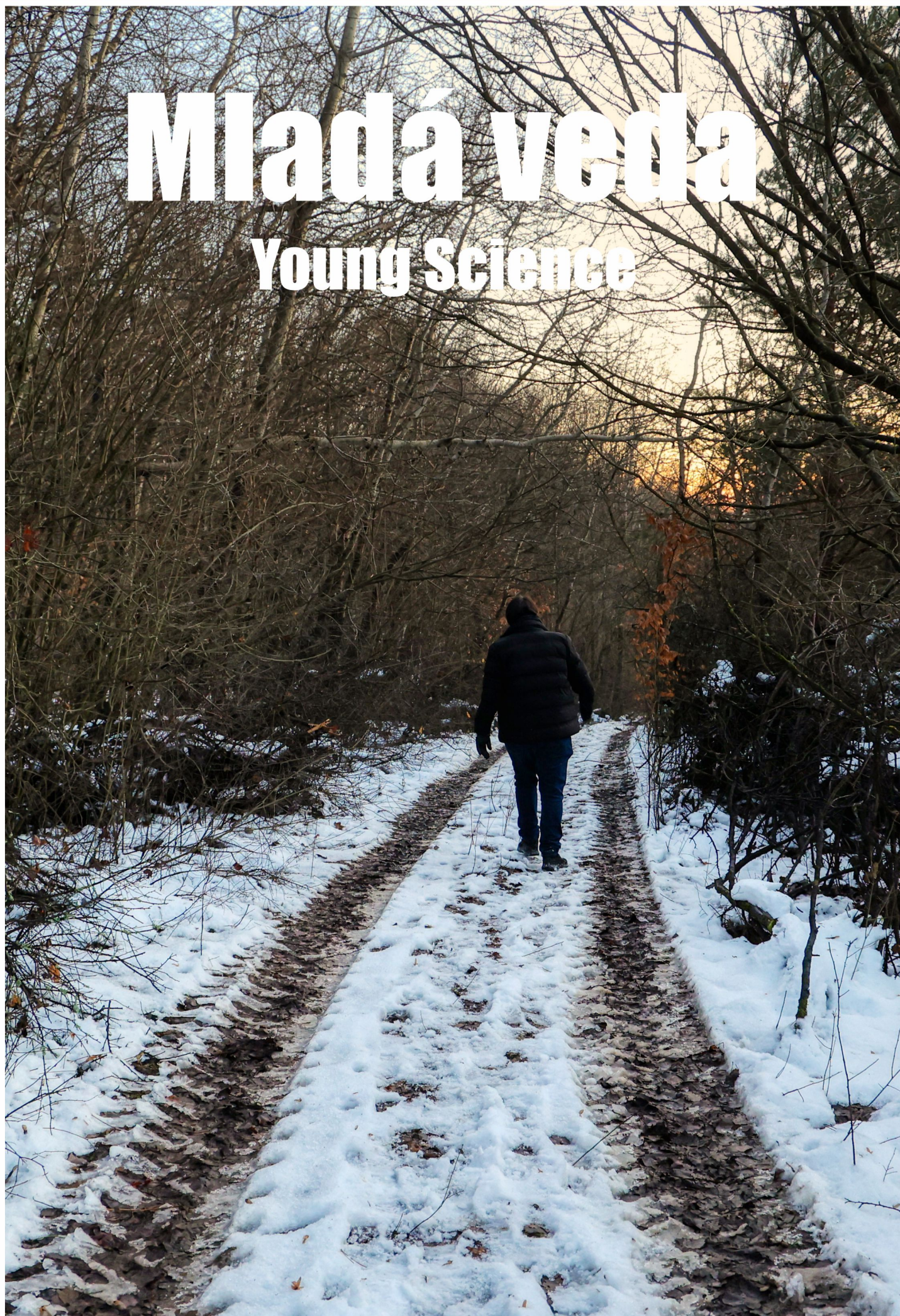


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MEDZINÁRODNÝ VEDECKÝ ČASOPIS MLADÁ VEDA / YOUNG SCIENCE

Číslo 5, ročník 11., vydané v decembri 2023

ISSN 1339-3189, EV 167/23/EPP

Kontakt: info@mladaveda.sk, tel.: +421 908 546 716, www.mladaveda.sk

Fotografia na obálke: Zimná prechádzka. © Branislav A. Švorc, foto.branisko.at

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TECHNOLOGICAL – ECONOMIC SOLUTION FOR THE FACADE OF THE ADMINISTRATIVE BUILDING – VARIANT I

TECHNOLOGICKO-EKONOMICKÉ RIEŠENIE FASÁDY ADMINISTRATÍVNEJ
BUDOVY - VARIANT I

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Abstract

Variant solutions in the design process of construction processes fulfil the requirement of achieving efficiency in the construction industry and bring an optimal solution. One of the decisive criteria is also the technologies and technological processes used during construction. It is important to find and consider the intersection of all input factors for the most advantageous solution. The article describes an example of a solution of brick cladding, variant I, of an administrative building in Nitra from a technological and economic point of view. The technological solution contains the sequence of the individual steps of the technological process, its duration, the materials used and their specifications, the control and test plan, safety and security at work, and environmental protection. The economic point of view represents the itemized budget together with the total costs.

Key words: brick cladding, technological process, economic point of view, itemized budget

Abstrakt

Variantné riešenia v procese návrhu stavebných procesov naplňajú požiadavku dosahovania efektívnosti v stavebníctve a prinášajú optimálne riešenie. Jedným z rozhodujúcich kritérií sú aj použité technológie a technologické procesy počas výstavby. Je dôležité nájsť a zohľadniť prienik všetkých vstupných faktorov pre najvýhodnejšie riešenie. Článok popisuje príklad riešenia tehlového obkladu, variant I, administratívnej budovy v Nitre z technologického a ekonomického hľadiska. Technologické riešenie obsahuje postupnosť jednotlivých krokov technologického procesu, jeho trvanie, použité materiály a ich špecifikácie, kontrolný a skúšobný plán, bezpečnosť a ochranu pri práci, ochranu životného prostredia. Ekonomické hľadisko predstavuje položkový rozpočet spolu s celkovými nákladmi.

Kľúčové slová: tehlový obklad, technologický postup, ekonomické hľadisko, položkový rozpočet

Introduction

The building envelope has a decisive influence on the architectural appearance of the building through its aesthetic effect. Beauty, as one of the basic principles of architecture, is an aesthetic requirement placed on the envelope. As an expression of the static properties of mass and structure, it is related in an artistic way to the arrangement and to the choice of composition of the individual elements. [1]

Variant II, in the following article, will describe the solution of the green facade of the same administrative building in Nitra as in Variant I from a technological and economic point of view. Both variants will be compared from these points of view.

Both solutions are designed on the southern façade of the building on the same surface area of 120 m². The valid STN will be considered when designing and comparing the most advantageous variant.

Ceramic cladding element - a cladding element made of clay and/or other inorganic raw materials. [2]

Drawn ceramic cladding element - a cladding element which is formed in a plastic state under high pressure, the resulting formation is cut into pieces of predetermined dimensions. [2]

Water absorption - the percentage of water absorbed by the element. [2]

Production dimension - the dimension of the facing element to be manufactured, with which the actual dimension must correspond within the range of specified permissible tolerances. [2]

Actual dimension - dimension obtained by measuring the face area of the element. [2]

Coordination dimension - manufacturing dimensions plus spacing width [2]

Construction - Technology Solution

The office building will be in the cadastral territory of the city Nitra. The office building will offer 3 parking garage spaces; another 8 parking spaces are designed on the investor's land behind the newly proposed building. The vertical load-bearing perimeter walls are made of aerated concrete blocks e.g., YTONG with a thickness of 300 mm. The brick cladding will be applied to the south side of the façade of the building. The approximate area of application is 120 m².

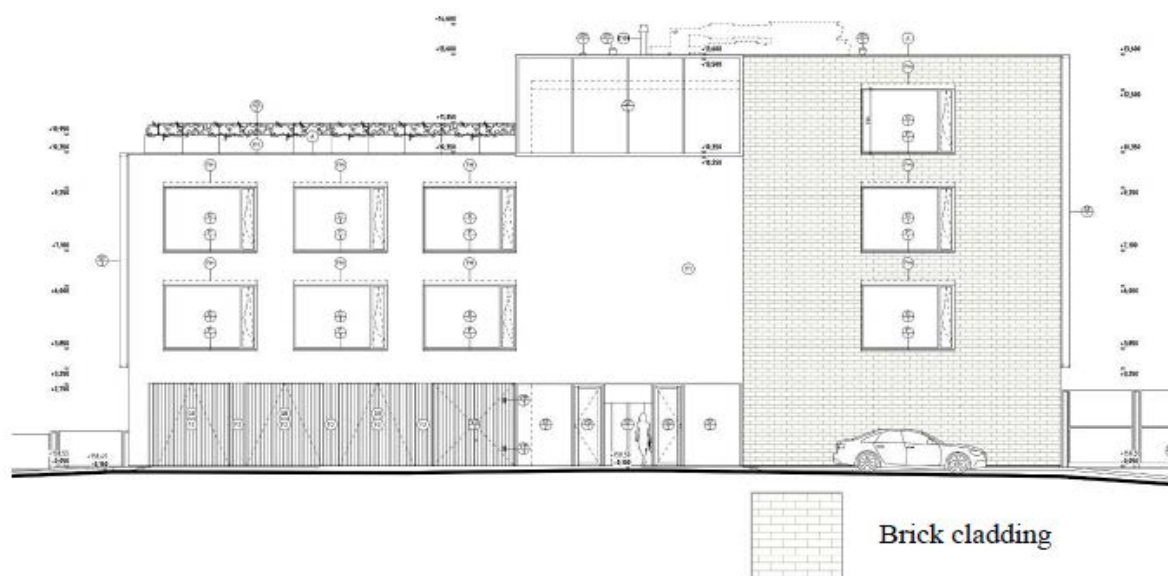


Figure 1 - South view of the Office building with brick cladding – Variant I
Source: authors

The designed load-bearing system is sufficient as a basis for a brick cladding if the insulation system is properly anchored and the surface is correctly treated – such as cement plaster.

When applying brick slips to a façade, there are few crucial details to keep in mind. It is necessary to know how to bond each element around openings or under the roofing system.

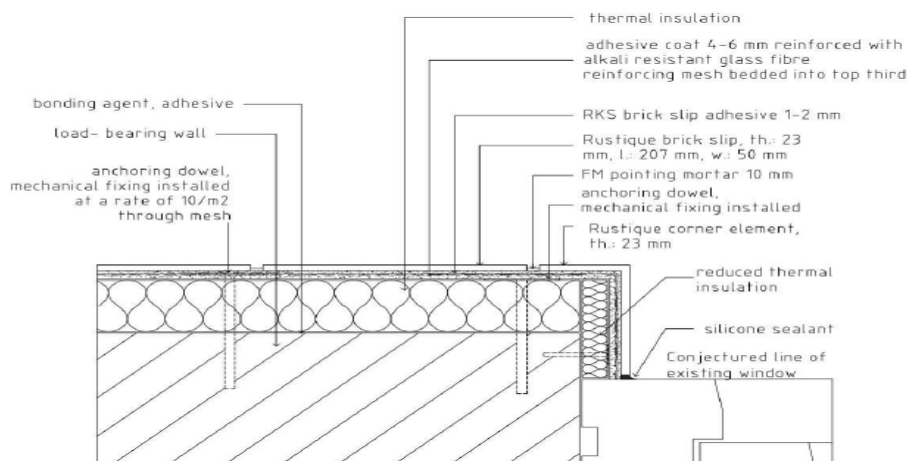


Figure 2 - Window jamb detail
Source: authors

In Figure 2 we can see the proper application of brick-facing strips close to the window jamb. To gain the look of real brickwork, it is advised to use corner pieces all around the window opening (the same applies around doors). The corner pieces should be cut to proper dimensions, so each one fits. Between the brick elements and the surface of the window frame silicone sealant is advised to be applied. The brick strips shall be attached to the surface with a layer of adhesive in the thickness of around 5-7 mm. For the perimeter masonry wall to be able to carry the load of the brick cladding, a glass fiber reinforcing mesh should be bedded onto its surface. It is important for the thermal insulation to be anchored.

The application of brick slips under windowsills also requires some basic instruction, which can be seen in the picture above. Between the bedded windowsill - secured with an anchor and sealed with silicone sealant - should be left a 40 mm gap, at least, to be able to apply the facing material with the layer of adhesive. The distance between each brick slip shall be kept at a thickness of 10 mm.

The application of brick slips directly under the roofing system requires a gap in the thickness of 10 mm. It should be sealed with a silicone sealant or the used grouting material itself.

Extent of validity

This technological regulation must be followed by all participants who become part of the construction process through the preparatory, implementation, inspection and acceptance stages of construction, according to STN 14411 Ceramic cladding elements. Definitions, classification of properties, conformity assessment and labelling. Also, according to the following laws and decrees:

- Act No. 137/2010 Coll. on Air Protection
- Act No. 364/2004 Coll. on Waters
- Act No. 17/1992 Coll. on the Environment
- Act No. 543/2002 Coll. on Protection of Nature and Landscape

- Decree No. 24/2003 Coll., implementing Act No. 543/2002 Coll. on Protection of Nature and Landscape
- Act No. 79/2015 Coll. on Waste and on Amendments and Additions to Certain Acts
- Decree No. 365/2015 Coll. Waste Catalogue

Preparation of the construction and building structures

The process of bonding the brick slips begins after finishing the VLBS (Vertical Load-Bearing System) and the construction of the contact insulation system under the ceramic cladding. The surveyor or other person responsible for the measuring works shall first check that no unauthorized deviations have occurred during the bricklaying process. If such anomalies exist, they shall be removed. The supports must have a flat surface, and sufficient strength to support heavy coatings. The insulation system shall be anchored with a minimum of 10 anchors per m² through the fiberglass reinforcing mesh with stainless steel mandrel plate dowels. The mesh and anchor pins should be covered with a final surface treatment – such as cement plaster – before bonding. [3]

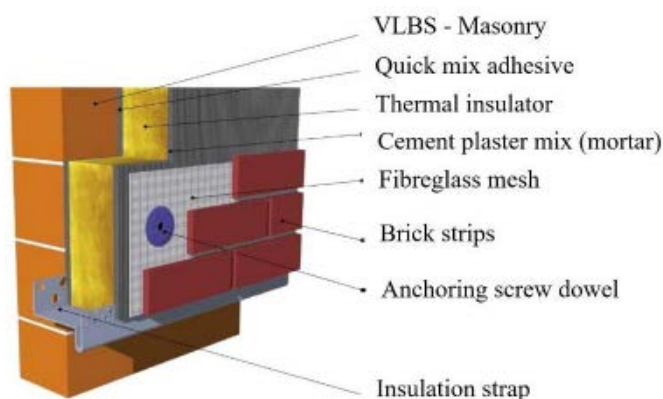


Figure 3 - System of composition
Source: [4]

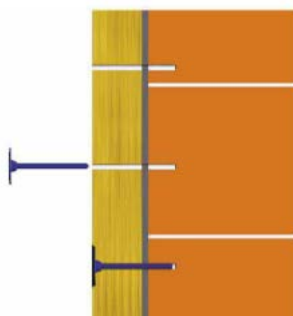


Figure 4 - Anchoring system using plate dowels
Source: [4]

The prepared surface is left to dry for a minimum of 48 hours, depending on the building conditions. If, after the sealant has set, there are major irregularities on the surface that may prevent the ceramic tiling elements from adhering properly, it is necessary to 33 regrind such surface. After sanding, any loose dust particles left on the surface shall always be removed. The surface of the structure must be dry and dust-free, so the bonding material will easily stick to the surface. [4]

These preparations must be done so that the structure can withstand the weight of the bricks. Usually, the brick tiling with addition of the glue and joints weighs 45 kg/m². [5]

Preparation of the workplace

The workplace must be equipped with a connection to the electrical network. The reason for this is the possible need to adjust the length of the brick slips using an angle grinder. The following tools must be prepared at the workplace: spirit level, measuring tape, angle grinder with a diamond disc, brush, and tile trowel.

The limiting factor of the bonding of cladding strips is the weather and the possibility of climate change. Under unfavorable conditions (heavy rain, low temperatures, strong winds) work should not be carried out.

The temperature during the bonding process must not fall below the permitted minimum of + 5 °C. At lower temperatures, the chemical reactions do not take place in the necessary way, the water contained in the mortar changes its volume due to freezing and damages the structure of the not yet hardened material and the system does not provide the necessary properties. In case of a gradual increase in temperatures above + 5 °C after a frosty night, the installation cannot be carried out unless the (water, mortar, and lining material), but especially the substrate, have been at lower temperatures for a long time and have not bonded with the required parameters. This could lead to consequences, such as the falling off the brick slips or the possibility of the formation of cracks in the joints. It is also not advised to work with these materials during windy or sunny weather. These might cause a rapid drying of the processed materials. The most important requirement is to protect the work before, during and after implementation from the ingress of excess moisture which may encourage efflorescence. [4]

Preparation of the building site

The site will have a water and electricity supply. Around the building, PERI scaffolding will be made, which is necessary not only for the actual bonding of the brick tiles but also for the installation of the contact insulation system. The scaffolding will have a hanging pulley in several places. The workers will also be able to use a construction lift for vertical transport around the building. Tools, adhesive mortar, and cladding strips will be stored in lockable sheet metal warehouses to ensure dryness and dust-free preservation. The roadway shall be sufficiently paved and prepared for the access of heavy vehicles.

All works will be supervised by a site supervisor who will ensure that the workers are trained in OHS before the start of the construction process.

The materials used.

RUSTIQUE specializes in the production of 100% natural brick tiles, which they cut from hand-formed Dutch, Belgian and German bricks. No artificial colors, admixtures or other "additives" can be found here. The products are made of water, clay, and sand, which never fade or change color and are resistant to weather and adverse external conditions. Maintenance-free, timeless ventilated façade with a lifespan of several decades is 35 guaranteed. The hand-formed bricks are fired at 1100 – 1200 °C. They use recycled boxes to package their goods. [6]



Figure 5 - RUSTIQUE brick slips – basic and corner element
Source: RUSTIQUE, a.s.

Technical specifications [7]

Length	[mm]	207	207	213	213	215	227	240
Width	[mm]	50	65	50	65	65	68	71
Thickness	[mm]				23			
Absorption	[% w/w]				10,4			
Packaging	[pc/pkg]		1 box = 1 m ² = 75 pcs					
Weight	[kg/pc]				0,4			

Dry mortar cement mix with shake for bonding EPS, XPS and MW insulation boards, screed with embedded reinforcement, bonding of brick slips, natural and artificial stone, and ceramic tiles to insulation systems. For bonding to the floor and walls. For indoor and outdoor use. RKS adhesive is certified in insulation systems with a brick slip finish. [8]



Figure 6 - RKS - highly flexible cementitious adhesive
Source: [8]

Technical specifications [8]

Material consumption	[kg/m ²]	5 – 5,5
Water consumption	[l/kg]	≈ 0,25
Packaging	[kg]	25
Processability	[h]	≈ 1 (at 20 °C)
Weight	[kg]	1 pallet = 48 pcs = 1200

Mineral, grouting mortar is designed for additional grouting of surfaces lined with absorbent and non-absorbent brick slips, natural or artificial stone, ceramic, concrete tiles, etc. Improved cementitious grout mortar with additional characteristics, and reduced water absorption

(CG2W). Used in indoor and outdoor applications environment for joints with a minimum width of 8 mm and a depth per strip thickness (min 15 - 20 mm). [9]

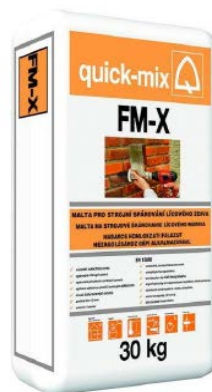


Figure 7 - FM – Grouting mortar for facing masonry
Source: [9]

Technical specifications [9]

Material consumption	[kg/m ²]	4,5 – 7,5
Water consumption	[l/kg]	≈ 0,1 – 0,15
Packaging	[kg]	30
Processability	[h]	≈ 1 (at 20 °C)
Weight	[kg]	1 pallet = 42 pcs = 1260

Transport and storage

The facing slips – packed in recycled cardboard boxes – will be delivered to the site along with Quick-mix RKS and Quick-mix FM – in paper bags wrapped in PE liner – by the supplier, RUSTIQUE, a.s. RUSTIQUE facing slips, Quick-mix RKS, and Quick-mix FM are stored on redeemable wooden pallets by FEZO PALLETS & MORE, Ltd. The transport of the material is entirely under the responsibility of the supplier. The pallets are stored by the designated mechanization and stored dry in covered warehouses in the original intact packaging.

Technological work procedure

One work crew will be involved in the execution of applying the brick slips on the facade, which will have 6 workers qualified by RUSTIQUE, a.s. This number of workers is sufficient to carry out the works associated with bonding, and grouting of the facing bricks in approx. 6 days.

Composition of the work crew:

- 3 workers for bonding and grouting the material
- 1 worker for constant cutting of material
- 1 worker for blending the adhesive and grouting mixture
- 1 additional assistant worker

Before the installation of brick slips on the façade, it is necessary to carefully measure the building object using a tape measure and to exclude any deviations between the actual

dimensions and the dimensions specified in the project documentation. The basis for the actual cladding is the cladding plan drawn up by the contractor.

Using the tape measure and spirit level, the walls are measured with respect to the size of the bricks with the additional free space for grout of 1 cm. The individual lines are plotted. It is important to make sure that the tread pattern is consistent between the openings of the building and with the bottom and top edges of the façade, where the actual bonding process begins. Regarding the production technology of the cladding elements, a layer of dust may be formed on the reverse side, which acts as a separator and has a very unfavorable effect on the adhesion of the bonded elements to the subfloor. For this reason, it is necessary to inspect the elements before gluing and to clean the dust layer well with a brush. As soon as the ground is covered with a protective layer of cardboard or foil, the adhesive is mixed according to the instructions the application of the cladding materials itself can begin. [5]



Fig. 8 - Drawing the lines using a spirit level
Source: [9]



Fig. 9 - Measuring the distances [9]
Source: [9]

Quick-mix RKS bonding mortar is applied to the brick slip. The mortar is spread flat with the flat side of the trowel with proper pressure to ensure necessary adhesion. A uniform layer of bonding mortar is then achieved by spreading the adhesive with the tooth side of the trowel.

The cladding is pressed onto the surface of the structure with a layer of adhesive RKS mortar and levelled. The bonding time of the mortar is about 1 hour under normal conditions. If the adhesive dries out quickly due to adverse weather conditions, the applied adhesive layer should be removed, and a new adhesive applied. [8]

Corner elements are used on the corners and edges of the brick slip. The finished cladding must be protected from rain and weather for at least 72 hours and must not be exposed to direct sunlight or frost for at least 5 days. It is advisable to mix the slips from several pallets to avoid possible color variations in the cladding parts of the façade. [6]



Fig. 10 - Bonding of corner elements

Source:[5]



Fig. 11 - Bonding of lining brick slips

Source:[5]

Grouting can begin during bonding process which is carried out with the grouting material Quick-mix FM, after the adhesive has cured completely.

The basis of everything is the good consistency of the grout. It needs to be mixed according to the manufacturer's instructions; a consistency resembling wet sand is ideal. This is what ensures that the mortar will not leak and stain other bricks during grouting; it will also ideally adhere the individual joints. When working with brick slips, there is an unwritten rule that you always grout horizontally first, then vertically, this way preventing staining of bricks. [5]



Fig. 12 - Grouting using spatula and trowel

Source: [5]



Fig. 13 - Brushing off the excess material

Source: [5]

A proven method of grouting is to press the semi-dry mixture using a pointing spatula off a trowel holding the material. The important thing is to press the compound in between the joints and then pass the surface through with a rubber stick for an even appearance. After grouting, dirt should be cleaned off with a brush. There is no need to wait between gluing and grouting. [5]



Fig. 14 - Final look of the finished brick cladding

Source: [5]

Treatment and protection of the finished product

The treatment of the already finished contact facade insulation system with a brick slip finish is carried out as required. If the slip system is implemented correctly, using the usual technology for the installation of this system, the maintenance of the façade is minimal. Maintenance is carried out by dry cleaning, wet cleaning or, for example, by application of an impregnating water-repellent coating which reduces the absorption and the dirtiness of the façade. Cleaning is carried out with pressure water. The water pressure shall be adapted to the conditions based on the cleaning test carried out so as not to damage the surface of the insulation system. The pressure shall be reduced by increasing the distance of the nozzle from the surface to be cleaned. The use of cleaning agents containing organic solvents, hydroxides, acids, or other chemicals is prohibited. Cleaning is recommended to be carried out at a time when freezing of the water, which could cause cracks in the system, can be ruled out, preferably in summer. Apart from the aesthetic effect, the primary purpose of protection is to remove dust build-up and fallout from the surface. This debris could cause mold and algae to form on the façade. It is recommended to consult the manufacturer for any repairs and cleaning of the façade. [10]

Finalization and preparedness for the follow-up processes

This work includes the process of dismantling the scaffolding, after a period of time that is defined for the protection of the finished product with an aesthetic netting. The prescribed procedure and safety regulations must be followed during the successive removal of the different parts of the scaffolding.

Waste management

The handling and disposal of waste is regulated by the laws: Act No. 79/2015 Coll. on Waste and on Amendments and Additions to Certain Acts. Decree No. 365/2015 Coll. Waste Catalogue. In the realization of ceramic tiling with brick slips the protection of the environment is governed by the principles and legislations described in Environmental protection. In the technological regulation in question, no process is involved which would impose a burden on the environment beyond the permissible limits. However, this process generates waste that can be categorized and must be sorted on site.

Number of groups, subgroup, type, and subtype of waste	Name of groups, subgroup, type, and subtype of waste	Category of waste	Estimated quantity [t]
15 01 06	Mixed packaging (Paper/PE)	O	0,55
15 01 10	Packaging containing residues of hazardous substances or contaminated with such substances	H	0,10
10 13 11	Wastes from composite-based materials cement-based composite waste other than those mentioned in 10 13 09 and 10 13 10	O	0,20
17 01 03	Tiles, cladding material, ceramics	O	0,10

Table 1 - Waste catalogue
Source: [11]

Health and safety at work

Each worker must undergo mandatory initial safety training and be demonstrably familiar with the technological procedure in question. Work at height, which is one of the riskiest works on the construction site from the point of view of OSH. Protection against falls from scaffolding will be in the form of collective protection.

Inspection and Test Plan

The inspections that will be carried out on the green façade are listed in the inspection and test plan (Tab.2).

Item	Construction process Description of activity	Responsible party	Method of inspection	Regulation, standard	Result Yes/No	Inspection performed	Inspection checked	Inspection taken over	Records
1	Realization of ceramic tiling Verification of conformity of properties of used products and materials	Foreman QA/QC	Initial and visual check	Certificate of conformity of the product		Name	Name	Name	
						Date	Date	Date	
						Signature	Signature	Signature	
2	Realization of ceramic tiling Checking the dimensions, flatness, and cleanliness of the substrate	Foreman QA/QC	Visual inspection Measuring	STN EN 14411		Name	Name	Name	
						Date	Date	Date	
						Signature	Signature	Signature	
3	Realization of ceramic tiling Output control of the final product	Foreman QA/QC	Visual inspection	Technological regulation		Name	Name	Name	
						Date	Date	Date	
						Signature	Signature	Signature	

Table 2 Inspection and test plan of brick cladding
Source: authors

Economic solution

The process of preparatory works, preparation of semi-finished products, bonding, and grouting of facing brick slips and corner pieces is set by the supplier itself, RUSTIQUE, a.s., to a value of approx. 0,5 h/m².

RUSTIQUE, a.s. secures the delivery unloading of the material by a hydraulic arm for 1,5 €/km throughout the whole territory of the Slovak Republic. The loss is only considered for

RUSTIQUE brick slips, since in terms of cladding technology the trimming is only related to this product. The loss declared by the manufacturer is at the level of 5%.

The total cladding area is 120 m². The consumption of lining slips per m² is 75 pieces. The price of the designed type of brick slip is GREY YELLOW at the price of 62,25 €/m². [16] The total length of the edges in total is 12 m. The consumption of corner pieces per meter is 17 pieces. The price of the designed type of corner piece is GREY YELLOW in the price of 34,51 €/m. [12]

The price of a 25 kg pack is 18.58 € and therefore the unit price is 0.74 €/kg. Consumption is 5 – 5,5 kg/m², for simplicity of calculation, the value of 5 kg/m² is considered. The price of a 30 kg pack is 16,32 € and therefore the unit price is 0,54 €/kg. Consumption is 4,5 – 7,5 kg/m², so for the sake of the simplicity of calculation, the value of 5 kg/m² is considered.

Material	Price/UM	Quantity	Price [€]
RUSTIQUE brick slips	62,25 €/m ²	120 m ²	7 470,00
Loss	62,25 €/m ²	6 m ²	373,50
RUSTIQUE corner pieces	2,03 €/pc	204 pc	414,12
RKS	0,74 €/kg	600 kg	444,00
FM	0,54 €/kg	600 kg	324,00
			Total of 9 025,62 €

Table 3 - Unit price

Source: authors

Material	Workload [h/m ²]	Quantity [m ²]	Duration [h]
RUSTIQUE brick slips	0,5	120	60
			Total of 60 h

Table 4 - Duration of the process

Source: authors

Process of installation	Price/UM [€/m ²]	Quantity [m ²]	Price [€]
Bonding + Grouting	35	120	4 200,00
			Total of 4 200,00 €

Table 5 - Price of the process

Source: authors

Price type	Price [€]
Price of material delivery	82,50
Unit price	9 025,62
Price of process	4 200,00
Total of 13 308,12 €	

Table 6 - Overall price

Source: authors

Tables 7 and 8 contain the itemized budget and the overall recapitulation.

BUDGET RECAPITULATION	
Construction:	Office building Veterná
Object:	Brick cladding
Place:	Date: 29.03.2022
Customer:	Construction d:
Contractor:	Compiler
Part code - description	Total price [EUR]
Budget costs	18,595.13
HSV - Work and supplies HSV	6,925.13
6 - Surface treatment, floors, installation	5,925.60
9 - Other construction and demolition work	999.28
99 - Mass transfer HSV	0.24
PSV - Work and supplies PSV	11,670.00
782 - Natural and conglomerated stone tiles	11,670.00

Table 7 - Budget recapitulation

Source: authors

CALCULATION							
Construction: Office building Veterná							
Object: Brick cladding							
Place:				Dátum: 29.03.2022			
Customer:				Designer:			
Contractor:				Compiler:			
IN	Type	Code	Description	UM	Quantity	U.price [EUR]	Total price [EUR]
Budget costs							18,595.125
	D	HSV	Work and supplies HSV				6,925.125
	D	6	Surface treatment, floors, installation				5,925.600
1	K	631440018300.S	Mineral wool th. 200 mm for contact thermal insulation systems	m2	120.000	49.380	5,925.600
	D	9	Other construction and demolition work				999.284
2	K	941942001.S	Installation of scaffolding with floors up to 0.75 m wide, above 10 to 20 m high	m2	120.000	1.860	223.200
3	K	941942801.S	Dismantling of frame system scaffolding with floors up to 0.75 m wide, above 10 to 20 m high	m2	120.000	1.610	193.200
4	K	941942901.S	Surcharge for the first and every other week started using scaffolding frame system width up to 0.75 m, height over 10 to 20 m	m2	120.000	0.840	100.800
5	K	944944103.S	Safety net on the side of the scaffolding	m2	120.000	1.634	196.080
6	K	944944803.S	Dismantling of safety net on the side of the scaffolding	m2	120.000	0.708	84.960
7	K	953945314.S	Aluminium plinth profile 203 mm	m	10.000	8.064	80.640
8	K	953995406.S	Window and door nets	m	12.000	4.820	57.840
9	K	953995411.S	Above-window net profile with hidden eaves	m	9.000	3.142	28.278
10	K	953995421.S	Corner net profile - integrated - fixed	m	14.000	2.449	34.286
	D	99	Mass transfer HSV				0.241
11	K	998713103	Mass transfer for buildings (801, 803, 812), vertical construction of bricks, blocks, metal height up to 24 m	t	0.031	7.790	0.241
	D	PSV	Work and supply PSV				11,670.000
	D	782	Natural and conglomerated tiles				11,670.000
12	K	782111120.S	Installation of wall cladding with straight slip stones, th. up to 25 mm slips	m2	120.000	35.000	4,200.000
13	M	596360000100.S	Brick slips, dim. 210 × 23 × 50 mm, straight	pcs	9,000.000	0.830	7,470.000
14	M	596360000100	Brick slips, dim. 210 × 100 × 50 mm, corner	pcs	204.000	1.690	344.760
15	M	998782104	Transfer of stone cladding materials in buildings over 12 to 60 m in height	t	3.722	31.544	117.407

Table 8 - Calculation

Source: authors

Conclusion

If we want to visually change the appearance of the building, cladding the facade is a great way to achieve this. Facade tiles bring several advantages. In addition to the aesthetic side, some types of cladding, such as stone or brick, provide natural insulation that helps maintain the building's internal temperature, which can reduce energy costs.

High-quality cladding on the facade can also significantly increase the overall market value of the building. Most types of facade cladding require only minimal maintenance. [13]

The article describes the structural, technological, and economical solution of the brick cladding of the facade of a specific object of the administrative building in Nitra as variant I. In the following article, variant II, the solution of the green facade of the same object will be presented. Both variants will be compared from these points of view.

*This article was recommended for publication in a scientific journal Young Science by:
Assoc. Prof. Sabah Shawkat, PhD.*

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Mladá veda

Young Science

ISSN 1339-3189