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Introduction

1.1 General

Anchors are everyday items when it comes to building work. Experience shows that both professional and amateur builders frequently use any random anchor without being able to assess in any detail, for example, the loads and the base material of the specific application. Enquiries received by the authors and the subsequent discussions on the topic of anchor technology are presented in this book as examples of the frequent mistakes and misunderstandings involving anchors (Figures 1.1–1.3).

Complications when fastening everyday objects are frequently the result of simply 'thoughtlessness' regarding the usually unknown and often not directly visible base material. Only professional advice can help clarify the loads expected on the anchor, the base material and the item to be fastened. Unfortunately, far too often, both professional and amateur builders are looking for 'quick answers' and baulk at the time and costs involved in determining the loads and base material accurately.

1.2 By Way of an Introduction: A Real Conversation About Anchors in a Private Situation

The aforementioned thoughtlessness can quickly lead to a discussion about anchors such as the following recent exchange via a messenger service between one of the authors of this book and an acquaintance. Extracts from this dialogue are quoted below.

ANONYMOUS: '*This is my pull-up bar* (Figure 1.3)*, which is fixed to the external wall of an old building. I managed to fasten the upper anchors really tight, but not the lower ones. The masonry here seems to have a different consistency. But I couldn't tell just by tapping on the wall. Apart from drilling a big, oversized hole and filling it with concrete, what practical options do I have here for fixing it firmly?*'

J. KÜENZLEN: '*Which anchors did you use for the top and bottom fixings? What type of masonry is it? Perforated? Who's going to use the bar? I mean, how much load will there be on the bar?*'

Anchor Technology in Concrete and Masonry for Practitioners and Engineers: With Recommendations for the Execution and Evaluation of Job Site Tests, First Edition.
Jürgen Küenzlen, Eckehard Scheller, Rainer Becker and Thorsten Immel.

Figure 1.1 Bathroom (photo: Adolf Würth GmbH & Co. KG).

Figure 1.2 Living room (photo: Adolf Würth GmbH & Co. KG).

ANONYMOUS: '*I used the anchors top and bottom. They came with the bar.* (Figure 1.4)'

ANONYMOUS: '*Type of masonry? Good question, difficult to say. This is all I can see. Here's a photo of the wall from the outside* (Figure 1.5)*. I'm not keen on removing the plaster from the wall in my rented apartment. The load is max. 95 kg static, but dynamic when I'm doing my exercises.*'

J. KÜENZLEN: '*I see, a sort of cross-your-fingers-and-hope-for-the-best fixing! Errr, that'll never work, sorry. I suspect it's some kind of masonry, so you can throw away the fixings that came with the bar. Without seeing the holes you drilled, I can't say exactly, but in the case of masonry and those loads, I would recommend an injection anchor.*'

Figure 1.3 Pull-up bar (private photo).

(a) (b)

Figure 1.4 Anchors supplied with the bar; (a) anchor length, (b) anchor diameter (private photos).

ANONYMOUS: '*It's certainly masonry, clay bricks I reckon, judging by the red dust during drilling. I'll throw the fixings away as soon as you can tell me what I should be using instead. My lack of knowledge might be dangerous here. I'm stumped!*'

J. KÜENZLEN: '*An injection anchor, fixed as deep as possible.*'

ANONYMOUS: '*I don't need a course on anchor technology, just tell me what to do, and like quick!*'

J. KÜENZLEN: '*Okay, clay bricks without holes? In that case use a threaded rod inserted as far as possible and fixed in place with injection mortar. Brush and blow out the hole according to the instructions. Use WIT VM 250 for the mortar.*' [authors' note: see Figure 9.43 in Section 9.4]

Of course, in order to specify a particular anchor, it would have been necessary to consider the loading in more detail, but our anonymous fitness fan wanted a quick solution!

Figure 1.5 Wall from outside (private photo).

This and similar discussions reveal again and again that anchors – products that seem unremarkable in themselves – are probably among those construction products that are used for the most diverse applications but, above all, by the most diverse users. Anchors are used to fasten everything from lightweight bathroom cabinets (Figure 1.1) to heavy industrial robots (Figure 1.6). Fastenings for the latter are subjected to higher dynamic and fatigue-relevant loads – affecting both the anchors themselves and the base material.

1.3 Anchor Technology for Professionals

The ever more complex world of building and the constantly growing demands of sustainability and environmental compatibility together with economic issues have led to anchor technology being investigated in more and more scientific detail in recent decades during the course of product development. Again and again, this has given rise and gives rise to new products that, in particular, also take into account the increasing diversity of the base materials. For the specific marketing of anchor products, while not ignoring the economic aspects, the scientific studies have resulted and continue to result in sometimes highly complex design methods that

Figure 1.6 Industrial robot fastened with anchors (photo: Küenzlen).

are specified in numerous codes of practice, e.g. EN 1992–4 'Eurocode 2 – Design of concrete structures – Part 4: Design of fastenings for use in concrete'. The upshot of this is that, more and more often, it is no longer possible to design an anchor with a simple, quick and easily grasped manual calculation. Basically, these days, such anchor technology for professionals is only understood by experienced civil and structural engineers who have the necessary software at their disposal.

Looked at globally, the history of anchor fixings has been far from consistent. Instead, there are specific regional differences, something we see today in the different English names for anchor systems that, in technical terms, are identical. For example, drive-in anchors (often used in the USA) are equivalent to drop-in anchors (often used in the UK).

However, the experience of the authors over the past 20 years shows that in order to gain the acceptance of users, more than ever before there is an urgent need to translate academic anchor theory into manageable anchor practice for real building sites.

Fast-track anchor installation along the lines of 'we've always done it that way', or without appropriate training, is simply no longer possible in professional situations.

It is exactly that gap that this book intends to fill. In everyday practice, users probably hardly ever ask themselves the question 'How does my anchor work?' Therefore, this book focuses on the practical use of anchors. The question this book poses is: 'Which anchor do I need for my fastening task and what aspects do I need to consider?' To answer this question, the authors guide the reader through the seemingly vast number of anchor systems and provide advice for everyday building situations.

The theory regarding the structural behaviour is only explained, and then only briefly, when it helps to solve the fastening task and understand the solution to that task.

Initial general information about the anchor design typically required can be found in Chapters 8 and 10. However, detailed information is not provided because

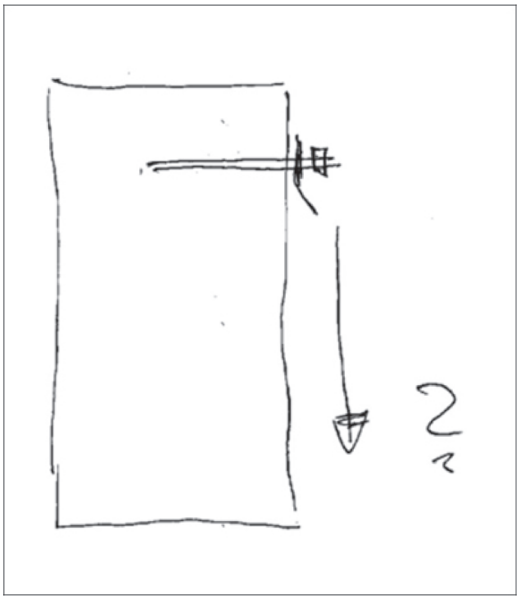

Figure 1.7 Quick sketch.

this activity is not usually carried out on the building site, instead is routine work in the offices of civil and structural engineers. For clarity, the reader is merely referred to the existing codes of practice and other specialist publications that provide summaries, e.g. Scheller & Küenzlen, 2013.[1]

Figure 1.7 illustrates in simple form the sometimes disillusioning everyday world of anchors on the professional level. This sketch really was sent to the applications adviser of an anchor manufacturer. Nevertheless, this simple sketch does reveal the complexity of anchor technology and the gaps in our knowledge.

What does the author of this sketch require from the anchor supplier? They are probably interested in knowing how many kilograms the anchor can carry, i.e. how much they can 'hang' on the anchor, and which product they should be ordering. So the author of the sketch, i.e. the prospective anchor customer, expects to receive a recommendation as to which anchor to use for their intended application.

However, to be able to provide a sound and reliable answer to this question, the applications adviser first has to clarify the intended application and the actual situation on site. That calls for much more detailed information than is available from the customer's sketch (Figure 1.7).

As a rule, the same key questions are asked for every anchor application. This book is intended to help users clarify the most important issues and provide the corresponding background information to real situations. So, although the sketch in Figure 1.7 is very simple, it does address the most important issues in standard anchor technology and therefore also serves to lay down the order of the topics treated in this book:

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1 Scheller, E. and Küenzlen, K. (ed.) (2013). *Handbuch der Dübeltechnik – Grundlagen, Anwendungen, Praxis* [in German]. Künzelsau/Germany: Swiridoff Verlag.

- Which fundamental rules apply to anchor products in Europe? (Chapter 2)
- In which material is the anchor to be installed?
  - In other words: Which base material is involved? (Chapters 3 and 4)
- Will the fixture be installed in a dry interior or outside or, for example, in a swimming pool?
  - In other words: What level of corrosion protection does the anchor require? (Chapter 5)
- How far is the fixture, or the anchor plate, from an edge?
  - Which also means: What dimensions are involved (member thickness, edge distance, anchor spacing)? (Chapter 6)
- Does the fixture have only one hole for one anchor or holes for two or more anchors?
  - What is the diameter of the clearance hole through the fixture? (Chapter 7)
- What is to be attached to the anchor/fixture/anchor plate?
  - In other words: Which loads need to be considered in which directions? (Chapter 8)
- Which anchor systems are available? (Chapter 9)

This book initially adheres to this order because, in principle, this approach can be applied to every fastening task. Making a universal statement, e.g. two or three different types of anchor as a recommendation for fixing a balustrade, is, however, not really helpful when – as we work through the above systematic approach – we discover that just one of the various boundary conditions actually calls for a fourth type of anchor. Therefore, the approach presented in this book can serve as an initial tool for every fastening task. The aim is to provide a how-to manual for the design and installation of anchors.

The most important and the first item to be considered should always be the base material, because most modern anchor systems are intended for a certain base material, indeed frequently only approved for that base material. When working through the other points, it is possible to use as a guide the product information and approvals plus the design software supplied by the anchor manufacturers.