

Fasteners of Concrete Anchor

– Failure Mode and Safety

by Wei-Ming Wang

1. Loading and Failure Mode of Concrete Anchor Fasteners

Fastening can be subject to tension, compression, shear forces, moments, torsion, or the combination of above. These forces are resolved into shear and tension of individual concrete anchor fastener. Therefore, a concrete anchor fastener can be subject to the following loading conditions:

- Tension force only
- Shear force only
- Combined tension and shear

In general, elastic analysis may be used for calculating the loads on individual anchor bolts both at ultimate and serviceability limit states.

Most loads of anchor fasteners are a combination of tensile and shear. Deeper embedment will increase tensile strength while high strength steel and full diameter bolts will increase shear strength (**Figure A**). The load bearing capacity of anchored area depends on force-transfer mechanism of anchors (**Figure B**).

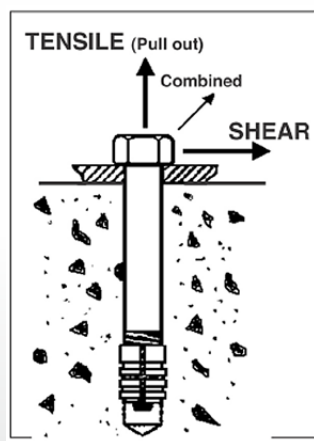
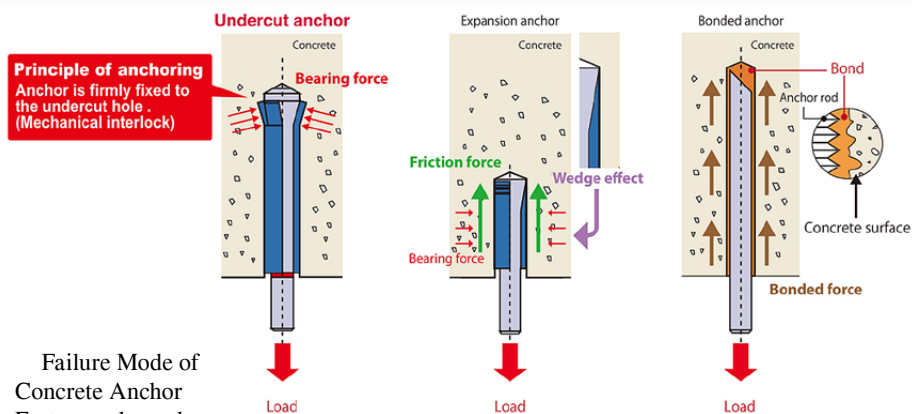


Figure A. Anchor loads are a combination of tensile and shear



Failure Mode of Concrete Anchor Fasteners depends on the interaction between base material (concrete or masonry) and anchor fasteners. **Figure C** shows the possible failure modes of 4 typical post-installed anchor fasteners types. The interaction between base material (concrete or masonry) and anchor fasteners will be schematically represented in **Figure D**.

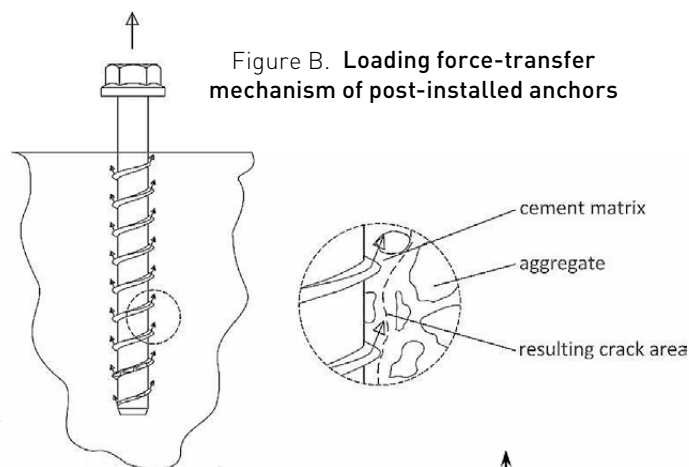
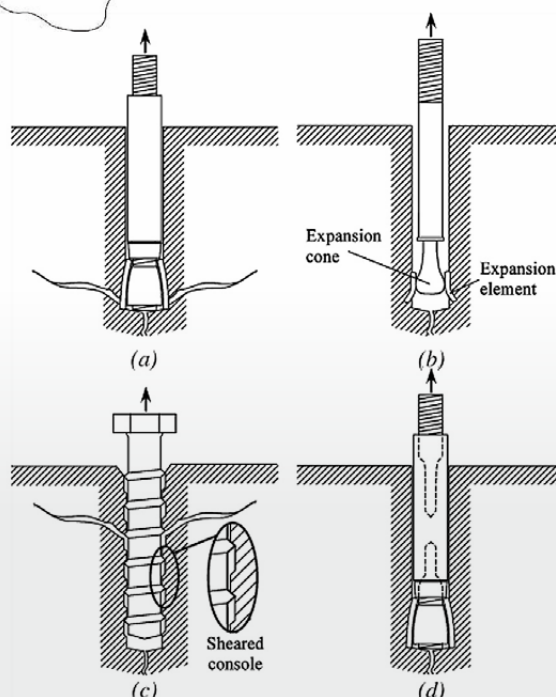


Figure B. Loading force-transfer mechanism of post-installed anchors

Figure C. Failure modes:

- Sleeve-type expansion anchor (concrete cone);
- Bolt-type expansion anchor (pull through);
- Screw anchor (pullout/concrete cone); and
- Modified expansion anchor (steel failure).

Concrete cone resistance, concrete edge resistance, pryout failure should be caused by concrete strength or installation position factors. Concrete cone failure occurs when a cone-shaped breakout body is separated from the base concrete. The concrete cone resistance depends on



a couple of factors such as the condition of concrete (cracked or non-cracked), concrete strength and embedment depth. If an anchor fastener is too close to the edge, the concrete actual cone area might be constrained by the edge distance. The actual cone area of an anchor bolt/fastener group is limited by the edge distance as well as the bolt spacing. Concrete cone area is affected by bolt spacing. Splitting failure is a failure mode where the concrete component splits completely or the concrete fractures along the fastening and the edge of the concrete element. If the edge distance is adequate, splitting cracks might develop between closely spaced anchor bolts/fasteners during installation. Splitting failure due to installation can be avoided if the minimum requirements of edge distance, spacing and the concrete thickness are met.

Failure of steel tension resistance and steel shear resistance are dominated by strength of fastener material itself lower than the need of load bearing capacity.

Steel failure is the most straightforward failure mode. It is observed by fracture in the shaft or the thread area. Pull-out resistance is dominated by tension stress. Pull-out failure is a failure mode where the complete anchor fastener is pulled out of the hole. The concrete pry-out failure mode is to certain extent similar to the concrete cone failure mode. In the case of combined pullout and concrete cone failure of the screw anchors (**Figure C(c)**), failure occurred when the consoles between the screw threads were sheared off. The Typical failure mode of a concrete screw is shown in **Figure E**.

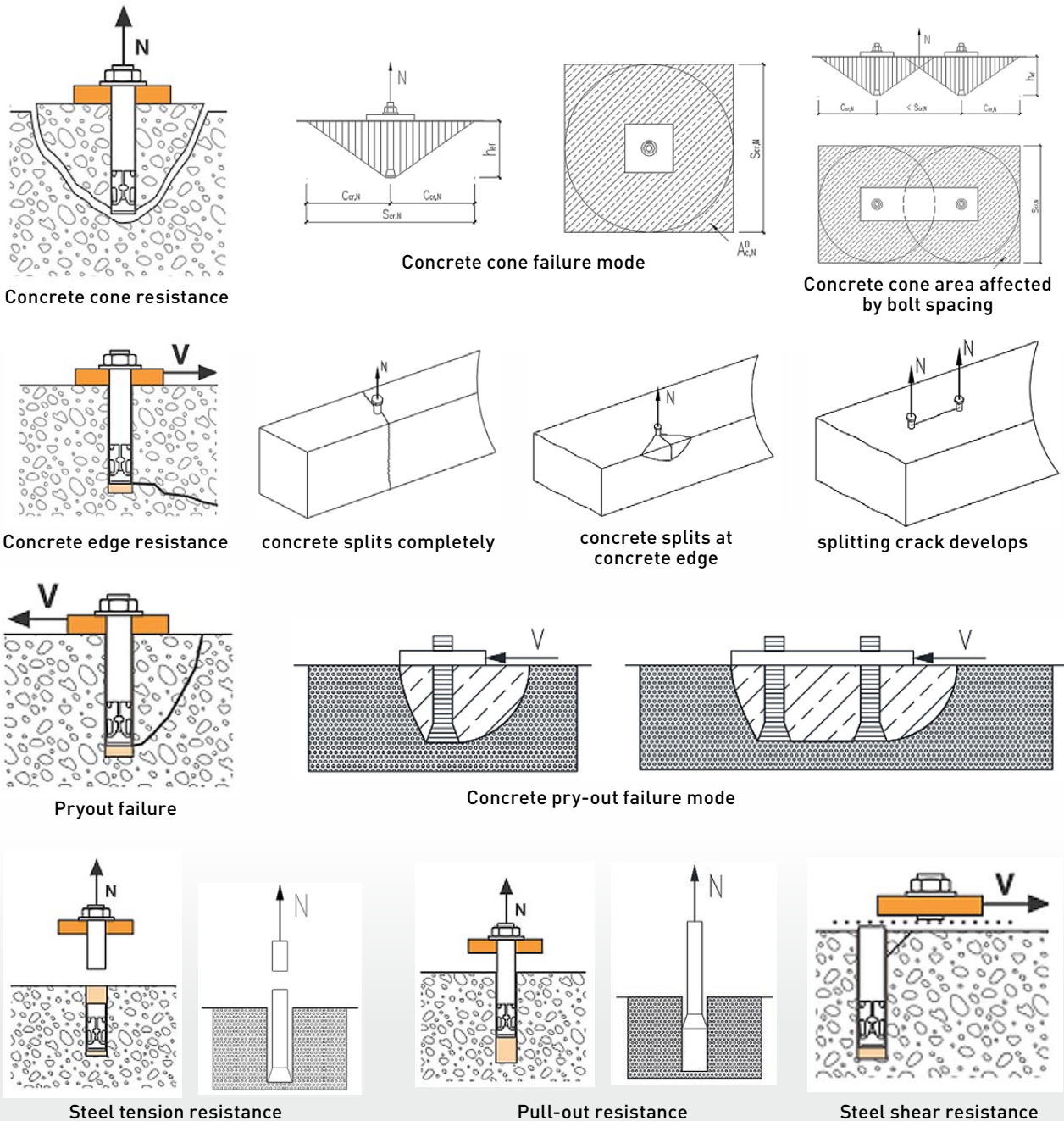


Figure D. Failure of interaction between base material (concrete or masonry) and anchor fasteners



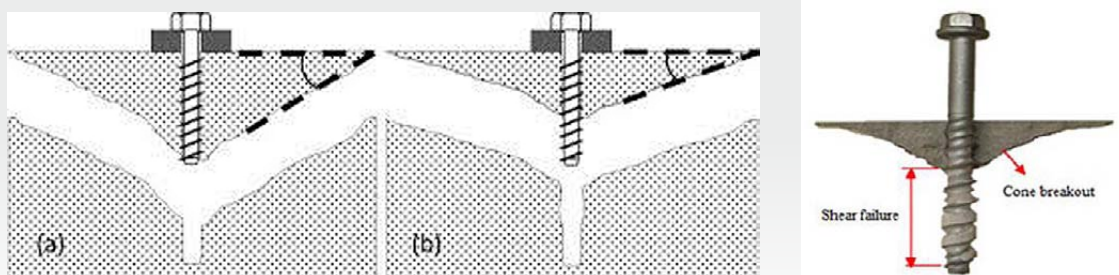


Figure E. The typical failure mode of a concrete screw (a) concrete cone (b) pullout/concrete cone

2. Information Supplied by Anchor Manufacturer/Supplier

In order to undertake an anchor design of concrete work for anchor fastener users, a minimum amount of information must be assembled beforehand. This includes information on:

- The concrete base material.
- How close the anchors will be to the edge of the concrete.
- The anchor plate.
- The type of anchor being considered.
- The approval/certification evidence of the anchor fastener.
- Fire rating requirements and corrosion protection.
- The loads acting on the anchor.
- Anchor Project details on concrete work.

If this information is not known, the specifier of anchor work will not be able to design the integral anchoring fixture. The design of the fixture is covered by separate standards. However, particular attention should be taken in relation to the diameter of the clearance hole in the fixture and the projection of the fixture beyond the clearance hole.

The manufacturers and suppliers of anchor fasteners have a duty to provide standard fixing details and design data to both the specifiers and the installers of the anchor work, on request. The anchor fasteners should also be clearly labelled or marked with all relevant details required for safe installation and intended use. Additional information regarding detailed anchor technology and design, approval/certification reports and safety data sheets, where applicable, should be made readily available. ■



168 Hsinleh St., Kangshan Dist.,
Kaohsiung City, Taiwan

haomou.taiwan@msa.hinet.net

Tel: 886-7-6229300 Fax: 886-7-6222249

www.fastener-world.com/en/supplier/haomou

**Professional Manufacturer
for nuts and spacer**



WELD NUTS

**ISO 9001
IATF 16949
certificated**

