The destruction of buildings walls brickwork on an unevenly deformed base

O Kichaeva\textsuperscript{1,3} and O Dobrokhodova\textsuperscript{2}

\textsuperscript{1} Soil Mechanics, Foundations and Engineering Geology Department, O.M. Beketov National University of Urban Economy, Marshala Bazhanova str. 17, 61002, Kharkiv, Ukraine
\textsuperscript{2} Engineering Geodesy Department, Kharkiv National University of Construction and Architecture, Sumska str. 40, 61002, Kharkiv, Ukraine
\textsuperscript{3} Email: o_kichaeva@ukr.net

Abstract. The article is dedicated to the analysis of the results of experimental testing of brick structures resistance. The experimental testing aimed at revealing a qualitative pattern of deformation and the character of losing the bearing capacity of a system “brick beam-wall – deformed base” and obtaining quantitative data about the strained and deformed state of the system undergoing short-term force and deformation at all stages of loading. Revealing the structure and phases of deformation and destruction of brickwork subjected to the increasing loading and the construction of dependences “loading – deformation” corresponding to the process of brickwork deformation and destruction was also an important task. It has been proved that the mechanism of the destruction of brick structures walls fragments, supported by uneven deformed base, occurs according to the scheme of shear, cut and breaking to pieces, as well as destruction of brick material and mortar with clear determination of deformation stages and brickwork destruction. The results of analysis of the experiments allowed to determine the influence of the amount of loading acting on cracks formation and brickwork functioning as a whole.

1. Introduction
Field testing of a brick wall was carried out on a single-span fragment of a building with the dimensions $1.68 \times 1.52$ m ($l \times h$) and thickness – 250 mm. A special stand, consisting of a tested object, a loading system and a measuring system, has been worked out for the experiment (Figure 1). A calculation scheme – beam-wall with two slots on a stationary support is subjected to evenly distributed loading; in this case the loss of stability of the first type – state stability is excluded [1, 2]. Three construction models of a beam-wall have been made for experimental testing of the interaction of the system “brick beam-wall – deformed base” [3, 4].

Simulated uneven base was created using a wall fragment resting on the layer of a wood-chip board (WCB) 30 mm thick:

- for a wall fragment (WF) – 1 for the value, equal approximately to 1/3 of the total length of the wall fragment (0.3$l$);
- for WF-2 – for the value, equal to 2/3 of the length (0.64$l$);
- for WF-3 – resting of two boundary sections of the wall on WCB 0.3$l$ of the total length of the wall fragment (Figure 2).
2. Discussion

When we analyzing the diagrams of the dependence “loading – relative deformations” for testing brick structures, obtained in the course of experiments, one can single out the following deformation phases:

1) a phase of elastic deformation of a sample where the dependence is close to linear;
2) a phase of plastic deformation in the form of non-linear dependence “loading – deformation”.

As the interval of loading is different for different brick structures, the correlation \( N/N_u \), where \( N \) – is the value of applied loading, \( N_u \) – destruction loading, has been taken as the limit criterion between the first and the second phases [5]. When the mechanic characteristics of a brick and mortar are similar, the loading level causing the phase of plastic deformations, is in the range 0.5-0.6 \( N/N_u \).

The process of deformation and destruction of brickwork in structures of walls samples as beams-walls on the uneven base consists of the following stages:
- the stage of elastic deformation;
- the stage of the formation of local zones of destruction (micro-destruction);
- the stage of increasing the volume of micro-destruction under increasing loading [6];
- the stage of the formation of a macro-destruction zone, characterized by the process of combining local destructions into through main cracks;
- the stage of increasing damage, after which a sample transfers to the destruction stage [7].

![Figure 1. General view of an experimental installation WF-3.](image)

On the results of experimental testing of brick walls fragments resting on materials with different modular, the following mechanism of brickwork destruction has been formulated.

1) The destruction occurs under the influence of stretching strains, acting in parallels with horizontal mortar joints. In this case brickwork destruction occurs in the plane perpendicular to the horizontal joints and passes along the vertical joint (Figure 3, a, b). Such type of destruction can be classified as a shear of a brick itself from the mortar stone.

2) The destruction occurs according to the scheme of cut along the plane, which is perpendicular to the horizontal joint and passes along the plane of a vertical joint, in this case cross sections of bricks and a vertical joint are included into the sphere of destruction. It has been determined that destruction may...
occur both on mortar joints and on bricks (Figure 3, c, d, e). The character of cracks is through; the destruction occurs on a stepped section [8].

3. Results

The following types of destruction mechanisms occur: shear destruction, cut destruction, breaking destruction, brick material destruction, mortar material destruction. A model, taking into account the parameters of crack formation in the structure because of the change of loading level, has been proposed. The model corresponds to the existing 4-stages model of crack formation [9, 10, 11].

We will construct diagrams of dependences of the width of cracks opening ($w_k$), cracks length ($l_k$) and density of cracks propagation ($d_k$) and the stages of loading (correlation $N/N_u$). They are presented in Figure 4.
Analyzing the results of the experimental testing of beams-walls one can make up a table, connecting the category of a technical state with the loading stage (Table 1).

**Figure 4.** Diagrams of the dependence: a - \( w_k \) from \( N/N_u \), b - \( l_k \) from \( N/N_u \), c - \( d_k \) from \( N/N_u \).
Table 1. The connection of loading stages with the category of technical state of brick beams-walls.

| The category of technical state | Defects and damages | $N/N_u$ | Values of acting loadings |
|-------------------------------|---------------------|--------|--------------------------|
| 1                             | No defects and damages | 0.1-0.15 | $N < N_{cr}$ |
| 2                             | Appearance of cracks with the opening width $\Sigma w_k = 1.5$ mm, $\Sigma l_k = 0.2$ m, $\Sigma d_k = 0.1$-0.15 m/m² | 0.15-0.3 | $N = N_{cr}$ |
|                               | Development of the existing cracks and appearance of new ones; $\Sigma w_k = 3$-5 mm, $\Sigma l_k = 1.2$ m, $\Sigma d_k = 0.6$ m/m² | 0.3-0.8 | $N_{cr} < N < N_u$ |
| 3                             | Appearance of cracks. Division of the structure into separate blocks; $\Sigma w_k = 6$-8 mm, $\Sigma l_k = 1.5$-1.7 m, $\Sigma d_k = 0.93$ m/m² | 0.8-1.0 | $N = N_u$ |

4. Conclusions
In the course of the experiment it has been proved that:

1. Brickwork destruction occurs according to the scheme of shear, cut, breaking, as well as destruction of brick and mortar materials.

2. The process of brickwork deformation and destruction in structures of samples of bricks consists of the following stages:
   - the stage of elastic deformation;
   - the stage of local destructions appearance (micro-destruction);
   - the stage of increasing volume of micro-destruction under the influence of increasing loading;
   - the stage of macro-destruction appearance, characterized by the process of combining of local destructions into through main cracks [12];
   - the stage of damages increase, after which an experimental sample transfers to the destruction phase stage.

3. In the elastic phase brickwork is deformed as monolithic composite material, in this case mechanic characteristics of base materials describe this phase rather strictly.

4. The model of brickwork functioning, taking into account the parameters of crack formation in the structure because of loading change, corresponds to the taken 4-stages model of crack formation.

5. The dependences of the technical state parameters – the width of cracks opening, cracks length and density of cracks propagation on the level of loading have been determined.

6. A table, connecting the category of the technical state of brick beams-walls, resting on non-homogeneously destructed base and the loading stage, has been made up on the results of experimental testing [13].

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