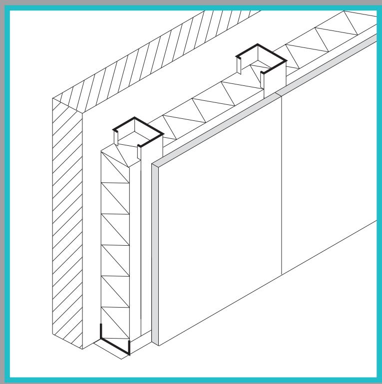
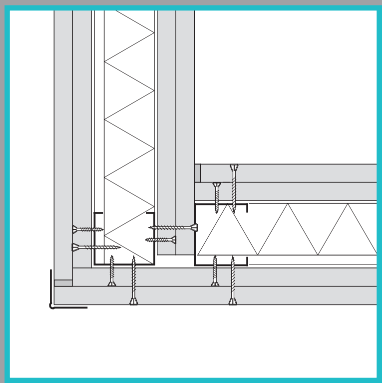
DETAIL Practice

Dry Construction

Principles
Details
Examples





Karsten Tichelmann
Jochen Pfau

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Contents

Introduction

"There is no inevitable rejection of dry and lightweight forms of construction. But there are huge gaps on the map of the constructional mind-set – among the public, but also among planners and architects. It is not the 'lightweight' that is causing the problem, but rather the lack of knowledge about the advantages of lightweight."
Karsten Tichelmann

Aspects of dry construction
The growing use of dry construction systems in the building sector is due to the many advantages of these systems, primarily their short construction times, good economics, superiority in terms of building physics and, first and foremost, their sound insulation and fire protection benefits compared to masonry and concrete with the same overall component thickness. Other advantages include the ease of installation and the ease of integrating fitting-out elements such as lighting units, loudspeakers, detectors and sensors flush with the finished surfaces, plus the almost limitless design freedoms of these systems. At the same time, shapes and surface characteristics can be adapted to suit individual architectural requirements.

The approach to minimising the masses to be moved, whether in the automotive industry, in shipbuilding or in aircraft construction, has led to highly developed lightweight construction technologies which in the construction industry, however, have remained insignificant, apart from a few mobile or temporary structures. Here, comparing natural forms of construction with high-performance technical configurations reveals the following similarities: the economic use of materials to achieve a high functional efficiency, and the care taken in the execution. If we grasp the quality of these principles, we adopt an attitude that is particularly relevant in the current architectural debate.

Economic, ecological, technological and social developments are resulting in the need to plan lightness and flexibility into the fitting-out of our buildings if we want them to remain useful in the future. Such an approach means that the demand for good architectural design is linked with economic forms of construction and a reduction in the use of materials. This demand is also mainly aimed at the internal enclosing elements in buildings of all kinds, regardless of whether newly built or part of the existing building stock.
It is here that dry construction plays a significant role today – a role that will grow in the coming years.

Dry and lightweight forms of construction are set to make major contributions. Their development is only just beginning, but is already proceeding at such a pace that very soon we shall be able to solve hitherto untypical tasks with an increasing number of composite and material optimisations (e.g. adaptive systems, "self-healing" systems, fitting-out forms that regulate the interior climate and cut the amounts of dangerous substances). Dry construction systems are lightweight hollow assemblies that adhere to the technological principles of lightweight construction. In dry construction we therefore speak less of components and more of systems, less of building materials and more of semi-finished and finished products, less of building or building processes and more of assembly and erection.

The use of systems in dry and lightweight construction, optimised for their particular functions, is generally associated with a gain in floor space and greater flexibility of usage – the so-called soft skills of this form of construction which were underestimated in the past. For example, the vast majority of buildings erected between 1950 and 1995 will become unusable in the long-term and will become increasingly difficult to let or sell. The small-format interior layouts acceptable in those days are no longer popular with users and buyers. Changing the room sizes means an expensive intervention in the solid building fabric. However, as infill development increases, there is also a rise in the demands for individuality and freedom of expression in housing and office cultures. We are witnessing more and more individualisation in the way buildings are used; buzzwords like “living work” and “work@living” reflect this trend. Buildings must react to the demands associated with such changes.

Owing to their building physics properties and their different building physics behaviour, dry construction systems differ fundamentally from the technology and construction of heavyweight, solid building components. The lightweight properties of dry construction must be understood if the high efficiency of this form of construction is to be fully exploited. The result is a highly economic, high-quality building with superior technical and building physics characteristics. Other important criteria for evaluating a form of construction are, for example, the thickness of components, the weight, the construction times and the subsequent adaptation to suit changing requirements. These characteristics are not covered directly by any statutory requirements. Nevertheless, they are critical when choosing a form of construction because there is a direct relationship between these and the cost, efficiency and economic factors of a building – all criteria where dry construction in fitting-out is far superior to heavyweight forms of construction.

Dry construction systems are especially suitable when a combination of building physics requirements – such as sound insulation and fire protection, moisture control and thermal performance – have to be fulfilled simultaneously. Depending on the choice of system, the supporting construction, the insulating materials and the boarding materials, the building physics properties required can be achieved by a number of different types of construction. Owing to the assembly-type construction, changing or adding an element, e.g. another layer of boarding or a different board material, can achieve better building physics properties.

Furthermore, dry construction systems can be added to existing constructions in order to improve specific properties, an aspect that is especially important for infill development tasks (extra storeys, expansion, extensions) and alterations to existing buildings. The low weight of dry construction systems means that loadbearing components can be sized more economically than would be the case with a fitting-out scheme involving masonry and concrete. A clear reduction in mass and at the same time better sound and thermal insulation properties is readily achievable, primarily with wall systems (partitions, external walls, facades).

The design of lightweight fitting-out constructions also always implies the design of multifunctional constructions. Reducing the demands placed on a construction to just one factor is, in principle, no longer up to date. Even apparently purely functional components such as non-loadbearing partitions, suspended ceilings, access floor systems or fire-resistant casing systems have to satisfy additional tasks other than those suggested by their names: they are always constituents in a building concept and always interact with the interior spaces, engage in a dialogue – both architectural and technological – with all other enclosing constructions. They therefore represent not only the fulfilment of a (mono-functional) purpose, but also a change in the environment, an architectural symbol, a visual mass, light, colour and shadow. There is therefore no subdivision into mono- and multi-functional, into important and less important constructions, only the need to come to terms with new developments and their influence on our own actions. Defining dry construction as the combination of lightweight construction and building with dry materials is not new, but its influence on the housing market – with its apparently unrecognised advantages and opportunities – is.

The design principles of dry construction
Dry construction systems are based on three fundamental principles, which may be combined in different ways:
- Lightweight materials
- Lightweight structures
- Lightweight systems

Lightweight materials
This is the use of building materials with a low density. In this form of construction, the density must be placed in relation to the stresses and strains to which the material is subjected. For the typical dry construction materials such as thin sheet metals, boards and wood-based products, this assessment concerns not only the maximum stresses and strains possible, but primarily the permanent loads plus creep effects and loss of stiffness. It is mainly through the combination of various materials that dry forms of construction are made considerably more efficient than a consideration of the individual materials alone leads us to suspect (see “Lightweight systems” below).

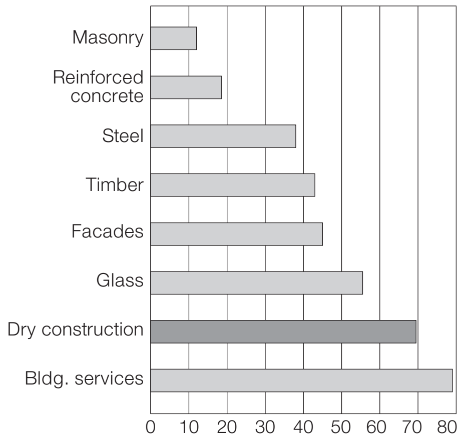
1

Lightweight structures
Moving on from the building materials level to the constructions and systems made up of those materials, we find that it is the lightweight structure that is faced with the task of resisting a given load with a minimum of self-weight. These are primarily mechanical loads that have to be transferred via suitable loading paths within a design framework that is usually restricted in some way. But this idea can be extended to cover all types of loads that act on dry construction systems (fire, sound, heat, radiation, electromagnetic fields, etc.). A lightweight structure therefore represents the solution to a minimisation, i.e. optimisation, problem for a series of given boundary conditions (loads, two- and three-dimensional functional requirements, lighting demands, etc.).

The choice of the load governing the system, structure and form is therefore of fundamental importance. In masonry and concrete constructions, it is primarily the loadbearing capacity and static loads due to the self-weight that represent the dominant effects determining the geometry. From our modern viewpoint, it is worthwhile relating the precision of a structural optimisation to the architectural and constructional aspects and their mutual dependency.

Lightweight systems
A lightweight system is one in which an element combines the loadbearing function with other functions, e.g. enclosing, sound insulation, fire protection, etc. Such a principle has always been assumed to apply to a whole series of building elements. Dry construction systems for walls and ceilings are just such multi-functional elements.
Developments in dry and lightweight construction have led to complex building elements in which, for functional and technical reasons, it is necessary to combine layers of materials which often exhibit fundamentally different mechanical and building physics parameters. In many cases the combination of disparate materials or components can also be exploited for structural purposes. The combination of thin-wall metal sections and board materials with optimised functions (e.g. gypsum- or wood-based board products) enables the creation of very simple, extensive, self-supporting, enclosing composite constructions.

Conscious design and planning means arranging the building materials – representing the optimum in many respects – at the appropriate places (a combination of lightweight materials and lightweight systems), which inevitably leads to dry construction systems.



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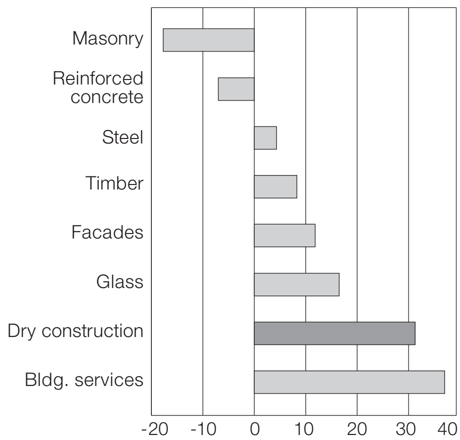

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1 “Pinakothek der Moderne” art gallery, Munich, 2002, Stephan Braunfels
2 The innovation potential of various forms of construction, expressed as percentages related to the current status of development
Source: VHT Study “FutureTrend”, 2007
3 Prognosis: market changes for various types and forms of construction up to 2015, expressed as percentages
Source: VHT Study “FutureTrend”, 2007

Dry construction systems for walls, ceilings and floors are, in principle, all based on the same concept of supporting framework (framing), boarding and usually some form of insulation in the intervening voids. The other materials involved are mechanical fasteners, special connectors and jointing elements, jointing compounds and adhesives plus films, foils and accessories specific to certain products. The physical properties of dry construction result from the combined action of the individual components.

Materials for the supporting framework

For reasons of stability (limiting the deformations), elements made from thin sheets or boards require a stiffening supporting framework if they are not glued or stapled to a substrate over their entire area. The sizes, type and spacing of the framing members determine the interaction with the boarding. Their fixings determine the structural properties of the elements (e.g. deflection) and also have an influence on the sound insulation and fire protection characteristics of the elements.

Metal sections

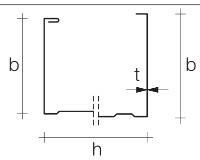
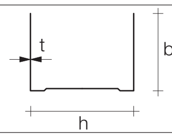
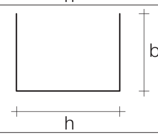
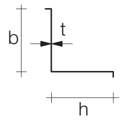
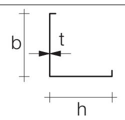
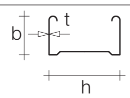
The majority of dry construction systems, e.g. independent wall linings, stud walls, ceilings and suspended ceilings, use metal sections for their supporting framework. Such metal sections provide the supporting construction to gypsum-based boards, wood-based board products and other board materials. Channel-type (U-shaped) sections are generally preferred.

Metal sections for ceilings or walls according to DIN 18182-1 (in future EN 14195) are made from corrosion-resistant (galvanised), cold-formed, thin-wall steel. DIN 18182-1 specifies a zinc coating of at least 100 g/m^2, which corresponds to a coating thickness of 7 μm each side and thus ensures adequate protection to any cut edges. A thicker coating is prescribed for sections used externally and those permanently exposed to the outside air (e.g. open sheds). Additional protective measures are required for applications in particularly corrosive conditions (e.g. chlorine gas in swimming pools), which usually means the addition of some form of organic coating.

The standard thicknesses of these thin-wall sections are 0.6 mm, 0.75 mm and 1.0 mm. Stiffer sections for the framing around wall openings, door frames, etc. are customarily 2 mm thick. Please refer to DIN 18182-1 for details of other section dimensions and metal thicknesses (see table T1).

- CW sections (= C studs for walls), i.e. inwardly lipped channels, are bent over at the ends of the flanges to improve their stiffness. Holes are usually punched in the web so that pipes and cables can be passed through. Openings are possible in the top and bottom thirds of wall studs ≤ 3 m high; the maximum side length of such an opening (length and width) may not exceed the

T1: Standard metal sections – dimensions and forms to DIN 18182-1

Type of section		Section abbreviation [nom. web depth × nom. metal thickness]	Web depth h [mm] (± 0.2 mm)	Flange width b [mm]
Example of a C stud with 2 different lip forms Designation CW		CW 50 × 06 (07, 10)	48.8	50 ± 3.0
		CW 75 × 06 (07, 10)	73.8	
		CW 100 × 06 (07, 10)	98.8	
Example of a wall channel Designation UW		UW 30 × 06	30	40 ± 0.2
		UW 50 × 06	50	40 ± 0.2
		UW 75 × 06	75	40 ± 0.2
		UW 100 × 06	100	40 ± 0.2
Example of a stiffening channel Designation UA		UA 50 × 20	48.8	40 ± 1.0
		UA 75 × 20	73.8	40 ± 1.0
		UA 100 × 20	98.8	40 ± 1.0
Example of a wall internal corner angle Designation LWi		LWi 60 × 0.6	60	60 ± 0.2
Example of a wall external corner angle Designation LWa		LWa 60 × 0.6	60	60 ± 0.2
Example of a suspended ceiling channel Designation CD		CD 48 × 0.6	48	27 ± 0.2
		CD 60 × 0.6	60	

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1 Internal lining of plasterboard, Frieder Burda Collection, Baden-Baden, 2004, Richard Meier
2 Longitudinal edge forms of plasterboards to DIN 18180
  a Tapered edge (AK)
    For filled joints; the taper accommodates the jointing compound.
  b Square edge (VK)
    Primarily for dry lining without filled joints.
  c Round edge (RK)
    Primarily when used as a background for plaster.
  d Half-round edge (HRK)
    For filled joints without jointing tape.
  e Half-round tapered edge (HRAK)
    For filled joints with or without jointing tape.
3 Perforated acoustic ceiling of plasterboard, combined police and fire station, Berlin, 2004, Sauerbruch Hutton

depth of the web. The flanges of CW sections provide the bearing surfaces for the boarding materials and therefore must be at least 48 mm wide so that there is enough material to fix two boards butted together over the flange. The depth of the web of a CW section is such that it fits into a UW section.

- UW sections (= wall channels) have no inward-facing lips, which means they can accommodate CW sections.
- UA sections (= stiffening channels) have no inward-facing lips and are made from 2 mm thick material; they are used for strengthening the framing around wall openings, door frames, etc.
- CD sections (suspended ceiling channels) are bent or folded inwards at the ends of the flanges to accommodate the hangers of a ceiling system. The bearing width for the ceiling materials (web width) must be at least 48 mm. Curved suspended ceiling channels are used for curved ceiling forms.
- UD sections (ceiling channels) are not bent/folded inwards at the ends of the channels, which means they can accommodate CD sections.
- Wall internal corner angles LWi or wall external corner angles LWa are used to construct wall junctions.

Many other sections are produced for various applications in dry construction. For ceilings, there are various clamping rails, resilient channels, T and Z sections plus inlay, supporting, long-span, modular grid and perimeter sections.

Solid timber

The softwood for timber framing must comply with the requirements of DIN 4074-1 grade S10, cutting class S (square-edged). Upon installation, the timber should have a moisture content appropriate to the conditions; however, in order to avoid drying-related deformations, the moisture content should not exceed 20%. Common timber sections are listed in table T2.

According to DIN 68800-2, constructions without chemical wood preservatives are always to be preferred if the constructional measures taken mean they can be allocated to risk class 0. This is generally possible with wall, roof and floor constructions. On the other hand, in interiors where the type of use can lead to a timber moisture content > 20% (swimming pools, abattoirs, etc.), a chemical wood preservative should be used in compliance with DIN 68800.

Materials for the boarding

The surfacing materials have a direct effect on the adjoining interior space (comfort, interior climate), but on the other hand are also directly influenced by the conditions in the room (moisture, mechanical loads, exposure to fire, etc.). Element properties important to biological living conditions, e.g. moisture balance, thermal mass, etc., are, first and foremost, properties of the element surfaces. From the structural viewpoint, the boarding materials brace the underlying supporting framework and reduce the buckling lengths of the individual members. Connecting the boarding to the framing with mechanical fasteners creates a composite construction with a loadbearing capacity much higher than the sum of the individual components.

Gypsum-bonded board materials

Gypsum-bonded board materials (plasterboard and gypsum fibreboard) are the most popular board types for fitting-out work. This is due to their favourable building physics and building biology characteristics, their adequate strength, their easy workability and the wide range of applications, which include sound insulation, fire protection, moisture control and thermal insulation, plus bracing the construction. Their physical properties can be influenced through the use of additives and fillers. In addition, the easy mouldability and short setting times of gypsum building materials represent good conditions for the industrial production of building boards.

Gypsum building boards contain chemically bound water. In the event of a fire, this water of crystallisation is released as water vapour, which means that the temperature on the rear of the board (not directly exposed to fire) remains in the region of 100°C, thus delaying the spread of the fire.

The porosity of gypsum building boards is the reason behind their good building biology characteristics. The high proportion of macropores enables a very fast absorption and release of water in both liquid and vapour form. It is this porosity that is responsible for the favourable moisture-regulating properties of gypsum building boards. Providing any given coating is diffusion-permeable, gypsum can absorb large quantities of moisture during periods of high humidity and release it again once the air is drier.

Gypsum-bonded boards are "warm-to-the-touch" building materials and therefore are comparable with timber. Thermal comfort is achieved because the low thermal effusivity of gypsum building boards