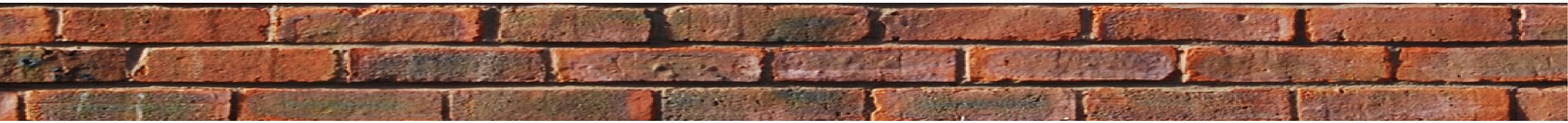
Co$_2$olBricks

Historic Brick Masonry

Part 1: **Material, production and history**

Baltic Sea Region
Programme 2007-2013
Part-financed by the European Union
(European Regional Development Fund
and European Neighbourhood and
Partnership Instrument)

AUSBILDUNGSZENTRUM-BAU IN HAMBURG GMBH
BAU



What is a brick?

- Bricks are a hand-made building material
- The oldest pre-fabricated building material
- **Rough ceramic material**

2. The brick and its ingredients

What are bricks made of?

- Main ingredient: **Clay/mineral alumina**
- The contained minerals are responsible for the colour of the bricks.

Foto: backstein.com

3. Overview of different brick types

- Brick is a general term for a variety of burnt bricks materials.
- There are solid clay bricks and hollow bricks.
- Common main ingredient: **mineral alumina**
- Composition and colour of the alumina give the bricks their special look and their typical properties.

Bricks

Clinker brick	Facing clinker	Face block	Hand-formed brick

Industrial brick	Facing clinker	Hand-moulded brick

The clinker brick in brief

- Clinker are bricks (like solid bricks or hollow bricks)
- Raw material: „Blue“ clay with high percentage of silicate
- Various colours shades through aggregates
- They are burnt under very high temperatures over 1100 C°.
- Very low moisture content under 3 %
- Through the sintering process all pores get closen.

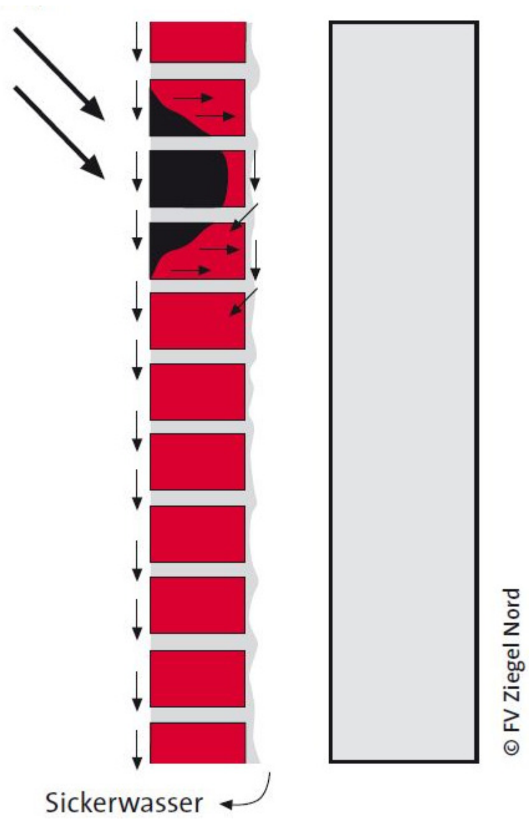
  >> Thereby very low water intake and very high resistivity
- When you hit two clinker bricks to one another you hear a light sound.

  >> Therefore the name \`clinker\`

Advantages of clinker bricks

- Advantage: high frost resistance and driving-rain protectic
- Application as facing brick (weather protection)
- Broad usage in Northern Europe due to rain and wind
- Moisture diffusion through capillar effect of the joints

  >> Moisture is being taken and given



Graphic: backstein.com

Traditional production: The hand pressure method

- Clay is dissolved in water for several weeks

  >> Moisture evens out and gas can exhaust, which might burst the brick while being burnt
- Mass is cleaned and then being put with pressure into forming frames
- Cut off overlaying material and dump the forming frame
- Dry the bricks at fresh air for several weeks
- Finally burn the bricks at 600°C up to 900°C in an oven

Industrial production: The pugstream machine method

- The clay is choped, merged and pressed to a pugstream
- Raw bricks (unburnt) are cut off the pugstream
- Drying >> Reduction of the moisture content down to 3 %
- Burning process in tunnel ovens at 1100°C up to 1300°C
- Clay quality and burning temperature are responsible for the coulour and the strength
- Special shapes are possible
- Various surface figuration from profiling to overglaze etc.

3. Short history of an ancient building material

Early high cultures

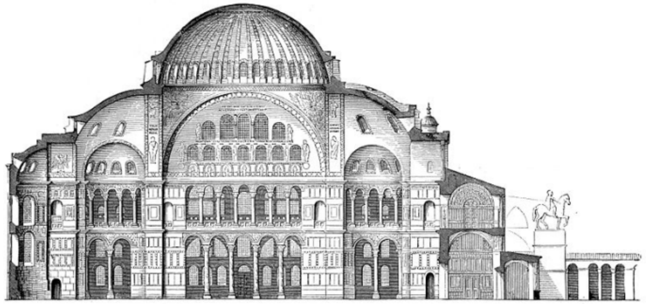
- Within the **New Stone Age** (ca. 6000 - 8000 B.C.) clay bricks were used as building material.
- They were hand-formed but still unburnt.
- Formed bricks for the first time around 6000 B.B. in **Mesopotamien**
- Burnt bricks for the first time around 3000 B.C.
- Development and optimisation of overglaze
- Outstanding example: **Ischtar portal** (562 B.C.)

The Ischtar portal from the Babylonian times at Berlin Pergamon museum

Photo: Wikipedia

Ancient world and late antiquity

- Burnt bricks until 2nd century AD spread by the Romans in the whole Roman Empire
- Typical for Romans bricks: Thin bricks and plastered/rendered or cladded masonry
- From 2nd century AD bricks were used decorated
- Further development of brick masonry in the im Byzantine and Western Roman Empire
- Outstanding example: **Hagia Sophia** (537 AD)



Axis section and picture of Hagia Sophia in today‘s Istanbul

Photo and graphic: Wikipedia

3. Short history of an ancient building material

Medieval Times

- Brick architecture had dissapeared in Northern Europe until the its relaunch by monks in the 12th century
- Reason: better dimensial consistency than natural stones and higher availability of the raw material
- Continous use only in Italy
- **Brick gothic** is height of brick decoration especially in the Haseatic League area
- Role model: **Marien church in Lübeck in Northern Germany**

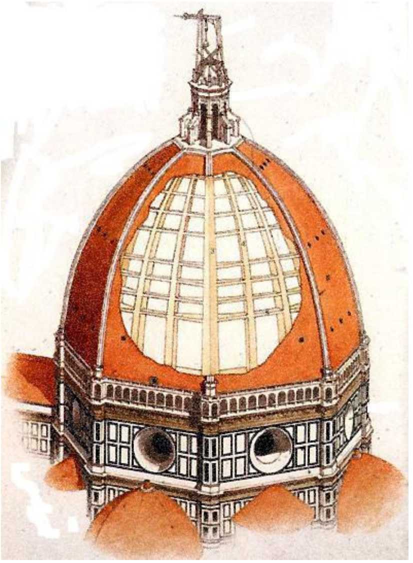
Brick Gothic from the Hanseatic League times: Marien church in Lübeck in Northern Germany

Photo: Wikipedia

Renaissance, Baroque and 18th century

- Facing brick masonry was at first mostly unpopular and was rendered or washed
- Nevertheless, bricks were the most used building material

  >> Advantage: Easy handling and cheap production compared to natural stones
- Since 1650 broad expansion especially in France, The Netherlands and England (large fire 1666)
- Outstanding example: **Cathedral of Florence** (1436)



Master piece from the early Renaissance: Brunelleschi's Cathedral of Florence

Photo and graphic: Wikipedia

3. Short history of an ancient building material

19th Century

- Very large expansion of the brick architecture in Northern Germany by the **Neo-Gothic**
- **Industrialisation of the brick production** enabled tremendous achievements such as residential blocks workers settlements, factories etc.
- Outstanding example: **Göltzsch valley bridge**

Residential blocks in Hamburg

Photo: Wikipedia

Largest brick bridge of the world:
The Göltzsch valley bridge in Saxony (1851)

3. Short history of an ancient building material

20th Century

- Steel, glass and concrete replace the bricks for economic and statics reasons (high rise)
- **Brick expressionism**, **‚Home style‘** and **New way of building** replace tradition of building with bricks
- In Northern Germany bricks are still popular as **clinker facing bricks**

  >> Advantage: Weather protection and cost effectiveness
- Outstanding example: **Chilehaus** from Fritz Höger

Brick expressionism in Hamburg: The Chilehaus (1924)

Photo: Wikipedia

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Part 2: **Mortar, formats and bonds**

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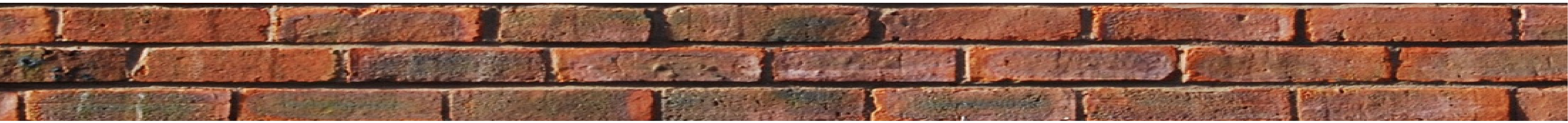
Ausbildungszentrum-Bau in Hamburg GmbH



1. Bond: The mortar

What is (historic) masonry mortar made of?

Historische Mörtel						Moderne Mörtel
Sand	+	**Bonding agent**	+	**Water**	+	**Aggregates**

Bonding agent
- Lime
- Gipsum
- Cement

- Fine-grained sand at particle size from 0 to 4 mm
- Bonding agent is an adhesive between sand graines and stones
- Aggregates enhance the plasticity and workability of mortar

Photos: Fotolia

Historic masonry mortar in an overview

Lime mortar	• Most used masonry or render / plaster mortar • Raw material lime natural available in various kinds • Industrial production since the middle of the 19th century • **Very smooth , high water diffusion**
Gipsum mortar	• Burnt out of Gipsum stone, in the past mixed with lime for bricklaying • **Extremley water-soluble,** constructive protection necessary
Cement mortar	• Introduction through industrialisation in the middle of the 19th century • Mixture of calcareous marl and clay >> Portland cement • **Very solid**, **water-impermeable**

The lime mortar: History

- Earliest emergence of lime mortar in Turkey, age of **14,000 years!**
- 2,600 B.C. use for building the **Pyramids** in Egypt
- 2,000 B.C. first „professional“ lime ovens in Mesopotamia
- Water-impermeable mortars around 1,000 B.C. in times of the Phoenician
- 100 B.C. the Romans developed „**Caementum**“, a mixtures of limestone tuff, aggregate of broken bricks and lime mortar; it is the messenger of concrete
- Knowledge of Antiquity got almost lost in the Middle Ages
- By the end of the Thirty Years' War in 1648 hydraulically setting bonding agents on basis of tuff gained of importance

Bonding agent lime: The production

- Raw material: Limestone (Calcium carbonate/$CaCO_3$) from quarries
- **Lime burning**: Limestone is being burnt to quicklime (unslaked lime) at 800°C >> CaO (Calciumoxid) + CO_2
- **Hydrating process**: Unslaked lime gets through aggregation of water in a extremely exothermal reaction to hydrated lime >> $Ca(OH)_2$ (Calcium hydroxide) >> $CaO + H_2O \longrightarrow Ca(OH)_2$

Hydrated lime/$Ca(OH)_2$ = **(white)lime hydrate**

Calcium hydroxide, Photo: Wikipedia

1. Bond: The mortar

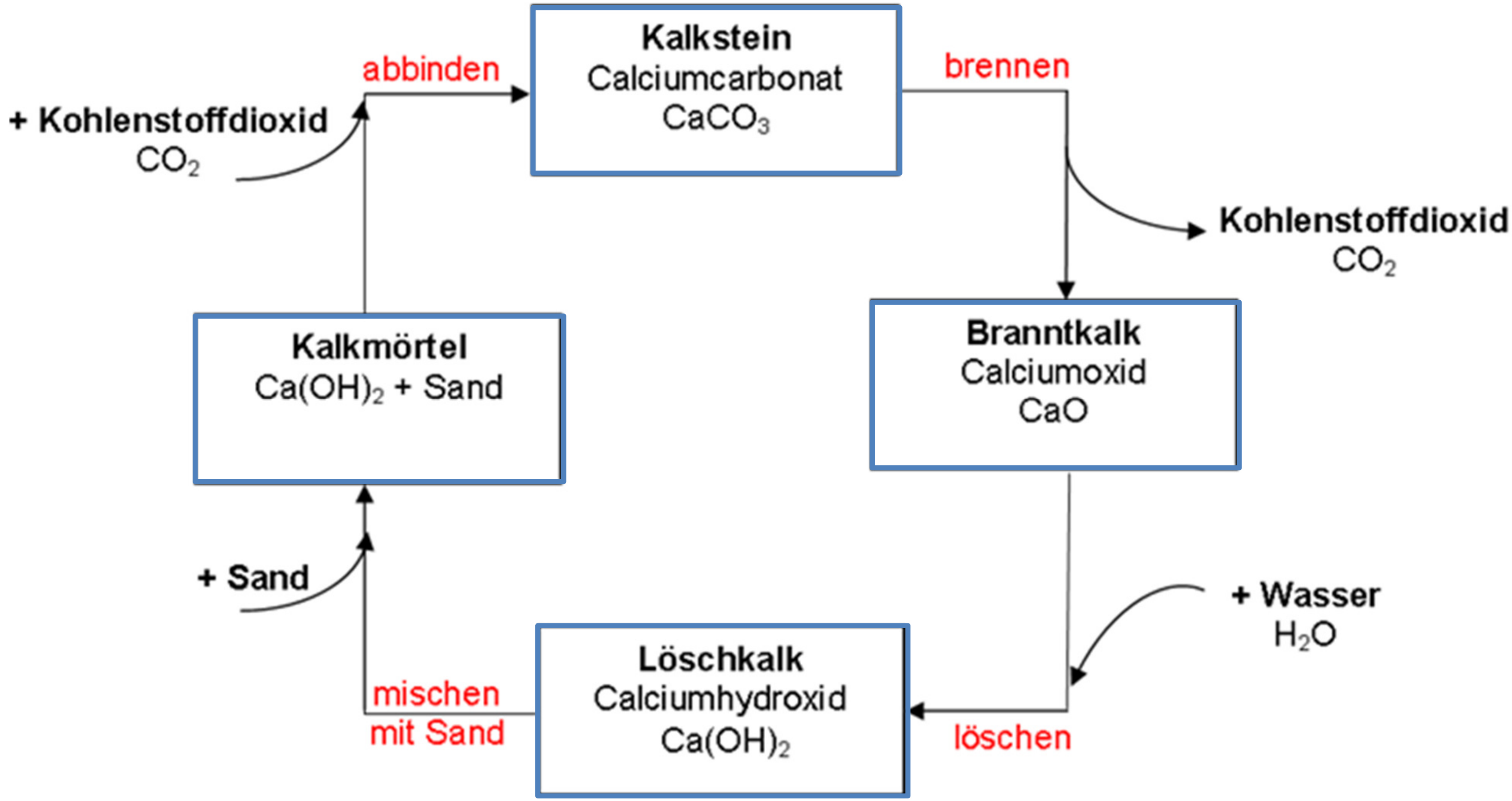
Bonding agent lime: The application for masonry

- **Merge:** Lime hydrate is being merged with sand and water to lime mortar.
- **Harden:** While applying the mortar Calcium hydroxide merges with CO_2 of the air to lime ($CaCO_3$ /Calcium carbonate).

  >> $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$
- **Bonding effect**: The fine needle like lime crystals mat in chemical bonding with the sand graines to a strong solid matter.

Caution: Calcium hydroxide is extremely caustic!

The technical lime circle



Graphic: Wikipedia

Properties and application of lime mortar

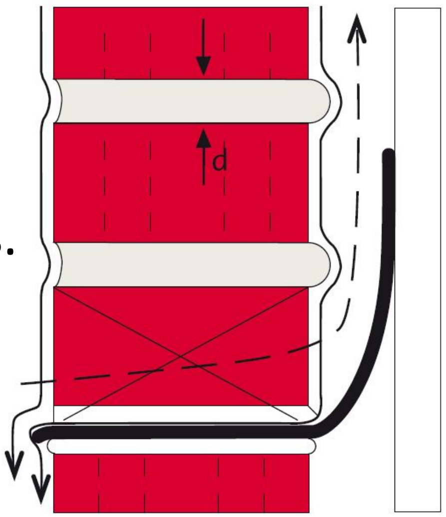
+	−
• Adequate for masonry with low compression strength • Well moisture regulating • Good indoor climate if applied as plaster • Good eco-balance: While bonding it re-absorbes the CO_2 that was set free durig the production	• Less compression-proof as cement bonded mortar

All about joints

Basic rule: The joint must be softer than the stone!

- Ideal mixing proportion of bonding agent to sand from **1:4 to 1:5.**
- Joints should ideally carried out applying the ‚smooth finishing method‘.
- Form a flat concave moulding into the joint.

  >> Use hereby a regular garden hose and draw it over the joint.
- **Control** the joints **every 5th to 10th year** and repoint broken ones.



Joint sealing applying the smooth finishing method ensures tightness of the masonry (robust and relyable method)

Graphic: backstein.com

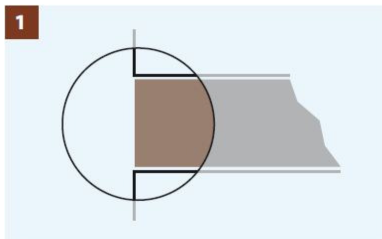
All about joints

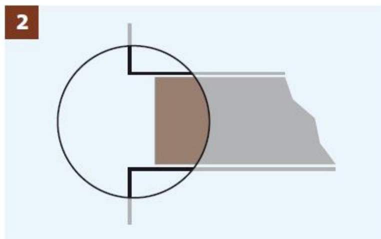
- The joint has got **constructive function** through covering and bonding of the stones >> Overlap gauge **≥ 0.4 ≥ 4.5 cm**
- **Colour and shape** of the joint has got strong **influence on overall image**
- **Two methods** of joint sealing

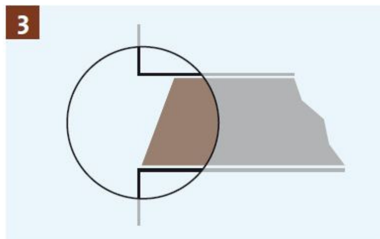
1 Joint sealing applying the **smooth finishing method**: Bricklaying and joint sealing in one step. Technically the best way.

2 + 3 Additional joint sealing: Butt and bed joints are scrachted out while bricklying and later sealed in an additional working step.





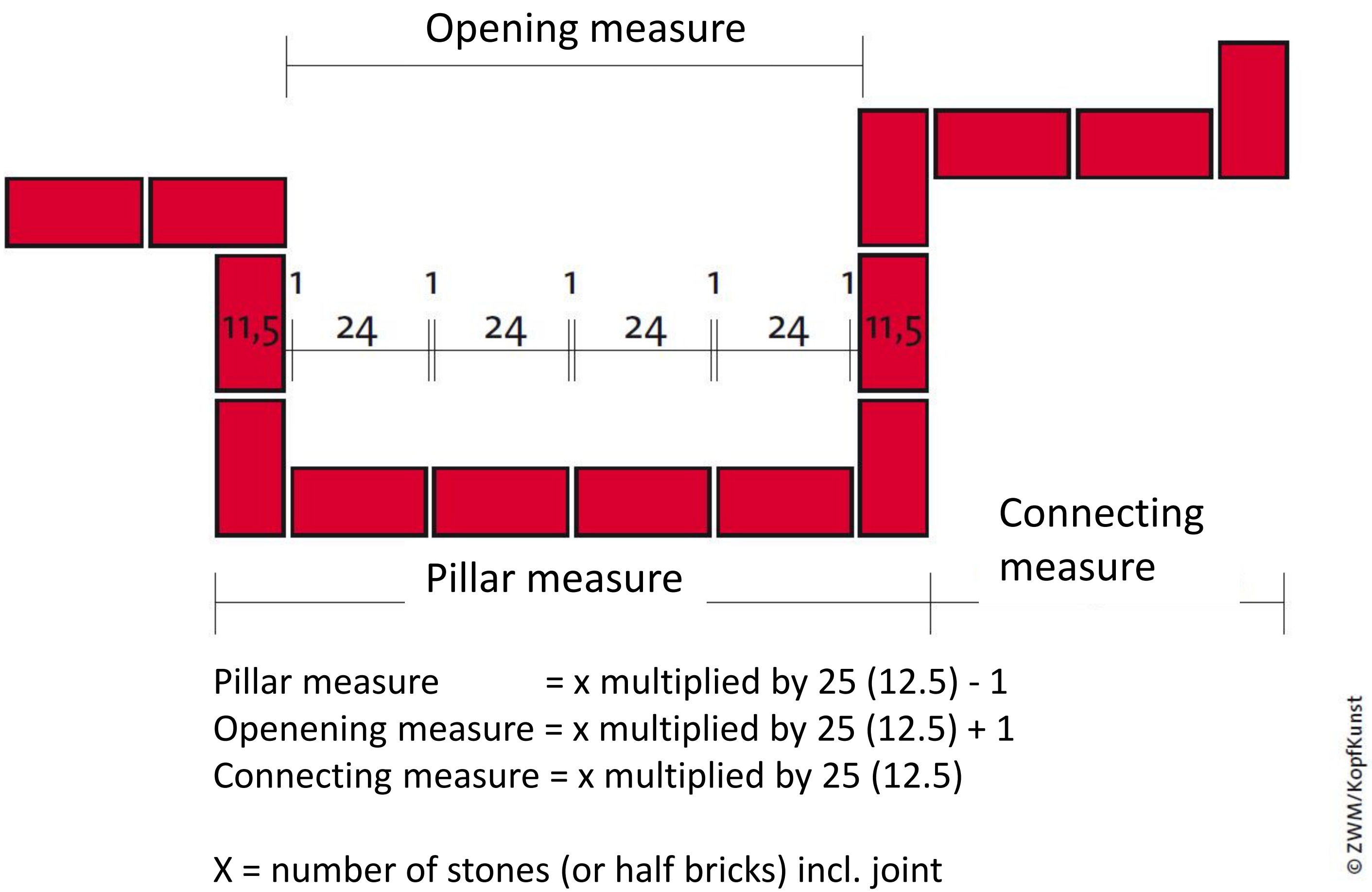


Graphics: backstein.com

The German ‚Reichsformat‘

- Common brick size in the German of the Wilhelmian times
- Launch of **‚Reichsformat‘** in 1872 by a law
- Measurements ‚Reichsformat‘ (today ‚Old Reichsformat‘): **25** cm x **12** cm x **6.5** cm
- **Metrical system** required **‚New Reichformat‘**
- Measurements of ‚New Reichsformat‘: **24** cm x **11.5** cm x **6.3** cm based on **octametrical system**
  >> brick length + 1 cm mortar joint = 1/8 meter-raster

The octametrical measure system



This measure system is based on a **12.5 cm module**:
Stone + mortar joint with **1 cm joint** = module-measurment.

Pillar measure = x multiplied by 25 (12.5) - 1
Openening measure = x multiplied by 25 (12.5) + 1
Connecting measure = x multiplied by 25 (12.5)

X = number of stones (or half bricks) incl. joint

Graphic: backstein.com

Further brick sizes

To avoid monotony there were further sizes in Northern Germany:

Oldenburger Format	22 cm x 10.5 cm x 5.2 cm
Kieler Format	23 cm x 11 cm x 5.5 cm
Hamburger Format	22 cm x 10.5 cm x 6.5 cm
Klosterformat	28.5 cm x 13.5 cm x 8.5 cm

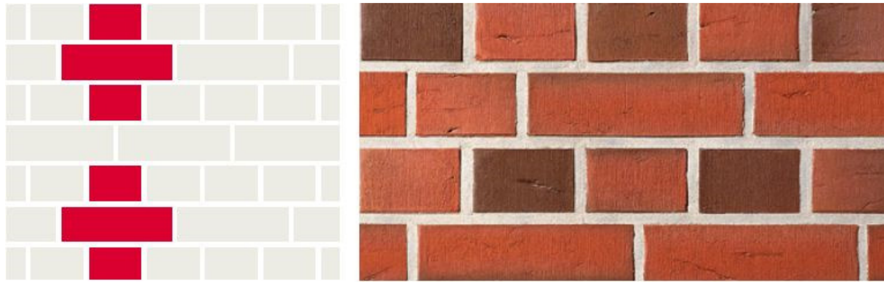
Why do you build in masonry bonds?

- To **transfer the strength** masonry has to be erected with **sufficient overlapping.**
- For a proper bond **all stones** must **have the same heigth.**
- The overlapping **avoids** the **disruption** of the bond because of tensile stress.
- We distinguish stretcher course and bond course.
- **Stretcher course**: Long side of the stone lies into alignment of the wall.
- **Bond course**: Narrow side of the stone lies into the alignment of the wall.

4. Bricks and bonds

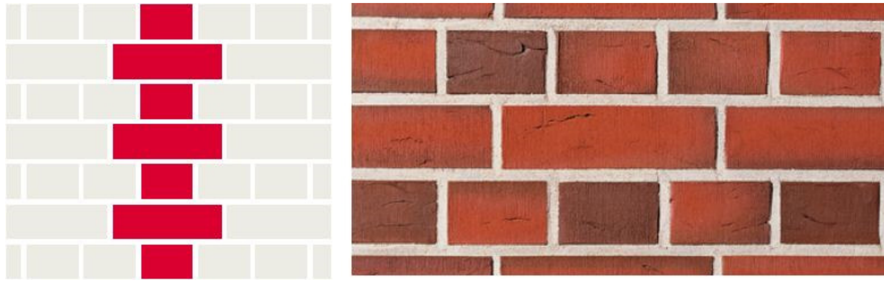
Crossbond

Stretcher and bond course alternate vertically. The butt joints of every 2nd stretcher course are shifted for 1/2 stone length.



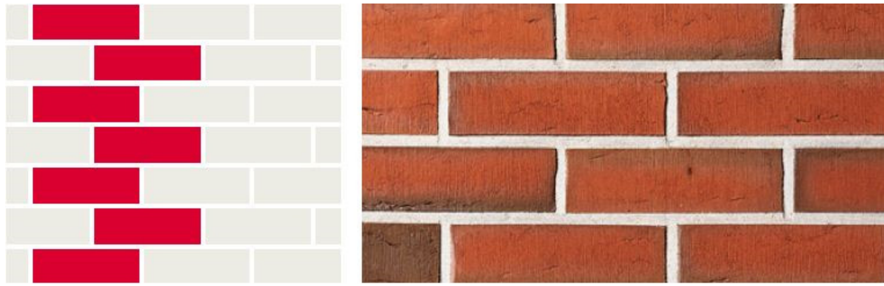
English bond (in German *Blockverband*)

Stretcher and bond course alternate periodically. The butt joints of all stretcher courses lie vertically one on another.



Stretching bond

All courses are composed of stretchers which are shifted from course to course for 1/2 stone length or 1/3 or 1/4 stone length.



Graphics: backstein.com/ZWM Kopfkunst

Binding bond

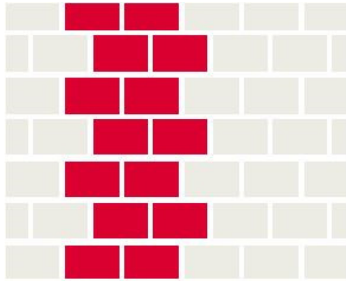
All courses are composed of Schichten bestehen aus binding stones which are shifted for 1/2 stone gauge. Thus lower load capacity.

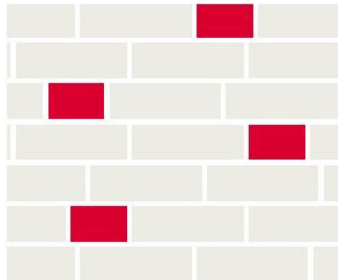
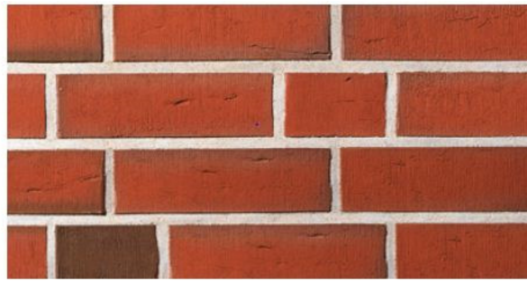
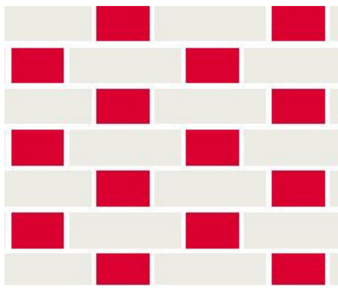
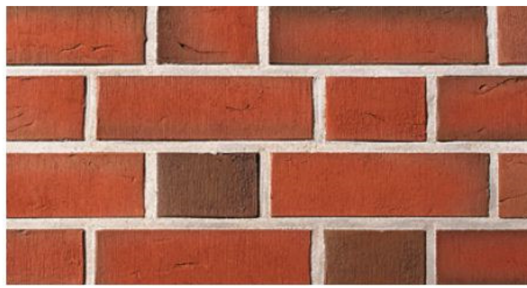
Wild bond

Very popular. Hereby the bond is erected without any order and often also with inordinate surface. Thus the image is very expressive.

Decorativ bonds

This bond is regionally applied. There are e.g. the Dutch bond, the Gothic bond or the ‚Märkischer Verband‘.
On the right it is a Flemish bond.



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