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Hazards in the construction industry

World at work: Bricklayers and bricklayers’ assistants

H F van der Molen, S J Veenstra, J K Sluiter, M H W Frings-Drenth

Spotlight on the construction industry

For ages people have been building shelters and houses using bricks and blocks bound together by mortar. As a result, the trade of bricklayer gradually evolved into what it is today. However, working methods, materials, tools, equipment, and workplaces may vary between workers, construction projects, and countries, leading to differences in health and safety risks.

In the Netherlands, codes of practice are developed for various professions in the construction industry aimed at reducing health and safety risks. These codes are based on consensus between health and safety experts, employers, and employee organisations. Recently, such a code of practice was developed for bricklayers. The facts presented here are based on that document or other sources as research studies, expert opinions, questionnaires, and interviews conducted with employers and employees. The risk assessments are compared with international standards and scientific literature. The aim of this paper is to give an overview of the tasks, health and safety risks, and control measures to reduce or eliminate hazards of the job and in the workplaces of bricklayers and their assistants.

Tasks of the job

Bricklayers are engaged in building and renovating houses, offices, and industrial complexes using bricks, blocks, and mortar. Each day the Dutch bricklayer handles some 800–1100 bricks or an average of 165–220 blocks. The bricks and blocks are delivered to the construction sites by truck, in packages or in bulk. The bricklayers’ assistant is responsible for the preparation and the transportation of materials and equipment to the actual workplaces. The bricklayer builds the walls by adding mortar and placing the bricks (one handed) or blocks (two handed) in their correct position. In general, one assistant works for two to five bricklayers. Over the years, bricklaying, transporting materials and equipment, and block laying have developed into three specialised professions, but combinations of them frequently occur. Table 1 shows the time spent on these different tasks by bricklaying teams working in the traditional way, handling bricks of 1.6–2.2 kg.

 Hazards of the job and in the workplace

Physical work demands and workload

At the work site, the most demanding task for the assistant in terms of physical work is the manual transportation of bricks, blocks, and mortar (the manual lifting and carrying of materials and pushing/pulling wheelbarrows for more than four hours every working day). For the bricklayers the most demanding task in terms of physical work is one handed repetitive lifting of bricks (1–6 kg with bended lower back for more than four hours per day) or two handed lifting of blocks (6 to >48 kg). Jäger and colleagues reported that an increase of the brick/block mass leads to an increase in the moment and compression curves of 20 Nm or 1 kN per 5 kg. Laiza and colleagues found an increased risk of low back pain (PR = 2.6) for workers laying large sandstones (7–10 kg) for at least two hours a shift compared with workers laying no such sandstones, while Sturmer and colleagues found that more than 10 years working as bricklayer increased the chance of low back disorders by 2.3 times (95% CI 1.2 to 4.5) compared with other construction workers.

Verstraten and colleagues reported an energetic workload index (VO2/VO2 max x 100%) of 35% for younger bricklayers (between 25 and 35 years of age) and 41% for older bricklayers (above 45 years of age). Internationally, a physiological limit for an eight hour working day varies, but generally 30–40% of VO2 max is thought to be acceptable.

Worldwide, bricklayers and bricklayers’ assistants experience musculoskeletal symptoms in one or more body regions more often than other construction workers. Table 2 shows the 12 month prevalences of musculoskeletal complaints among Dutch bricklayers and bricklayers’ assistants. The 12 month prevalence of sustained or regular lower back complaints is 45%, while shoulder and knee complaints are reported as second highest by 26%. The 12 month prevalences of any back and shoulder complaints in the Netherlands are consistent with the data reported in Sweden and the USA.

Toxic substances

Bricklayers are exposed to dust when sawing bricks/blocks or when mixing cement/glue. This dust may contain quartz. The highest dust concentrations will occur when working indoors. Short term exposures may exceed the Dutch threshold limit value for “inert” dust (10 mg/m3 for inhalable particles and 5 mg/m3 for respirable dust). The Dutch threshold limit value for respirable quartz dust (0.075 mg/m3) can be exceeded, especially when sawing blocks containing quartz indoors. In the Netherlands quartz dust concentrations of up to 0.2 mg/m3 have been measured when preparing and handling blocks. In the USA bricklayers are exposed to median concentrations of respirable dust and respirable quartz dust of 2.13 and 0.32 mg/m3 respectively. Long term exposure to high concentrations of quartz dust may result in silicosis. Moreover, quartz dust is considered to cause lung cancer in humans. In the Nordic countries an increased standardised incidence ratio of lung cancer (119; 95% CI 112 to 127) was found in bricklayers compared with a reference population of 53 occupational groups. The dust generated when handling insulation materials contains mineral fibres. In general, the applicable threshold limit value for the mineral fibres is not exceeded.

Mortar contains cement. Cement is alkaline and regular prolonged skin contact can result in skin complaints. Allergens that are present in the cement can cause allergic contact dermatitis. The prevalence of self reported skin complaints in Dutch bricklayers is estimated at 10.3%. In Finnish bricklayers an incidence rate of 3.44 per 10 000 working years was found for allergic contact dermatitis from chromium.

Noise

Bricklayers are exposed to noise caused by the equipment present in their environment, to impulse noise when positioning bricks and when chipping bricks to size, to noise caused by cutting bricks/blocks, and by work involving power tools (drilling, sawing, grinding). The European action limit of 80 dB(A)
may be regularly exceeded, which can result in hearing protection or insufficient hearing protection is used. Full shift personal exposure levels in Dutch bricklayers (n = 17) were measured as varying from <80 to 93 dB(A), with an average exposure level of 87 dB(A) (Veenstra, 1982, unpublished results). In Canada an average exposure level among bricklayers (n = 14) was reported of 90.8 dB(A).25

Vibration
People who work with grinders, drills, saws, or chisel hammers are exposed to hand/arm vibrations. Long term exposure to high levels of hand/arm vibration may result in "white finger syndrome" or damage to the wrists or other parts of the body. For most teams of Dutch bricklayers, average exposure levels are expected to be below the EU vibration guideline, in which the action limit for hand/arm vibration is 2.5 ms$^{-2}$ 2.2 In the United Kingdom, however, Palmer and colleagues27 reported high estimated doses (A(8)>5 ms$^{-2}$) in bricklayers and masons based on self reported exposures. This difference in exposure level may be due to different tasks performed by bricklayers in the two countries (for example, the use of a grinder or air hammer when cutting joints between bricks).

Climate
The work is conducted outdoors and partly indoors. Working outdoors involves exposure to cold or heat, wind, and rain. Indoors, exposure to cold and draughts may occur if the rooms are not fully glazed yet. This may lead to musculoskeletal complaints28 and colds. During the summer, and during sunny weather in particular, there is exposure to ultraviolet radiation, which may result in sunburn or eye irritation. Years of exposure may lead to skin cancer later in life.

Safety
Construction workers are at high risk of occupational accident.29–31 Various scenarios may result in accidents, such as bumping into something, tripping or slipping, being trapped by a swinging load, being hit by falling material or equipment or by a load falling from a crane, being hit by falling or collapsing scaffolding, or being trapped by a falling pile of stones or a toppling wheelbarrow. There is the risk of falling from floors or scaffolding, caused by missing railings or floor jams not being closed up or sealed off, or as a result of slipping off a ladder. There is also the risk of being injured when handling stones or blocks or when using power tools. Inadequate lighting hampers work and increases the chance of accidents.

In 2002 a total of 2380 work related accidents affected the 31 500 Dutch bricklayers. An estimated 59% of these occurred at the work site.24 Most accidents involving construction workers were caused by falling, sprains and strains, or hits by falling materials. Of all work related accidents, almost two thirds of those caused (temporal) disability for work.

Psychosocial work demands
Economic factors like recession, piece-work payment, scheduling, and production demands may tend to increase the pressure of work on construction workers.32 Time pressure (34%), insufficient involvement in work planning (17%), and poor day to day management (16%) are the main psychosocial demands perceived by Dutch bricklayers,22 and may therefore, represent a risk for health complaints or increase the chance of injuries.

MEASURES TO PROTECT WORKERS
Many consensus based recommendations have been reported in the literature to reduce or eliminate health and safety risks. However, the effects of these recommendations often remain unclear and controlled studies on intervention measures are scarce, particularly those on combinations of work demands and workload. Moreover, the knowledge about the effects of implementation strategies for the adoption of preventive measures at the workplaces is even scarcer. Both knowledge about effective measures and implementation strategies, might be conditional to reduce the health and safety risks at

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Bricklayer Mean (min) (SD) %</th>
<th>Bricklayers’ assistant Mean (min) (SD) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>49.6 (12.3) 18.4</td>
<td>40.0 (47.4) 14.8</td>
</tr>
<tr>
<td>Removing mortar</td>
<td>24.4 (9.3) 9.0</td>
<td>17.2 (9.8) 2.9</td>
</tr>
<tr>
<td>Consultation</td>
<td>2.6 (2.1) 1.0</td>
<td>11.6 (9.8) 4.3</td>
</tr>
<tr>
<td>Cleaning</td>
<td>2.5 (2.8) 0.9</td>
<td>7.7 (13.9) 2.9</td>
</tr>
<tr>
<td>Breaks</td>
<td>35.9 (4.9) 13.3</td>
<td>38.7 (7.3) 14.3</td>
</tr>
<tr>
<td>Intermediate task</td>
<td>1.1 (2.1) 0.4</td>
<td>1.8 (2.7) 0.6</td>
</tr>
<tr>
<td>Micro pauses</td>
<td>12.3 (11.5) 4.6</td>
<td>19.9 (12.3) 7.4</td>
</tr>
<tr>
<td>Transportation of materials</td>
<td>4.6 (4.1) 1.7</td>
<td>141.4 (60.1) 52.4</td>
</tr>
<tr>
<td>Other, undefined tasks</td>
<td>2.0 (1.5) 0.7</td>
<td>0.8 (1.1) 0.3</td>
</tr>
<tr>
<td>Total</td>
<td>270 100</td>
<td>270 100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No, never (%)</th>
<th>Yes, once (%)</th>
<th>Yes, regular (%)</th>
<th>Yes, sustained (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck</td>
<td>56</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>Shoulders</td>
<td>43</td>
<td>31</td>
<td>18</td>
</tr>
<tr>
<td>Lower back</td>
<td>21</td>
<td>34</td>
<td>35</td>
</tr>
<tr>
<td>Upper back</td>
<td>61</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Elbows</td>
<td>63</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Wrists/hands</td>
<td>61</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>Hips/thighs</td>
<td>68</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Knees</td>
<td>46</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>Ankles/feet</td>
<td>72</td>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>
Measures to reduce the physical work demands and workload

Lifting devices tailored for the workplaces of bricklayers, block layers, and their assistants are recommended for adjusting working height, mechanising block laying, and mechanising transportation of materials.\(^4\)\(^7\)\(^3\)\(^4\)\(^5\)\(^6\)\(^7\)\(^8\)

For advanced mechanical transportation of bricks (see fig 1), it is necessary to deliver bricks in subdivided packages. Devices can be used to supply bricks and mortar in an elevated position (see fig 2) to reduce bending by the bricklayer. To ensure that the predicted lumbar load during bricklaying remains below computed strength values, Jäger and colleagues\(^7\) advise that the brick supply be stacked higher than 50 cm. Meijer and colleagues\(^8\) found that greater working heights (30 and 50 cm) for picking up the bricks and mortar significantly reduced oxygen uptake up to 20% from the twelfth layer (±75 cm height of bricklaying) compared with a situation in which there was no adaptation in the storage height of bricks and mortar.

To stay below the NIOSH recommended weight limit,\(^9\) the weight of blocks lifted manually should be no more than 6 kg.\(^5\) However, De Looze and colleagues\(^9\) reported that peak compression was found to increase at higher brick/block weights but that no differences in time integrated spinal compression force were observed in four of five combinations of weight and frequency.

Table 3 lists all technical measures aimed at reducing the physical work demands of bricklayers. Most Dutch bricklayers are well aware of these measures, but the degree of use varies considerably throughout the Netherlands. Some measures are not widely used, such as an elevation for bricks and mortar tubs (26%), the electric wheelbarrow (15%), mechanical transportation of mortar (11%), and mechanical height adjustable scaffolding (4%), while mechanical transportation and mechanical positioning of blocks (see fig 3) are reported to occur frequently or always by 58% and 47% respectively.

Measures to reduce exposure to toxic substances

A combination of three measures—using gloves, good hygiene, and skin care—reduces the risk of skin damage caused by cement. To prevent allergic eczema through chromium in cement/mortar, EU legislation sets a limit of \(0.0002\%\) soluble chromium in cement.\(^4\) Skin contact with insulation material can be reduced by the use of mineral wool wrapped in foil and by avoiding the cutting and trimming of insulation material. Close-fitting clothing prevents the skin being exposed to the material.

Dust exposure caused by manual mixing of mortar/glue can be largely avoided by mechanical feeding and mixing of mortar or glue components. When carrying out work at eye level or above head level, facial exposure to mortar and glue can be avoided by wearing a cap and a face shield. Exposure to quartz can be reduced in various ways: use of materials containing little or no quartz, limiting the amount of sawing work by having the blocks supplied already cut to size, or using tools with water supply or local exhaust ventilation. When these measures are insufficient the use of respiratory protection may be necessary.

Measures to reduce exposure to noise and hand/arm vibrations

Noise levels can be reduced by replacing old and noisy machines by new more silent equipment. However, in the case of handheld tools such as drills and saws, the amount of reduction is limited. It is even more difficult to reduce impulse noises caused by handling or hitting bricks. Therefore, the action limit for harmful noise (80 dB(A) for an eight hour working day) may be exceeded and hearing protection should be worn.
Mechanical lifting of blocks.

To prevent health complaints such as “white finger syndrome” or joint problems resulting from exposure to hand/arm vibrations, working with drills/mixers, saws, pneumatic hammers, or grinders should be reduced to 0.5–1 hour per day. Job rotation can be used to reduce the exposure time.

Measures to protect against climate

Measures to protect against the adverse influence of the weather include personal protection (for example, adequate working clothes, hats/helmets, gloves, shoes, sun creams), work planning and organisation (for example, starting in the shadow, working-rest schedules, clearing snow and ice from ladders and scaffolding), covering or screening workplaces (for example, placing windows or roofing with plastic materials), and equipment and facilities (for example, temporary heating or cooling, drying places for clothes). However, a survey among painters working behind screening showed more complaints about the climate than in a reference population of all painters. Moreover, lighting, views and ventilation could be improved.

Measures to increase safety

To prevent unsafe work situations, a safety plan and prescriptions are thought to be conditional. Table 4 lists the measures, technical and otherwise, for improving safety at the work site. These measures should be part of the safety plan adopted by the bricklaying companies. On a national scale, these measures are best promoted industry-wide, for instance, through labour-management organisations. Schneider and colleagues argued in favour of supplementary legislation in this respect. Labour inspectorate (USA) or covenants (the Netherlands) are examples of supplementary legislation to assure widespread adoption of safer and less risky work practices.

Measures to reduce psychosocial work demands

Certain trends and developments in the construction industry (for example, improved logistics, multifunctional teams, educational programmes, and certification) may help to reduce time pressure and to improve the perceived or actual involvement of bricklayers and their assistants in work planning.

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