cool the materials

Store bags in shade or air-conditioned stores; use chilled or iced mixing water

02

Choose the time

Pour early morning or evening, when foundation and plate are coolest

03

Shade and shelter

Screen the foundation, plate and mixing area from sun and drying wind

04

Never retemper

Do not add water to grout that has stiffened; discard it and mix fresh

05

Cure at once

Wet hessian or curing compound on exposed shoulders as soon as practical

Cementitious grouting dos and don'ts

Do

- Pre-soak the foundation, then remove all free water
- Mix full bags with measured water for the full time
- Place continuously from one side
- Keep exposed grout moist during early curing

Don't

- Add extra water to improve flow
- Vibrate fluid grout or rod it vigorously
- Leave standing water in bolt holes or pockets
- Load the machine before the specified strength

A fluid cementitious grout is specified for a long flow path. Which site test best confirms its consistency?

A Slump cone test as used for concrete

B Flow table spread measurement

C Flow cone efflux time

D Compressive strength of cubes at 1 day

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WHY Fluid grouts are too runny for the flow table; their consistency is checked with a flow cone efflux time, as in ASTM C939.

03

MODULE 03 · 11 MIN · LO2

Epoxy grouts and grout selection

Epoxy grout properties and testing, and choosing between epoxy and cementitious

Why epoxy grouts are used

01

High early strength

Reaches service strength quickly, shortening shutdowns and recommissioning time

02

Dynamic load resistance

Tolerates vibration and cyclic loading from rotating and reciprocating machinery

03

Chemical resistance

Resists lubricating oils and many process chemicals that attack cement paste

04

Strong adhesion

Bonds well to clean, prepared steel and concrete, helping the system act together

05

Low permeability

Limits ingress of water and contaminants into the foundation

Key tests for epoxy machinery grouts

Property	Test method	Why it matters
Compressive strength	ASTM C579	Confirms bearing capacity; method states specimen and cure regime
Shrinkage and CTE	ASTM C531	Shrinkage affects contact; thermal expansion drives edge cracking
Compressive creep	ASTM C1181	Deformation under sustained load at temperature; affects bolt preload
Exotherm, working life	Manufacturer data	Sets maximum depth per lift and the placing window

Compare data only where test conditions, temperatures and specimen sizes match

Epoxy moves more than concrete

2–3×

Typical thermal expansion of filled epoxy grout relative to concrete

1.2–1.8 m

Typical expansion joint spacing in long epoxy pours

Temperature change makes epoxy grout move more than the concrete beneath it. Long, continuous pours crack unless joints, rounded corners and stress relief are detailed.

SELECTION

Cementitious and epoxy grouts compared

Cementitious

- Gaps typically 25–100 mm; deep pours possible
- Lower material cost; familiar to most crews
- Needs pre-soak, moist curing, temperature control
- Limited resistance to oils, acids and fatigue

Epoxy

- Thinner gaps; depth per lift limited by exotherm
- High early strength and fatigue resistance
- Good resistance to oils and many chemicals
- Needs dry substrate, joints and creep data

Epoxy costs more per litre; weigh that against downtime, service life and exposure

Selecting by five criteria

01	**Gap**	Deep gaps favour cementitious; thin gaps suit epoxy within its lift limits
02	**Load and vibration**	Heavy dynamic or impact loading favours epoxy with proven fatigue and creep data
03	**Temperature**	Check service and placing temperatures against creep data and working time
04	**Chemical exposure**	Oil, acids or process spillage generally point towards epoxy
05	**Programme and cost**	Short shutdowns favour epoxy; large static bases usually favour cementitious

WORKED EXAMPLE

Grouting a reciprocating compressor base

THE BRIEF

Equipment

Reciprocating gas compressor frame on a reinforced concrete block

Gap

40–50 mm under sole plates; frame about 6 m long

Exposure

Strong cyclic loads, lube-oil drips, outdoors in a hot, arid region

Constraint

Short shutdown; machine must return to service within days

01 **Select epoxy grout**

Cyclic load, oil and a short shutdown favour an epoxy machinery grout with creep data

02 **Plan joints and lifts**

Joints typically every 1.2–1.8 m; check lift depth against exotherm limits

03 **Prepare surfaces**

Chip to sound concrete and keep it dry; blast steel; seal bolt sleeves

04 **Place in cool conditions**

Place from one side with a head box; control material temperature

05 **Verify**

Tap-test for voids after cure; check alignment and bolt preload before start-up

Which condition most strongly favours an epoxy grout over a cementitious grout?

A A 90 mm gap under a static storage tank

B A damp foundation that cannot be dried before grouting

C A large, low-cost pour with no vibration or chemicals

D Regular lube-oil spillage under a reciprocating compressor

QUICK CHECK · LO2 · ANSWER

Which condition most strongly favours an epoxy grout over a cementitious grout?

A — A 90 mm gap under a static storage tank

B — A damp foundation that cannot be dried before grouting

C — A large, low-cost pour with no vibration or chemicals

D — Regular lube-oil spillage under a reciprocating compressor

WHY Cyclic loading and oil exposure are where epoxy grouts outperform cementitious grouts; the other cases favour cementitious grout.

04

MODULE 04 · 11 MIN · LO3

Designing the grouting detail

Gap, shoulder, formwork, head box, venting, joints and placement method

Setting the key dimensions

01	**Gap thickness**	Typically 25–100 mm for cementitious; epoxy thinner, within stated limits per lift
02	**Shoulder width**	Typically 50–100 mm beyond the plate: enough to confine, small enough to resist cracking
03	**Shoulder top**	Finish at or near the plate underside with chamfered edges, never feathered
04	**Placement side clearance**	Wider on the pouring side to suit the head box; tight on the far side

Formwork that holds fluid grout

01

Rigid and braced

Strong enough to resist the hydrostatic head without bulging or moving

02

Liquid-tight

Joints and the foundation line sealed so grout does not leak away and leave voids

03

Held down

Anchored against uplift from grout pressure, especially at the head box

04

Release treated

Waxed or treated faces so forms strip cleanly without damaging shoulders

05

Chamfer strips

Fitted at exposed corners to prevent sharp edges that crack and spall

Pouring, head box or pumping

Pouring

- Small plates and short flow paths
- Gravity only, with little driving head
- Air trapped if poured from several sides

Head box

- Hydrostatic head drives grout under the plate
- Keeps a continuous supply from one side
- Head maintained until grout appears opposite

Pumping

- Large or remote pours and long flow paths
- Continuous supply, fewer cold joints
- Pump from one point, filling low to high
- Needs primed lines and a standby pump

KEY PRINCIPLE

Pour from one side only

Pour from one side only. Grout entering from two sides traps a pocket of air under the plate that no amount of rodding will remove.

Grouting sequence on the day



01 Prepare substrate

Remove laitance and contamination; pre-soak or dry to suit the grout type

02 Final checks

Confirm alignment, sealed sleeves, tight forms, head box and enough material

03 Mix and test

Mix full units, check temperature and flow before placing begins

04 Place continuously

Feed from one side, keep the head up, close vents as grout emerges

05 Finish shoulders

Trim and finish exposed grout once stiff; keep chamfers clean

06 Cure and protect

Cure as specified; no load or bolt tensioning until strength is reached

A written method statement, agreed in advance, is the best single safeguard

Vents, joints, sleeves and shims

Feature	Purpose	Typical detail
Vent holes	Let air escape from enclosed bays under the plate	Drilled at high points and in each enclosed bay
Expansion joints	Control cracking in long epoxy pours	Typically every 1.2–1.8 m, full depth, then sealed
Bolt sleeves	Keep grout off the bolt stretch length	Filled with non-bonding material or sealed at the top
Jack screws or shims	Hold level until the grout cures	Back out jack screws or leave shims as the method states
Chamfers	Reduce stress at shoulder corners	Chamfer strips in forms at exposed corners

Grout must travel 1.5 m under a large sole plate. Which approach best avoids trapped air?

A Pour simultaneously from all four sides

B Dry-pack from both ends towards the middle

C Pour from the centre outwards through bolt holes

D Place from one side with a head box and vent the bays

QUICK CHECK · LO3 · ANSWER

Grout must travel 1.5 m under a large sole plate. Which approach best avoids trapped air?

A Pour simultaneously from all four sides

B Dry-pack from both ends towards the middle

C Pour from the centre outwards through bolt holes

D Place from one side with a head box and vent the bays

WHY Placing from one side under a maintained head pushes air ahead of the flow front and out through vents and the far side.

05

MODULE 05 · 11 MIN · LO4

Anchoring bolts and starter bars

Resin and cementitious anchor grouts: design, installation, curing and testing

Resin and cementitious anchor grouts

Resin (bonded) anchors

- Epoxy, vinyl ester or hybrid resins, injected
- Small annulus, typically a few mm over the bar
- Fast load-up; cure time depends on temperature
- Sensitive to hole cleaning and moisture

Cementitious anchor grout

- Fluid non-shrink grout in larger holes or pockets
- Suits large bolts and cast-in pockets
- Slower strength gain; needs moist curing
- No resin exotherm limit in deep pockets

Use only systems assessed for the application, base material and installation conditions

Qualification and design references

Topic	Reference	What it covers
Qualification (N. America)	ACI 355.4	Qualification of post-installed adhesive anchors, incl. sustained load
Assessment (Europe)	EAD 330499	European Assessment Document for bonded fasteners in concrete
Anchor design	EN 1992-4; ACI 318 Ch. 17	Design of fastenings and anchoring to concrete, all failure modes
Rebar anchoring	EN 1504-6	Anchoring of reinforcing steel bar in concrete repair works
Machinery bolts	ACI 351.1R; API RP 686	Grouting and installation practice for equipment foundations

Qualification gives the design values; design checks the anchor in its real geometry and loads

Design parameters that govern capacity

01	**Embedment depth**	Longer embedment raises bond and concrete cone capacity, within the system limits
02	**Edge distance and spacing**	Close edges or anchors reduce breakout capacity and can cause splitting
03	**Concrete condition**	Cracked or uncracked concrete, strength class and member thickness
04	**Installation conditions**	Dry, wet or flooded holes, drilling method and temperature range
05	**Load type**	Sustained tension, seismic or fatigue loading each need specific design values

Installing a bonded anchor or starter bar



Drill

Correct diameter and depth, method as approved; avoid cutting rebar

Clean the hole

Blow, brush, blow, repeated as the approved method states

Inspect

Check depth, cleanliness and moisture state; mark embedment on the bar

Inject

Discard first resin; fill from the bottom up, avoiding air pockets

Insert and hold

Insert clean bar with a slight twist; do not disturb within gel time

Cure, then load

Respect cure time at the actual base material temperature

KEY PRINCIPLE

Hole cleaning decides bond

Hole cleaning decides bond. Drilling dust left in a hole can cut adhesive anchor capacity substantially. Blow, brush and blow again, exactly as the approved method states.



Cure time depends on temperature

20 °C

A common reference temperature for published gel and cure times

Longer

Cure time at low base material temperatures, often by a large margin

Resin chemistry is temperature-dependent. Cold concrete greatly extends cure time; heat shortens gel time and working window. Use the table for the actual base material temperature.

VERIFICATION

Proof testing and acceptance

01	**Define the test**	Proof load, sample size and acceptance criteria set in the specification
02	**Load safely**	Tension test without exceeding steel yield or damaging the surrounding concrete
03	**Check for slip**	No measurable displacement or loss of load beyond the stated limit
04	**Keep records**	Installer, batch, base temperature, cure time and test results for each anchor

What installation error most often causes low capacity in resin-bonded starter bars?

A A drilled hole a few millimetres larger than the bar

B Inserting the bar with a slight twist

C Inadequate removal of drilling dust from the hole

D Discarding the first resin from a new nozzle

What installation error most often causes low capacity in resin-bonded starter bars?

A — A drilled hole a few millimetres larger than the bar

B — Inserting the bar with a slight twist

C — Inadequate removal of drilling dust from the hole

D — Discarding the first resin from a new nozzle

WHY Dust left on the hole wall prevents the resin bonding to the concrete; the other options describe correct practice.

SUMMARY

Four things to take away

LO1 Grout performance depends on flow, no bleed and controlled volume change to reach full effective bearing

LO2 Choose cementitious or epoxy grout by gap, dynamic load, temperature, chemical exposure and programme

LO3 Detail gap, shoulders, sealed forms, head box, vents and joints; place from one side only

LO4 Bonded anchors rely on assessed systems, clean holes, temperature-correct cure and proof testing

EARN YOUR CREDIT

Complete the online assessment

10

questions drawn at random from the four objectives

80%

to pass; two attempts, reshuffled each time

1.0

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Sign in to SpecWorld, open the course and take the assessment. Your certificate is issued on passing and kept in your Workdesk under CPD & Certificates.

Standards and references

ACI 351.1R

Report on Grouting between Foundations and Bases for Support of Equipment and Machinery

API RP 686

Recommended Practice for Machinery Installation and Installation Design

ASTM C1107/C1107M

Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

ASTM C827/C827M

Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures

ASTM C1181/C1181M

Compressive Creep of Chemical-Resistant Polymer Machinery Grouts

ACI 355.4

Qualification of Post-Installed Adhesive Anchors in Concrete

EN 1992-4

Eurocode 2: Design of concrete structures. Part 4: Design of fastenings for use in concrete

EN 1504-6

Protection and repair of concrete structures. Part 6: Anchoring of reinforcing steel bar

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THANK YOU FOR ATTENDING

Questions?

Kashif Aijaz
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This concludes The American Institute of Architects Continuing Education Systems course.

