Technological Application Features of Brickwork Bonding Types

Pavel Medvedev 1, Evgeniy Pugach 1, Pavel Gaidukov 1

1 Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia
iydkngkhtgyn@icloud.com

Abstract. Purposes of research are the following: investigation of aspects affected application of different brickwork bonding types, and description of using traditional bonds in Russia and offering more effective analogues for them. They are many different brickwork bonding types now and have different characteristics: constructive, technological and architectural. But they are using just a few of them in Russia, despite the fact that some types are more technologic than others. Principal cause of this problem is researching lack of this theme. It is necessary to analyse technologic features of different brickwork bonding types and determinate their characteristics including the technical-economic indexes. The research results are set below. The constructions built with using English bond have lower longitudinal stiffness than the same ones raised with using Flemish bond. The main reason is the Flemish bond has square of bonded section larger than English one. Professor Onishik’s bond is more technologic. It is connected with the fact that Scottish bond needs a half bats as opposed to Onishik’s one. It excludes brick splitting that makes bricklaying process less labour-consuming. Using a Rat-trap bond for building a self-supporting constructions more effective and economically, than using English or Scottish ones. It is depends on a smaller quantity of bricks and technologically necessity, and needs less time to get finished constructions. Major conclusions are the following: the information lack on different types of brickwork bonding makes process of choosing optimal decision. Possibility of using non-typical brickwork bonding types allows to correct technical-and-economic indexes (labour hours and materials intensity) with saving all functions and quality of construction. Continuation of the researching of brickwork bonding types is necessary because of using unexplored bonds can make building processes more effective.

1. Introduction
Different principle of bricks laying are put relative of each other in emerged space during the masonry time progress. This type of process is named bond. There is large quantity of different bond types which have unique characteristics – constructive, technological and architectural – now. But only some of them are using now in national practice. Nowadays the topic lack research is preventing spreading of some other bond types. The most recently it has included the information about different types of brick bonding, named as “Catalogue of brickwork bonding types of masonry”, published by MosOrgStroy in 1974 [1]. This catalogue consists of possible drawings variations of brickwork bonding and excludes their characteristics and technological application features. There is no similar information in previous technical manuals such as “Project manual of new brickwork bonding types”
and “Brickwork Bonding Types. Methodical Manual for laboratory works” [3]. The named above publications content only overviews and exclude the analysis of advantages and disadvantages of different bonds. Some foreign sources include information of different brickwork bonding types.

However, they are not informative or actual, as well. “The Builder’s Pocket Manual; Containing the Elements of Building, Surveying and Architecture; with Practical Rules and Instructions in Carpentry, Bricklaying, Masonry &c” [4] by A.C. Smeaton was published in London in 1837, and contents of English and Flemish bonds description and comparison. The “Building Construction. Part 1. First Stage or Elementary Course” [5] written by C.F. Mitchell expands the description of English and Flemish bonds and their subtypes. “A History of English Brickwork” written by N. Lloyd in 1925 contents the historical and architectural aspects of brickwork bonding types. The “Brick Building in Britain” by R.W. Brunskill describes different types of non-traditional bonds. All of these publications content constructive and architectural aspects and lack characteristics technological makes these works similar. J. Nalimansi and G. Mwesige published “Determining Productivity of Masons for both stretcher and header Bonding on Building Sites” [8] in 2011. This title describes labour hours and changing of mason’s productivity during a day for 2 bonds only. By reason of different technological aspects between traditional and non-traditional types of bond, this labour hour is useful for calculations all masonry labour costs.

2. Materials and methods

The analytic method should be used for technological application researching features of brickwork bonding types. The traditional bonds types were compared to non-typical bonds, used in one construction type. There are constructive and technological parameters of different bonds in bearing and self-bearing walls researched.

3. Technological features of bonds

English (or “one-lined”, “chained”) bond is one of the most widespread in Russian building. This feature type is an alternating of stretching course per heading course. It has advantages over the Scottish (or “American”, “five-line”) bond (strength is larger, front of English bond more pretty), but its longitudinal stiffness is lower [9]. Increasing of bonded section square with changing sequence of bricklaying could be made longitudinal stiffness higher. Replacing English bond by Flemish is one of ways of manage ways of it. (figure 1).

Courses alternate of mixed headers and stretchers is feature of Flemish bond [7]. This bond has larger bonded section square and increase longitudinal stiffness of walls. Labour hours of Flemish bond is equal to the labour hours of English one. This depend on the fact that both of them have one quantity of header and stretchers in m³ (Table 1).

Scottish bond is widespread, as well. Its advantage over other bonds is high workability because it has 5 monotonous stretcher courses. But this bond type is not perfect cause it needs the brick cutting for laying the corners. Brick cutting increase labour hours and make building process less technologic. One of the ways to manage that is using the Onischik’s bond (figure 2). Main feature of that brickwork bonding type is not necessary bonding corner headers and stretchers. Wall front could content coincident commissures [10]. Application of this bond makes the building process more technologic and decreases the labour hours and time of building.
Bonds are used for building bearing and self-bearing wall are the same despite the fact that self-bearing walls need less strength then bearing walls. It is advantageous to use the more technologic and less material intensity bond with minimum required strength for bricklaying of self-bearing walls. Example of that bond is rat-trap bond (figure 3) [6]. Its feature is using of shiners and rowlock bricks and air cavity inside that provides less material intensity for 20% and time of building. This air cavity increase acoustic absorptivity of walls and there is no need for room audio correction.

English and Scottish bonds are traditionally used for front veneer. The quantity of headers that have small front square is large, and it increase number of brick that makes front veneer too expensive. There is one more reason for using less quantity of headers - headers provide large part of brickwork strength [10], but front veneer doesn’t need a big strength. It is advantageous to use bond that have more stretchers then headers. One of that bond is “Variant 7” (figure 4) from the “Catalogue of brickwork bonding types of masonry” has been published by Mosorgstroy trust [1]. Its main features are large quantity of stretchers with small number of headers that form pattern on the wall front. That bond is more technological cause it doesn’t need to change brick orientation often, that decrease time for building.

4. Results and discussions

Flemish bond should be used for buildings with higher requirements of spatial rigidity. This bond usage provides larger longitudinal stiffness than other ones. Application of Flemish bond is advantageous for higher wind loaded brick buildings.

Onischik’s bond should be alternative for Scottish one in bearing walls. It is advantageous because its labour hours are less than Scottish’s. The number equivalent is 2.96 h.h./m³ and 3.2 h.h./m³ respectively.

The rat-trap bond should be used for self-bearing walls buildings. The main reason is so, that its labour hours and material intensity are 2.93 h.h./m³ and 318.4 bricks/m³ respectively. This is less than English’s - 3.2 h.h./m³ and 398 bricks/m³ respectively. The air walls cavity built with usage that type o bond makes the walls more acoustic absorptivity. That bond should be used in rooms that are used for high noise processes, as shooting galleries, sound-recording studios, etc.

Variant 7 should be used for front veneer making. It is more advantageous than using traditional bonds for this role (English and Scottish), because its labour hours is 3.1 h.h./m³ and less than English’s or Scottish’s 3.1 h.h./m³.
Table 1. Functions and technical-economic indexes of brickwork bonding types

| Characteristics                      | English | Flemish | Scottish | Onischik’s | Rat-trap        | Variant 7        |
|--------------------------------------|---------|---------|----------|------------|----------------|-----------------|
| Function of construction             | Bearing walls | Bearing walls | Bearing walls | Bearing walls | Self-bearing walls | Self-bearing walls |
| Maximal height of wall               | 4.2     | 4.2     | 4.2      | 4.2        | 3.6            | 3.6             |
| Maximal quantity of floors           | 9       | 9       | 9        | 9          | -              | -               |
| Lay technic                          | Buttered joint | Buttered joint | Buttered joint | Buttered joint | Shove joint     | Buttered joint |
| Changing of brick orientation during the bricklaying process | No | Yes | No | Yes | Yes | Yes |
| Brick cutting                        | Yes     | Yes     | Yes      | No         | No             | No              |
| Work instruments                     | Trowel, brick layer's hammer, mortar shovel, brick jointer |
| Testing instruments                  | Bricklayer’s gauge, bricklayer’s string, perpendicular, level |
| Bricklayer’s qualification           | 4- class | 4- class | 4- class | 4- class | 4- class | 5- class |
| Brigade type                         | 2 bricklayers |
| Labour hours                         | 3.2     | 3.37    | 3.2      | 2.96       | 2.93           | 3.1             |
| hours/m³                             |         |         |         |            |                |                 |
| Material intensity, bricks/m³        | 398     | 389.4   | 398      | 398        | 318.4          | 398             |
| Compressive strength, MPa            | 3.47    | 3.4     | 3.4      | 3.35       | 3.16           | 2.72            |

5. Conclusions
The information lack on the brickwork bonding types prevents the selection of optimal way process. The ability usage of non-typical bonds allows us to correct technical-economic indexes and materials intensity with saving functions and construction quality.

References
[1] Mosorgstroy Trust. Katalog system perevyazki v kirpichnoi kladke [Catalogue of brickwork bonding types of masonry]. Moscow, Pechatnik, 1974. 72 p.
[2] Central Bureau of Building Industry Standardisation of Central National Research Institute of Building Technologies. *Instrukciya po proektirovaniyu novykh sistem kirpichnoi kladki* [Project manual of new brickwork bonding types]. Moscow, ONTI, 1937. 42 p.

[3] Andreev B.K. *Perevyazki kirpichnoi kladki. Metodicheskoe rukovodstvo k provedeniyu laboratornyh rabot* [Brickwork Bonding Types. Methodical Manual for laboratory works]. Moscow, MIIT, 1965. 26 p.

[4] Smeaton A.C. *The Builder's Pocket Manual; Containing the Elements of Building, Surveying and Architecture; with Practical Rules and Instructions in Carpentry, Bricklaying, Masonry &c.* London, Gresham College, 1937. 273 p.

[5] Mitchel C. F. *Building Construction. Part 1. First Stage or Elementary Course.* London, B.T. Batsford, 1889. 194 p.

[6] Lloyd N. *A History of English Brickwork.* London, Antique Collectors Club Dist, 1925. 464 p.

[7] Brunskill R. W. *Brick Building in Britain.* London, Weidenfeld & Nicolson, 1997. 208 p.

[8] Nalumansi J., Mwesige G. Determining Productivity of Masons for both Stretcher and Header Bonding on Building Sites. *2nd International Conference on Advances in Engineering and Technology Nagapattinam.* Nagapattinam, 2012, pp. 339-345.

[9] Bedov A. I. *Proyekrirovanie kamennyh I armokamennyh konstrukciy* [Designing of Brickwork and Reinforced Brickwork]. Moscow, ASV, 2003. 121 p.

[10] Onischik L.I. *Kamennye konstrukcii* [Brickwork constructions]. Moscow, Stroyizdat, 1939. 208 p.