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MAIN CHARACTERISTICS OF 11TH-15TH CENTURIES BRICKS FROM MONUMENTAL BUILDINGS OF THE PECHERSK MONASTERY IN KYIV

Abstract. The relevance of the proposed work lies in the fact that the powerful collection of building materials has been assembled in the scientific funds of the National Preserve „Kyiv-Pechersk Lavra” over a 100-year history of archaeological research into architectural monuments from the 11th-15th centuries (the Dormition Cathedral, chapel of St. John the Baptist, Trinity Gatech church, a brick refectory, and a stonewall from the 12th century). It consists of bricks (plinths), ceramic tiles and stone floor slabs, roof tiles, glass hutters, frescoes, mosaics, samples of stones and solutions, marble decorative elements, etc. Among the most massive and informative materials is a plinth. The study of its characteristics and historical and cultural significance is aimed at acquiring a body of knowledge about building materials. M. Kholostenko, G. Ivakin, O. Syromyatnikov, and D. Jolshin were engaged in the study of bricks from the Pechersk monastery. However, no generalizing work on construction materials of the 11th-15th centuries of these monuments of ancient Kyiv has been carried out till now.

Keywords: Kyivan Rus', plinths, architecture, Pechersk monastery.

INTRODUCTION

Kyiv of the princely era was the capital of the state and one of the best developed cities in Eastern Europe. After the adoption of Christianity in 988, the city's first monumental constructions of religious and civil purpose emerged. They were built by Byzantine masters who also introduced their construction technologies, including the production of bricks (Ivakin, Ioanisian, Jolshin and Lukomskiy 2010, p. 73). This building material was known in ancient Greece and Rome. Plinth (plintha, plinth, from Greek “plate”) – a wide flat fired brick, which, along with stones, served as the main material for the construction of building walls in Byzantium (Fig. 1). Due to the multilevel production, this construction material was relatively expensive. The brick production technology has its peculiarities and differs from other ceramic production. Raw materials for brick were refractory and

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hydrophilic sorts of potter clay. These properties have influenced the quality and structural integrity of the building materials. The masters carefully prepared the clay mass by cleaning it, soaking, and dissolving (Fig. 2). Special impurities (fractions of small quartz stones or shredded pieces of fired clay) were added for structural strength. Special wooden forms-frames were used to shape the bricks into rectangles or forms.



According to written and archaeological sources, more than 50 monumental architectural buildings from the late 10th- the early 13th century are known in today's Kyiv (Koziuba 2010, p. 238). Plinthis were used in the construction of all of them. Most of these monumental architectural buildings are city temples and monasteries. According to various sources, there were almost two dozen of them in Kyiv, half of them located outside the city. These are Pecherskyi, Spaskyi, Kirilovskiy, Klovskyi of Saint Mary of Blachernae, Vydubyskyi of St. Michael, Hnyletsykyi, and other monasteries.



Pecherskyi Monastery was the greatest religious complex in Kyivan Rus'. The written sources date its foundation back to 1051. The Virgin Assumption (the Great Pechersk Church, Dormition (Assumption) Cathedral) was established in 1073. According to "Kyiv-Pechersk Paterik", Greek masters from Constantinople were invited to build the temple. The cathedral was completed in 1075, but the decoration and consecration were not completed until 1089.

In several years, on the north side of the Great Pechersk Church, a small chapel (church) of St. John the Baptist was built (Kholostenko 1976, p. 131). At the same time, around the cathedral was completed a monastic complex with wooden cells for the monks, household buildings, and the fencing. During the 12th century, the architectural ensemble of the monastery was completed with a stone refectory, the main gate – with the Trinity church above it, and at the end of the century, a massive new fence appeared.

In the production of bricks for monuments in the central part of Kyiv late 10th – first half of the 11th centuries, a separable frame with a wooden bottom was a typical solution. At the same time, in the production of the plinthis for monuments of the 11th-13th centuries, including the Pechersk monastery, fixed wooden frame moulds were used, bereft of the bottom. This brick bears traces of its bottom being laid on the ground, grass or hay (Table 1. 5). The excess of clay was removed using the "pravlyo" – a special wooden knife for levelling the upper surface of the bricks. This instrument left small longitudinal traces of the stretching of solid impurities in the clay mass on the top of the bricks (Table 1. 3). Due to the structure of the frame, the plinthis had to be shaken out of it while semi-raw (Table 1. 6). Therefore, often vertical clay sides remained on the upper brick surface, along the contour of the brick, called "zakrainy" (Table 1. 1). In addition to these traces from the moulds, traces of correction of the external defects of the upper surface made by the masters have been recorded. In particular, after making a brick in a bottomless mould, part of the clay at the bottom went outside beyond

Table 1. Technological traces on the bricks of the ancient monumental monuments of the Pechersk monastery

№	The types of the technological traces
1.	<p data-bbox="547 369 805 396">“Zakrainy” (vertical clay sides)</p> 
2.	<p data-bbox="399 897 950 924">Part of the clay at the bottom which went outside beyond the limits</p> 

3.	<p data-bbox="258 243 1092 265">Small longitudinal traces of the stretching of solid impurities in the clay mass on the bed of the bricks</p> 
4.	<p data-bbox="619 842 731 864">Traces of rain</p> 

the limits (Table 1. 2), so there are traces of cutting thereof with a knife. Also, from time to time, the masters tried to cut the “zakrainy» with a knife or to press them with a frame after the brick was taken out of the mould. As a result, the excess liquid clay flowed down the headers of the brick, forming “naplyvni bortyky (‘‘hanging sides’’))». There are traces of the levelling of the surface with fingers, and traces of the rain on the bricks from the Pechersk Monastery’s ancient architectural monuments (Table 1. 4).


5.	<p data-bbox="564 533 786 556">Deformation of the plinthoi</p> 
6.	<p data-bbox="577 1133 774 1157">Traces of semi-raw clay</p> 



Fig. 1. Kyivan plinthoi

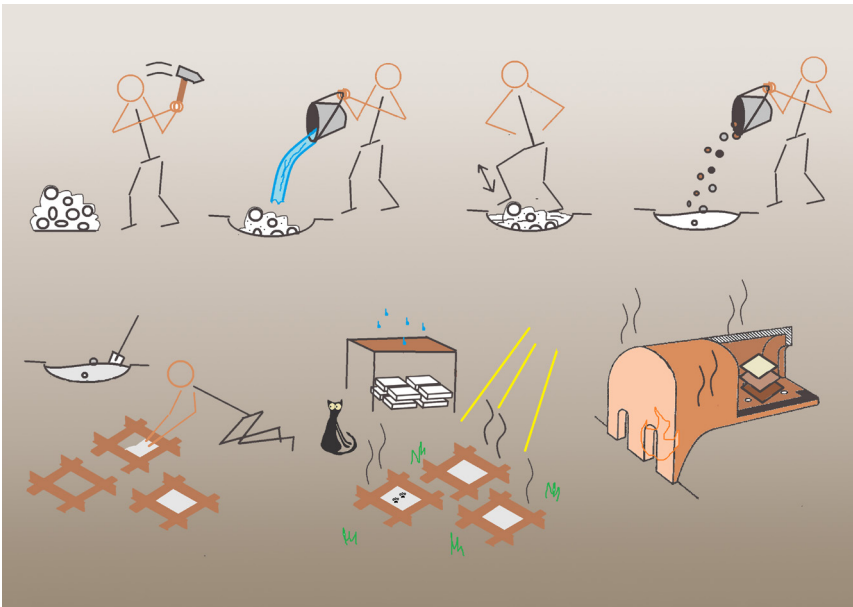


Fig. 2. The process of the making plinthoi

THE METHODS AND METHODOLOGY OF THE RESEARCH

The main characteristics of the plinthois from the second half of the 11th-12th centuries became known after many years of research into the samples of ancient bricks in Kyiv. These studies have always attracted the attention of historians of the architecture of Kyivan Rus'. The interest in the scientific potential of plinthoi grew in the first half of the 20th century, with the publication of the first works on the study of ancient construction machinery and building materials. The studies were carried out by V. Suslov, I. Khozerov, M. Baklanov, V. Stasov, V. Hvojka, S. Polyanskiy, V. Gese (Beliaev 1982, p. 10). I. Antipov proposed to divide the general history of the research into Kyivan Rus' bricks into three periods: 1940-1960, 1960-1980, 1990 – to present days (Antipov 2003, p. 124-129).

The research into the peculiarities and typology of the Kyiv plinthois was carried out in the general context of the development of plinthology. It attracted a lot of attention because Kyiv was the centre of the development of the monumental architecture of the princely era. The plinthoi production technology spread from here to other territories of Kyivan Rus'. So, research into the Kyiv plinthoi production directly affects the general study of building materials in the 11th-13th centuries. The difference in forms, sizes, and appearance of the bricks had been noted during the archaeological research in the second half of the 19th century. This allowed accumulating in archaeological reports the first knowledge about the size of Kyiv plinthois.

M. Karger was one of the first to pay attention to the importance of studying bricks in Kyivan Rus' and their formation (Karger 1961). Before WWII, the researcher excavated the local ancient architectural monuments, began to collect data and systematize the information about the Kyiv plinthois. WWII influenced the development of research on the building materials in Kyivan Rus'. As a significant number of monuments from the Old Rus' period were destroyed during the Nazi occupation of Kyiv, this greatly facilitated access to the plinthois. Thus, from 1945 to 1972, during the dismantling of the ruins of the Dormition Cathedral of the Pechersk Monastery (V. Bogusevych, Yu. Aseyev, G. Logvin, V. Petychynsky, V. Govdenko, M. Kholostenko at al.), in addition to studying the architecture of the Great Pechersk Church, attention was paid to the clarification of the nomenclature of Kyivan Rus' building materials, primarily the bricks. V. Bogusevych used a visual method to describe the plinthoi, measuring the dimensions of each unit and fixing the labels on the front of the item (Fig. 3) (Makhota 2022, p. 42).

In 1953-1954, Yu. Aseyev and G. Logvin attempted to describe the construction materials. They separated three subgroups of the plinthois by size and form. The first subgroup is close to the square in form, with typical dimensions of 32×21×4, 35×28-29×4, and 38×25×4 cm. The second subgroup has a rectangular shape, with dimensions 44×22×4, 45×15, 20×4, 35×15×3.5 cm. There are four variants of the dimensions of the rounded plinthoi, which the authors attribute to the third

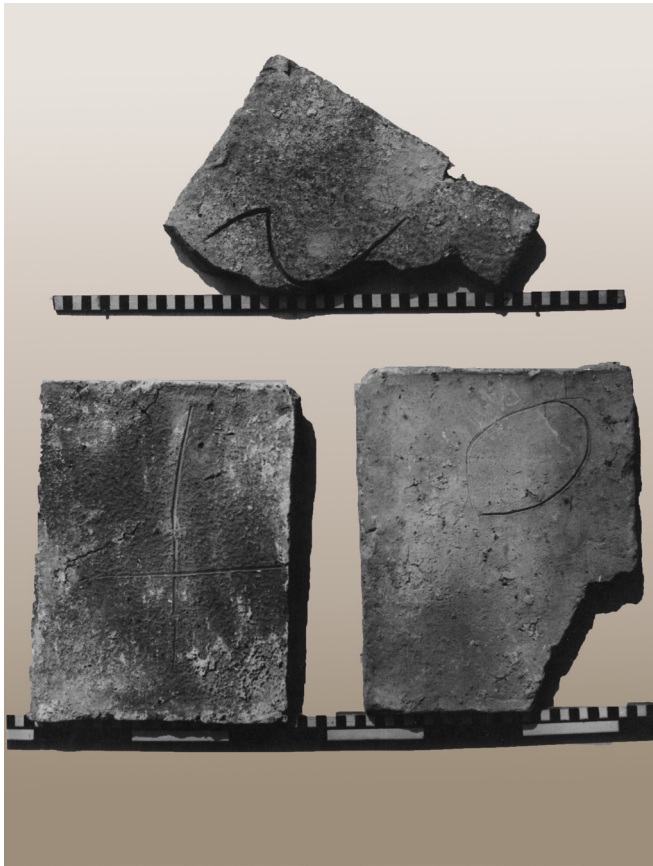


Fig. 3. Plinths found in the 1950s. The Dormition cathedral

subgroup of the brick (Sitkar'ova 2000, p. 59-60). Architects V. Petychynskyy and M. Govdenko continued work on the recording of brick sizes in the early 1960s. From 1969 to 1972, V. Petropavlivskiy described and painted the most interesting finds of a plinths in the expedition diary on the excavation of ruins of the Uspensky cathedral in the John the Baptist chapel. They usually had finger marks on the outer surface (Fig. 4).

The biggest contribution to the research of the Kyiv plinths was made by M. Kholostenko in the 1970s (Kholostenko 1975). He is an author of several works devoted to the research of Dormition Cathedral, in which he made the first attempts at the typology and chronology of the samples of the Kyivan Rus' bricks (Fig. 5). In addition, he prepared fundamental works on the construction materials of the Dormition Cathedral and the John the Baptista chapel (Kholostenko 1976) and a catalogue of stamps and end signs, which, unfortunately, remain in the

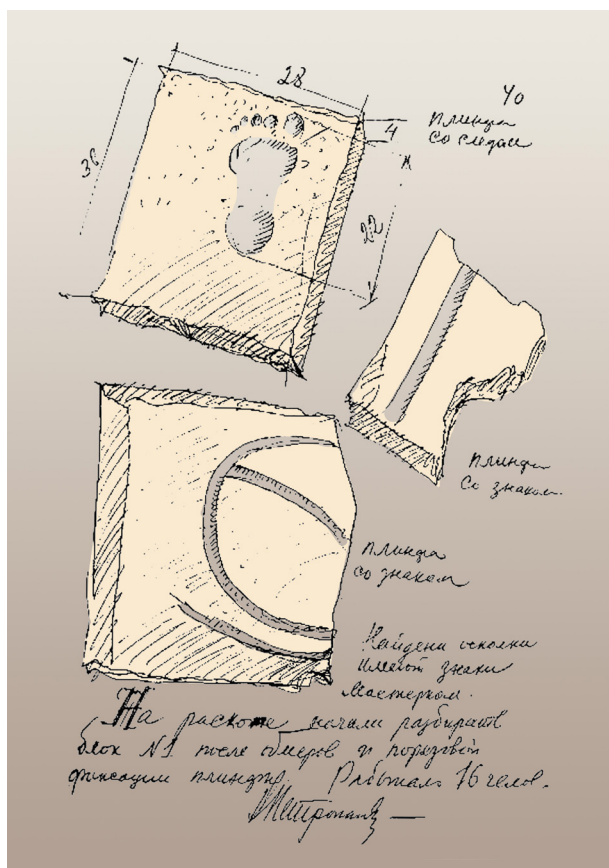


Fig. 4. Page from the expedition diary of V. Petropavlovskiy

handwritten form and have not been published (now they are being digitized in the archives of the National Preserve “St. Sophia of Kyiv”).

Recent studies have been conducted by G. Ivakin (2003), O. Sitkar’ova (2000), O. Syromyatnikov (2004), D. Jolshin (2010) and the author of this article, with emphasis laid on the difference in the formation of raw materials as a chronological feature. The only comprehensive study devoted to typological differences of the Kyiv plinthoi is D. Jolshin’s publication (Jolshin 2017). The researcher singled out specific technological traces on the bricks of the ancient monuments of Kyiv and carried out their chronological attribution. Thanks to the well-described methods of fixing all signs of bricks in this work, researchers into building materials could collect more data for further study of brick production.

Today the Pechersk monastery monuments are part of the National Preserve “Kyiv-Pechersk Lavra”. The collection includes a significant number of building



Fig. 5. Sizes of the plinthis by M. Kholostenko

materials from the 11th-15th centuries. The plinthis collection started in the second half of the 1940s (Makhota 2020, p. 363). The collection also was supplemented by unique samples of medieval and modern building materials discovered during archaeological research in this area. In 2022, the “Building Materials” collection of National Preserve “Kyiv-Pechersk Lavra” consisted of 1,630 museum items, of which 83% are dated to the 11th-13th centuries.

Since 2001, the Ministry of Culture of Ukraine launched an initiative of passport-protecting the objects in the National Preserve “Kyiv-Pechersk lavra” museum collection (stocks), which includes the “Building Materials” collection. In 2019 and 2021, the existing attribution of the collection of the Kyivan Rus’ brick was clarified by the author of this article (Fig. 6), and the collection was fully developed. On the basis of the results, a dissertation study “Building ceramics of monumental monuments of the 11th-15th centuries from the territory of the National Preserve «Kyiv-Pechersk Lavra»” is being prepared.



Fig. 6. Attribution of the collection of the bricks in Kyivan Rus' by O. Makhota

THE RESULTS

There is a detailed examination of the author's attribution of the plinths from the monumental buildings of the 11th-12th centuries of the Pechersk monastery.

The Great Pechersk Church (the Dormition (Assumption) Cathedral) (Fig. 7a). As already noted, the construction and decoration of the cathedral continued from 1073 to 1089. The first mentions of the Pechersk Church refer to the "Povist' mynulikh lit" (Lykhachev, Romanov and Adrianova-Peretc 1950) and the "Kyiv-Pechersk Paterik" (Abramovich 1991). It was a six-pillared cross-domed temple, built in the *opus mixtum* masonry technique with a hidden row. The church was rebuilt several times and repaired in the 12th-13th centuries, also following the earthquakes of 1124 and 1230. The last repairs in the first initial volume of the church were completed in 1470 for Prince Simeon (Semyon) Olelkovich (Holostenko 1976). The Dormition Cathedral was destroyed during WWII, on November 3, 1941.

The Dormition Cathedral was studied several times by archaeologists (Taranenko, Mysko and Zazhygalov 2017). The studies were headed by V. Bogusevych (1946-1948), S. Kilievych (1961), M. Kholostenko (1962-1963) and (1968-1972),

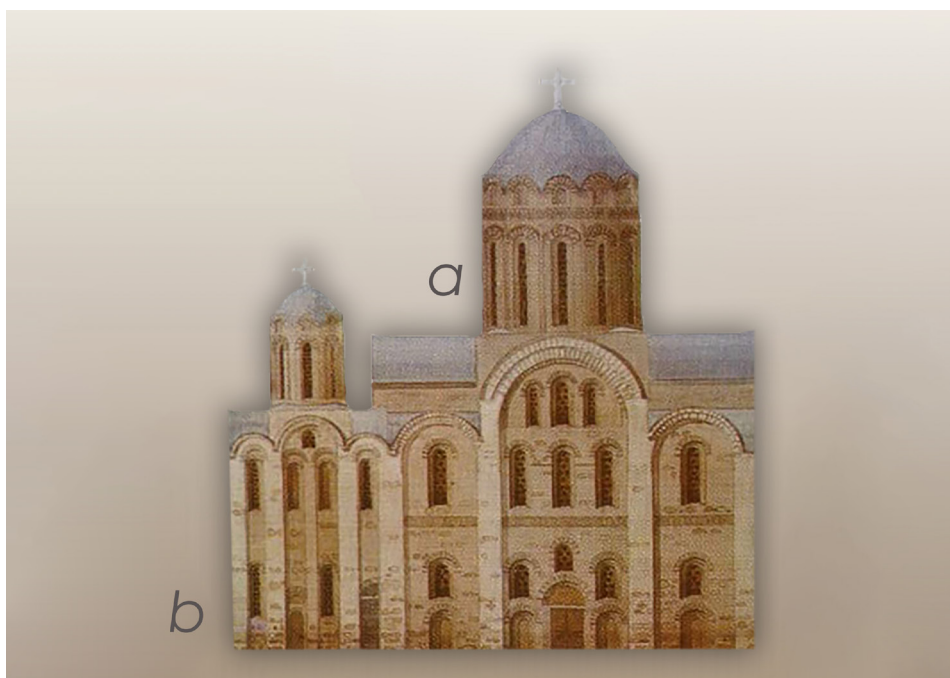


Fig. 7. a – The Dormition Cathedral; b – St. John the Baptist chapel (reconstruction by M. Kholostenko)

V. Kharlamov (1982, 1986), V. Chaika (1983), O. Syromiatnykov (1995), G. Ivakin (1997-1999). The purpose of the research was to take apart the ruins and study their architectural evolution for conservation, museum-collection purposes, and reconstruction of the cathedral, consecrated in 2000.

The characteristics of the plinthis. To the extent that during the Middle Age (from the 11th to 15th century), the Great Pechersk Church was restored several times, more than 70 sorts of plinthis and bar bricks have been recorded here. They differ in size, form, technology, and dating.

The plinthis of the main volume of the monument of the last quarter of the 11th century are made of kaolin clay. After the firing, the brick mostly assumed beige and terracotta shades. The ceramic dough contains a large number of impurities in the form of fired feldspar, quartz, and sand. The main technological features of the brick include forming in a wooden, bottomless frame; small longitudinal traces on top of the plinthoi from the stretching of solid impurities in the clay mass; vertical traces at the headers and “zakrainy” after the frame was removed; traces of removing the excess clay with a wooden knife on the upper plane. The most common sizes are 34-37×23-29×3.5-4.5 cm.



Fig. 8. A floral ornament made with a finger on the bed of the plinthois from the Dormition cathedral

In the early 12th century, the plinthois were made of kaolin clay. According to the manufacturing technology, they are as close as possible to the former brick but are smaller and thicker (27-28×18-19×4.5-6 cm). At the end of the 12th century, when the crypts were added to the cathedral, a square plinthois was used (30×25×5 cm) (Plamenyts'ka 2003, p. 59).

There are different convex signs on the headers of the bricks from the 12th century. Special collapsible frames were used for their production. The craftsmen cut out specially shaped furrows on the inside, later filled with clay. After drying, marks remained on the end, namely various geometric shapes, letters of the Cyrillic alphabet, princely signs, etc.

Some bricks had marks on the upper side. Most often, such marks were made with a finger or a sharp object, and depicted simple lines, crosses, semicircles, or circles.

In total, there are more than 190 varieties of labels among all the plinthois samples: 52 types of finger marks on the top surface of the brick, and 138 end signs. The interpretation of the end signs remains open (Beliaev 2006, p. 87-88). According to one version, they are the master's technical marks on the quality of

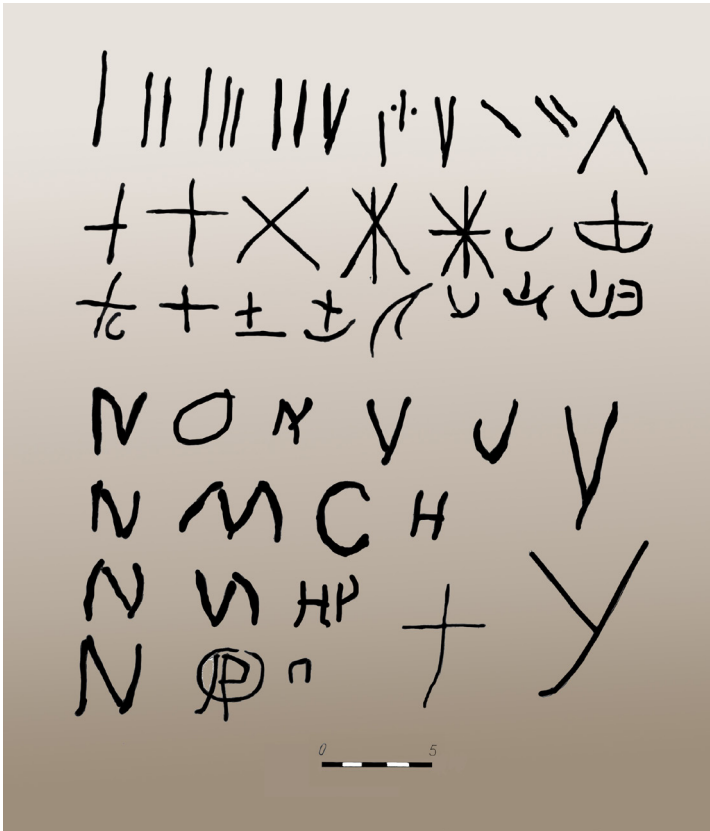


Fig. 9. Headers marks from the Dormition cathedral

the product, or the degree of drying of the sample. Another interpretation has it that the end mark is the batch number or the number of the brick (Fig. 8, 9).

The church was renovated in the 13th century, which shows the plinths of another building group. The brick's red colour has a porcelain structure in the fault. Its size is 29-30×17-18×4,5 cm. Often, there are zigzag traces made on its upper surface with a comb.

A new form of bricks was used during the last repair works of the princely period in the 15th century, the so-called “bruskova tsegla” (in the form of bars). This is a brick of European Romanic origin, proportionally different from the plinths (narrow and thick), with continuous finger marks on the upper side (Rapport 1952). This brick is often called a “pal’chatka”, from the Ukrainian word “finger”. Its dimensions are 25×13-15×8-9 cm. It was formed manually, similar to the plinths. The specific recipe of the clay mixture, with a large number of sand

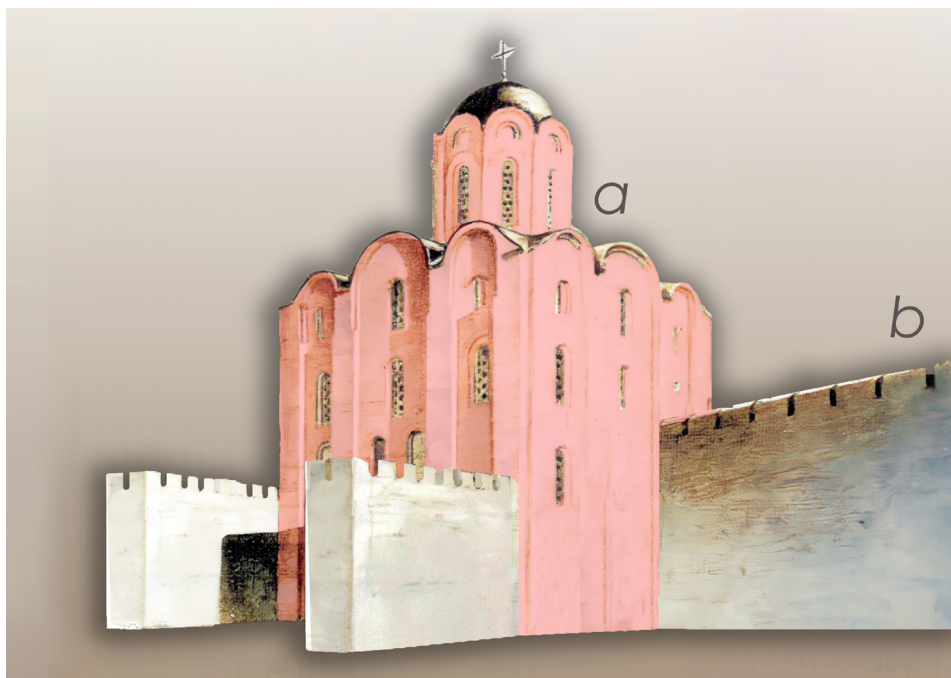


Fig. 10. a – Trinity Gate Church (reconstruction by Yu. Aseyev), b – Defensive wall of a 12th century (reconstruction by S. Taranenko 2021b)

admixtures, made it much easier to remove the bricks from the frames. Manual shaping is indicated by finger marks on the upper side of the items.

Chapel (church) of St. John the Baptist (Fig. 7b). According to the report on the “Kyiv-Pechersk Paterik” (early 13th century), the chapel of St. John the Baptist was built near the Dormition Cathedral several decades later (Abramovich 1991). It was a small, four-pillared, cross-domed temple, built in the *opus mixtum* masonry technique with a hidden row. The chapel was merged with the cathedral during renovations, and was subsequently absorbed by the cathedral structure. In 1941, explosives were laid in the chapel, which destroyed it along with most of the Dormition Cathedral (Kabanets 2011).

After the destruction, the chapel was archaeologically explored several times (Taranenko, Mysko and Zazhygalov 2017). The leaders of the expeditions were M. Kholostenko (1972) and G. Ivakin (1998). The researchers identified the main architectural features of the monument and reconstructed its hypothetical appearance.

Characteristics of the plinthois. The brick of the chapel of St. John the Baptist is almost similar to the main volume of the cathedral. The difference is a set of bricks of another size (44×19×5 cm) (Plamenyts`ka 2003, p. 58). The fact that this

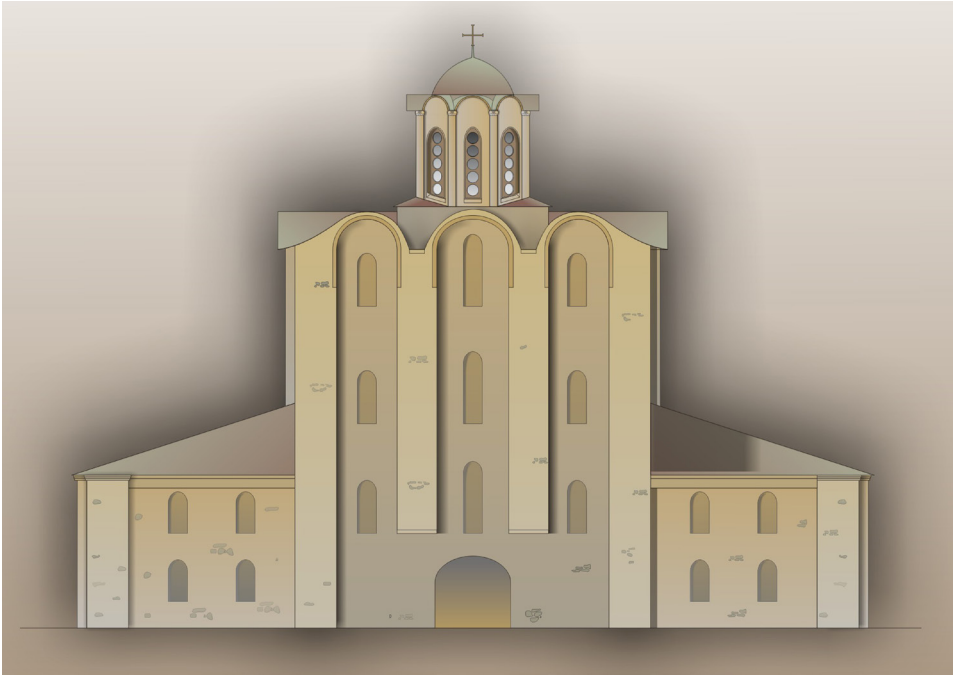


Fig. 11. Brickwork refectory from the 12th century (reconstruction by G. Trofimenko, V. Gonchar)

size of the plinthoi was not found in the cathedral indicates that the chapel and the temple were raised at different times.

Trinity Gate Church (Fig. 10a). The gates to the church were built in around 1106-1108. The “Kyiv-Pechersk Paterik” is connected with Svyatoslav (Mykola Svyatosha after the tonsure), the son of the Chernihiv prince David –(Abramovich 1991). It was a small four-pillared, cross-domed temple, built in the *opus mixtum* technique with a hidden row. The church of the Pechersk monastery had not been destroyed for many centuries. As a result of reconstruction works in the 1620-1630s, its facade underwent significant changes which have survived until today.

Characteristics of the plinthois. The plinthoi is mostly 37×27 and 44-41×28 cm, from 3.8 to 5.5 cm thick. It was formed in a wooden, bottomless frame. It was made of several types of clay, kaolin and red mica clay. There bricks are red and orange. The existence of signs on the bed of the brick remains in question, as the monument was preserved in the full shape from the 12th century and only the headers of the plinthois are available for study now.

The brick refectory from the 12th century (Fig. 11) was funded in 1108 by Prince Glib Vseslavich in the southwest of the Dormition Cathedral. Mentions of the refectory of the Pechersk monastery are found in the annals of that time. According to researchers, the building has two stories. The first floor had an

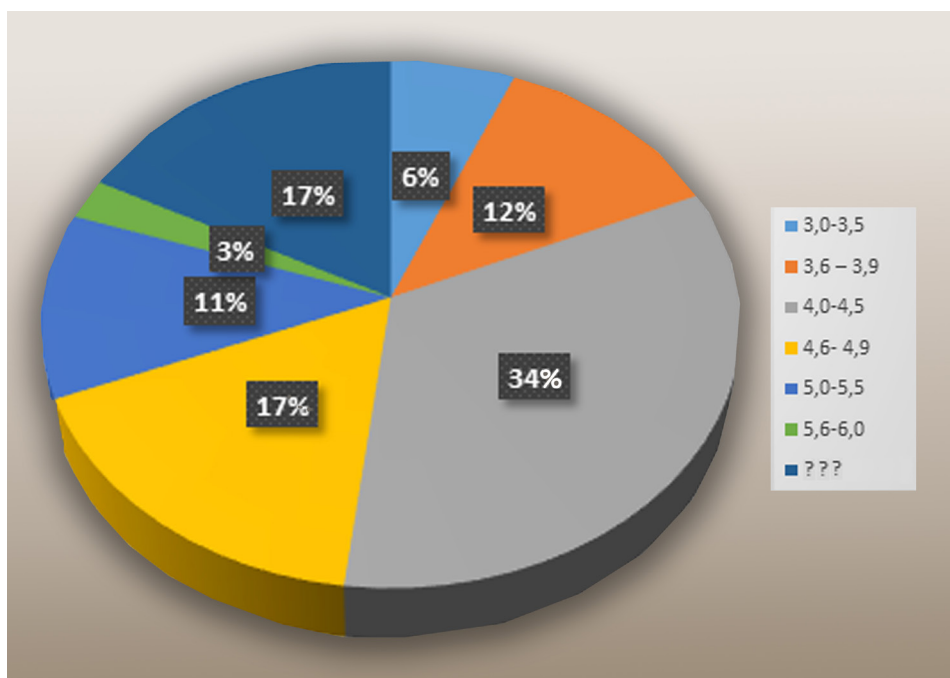


Fig. 12. The types of clay used for the production of the plinths from the 12th century defensive wall

exclusively economic function (storage of provisions and cooking); on the second floor, meals were served and the preceding religious events took place (Gonchar 1999; Trofimenko and Gonchar 2002). It was slightly damaged by the earthquake of 1230.

The site has been archaeologically surveyed by several researchers (Taranenko, Mysko and Zazhygalov 2017); V. Kharlamov (1984-1985, 1991); O. Syromyatnikov (1990); G. Ivakin (2000); S. Balakin (2009). The scientists identified the main architectural features of the monument and reconstructed its hypothetical appearance. Since the monument is intersected by the foundations of later buildings in the southern part, it is possible that the building had other forms. Therefore, this reconstruction may need to be revised in the future.

The characteristics of the plinths. Bricks from the stone refectory from the 12th century are typologically and morphologically close to the brick of the previous monuments. The scientists have identified four stages of the building's construction and reconstruction, characterized by plinths of different sizes (Ivakin 2003, pp. 69-70). During the first two stages, bricks measuring 34-28×29-26×4-5 cm were used. All the samples come from a bottomless mould; the bed of the brick often bears traces of outdoor moulding (rain, footprints of animals, etc.). The bricks



Fig. 13. Masonry of the the 12th century defensive wall

are made of oily kaolin and red sedimentary clays with admixtures of large spar fragments. The plinthoi of the third stage of construction is significantly different from the previous, and measures 30-29×26-24×4 cm. The plinthoi is yellow-gray, red, and orange. The brick of this stage contains more than 15 varieties of header marks in the form of ordinary two-pronged and ligature-like symbols. The fourth stage of repairs used a red brick of so-called “pereyaslav’ type”, measuring 20×25×4-4.5 cm.

The defensive wall from the 12th century (Fig. 10b). Written sources which mention the stone wall of the Pechersk Monastery from the last quarter of the 12th century are laconic and scarce. It is traditionally believed that the only known reference to its construction is in the “Message of an old man to the blessed Basil archimandrite of Scythia”. The masonry was built in the *opus isodos* masonry technique, typical for this period. The facade masonry of the wall is laid out to a thickness of two plinthois. The inner space was filled with broken bricks and iron sandstone boulders. The inside part of the construction was filled with a lime solution. The wall was destroyed during the Mongol-Tatar invasion of 1240.

The remains of this structure were found in the Mytropolychy (Metropolitan) Garden of the Kyiv-Pechersk Lavra during an archaeological survey in 1951

(V. Bogusyevych). Fragments of this wall were also investigated in 1991-1992 (V. Kharlamov) and 2007 (S. Balakin) on the other sections of Upper Lavra (Taranenko, Mysko and Zazhygalov 2017). In 2018, under the direction of S. Taranenko, an archaeological survey of the object was carried out again in order to verify the data provided by V. Bogusyevych (Taranenko 2021a; 2021b). As a result, new sections of the wall were opened. The archaeological survey there of is planned for the next seasons.

The characteristics of plinths. In the constructions from the 12th century, both specially made bricks and plinths of secondary use were used. A small-format plinth measuring 28-26×21-18×4-4.5 cm was made for the facade of the wall (Makhota 2019, p. 43). As in the other sights of 12th century Kyiv, this brick was formed in a bottomless mould. Fragments of the plinth from the Dormition Cathedral and Trinity Gate Church were used in the inner filling of the walls. It was made of mica and kaolin clay (Fig. 12). No marks on the surface have been recorded.

As a result of the study, the author of the article has created a table with all the known sizes of plinths from buildings from the 11th-15th centuries of the Pechersk Monastery (Table 2).

DISCUSSION

From the construction of one landmark of the Pechersk Monastery to another, from the last quarter of the 11th century to the second half of the 12th century, the continuity of the use of brick production technology has been traced, brought by Constantinople masters for the construction of the Assumption Cathedral. Most likely, the construction of the Dormition Cathedral and the John the Baptist Chapel, which are close in time, can be associated with the originators of the same construction school. However, in the first half of the 13th and the second half of the 15th centuries, these monuments were rebuilt from bricks made as part of different technologies.

A rather interesting question is the prerequisites for the construction of the Trinity Gate Church. A special feature of this monument is use of plinths from several types of clays: kaolin clay and mica loam (red sedimentary clays), common in the 11th-12th centuries. According to the technological features of the kaolin plinth, its construction can be associated with the same building group as the previous two monuments. However, the sediment clay brick is of different sizes and is very poorly attributed because its visible headers are in a dilapidated state. Quantitative statistics of the colour distribution of the plinths indicate that 90% of the samples are red or orange. Only 2% of the light beige plinths made of kaolin clay is recorded in the lower part of the passage of the gate, namely in the masonry of the internal volume of the first tier. The remaining 6% can be

Table 2. The main sizes of the plinthois from the monuments 11th-15th century of Pechersk monastery

The table shows the sizes of the bricks used in the construction of monumental buildings in the Pechersk Monastery from the 11th to the 15th centuries. Here are all the known sizes of bricks from academic publications and archaeological reports. The table has been developed on a chronological principle. All the dimensions are provided as quoted in the sources and are arranged in the ascending order. In quotation marks are references to authors from the bibliography. All the sizes are provided in centimeters. The main principle of measurement is "Length × width × thickness" (which may differ from one researcher to another)

Second half of the 11 th century	First half of the 12 th century	Second half of the 12 th century	12 th -13 th centuries	13 th century	15 th century
32×21×4; 35×28×4; 35×29×4; 38×25×4; 45×20×4; 35×15×3.5; 44×22×4; > (Aseyev, Logvin 1954) 28×20, 22, 23, 25, 27; 29×12, 13, 15, 19, 20, 23, 25, 28, 29; 30×14, 15, 17, 20, 27, 28, 30; 31×14, 15, 18, 19, 20, 23, 25, 27; 32×12, 14, 15, 21, 23, 26-29, 32; 33×15, 17, 19, 21, 23, 26-28, 30; 34×17, 19, 23, 25-29, 34; 35×18, 23-25, 30, 35; 36×19, 23, 26-31, 35; 37×20, 22, 24, 26-30; 38×26-31, 34; 40×29; 40×35; 39×26-29; > (Kholostenko 1975, p.117) 3.5-5×27-29×34-36; (Rappoport 1982, p. 25) 33.5×27.5×3.5;	36-37×27-29×4-4.5; 38×28×4; 36×28×4; > (Kharlamov's archive)	28×19×6; 27×18×6 > (Kholostenko 1975) 5×20-22×26-29 > (Rappoport 1982, p. 25) 27-28×18-19×6; 26.5×18.5×5; > (Kharlamov's archive)	30×16, 20-22, 26; 31×20-25, 27; 32×20-26, 29; 33×21, 23, 27, 29-35; 34×14, 21, 23, 25, 27; 35×23-25, 27, 28; > (Kholostenko 1975, p.119)	35×22-26, 6.5×5-6; 22-33×21.5-24×4-5.5; 29-30×17-18×4.5; 31×24×3.5; 28×25×5.7; 28×24×5.5; 31×14×4; 25×25×5.5; > (Kharlamov's archive) 32×19×3.5-5; 32×32×5 > (Kharlamov 1986, p. 16) 32-33×21.5-22×4.5-5; 31×21-22×5-5.5; 35×22-26×5-6.5; 29-30×17-18×4.5 > (Sitkar'ova 2000)	6 inches, width 2 _{1/4} inches, and thickness 1 _{2/3} inches > (Lashkar'ov 1898, c. 211) 25×13×8; > (Kholosten- ko 1955, p. 353) 25×13-15×8-9 > (Kharlamov's archive)
Dormition Cathedral (1073-1460)					

Second half of the 11 th century	First half of the 12 th century	Second half of the 12 th century	12 th 13 th centuries	13 th century	15 th century
<p>34×26.5×3; 34×27.5×4; 35×29×4; 35-36×17.5-19×3.5-4.5; 35-36×27-29×3.5 4.5; 36×23.5×4.5; 36×28×4; 36×29×4; 37×28×3.5; 43-44×15-16×4.5-5;</p> <p>➤ (Kharlamov's archive) 27×24×4; 30×30×5; ➤ (Kharlamov 1986, p. 16) 35×27×4 ➤ (Ivakin, Balakin 1998-1999) 35-36×26-29×4; 36×28×4; 35×23×5; 35.5×27×5; 36×28-29×3-4; 34-35×28-29×3.5-4; 37×23×3.5; 33.5-35.5×26-29×3-4.5; 33-36×27-29×3-4.5; 35-36.5×27.5-29×3.5-4.5; 37×26.5×4; (Sitkar'ova 2000, p. 59-60)</p>					
Chapel (church) of St. John the Baptist (1088-1089)					
<p>33×26-29; 37×24 26, 28, 29×3 5; 34×15-29×4.0; 35×16×27-29×4.0; 45×15-17, 20, 27-29×4.0; 38×13, 26, 30, 36; 36×16, 20, 27-29, 31×3.5-4.0;</p>					

Second half of the 11 th century	First half of the 12 th century	Second half of the 12 th century	12 th –13 th centuries	13 th century	15 th century
<p>43×16; 19, 21, 22×4.5; 46×15, 17, 19, 21, 23×4.5–5.0 44×15, 18, 21, 23, 27, 44; ➤ (Kholostenko 1975, p. 118) 33.5×27×3 34×27×4 35.5×27×4 35×28×4.4 36×24×4 36×28×3.5 43×16.5×4.5 ➤ (Petropavlivskiy 1967–1972) 28–36×3.5–4 36×23.5×4–5 ➤ (Sitkar'ova 2000, p. 59-60)</p>	<p>34×27×4 44–41×28×4 ➤ (Bogusevych 1951) 34×26×4–4.5 ➤ (Kileso 1975) 27–33×19–24×4 ➤ (Rappoport 1982, p. 25) 34×26×4–4.5 ➤ (Aseyev 1982, p. 151) 34×28×4–4.5</p>				
Trinity Gate church (1106-1108)					
Defensive wall of the 12 th century (1180s)					
	<p>➤ (Jolshin 2017) 31×27×4.8–5.0 <i>from red mica clay</i> 34–35×27.5, 29, 30×4–4.8 <i>from kaolin clay</i> ➤ (by O. Makhota)</p>	<p>20×28×4 23×26×4 ➤ (Aseyev, Bogusevych 1951) 19.5–22.5×25.6–28.8× 3.9–4.2 ➤ (Karger 1961 p. 373) 3.9–4.2×19.5–23.5×29</p>			

Second half of the 11 th century	First half of the 12 th century	Second half of the 12 th century	12 th 13 th centuries	13 th century	15 th century	
	<p><i>Pylons 1-5</i> 27×32×4; 26×34×4; 26×30×4; 34×27×4 –4.5 28×35×4.5; 27×32×4.5</p> <p><i>Reinforce of pylons</i> 26×24–35×4 27–33–35×4; 33×35×4</p> <p><i>Walls</i> 36×29×5 23×30×4; 27–34×35×4; 34×4–4.5 25×30×4.5; 25×29×4.5; 24×30–28.5×4–4.5; 24.5×31×5;</p> <p>➤ (Kharlamov 1985) 26–29×34–37×4–4.5; 32–35×28–29×4–4.5; ➤ (Kharlamov 1991, p. 6) 25–29×29–36×4–5; 26–29×34–37×4–4.5 <i>from the floor</i></p>	<p>➤ (Rappoport 1982, p. 25) 37×28×3–4 ➤ (Kharlamov 1992) 26×19–22×4–4.5 ➤ (Jolshin 2017) 27–28×21×4 ➤ (Balakin 2007) 26–28×18–21×4–4.5 ➤ (Makhota 2019)</p>	<p>Brick's refectory of the 12th century (1108)</p>	<p>➤ (Trofimenko, Gonchar 2002, p. 20) <i>Reinforce walls</i> 29×19–20×4; 20×26–28×5; 29×23–26×4–4.5; 25×20×4.5–5; <i>Reinforced pylons 1–3</i> 28×19–22×4–4.5; 19×28–29×4; 28–29×20–21×4; ➤ (Ivakin 2003, p. 69) <i>The fourth period of construction</i> 20×25×4.5–5; ➤ (Kharlamov 1985, c. 5) 29–30×19–21×4.5–5.5; ➤ (Syromiatnykov archive) 25×20×4.5–5; ➤ (Jolshin 2017, p. 120)</p>		

Second half of the 11 th century	First half of the 12 th century	Second half of the 12 th century	12 th –13 th centuries	13 th century	15 th century
	<p> > (Gonchar, Trofimenko 2002, c. 16) <i>The first and second periods of construction</i> 29–37×24–29×4–5 <i>from the southern wall</i>; 28–31×24–26×4–4.5 <i>from the southern wall</i>; 34–37×26–29×4–5 <i>from the western wall</i>; 34–37×26–29×4–5 <i>from the floor</i>; > (Ivakin 2003, c.69) <i>The first and second periods of construction</i> 30–35×26–29×4–5; > (Syromiatnykov archive) Originals pylons 34–37×26–29×4–5 <i>from archive IA NANU</i>; 33×25.5×4 <i>from the National Preserve «Sophia of Kyiv»</i>; <i>Originals walls</i> 28–31×24–29×4–4.5; <i>Reinforce of pylons of the second period</i> 34–35×27×5 <i>from archive IA NANU</i> > (Jolshin 2017 p. 119) 32×29.5×3–5; 34.5×26.5–24×4–4.5; 30×22×4.5; 32×28–28.5×4.5; (Logbook of the building materials) </p>				

attributed to the repair works from the late 12th – the early 13th century, distinct in the upper part of the temple vault. Perhaps these brick colours were meant to imitate the Kyivan Golden Gates from the 11th century because these two monuments belong to a rare kind of gate churches. It has been proved that the church was built shortly after the completion of the Dormition Cathedral and the Church of St. John the Baptist. This is indicated by a large number of impurities of quartzite and fractions of sand in the structure of the plinthoi from the gate. It remains unclear why, in the construction of the gate with the over-gate church, the masters used red sedimentary clay in parallel with the manufacture of bricks from kaolin clay. Red clay does not have good hydrophobic properties and is subject to weathering. There are several possible explanations for this variety of materials:

1) lack of funding – therefore, the remains of materials from other buildings of the monastery were used for laying the inner walls;

2) lack of kaolin clay – which is unlikely due to the massive temple construction at that time using a plinth made of this type of clay;

3) an attempt to find a cheaper building material;

4) intent to emphasize the red colour of the building. An obstacle to the production of a sufficient amount of red plinth from kaolin clay is the construction of the bugle. Only the plinthoi that was closest to the source of the fire acquired such a shade. All the bricks that were higher in the furnace had lighter shades (from light orange to almost white).

According to the composition of the ceramic mixture and the technological features, the plinth from the brick refectory built at the early 12th century can be attributed to the same construction school.

Unfortunately, we cannot yet draw conclusions about the group of craftsmen who built the stone wall in the 12th century, since the facade plinthoi has been recorded only in this section. Further archaeological surveys at the site will likely resolve this issue.

CONCLUSIONS

The construction of the first stone church in the Pechersk Monastery significantly influenced the formation of the characteristic technology of plinthoi production in the second half of the 11th-12th centuries. The technique, introduced by Greek masters, became widely used not only in the monuments of Kyiv, but also in almost all largest cities of Kyivan Rus'. In the Pechersk monastery, the use of one construction tradition can be traced by the technological features, the method of formation and the quantitative ratio of clay filling in the period up to the second half of the 12th century. It includes a specific brick manufacturing technology, the main parameters of which include formation in a wooden, bottomless mould that did not allow disassembly there of; traces of sand filling on the lower

side of the brick; vertical marks on the headers and vertical clay sides after removing the frame; marks from the removal of excess clay with a wooden knife on the bed of the brick. This is also indicated by the ingredients of the ceramic mixture.

The attribution of the plinths plays an important role in the precise dating of monuments. However, it is important to use a comprehensive approach, which includes technical and technological analyses of mortars and bricks, the stylistic architectural features and data from written sources. In addition, there are still issues of organizing the monument construction process. No traces of construction sites and production furnaces for brick firing were recorded during more than 100 years of archaeological surveys in the Pechersk Monastery. Perhaps they were located in the east of the Assumption Cathedral, towards the slopes of the mountain by the Dnieper river, and their traces were destroyed during the construction of modern brick buildings. Only subsequent archaeological research can confirm or deny this statement.

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