1.2 SELECTING A FASTENER

About 70 years ago, two of the earliest concrete and masonry fasteners, the lead caulking anchor and the self drilling anchor, were introduced to the construction industry. Since that time, a host of diverse anchors, including chemical anchors, have appeared on the market. This has made anchor selection, for a specific application, increasingly difficult.

There are a number of considerations which must be examined when an anchor is to be selected. This includes:

- Type of base material
- Strength and condition of the base material
- Thickness of the base material and the fixture
- Direction of the applied load
- Loading conditions
- Anchor embedment
- Spacing and edge distances
- Corrosiveness of the environment
- Acceptable load displacement
- Pre-tensioning requirements
- Safety factor
- Strength of the anchor material
- Mode of failure
- Installation cost

In this Technical Manual we will briefly examine these considerations so that the designer can make an informed anchor selection. If a particular application requires special attention, please contact us.

1.3 BASE MATERIAL

The most typical base materials for anchoring are:

- concrete (with or without reinforcement),
- masonry consisting of various masonry units (brick, concrete block, stone, clay tile blocks etc.) bonded together with a cement-sand mortar
- wall boards (drywall, etc.)

Here are a few base material considerations that must be examined before selecting an anchor:

1.3.1 The Strength of the Base Material

For maximum anchor performance, the base material must be capable of supporting the same load as the anchor. The higher the compressive strength of the base material, the higher the load it is capable of supporting, depending on the anchor material strength. Generally, anchors which are required to carry medium to heavy loads should not be used in concrete with compressive strength less than 2000 psi (14 MPa) or uncured concrete (less than 7 days old). When fastening into low strength base material, a light duty anchor is recommended.

1.3.2 Conditions of the Base Material

Most bricks and blocks are very brittle, thus anchors, which exert little or no expansion force on the base material (nylon; lead; zinc; etc.), are recommended for these applications.

Due to the inconsistency of mortar mixtures, critical applications should not be made in mortar joints. Light duty or temporary fastening can be made in horizontal mortar joints only, never in vertical joints.

When installing anchors in the cracked tensile zone, a follow-up expansion type anchor should be used. Other anchor types can be used as long as they are embedded past the neutral axis and into the compressive zone. The latest development in chemical and mechanical anchoring technology has created anchoring systems suitable for tension zone fastening. Please call the UCAN for more information.

1.3.3 Thickness of the Base Material

When concrete or masonry is drilled, with a hammer drill or rotary hammer, the force could cause spalling near the back of the base material. To ensure that the anchor performs to specification, the base material must be a minimum of 25% thicker than the required embedment of the anchor.

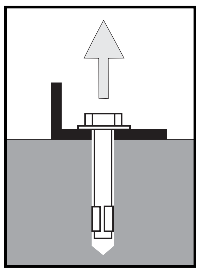
ANCHOR DESIGN

1.4 ANCHOR EMBEDMENT

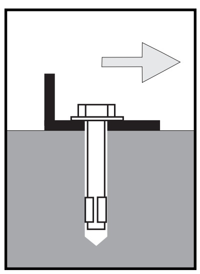
The depth of embedment affects the ultimate pull out capacity of an anchor. For example, anchors installed at less than the recommended embedment will exhibit reduced holding power. Deeper embedment will increase the anchor's holding power up to the point where the mode of failure changes to anchor breakage. Further increase of concrete strength or embedment depth will not increase the holding power.

1.5 DIRECTION OF THE APPLIED LOAD

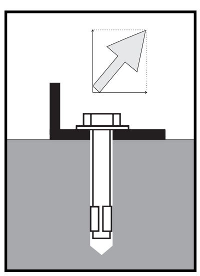
The applied load on an anchor can be separated into the following categories:



Tension load
The direction of the acting load is parallel with the longitudinal axis of the fastener



Shear load
The direction of the acting load is perpendicular to the longitudinal axis of the anchor



Combined loading
Anchors loaded in tension and shear simultaneously will have lower ultimate load capacities than an anchor loaded in pure shear or tension separately.

Anchors required to resist both tension and shear load shall be proportioned so that:

$$\left(\frac{N_{applied}}{N_{allowable}}\right)^{5/3} + \left(\frac{V_{applied}}{V_{allowable}}\right)^{5/3} \leq 1$$

N - Tension load
V - Shear load

1.6 BENDING MOMENT

When the acting force on the anchoring connection is at some distance from the surface of the load bearing base material, it is often the strength of the anchor material that determines the anchor's holding power. In that case the allowable bending load should be calculated using the anchor rod's material strength properties according to the current local and national design code.

1.7 LOADING CONDITIONS

The type of the load acting on the anchoring connection is an important factor when selecting an anchoring system. Anchors are designed to carry certain types of loads and should be matched to the expected load type. The following loads must be considered when selecting an anchor:

Live Loads
Loads due to the intended use and occupancy of the building, moving equipment, snow, rain soil or hydrostatic pressure and any other live loads stipulated by the applicable building code and by-law

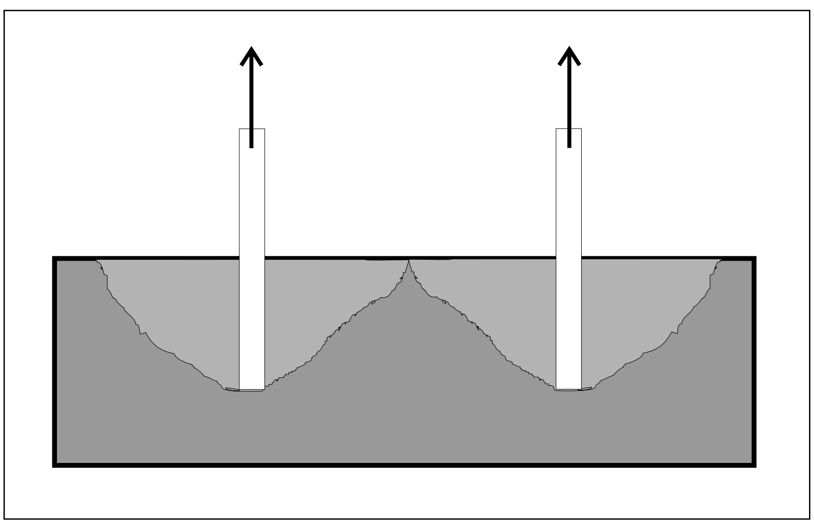
Dead Loads
Loads permanently in place during the life of the structure

Static Loads
Forces which are acting on the structure at a continuous and constant rate

Dynamic Loads
Forces applied at various rates which continue to change over time. Seismic, shock and vibratory loads are examples of dynamic loads.

1.8 ANCHOR SPACING AND EDGE DISTANCE

Most anchoring connections are designed for the mode of failure of concrete breakage under pure tensile (pull-out) loading, where a conical piece of concrete is pulled away from the concrete when the anchor fails. Although the shape and the taper angle of the surface of the cone are somewhat different for various anchor systems, in general for expansion anchors, the approximate diameter of the cone at the concrete surface is about 3 to 3.5 times the embedment.
The concrete cone for adhesive anchors is considerably smaller, due to their different load bearing behavior. The mean diameter of the cone is about 2 times the embedment.

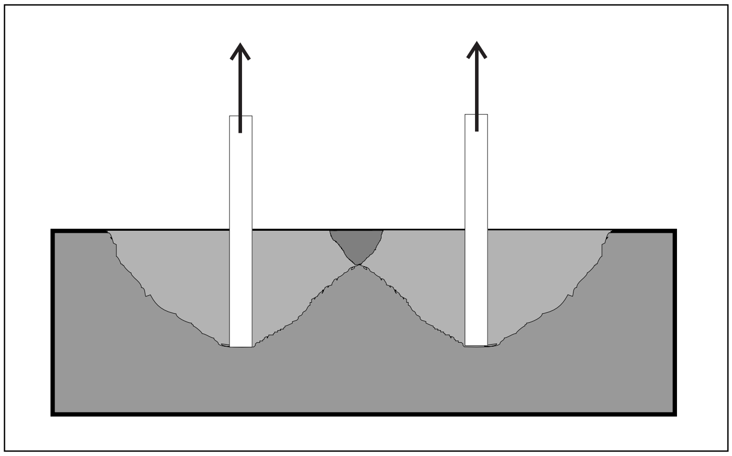


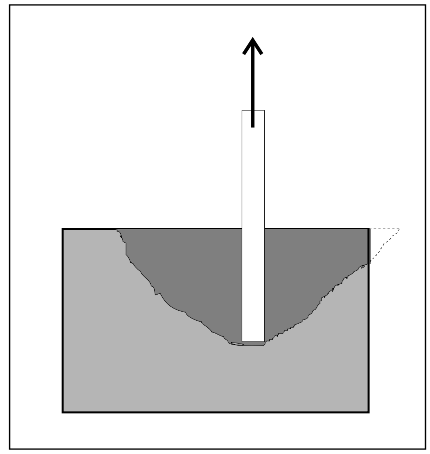
When anchors are close to one another, or to edges, the cone of the concrete cannot form fully. Therefore a reduction in the ultimate load bearing capacity of the anchor is anticipated.

ANCHOR DESIGN

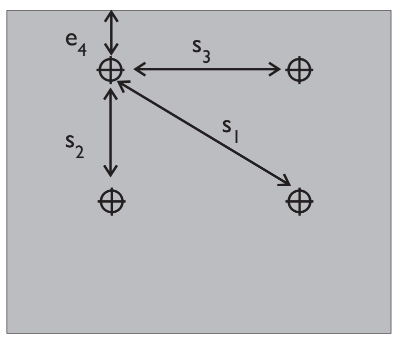
1.8.1 Reduction factors

If the distance between anchors in a group is less than the standard spacing, or the anchor is closer to the edge than recommended, the ultimate load capacity in both tension and shear must be reduced by applying an appropriate reduction factor. The total reduction factor is obtained by multiplying all applicable factors. Between the limiting values, (standard and minimum), a linear relationship is established. The UCAN technical data sheets include tabulated reduction factors for most anchors.





Sample calculation:



Anchor #4 is the most effected by edge and spacing conditions in the anchor group.

The reduced ultimate load for anchor #4 is:

$F_r = f_{total} \times \text{Ultimate Load}$ where $f_{total} = f_{e4} \times f_{s1} \times f_{s2} \times f_{s3}$

1.9 ACCEPTABLE LOAD DISPLACEMENT / PRE -TENSIONING REQUIREMENTS

To limit anchor displacement, a correct initial pre-tensioning (torque) must be applied. As the anchor is torqued, the concrete is placed locally in compression, and the anchor has no displacement (movement) until the external load overcomes the internal pre-tensioning force. For most anchor systems the initial pre-tensioning (installation torque) guarantees minimal anchor movement at the safe working load level.

1.10 SAFETY FACTOR

All published loads in this Engineering Manual are average ultimate loads based on actual anchor testing. In fastening design, in addition to influencing factors (spacing, edge distance, embedment, concrete strength, etc.) a safety factor must be used to compensate for variations in loading, material strength and installation conditions and to ensure minimal load displacement.

The following safety factors are recommended for Ucan anchors in order to calculate safe working loads:

$$P_{allowable} = \frac{P_{ultimate}}{4}$$

where $P_{allowable}$ = Allowable working Load
$P_{ultimate}$ = Ultimate Tension or Shear Load

If the anchor is subjected to dynamic loading, further reduction of the allowable load is to be considered due to material fatigue. The allowable static load must be reduced by a factor ranging from 0.3 to 1.0 to keep the stress levels in the anchor system within the range of fatigue stress of the stressed parts.

If only the breakage of the steel anchor rod occurs (e.g. breakage due to deep embedment or a steel of lower strength) a smaller safety factor can be used with the minimum yield strength of the anchor steel. This factor must be in line with current design code requirements for steel breakage in tension.

A larger safety factor should be used in calculation if:
- the failure of the fastener would create a hazardous situation
- the code specifies a larger safety factor

It is the design engineer's responsibility to analyze all conditions and select the appropriate safety factor.

1.11 CORROSION

Corrosion is the destruction of material resulting from its environments. In the case of fasteners, this process is usually electrochemical. Rain, condensation, dew and water in different amounts provide the electrolyte for atmospheric corrosion. The rate of corrosion is influenced by

- the type of dissimilar metals coupled together
- the ratio of the area of the dissimilar metals
- concentration of the electrolyte

To fully protect against corrosion, in-depth knowledge of corrosion and the specific application must be known. However, the following basic steps can minimize corrosion problems with anchors:

- eliminate some of the causes of potential corrosion
- do not attach dissimilar metal parts together
- use protective coating or corrosion resistant fastener
- keep materials dry
- separate dissimilar metals with an inactive material

All anchor parts are protected against corrosion by zinc plating. This type of protection is sufficient for indoor applications with no particular influence of moisture or for applications where the anchors will be covered with concrete.

Hot dip galvanizing provides additional protection in damp indoor areas and slightly corrosive outdoor environments.

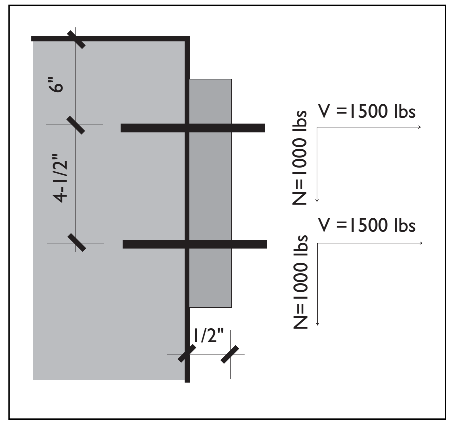
On small diameter self drilling screws (U-DRILLS) Ucan applies proprietary barrier coatings to provide protection against corrosion. For detailed information on the available coatings and their corrosion protection properties, see Section 7 in the Technical Manual.

Stainless steel anchors provide the most protection against corrosion in industrial, marine and city environments. The various types of stainless steel grades provide different degrees of protection. The best corrosion protection is provided by the UCAN Heavy Load stainless steel anchor in grade A4-70 alloyed with Titanium.

If you have a specific corrosion problem, please call UCAN Fastening Products.

ANCHOR DESIGN

1.12 SAMPLE ANCHOR DESIGN



Design data:

- Concrete strength = 4,000 psi (28MPa)
- Design loads (working, unfactored)
  Shear = 1,000 lbs
  Tension = 1,500 lbs
- No specific corrosion protection is required
- Embedment = 80mm (3-1/4")
- Fixture thickness = 25mm (1/2")

Design steps:
1. select anchor suitable for reduced edge and spacing conditions
2. select anchor with no, or minimal displacement feature

Based on the above criteria, the UCAN Heavy Load Anchor is selected.

Try UCAN Heavy Load Anchor LHL 1225

Product data as per UCAN data sheet:

		Ultimate	*Allowable*
Average ultimate loads:	Tension	= 11,463 lbs	3,275 lbs
	Shear	= 19,278 lbs	5,508 lbs

Check anchor spacing and edge distance:

Reduction factors:

For edge distance
fes = 0.47 x 152/80 - 0.17 = 0.72
fes = 0.20 x 152/80 + 0.50 = 0.88

For spacing
fs = 0.15 x 114/80 + 0.55 = 0.76

Calculate allowable working loads:

Modified ultimate loads :
Tension : 11,463 x 0.88 x 0.76 = 7,666.45 lbs
Shear: 19,278 x 0.72 x 0.76 = 10,548.92 lbs

Factored allowable working loads:

Tension: 3,275 x 0.88 x 0.76 = 2,190.32 lbs
Shear: 5,508 x 0.72 x 0.76 = 3,013.98 lbs

Check combined load condition:

$$\left(\frac{N_{design}}{N_{allowable}}\right)^{5/3} + \left(\frac{V_{design}}{V_{allowable}}\right)^{5/3} \leq 1$$

(1500 / 2190.32)5/3 + (1000 / 3013.98)5/3 = 0.53 + 0.16 = 0.69 < 1 ok!

Specification: 2 - UCAN LHL 1225 Heavy Load anchor installed into 18mm diameter hole (embedment = 80mm).