Article
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Investigation of adhesive bond strength when facing furniture boards with flexible stone veneer

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Abstract

Stone veneer has been known for a long time. But mostly it has been used as a finishing material, which is widely applied in decorating the outer surfaces of buildings and facilities. Stone veneer is a thin cut of natural stone - slate, which is applied to fiberglass or textiles. The thickness of the veneer is in the range of 2-3 mm. Stone veneer is available in the form of rolls or tiles. Due to its flexibility, it can be used to refine surfaces that have angles and small radius of curvature. The flexibility of stone veneer is a unique property, since natural stone is not flexible. In today's world stone veneer is trying to find new fields of application. This material is used not only in interior and exterior designs, but also as a decorative coating of furniture panels. In this work we have established the possibility of wood board materials facing by stone veneer using standard technologies and the most common adhesives used in our country, such as urea-formaldehyde resin and polyvinyl acetate dispersion.

Keywords: *stone veneer, cladding modes, glue, adhesive joint strength, glue seepage*

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Оригинальная статья

Исследование прочности клеевого соединения при облицовывании щитовых деталей мебели каменным шпоном

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Каменный шпон известен достаточно давно. Но в основном он использовался как отделочный материал, который широко применяется для декорирования наружных поверхностей зданий и сооружений. Каменный шпон представляет собой тонкий срез природного камня - сланца, который наносится на стекловолокно или текстиль. Толщина шпона находится в пределах всего 2-3 мм. Каменный шпон выпускается в виде рулонов или плитки. Из-за гибкой основы, каменным шпоном можно облагораживать поверхности, имеющие углы и небольшие радиусы кривизны. Гибкость каменного шпона является уникальным свойством, так как природный камень в природе не изгибается. В современном мире каменный шпон находит новые зоны применения. Дизайнеры используют этот материал не только в интерьере внутри и снаружи помещений, но и как декоративное покрытие щитовых деталей мебели. В своей работе мы установили возможность облицовывания плитных древесных материалов каменным шпоном по типовым технологиям и самым распространенными клеями, которые используются в нашей стране, такими как карбамидоформальдегидная смола и поливинилацетатная дисперсия.

Ключевые слова: *каменный шпон, режимы облицовывания, клей, прочность клеевого соединения, просачивание клея*

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Introduction

Over recent years, the amount of forest resources on the planet, due to global warming and climate change, frequent fires and other disasters, has decreased. Russia, as the richest country in forest resources, is also experiencing difficulties in developing new areas of deforestation for industrial use, including furniture production. Resource depletion and environmental challenges have stimulated research into renewable and recyclable materials in the furniture industry [1-3]. Modern furniture is mostly made from wood-based board materials, which are cladded with wood veneer or synthetic films [4]. Designers are looking for opportunities to use new facing materials that are not quite typical for furniture. Among them is flexible stone veneer [http://www.tg-stone.ru/shpon/ (date of access: 15.11.2023); http://www.samplestone.ru/mebel-iz-kamennogo-shpona/ (date of access: 15.11.2023); http://www.niasam.ru/ (date of access: 15.11.2023].

Stone veneer, like many other loud discoveries, was designed by accident, during a stone countertop repairing process in Germany in the late 20th century. It was possible to separate a thin layer of stone from a massive slate. Further, as a result of long experiments, a modern version of stone veneer was obtained. The material completely mimics natural stone.

The main advantage of stone veneer is its decorative effect, due to the large number of colors and unique natural stone pattern [5]. We also note high water and temperature resistances, eco-friendliness, flexibility, durability. All these properties make it possible to use this material for external and internal finishing of surfaces of complex configuration. Natural stone veneer goes well with other materials such as wood, leather, wallpaper, concrete, ceramic, glass and metal, which allows its using for indoor wall and floor coverings, fireplace facades, bathroom surfaces, ceilings, kitchen splash backs. Transparent fiberglass and a light source allow to create amazing stone patterns; such stone veneer is used including for the manufacture of unique lampshades for lamps and light panels [6]. The cotton base allows to produce a highly flexible stone veneer which expands the possibilities of its practical use. Such stone veneer is used in furniture manufacturing, car tuning, decorating of clothing and accessories.

New generation stone veneer is a "sandwich" consisting of a substrate, adhesive and stone layer. The substrate is fiberglass, transparent fiberglass and cotton. The type of substrate is mainly determined by the properties of stone veneer and its field of application.

The popularity of stone veneer in interior design is very high, thus many designers wish to use it also in furniture design [7,8]. Stone veneer manufacturers provide recommendations on the use of certain types of adhesives for interior decoration on individual projects. There are no recommendations on the use of stone veneer for facing furniture panels. Ceramide - and melamine-formaldehyde adhesives are widely used in furniture production. Due to the increasing requirements for the environmental friendliness of materials in furniture production, new multifunctional non-toxic adhesives based on polyurethane and natural rubber are currently being developed [9-11], as well as modified melamine-formaldehyde resins [12]. These materials have not yet been sufficiently studied and have not found wide application. In that context, it would be interesting to consider serial use of stone veneer in furniture manufacturing, as well as the possibility of using standard pressure equipment, traditional adhesive systems [13-16], adhesive application methods and its consumption.

The purpose of the work is to determine the effect of the type and consumption of glue on the strength of the adhesive joint when using flexible stone veneer [17-19] as a facing material for furniture blanks made of wood–based materials under different operating conditions [20].

Materials and methods

Particleboard (chipboard) was used as the base for cladding according to EN 312:2010 [Particleboards - Specifications; German version EN 312:2010 Spanplatten - Anforderungen] 16 mm thick, 750 kg/m_3 density. Slate-Lite stone veneer with a cotton substrate was used as facing layer, Tytan Hydro Fix Professional assembly adhesive – as a binder, KF-Zh urea formaldehyde resin (UFR), PVA DE 51/15V.

Tytan Hydro Fix is a water-based multipurpose assembly adhesive for working with fire hotspots, manufactured by Libra sp.z.o.o. (Poland). Technical characteristics: mass fraction of dry residue is 52%, application temperature 10-30 ^{0}C, operating temperature -20+60 ^{0}C.

Resin KF-Zh - urea-formaldehyde resin of high vitality according to GOST 14231 [Smoly karbamidoformal'degidnye. Tekhnicheskie usloviya [Carbamide-formaldehyde resins. Technical conditions] – 1989-07-01.]. Technical characteristics: mass fraction of dry residue is 67%, relative viscosity at (20.0 + 0.5) 0C, according to the VZ-246 viscometer with a nozzle diameter of 6 mm 35-50 s, pH 7.5-8.7, gelatinization time at 100 ^{0}C 40-65 s, at 20 ^{0}C – 8 hours.

DE 51/15V is a polyvinyl acetate (PVA) dispersion plasticized according to TU 2241-010-25031183-06 [These technical conditions apply to the glue PVA DE 51/15 V]. (in Russian)]. Produced by"Edos" (Russia). Specifications: dry residue mass fraction 51±1%, conventional viscosity according to a standard VMS cup 10-40 s, pH 4-6.5. The formulations of adhesive solutions are presented in table 1.

During the experimental part we produced a set of works on chipboard facing with stone veneer using cold and hot methods according to standard technological modes and applying different adhesive formulations. Technological modes of chipboard facing are shown in table 2. The size of the faced boards is 300×200 mm, the size of the facing layer with an allowance is 310×210 mm.

Since stone veneer was originally used for interior decoration, we applied the following formula to calculate the adhesive consumption for the cold method:

$$V = S \cdot t \cdot R \cdot К \quad (1)$$

where V is the adhesive volume, l; S – the area of application surface, m^2; t – the thickness of the adhesive layer, m; and K – the number of adhesive layers.

For Tytan adhesive, the consumption according to formula 1 was 400 g/m^2. However, the practical application of this consumption led to the extrusion during the hot pressing, and therefore the adhesive consumption was adjusted from 200 to 300 g/m^2. For other types of adhesives, the consumption varied from 180 to 220 g/m^2.

Table 1

Compositions of adhesive solutions

Таблица 1

Рецепт рабочих растворов клеев

№ Formulation| Рецепт клея	Composition of adhesive solutions| Состав рабочего раствора клея, м.ч.				
	Tytan| Tytan	KF-Zh| КФ-Ж	PVA DE 51/15V| ПВА ДЭ 51/15 В	Ammonium-chloride| Хлористый аммоний	10% oxalic acid-based solution | 10-% водный раствор щавеливой кислоты
1	100	-	-	-	-
2	-	100	-	-	6
3	-	100	-	1	-
4	-	75	25	-	6
5	-	75	25	1	-

Источник: собственные вычисления автор(ов)
Source: own calculations

Table 2

Technological modes of facing

Таблица 2

Технологические режимы облицовывания

Technological modes of facing |Технологические режимы облицовывания	Formulation | Рецепты клеев				
	1	2	3	4	5
Adhesive consumption, g/m^2| Расход клея, $г/м^2$	200-400	180-220	180-220	180-220	180-220
Specific pressure, MPa| Удельное давление, МПа	0,2	0,2	0,7-1	0,2	0,7-1
Adhesion duration, min |Продолжительность склеивания, мин.	120	35-40	3	90-120	3
Board temperature in the press, ^0C| Температура плит пресса, ^0C	20	20	120	20	120
Holding after depressurization, h| Выдержка после снятия давления, час	48	18-24	18-24	18-24	18-24
Room temperature, $\leq$ ^0C |Температура в помещении, не менее ^0C	18	18	18	18	18

Источник: собственные вычисления автор(ов)
Source: own calculations

Samples of 100×100 mm were used to determine the possible adhesive absorption by the stone veneer basis. The samples were weighted on the scales with a weighing accuracy of 0.01 g, the adhesive was applied in an even layer and kept for 60 s. Excess adhesive was removed and the surface was dried with filter paper. Next, the samples were weighed again and the amount of absorbed adhesive was determined by the formula:

$$Q = m_к - m_n, \quad (2)$$

where, $m_к$ is the mass of the sample with the adhesive absorbed into the sample; m_n – the initial mass of the sample.

To determine the adhesive leakage, a package was assembled: a facing layer of stone veneer is laid on the base, and filter paper is placed on top. Next, the package was placed in a press. Paper was removed from the finished sample, and the absolute leakage area were determined from the adhered pieces by applying glass with a grid. The relative seepage area was determined by dividing the absolute seepage area by the sample area.

Strength tests of the adhesive bond for uneven separation were carried out according to GOST 15867. Sample workpieces are made individually or cut in the form of rectangular bars with a length that is a multiple of the length of the sample with sawing allowances. The thickness of the base is equal to the thickness of the chipboard. Overhangs of stone veneer relative to the base were 5 mm on each side (figure 1).

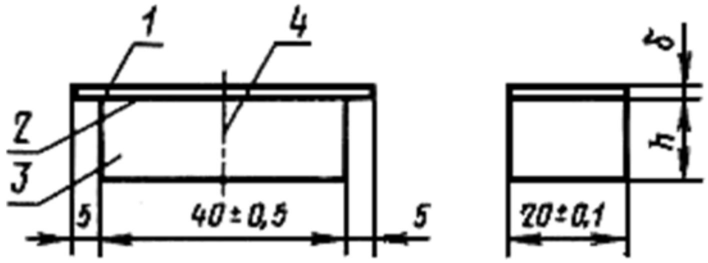


Figure 1. The shape and dimensions of the sample:
1 – flexible stone veneer, 2 – adhesive layer, 3 – chipboard base, 4 – punch line
Рисунок 1 – Форма и размеры образца:
1 - каменный шпон , 2 – клеевой слой, 3 – основание ДСтП, 4 – линия для установки пуансона

Source: GOST 15867-79 Detali i izdeliya iz drevesiny i drevesnyh materialov. Metody opredeleniya prochnosti kleevogo soedineniya na neravnomernyj otryv oblicovochnyh materialov. [Details and products made of wood and wood materials. Methods for determining the strength of the adhesive joint for uneven separation of facing materials]. – Введ. 1980-07-01. - M.: IMK Izdatel'stvo standartov [Publishing House of Standards], 1980 г. – 8 p. (in Russian)
Источник: ГОСТ 15867-79 «Детали и изделия из древесины и древесных материалов. Методы определения прочности клеевого соединения на неравномерный отрыв облицовочных материалов». – Введ. 1980-07-01. - М.: ИМК Издательство стандартов, 1980 г. – 8 с.

To determine the strength of the samples, an MP-0.5 tensile strength testing machine was used (maximum load 50000 N, manufacturer Ivanovskij ZIP, Russia). The sample is loaded at a constant travel speed of 30 mm/min. The test instrument is shown in the Figure 2.

The strength of the adhesive bond during the uneven separation test (kN/m) was determined by the formula

$$g = \frac{P}{2b}, \quad (3)$$

where P is the breaking load, kN; b – the sample width, m.

The tests were carried out in three stages. In the first stage - immediately after the end of the technological exposure of the samples after storage at a temperature of (18±5) ^{0}C and relative air humidity (65±10) %. In the second and third stages, the determination of the strength and water resistance of adhesive bonds was carried out according to European standards: DIN EN 204, 205. According to EN 204, 205 adhesive bonds must satisfy specific requirements for the relevant load group. We have considered the load groups D1 and D2 (table 3).

The minimum values of adhesive bond strength according to DIN EN 204 are shown in table 4.

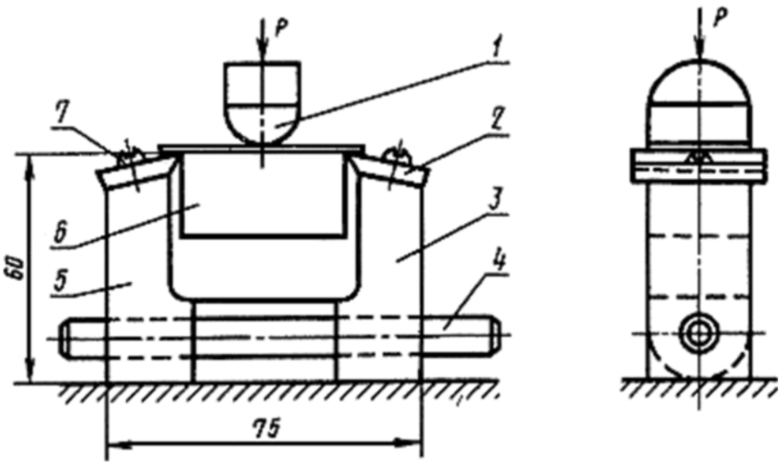


Figure 2. Instrument for determining the strength on uneven separation: 1 – punch, 2 – knife, 3 – self-aligning support with cylindrical base , 4 – rod, 5 – support with a flat base, 6 – sample, 7 – M5 crew

Рисунок 2. Приспособление для определения прочности на неравномерный отрыв: 1 – пуансон, 2 – нож, 3 – самоустанавливающаяся опора с цилиндрическим основанием, 4 – стержень, 5 – опора с плоским основанием, 6 – образец, 7 – винт М5

Источник: ГОСТ 15867-79 «Детали и изделия из древесины и древесных материалов. Методы определения прочности клеевого соединения на неравномерный отрыв облицовочных материалов». – Введ. 1980-07-01. - М.: ИМК Издательство стандартов, 1980 г. – 8 с.

Source: GOST 15867-79 Detali i izdeliya iz drevesiny i drevesnyh materialov. Metody opredeleniya prochnosti kleevogo soedineniya na neravnomernyj otryv oblicovochnyh materialov. [Details and products made of wood and wood materials. Methods for determining the strength of the adhesive joint for uneven separation of facing materials]. – Введ. 1980-07-01. - М.: IMK Izdatel'stvo standartov [Publishing House of Standards], 1980 г. – 8 p. (in Russian)

Table 3

Description of load groups

Таблица 3

Описание групп нагружаемости

Load group | Группа нагрузок	Areas of application | Примеры для областей применения
D1	In a room with temperature briefly above 50 ^{0}C and humidity of max 15% | В помещении, причем температура только кратковременно составляет более 50^0 С и влажности max 15%
D2	Indoors, with short-term exposure to running water or condensate and/or short-term high air humidity with an increase in humidity up to 18% | В помещении, с кратковременным воздействием стекающей водой или конденсатом и/или кратковременной высокой влажностью воздуха с повышением влажности до max 18 %

Source: Klassifikaciya termoplastichnyh kleev dlya drevesiny dlya primeneniya ne v proizvodstve kon-strukcionno-go silovogo brusa [Classification of thermoplastic adhesives for wood for use not in the production of structural power beams]: DIN EN 204-2001. – 01.05.2001. – CEN, 2001. – 5 p. (in Russian); Klei. Klei nekonstrukcionnye dlya dereva. Opredelenie prochnosti skleivaniya prodol'nyh skleek ispytaniem na razryv [Adhesives. Non-structural adhesives for wood. Determination of the bonding strength of longitudinal glues by a tear test]: DIN EN 205−2003. – 21.11.2002. – CEN, 2003. – 10 p. (in Russian)

Источники: Классификация термопластичных клеев для древесины для применения не в производстве кон-струкционного силового бруса: DIN EN 204-2001. – Введ. 01.05.2001. – CEN, 2001. – 5 с.: Клеи. Клеи неконструкционные для дерева. Определение прочности склеивания продольных склеек испытанием на разрыв: DIN EN 205−2003. – Введ. 21.11.2002.

Table 4

Minimum values of adhesive bond strength according to DIN EN 204, 205

Таблица 4

Минимальные значения прочности клеевого соединения по DIN EN 204, 205

Exposuresequence| Последовательность экспозиции	Typeandduration| Вид и продолжительность	Loadgroups/adhesivebondstrengthN/mm^2| Группы нагрузок/прочность клеевого соединения Н/мм^2	
		D1	D2
1	7 days[1]innormal climate[2] | 7 дней[1)] при нормальном климате[2)]	>10	≥10
2	7 days[1]innormalclimate[2], 3 hincoldwater[3], 7 daysinnormalclimate[2] | 7 дней[1)] при нормальном климате[2)], 3 часа в холодной воде3), 7 дней при нормальном климате[2)]	-	≥8

[1]day – 24 h.
[2]Room temperature of 23±2 ^{0}C and relative air humidity of 50±5%.
[3]Water is the same temperature as the environment.
Примечание: 1)-1 день – 24 часа; 2)температура в помещении (23±2)^0 С и относительная влажность воздуха (50±5)%; 3)вода должна иметь ту же температуру, что и окружающая среда

Sources: Klassifikaciya termoplastichnyh kleev dlya drevesiny dlya primeneniya ne v proizvodstve konstrukcionno-go silovogo brusa [Classification of thermoplastic adhesives for wood for use not in the production of structural power beams]: DIN EN 204-2001. – 01.05.2001. – CEN, 2001. – 5 p. (in Russian); Klei. Klei nekonstrukcionnye dlya dereva. Opredelenie prochnosti skleivaniya prodol'nyh skleek ispytaniem na razryv [Adhesives. Non-structural adhesives for wood. Determination of the bonding strength of longitudinal glues by a tear test]: DIN EN 205−2003. – 21.11.2002. – CEN, 2003. – 10 p. (in Russian)

Источники: Классификация термопластичных клеев для древесины для применения не в производстве конструкционного силового бруса: DIN EN 204-2001. – Введ. 01.05.2001. – CEN, 2001. – 5 с.: Клеи. Клеи неконструкционные для дерева. Определение прочности склеивания продольных склеек испытанием на разрыв: DIN EN 205−2003. – Введ. 21.11.2002.

Results

The absorbency of the glue by the base of the stone veneer was determined on 10 samples obtained from different sections of the sheet. Figure 3 shows that the base of stone veneer under the influence of adhesives and water can plasticize, soften and absorb a small amount of adhesive and water. As we are considering the use of traditional adhesives when facing facades and furniture walls with stone veneer, we conclude that with small façade area (about 1 m^2), recalculation of the adhesive, based omits absorption, is not necessary. If the area of facades or other furniture details is large, it is recommended to increase the adhesive consumption, based on its absorption into the stone veneer base.

After holding the samples in a cold press, we noticed that some of them partially acquired a darker cooler. It is assumed that stone does not allow moisture to pass through, thus adhesive leakage onto the front side is highly unlikely. It is apparent that, when pressure is applied for the cold method, adhesive curing does not happen immediately, but within a certain time. The stone veneer production technology suggests the destruction of a massive stone beam. Microcracks forming in it and, at the moment of application of force, adhesive leaks onto them. It is an interesting fact that at the end of the technological exposure, the veneer dried out and returned to its original color. When exposed to hot presses, no leakage effect was observed. Obviously, it is due to the fact that the duration of the adhesive curing in hot presses is only a few minutes.

The leakage area and the relative leakage area on the front side during the cold method, depending on the brand and type of adhesive, are presented in table 5 and figure 4.

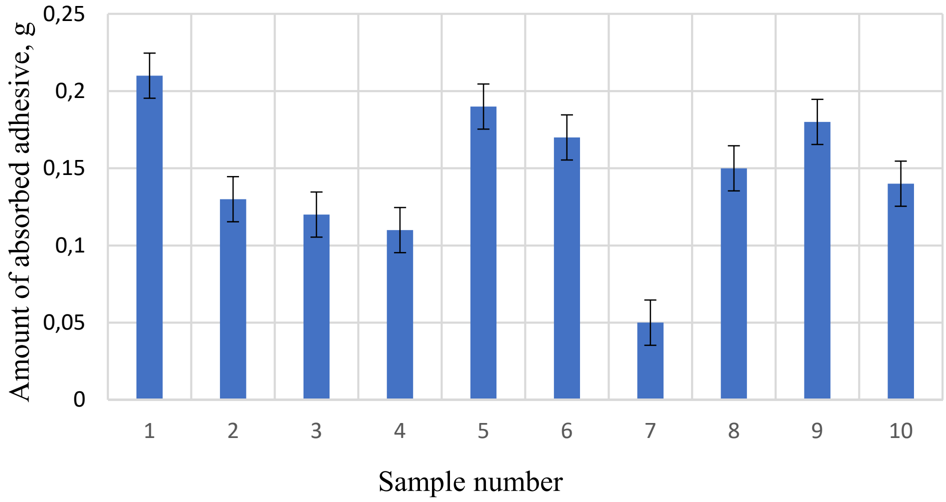


Figure 3. Adhesive absorption by the stone veneer base

Рисунок 3. Впитываемость клея основой каменного шпона

Source: author'sresults

Источник: собственные результаты авторов

When using the Tytan adhesive with an adhesive consumption of 200 g/m^2 no leakage was observed, with an increase in the adhesive consumption to 400 g/m^2 the leakage was very low and the average value of the relative leakage area was only 0,134 (table 4 Formulation 1/figure 3). It should also be noted that leakage was observed in only 30% of the samples. Almost the same leakage was shown by the use of resin KF-Zh-based adhesive – 0,133 (table 4 Formulation 2/figure 3). But leakage was noted in 40% of the samples. For the combined adhesive (KF-L+PVA), the average value of the relative leakage area was 0.49 and 100% of the samples (table 4 Formulation 3/figure 3). This can be explained by the longer curing time of the adhesive in the cold state compared to hot method.

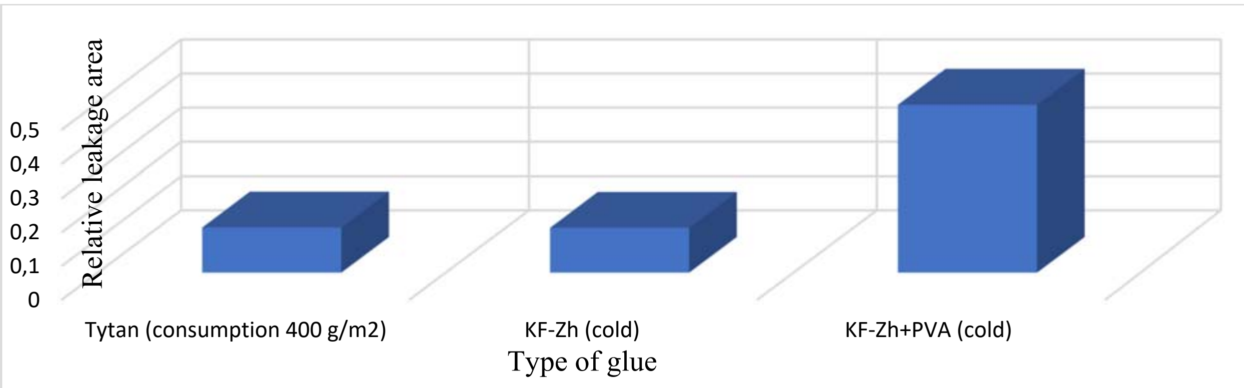


Figure 4. Glue seeping onto the front surface during cold bonding

Рисунок 4. Просачивание клея на лицевую поверхность для холодного способа склеивания

Source: author'sresults

Источник: собственные результаты авторов

Table 5

Leakage area and relative leakage area

Таблица 5

Площадь просачивания и относительная площадь просачивания

Рецепт клея					
1 с расходом клея 400 г/м^2		2 с расходом клея 200 г/м^2		4 с расходом клея 200 г/м^2	
Площадь просачивания, см^2	Относительная площадь просачивания	Площадь просачивания, см^2	Относительная площадь просачивания	Площадь просачивания, см^2	Относительная площадь просачивания
1,07	0,134	3,63	0,133	3,95	0,493

Source: author's results

Источник: собственные результаты авторов

During the production of samples in order to determine the strength of the adhesive bond for uneven separation not all of the samples turned out to be suitable to perform tests. The percentage of suitable samples ranged from 50 to 70%. The rest of the samples had a very low adhesive strength. We assume that this result is due to the fact that the surface of the stone veneer has different thicknesses and at the time of load application in a flat press, the pressure exerted on the board was uneven. This resulted in the fact that those places where the pressure was weakened, the adhesive bond strength was very low.

The results of definition of adhesive bond strength for uneven separation for various adhesive formulations and modes from load groups are presented in figures 5-9.

Figure 5 allows to establish that after technological exposure (24 h) with load group D1 and at adhesive consumption of 200 and 300 g/m^2, the adhesive bond strength for uneven separation is within 3.25 kN/m. With an increase in the adhesive consumption up to 400 g/m^2, the strength not only does not increase, but, on the contrary, decreases. A large thickness of the cured adhesive layer leads to a large shrinkage, destruction and a decrease in strength. After the load group D2, the adhesive bond strength for uneven separation at any adhesive consumption is approximately the same and is within 0.4 kN/m. This clearly demonstrates that exposure to water impacts negatively on the strength characteristics of the Tytan adhesive.

Figure 6 demonstrates that at the highest strength of the adhesive bond for uneven separation is observed after the load group D 1 at all adhesive consumptions, the maximum value, slightly more than 0.8 kN/m, falls on the adhesive consumption of 200 g/m^2. After technological exposure for 24 h, the strength at all adhesive consumptions is within 0.4 ... 0.6 kN/m, after load group D – 0.25 ... 0.3. We see that these figures are lower than for Tytan adhesive, but still sufficient for facing furniture facades.

As shown in figure 7, the correspondence between the strength of the adhesive layer for uneven separation after technological exposure and after the load group D1 and D2 is similar to the previous adhesive, but the average values are in a lower range. The highest strength value is achieved at an adhesive consumption of 200 g/m^2 and is 0.578 kN/m and load group D 1.

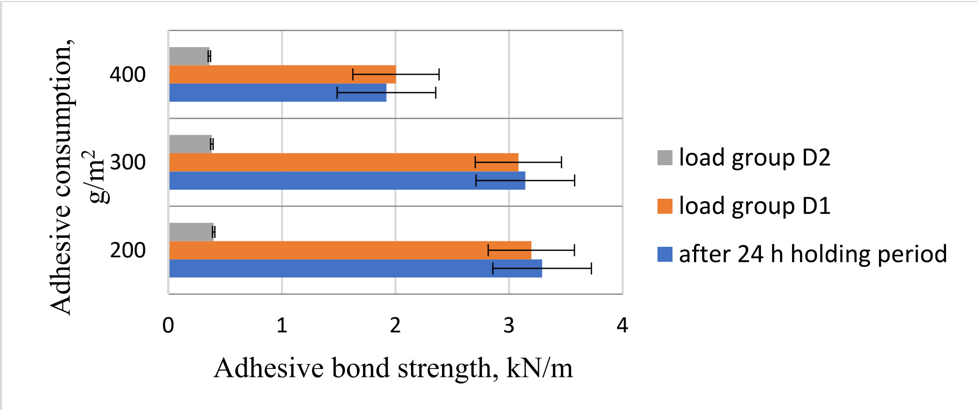


Figure 5. Dependence of adhesive bond strength for uneven separation on the consumption of Tytan adhesive

Рисунок 5 ЗависимосьпрочностиклеевогосоединенияотрасходаклеяTytan

Source: author's results

Источник: собственные результаты авторов

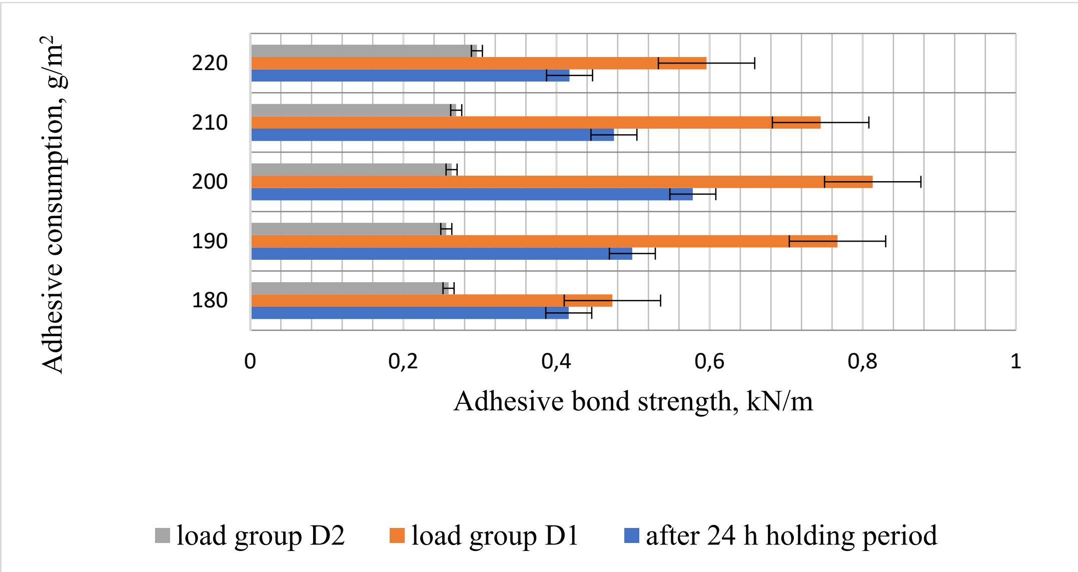


Figure 6. Dependence of the adhesive bond strength on the consumption of KF-Zh adhesive (cold method)

Рисунок 6. Зависимось прочности клеевого соединения от расхода клея КФ-Ж (холодный способ склеивания)

Source: author's results

Источник: собственные результаты авторов

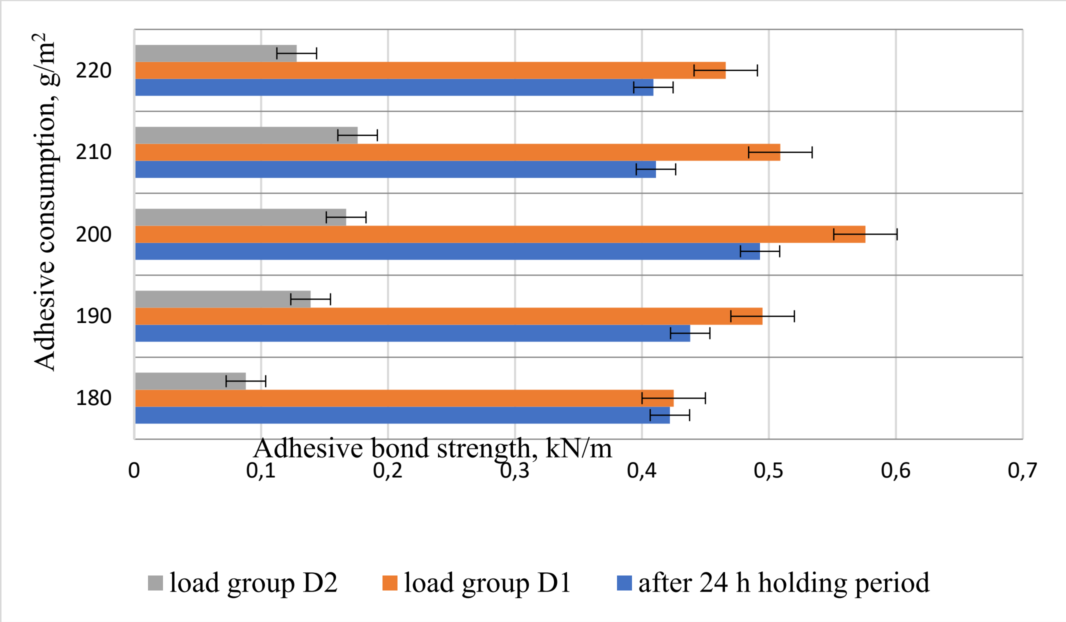


Figure 7. Dependence of the adhesive bond strength on the consumption of KF-Zh adhesive (hotmethod)

Рисунок 7. Зависимось прочности клеевого соединения от расхода клея КФ-Ж (горячий способ склеивания)

Source: author’s results

Источник: собственные результаты авторов

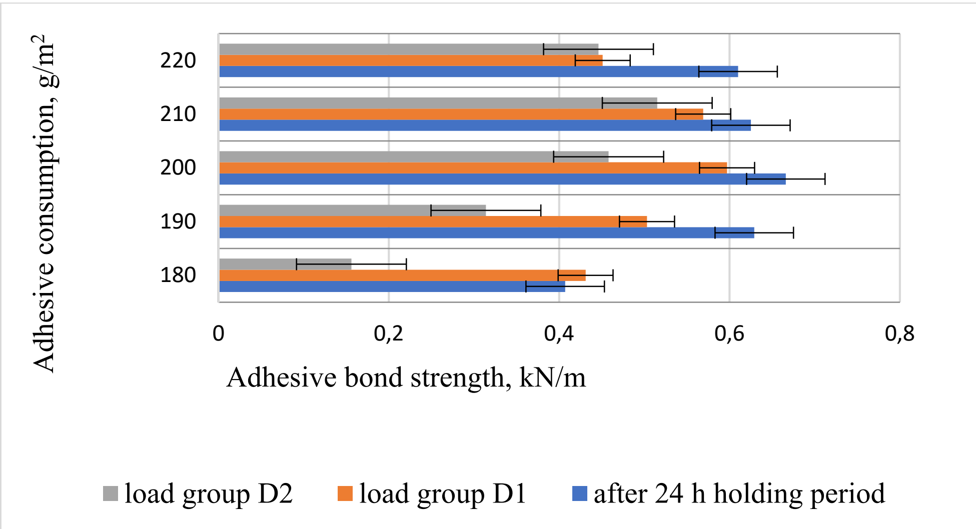


Figure 8. Dependence of the adhesive bond strength on the consumption of KF-Zh + PVA adhesive (cold method)

Рисунок 8. Зависимось прочности клеевого соединения от расхода клея КФ-Ж+ПВА (холодный способ склеивания)

Source: author’sresults

Источник: собственные результаты авторов

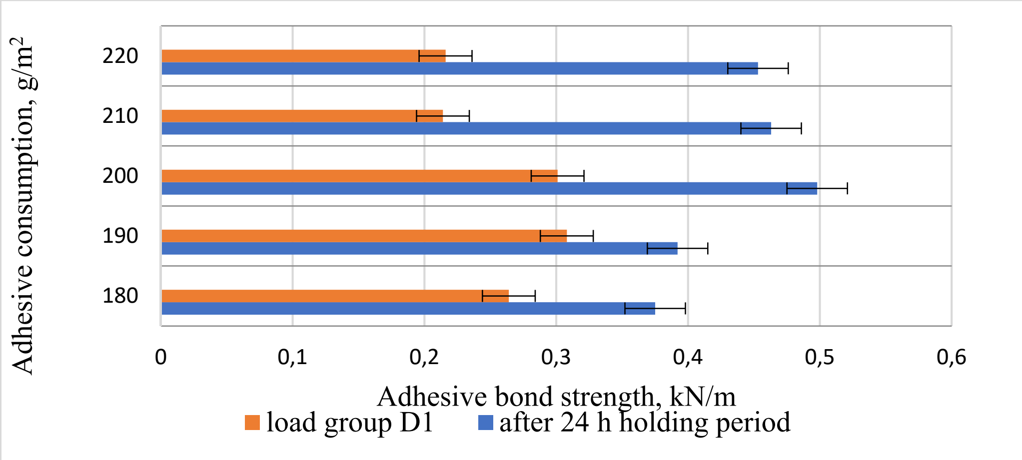


Figure 9. Dependence of the adhesive bond strength on the consumption of KF-Zh + PVA adhesive (hot method)

Рисунок 9. Зависимось прочности клеевого соединения от расхода клея КФ-Ж+ПВА (горячий способ склеивания)

Source: author's results

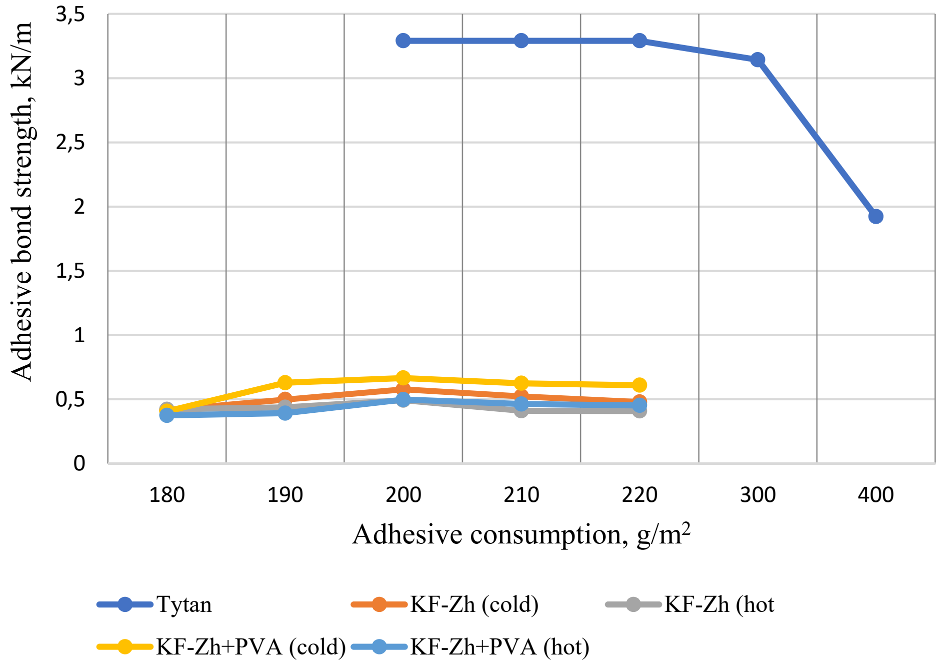
Источник: собственные результаты авторов

From figure 9 it can be seen that the maximum strength for uneven separation is observed after a technological exposure of 24 hours and is in the range of 0.4 ... 0.5 kN/m. The lower strength range is of load group D1, and lies within 0.2 ... 0.32 kN/m. An analysis of the diagrams shows that the adhesive bond strength for uneven separation of the combined KF-Zh + PVA adhesive (hot method) is close to the strength of the KF-Zh adhesive (hot method). It should be noted that the samples of load groups D2 fell apart before the test.

Comparison of the bonding strength of various adhesive formulations is represented in figures 10-12. After technological exposure (in our case, it was 24 h), the adhesive bond strength for uneven separation for Tytan adhesive is significantly higher than for other adhesives and is 3.143 kN/m at an adhesive consumption of 300 g/m^2 (figure 10 a). The strength of other types of adhesives is much lower and is in the zone of less than 1kN/m (figure 10 b). It should also be noted that cold bonding adhesives show a greater strength than hot bonding adhesives.

For the load group D1, the adhesive bond strength for uneven separation for Tytan adhesive is superior to other types of adhesives and is in the range of 3.0 ... 3.5 kN/m at adhesive consumption of 200 and 300 g/m^2 (figure 11 a). As in the previous case, other types of adhesives showed a lower strength for uneven separation and are in the zone of less than 1kN/m (figure 11 b).

As shown in figure 12, for the load group D2, the adhesive bond strength for uneven separation turned out to be the highest for the combined adhesive KF-Zh + PVA (cold) and is 0.515 kN/m at an adhesive consumption of 210 g/m^2; for Tytan adhesive – 0.4 kN/m at an adhesive consumption of 200 and 300 g/m^2. It should also be noted that the combined adhesive KF-Zh + PVA (hot) did not pass the test and all the samples were destroyed without showing strength values.



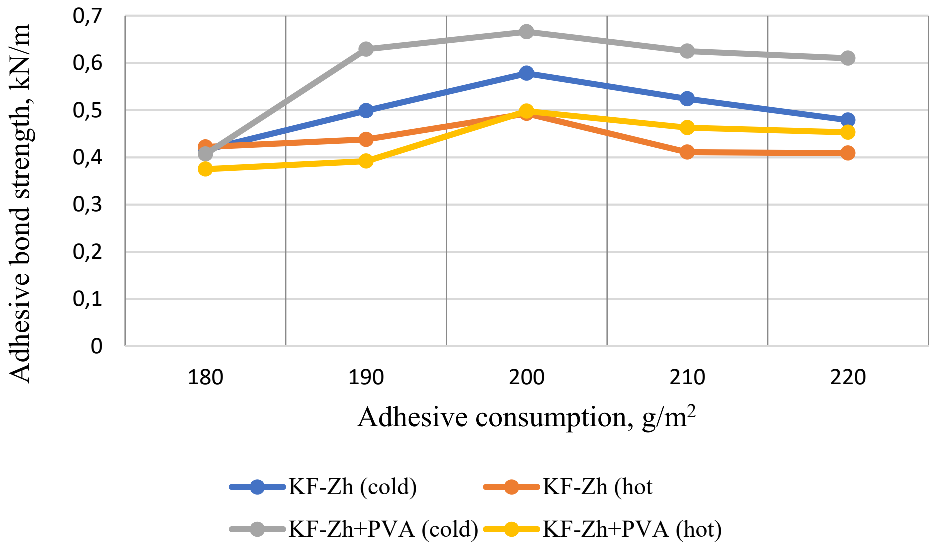
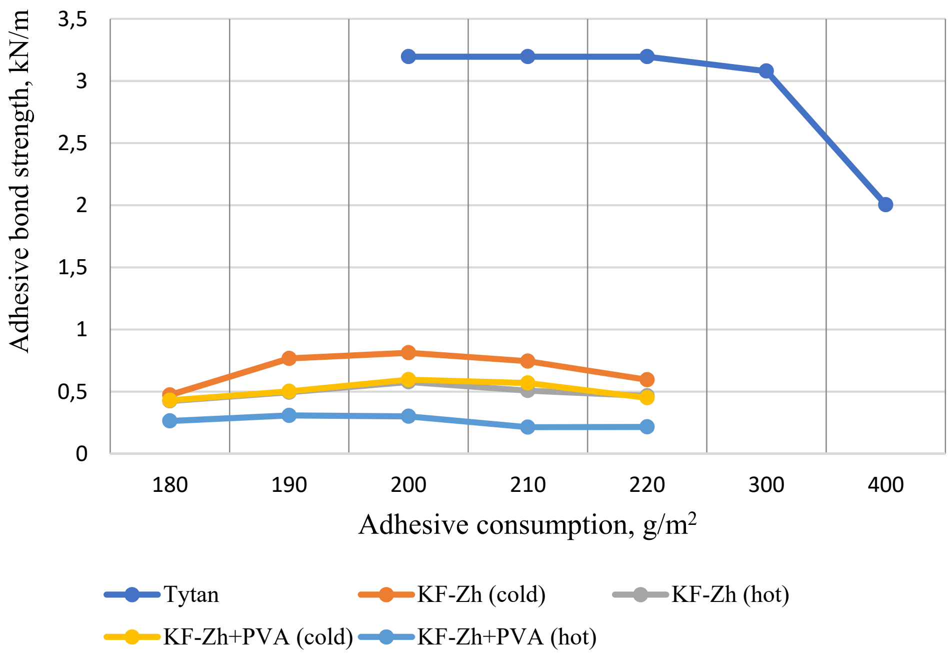


Figure 10. Dependence of the adhesive bond strength for uneven separation on the adhesive consumption (after technological exposure): a – all the investigated adhesives; b – planned adhesives

Рисунок 10. Зависимось прочности клеевого соединения от расхода клея (после технологической выдержки): а – все исследуемые клеи; б – планируемые клеи

Source: author's results

Источник: собственные результаты авторов



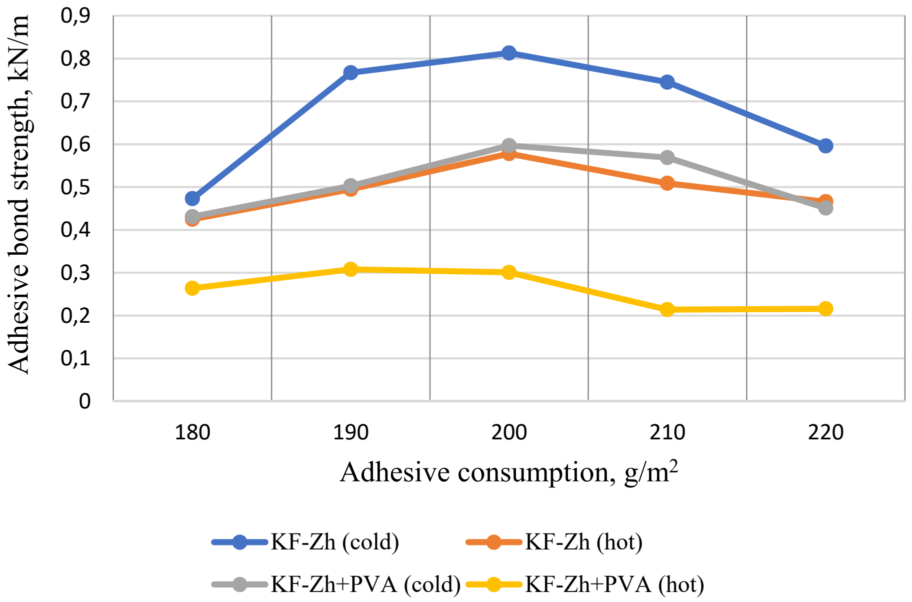


Figure 11. Dependence of the adhesive bond strength on the adhesive consumption (load group D1): a – all the investigated adhesives; b – planned adhesives

Рисунок 11. Зависимось прочности клеевого соединения от расхода клея (по группе нагрузок D1): a – все исследуемые клеи; б – планируемые клеи

Source: author’s results

Источник: собственные результаты авторов

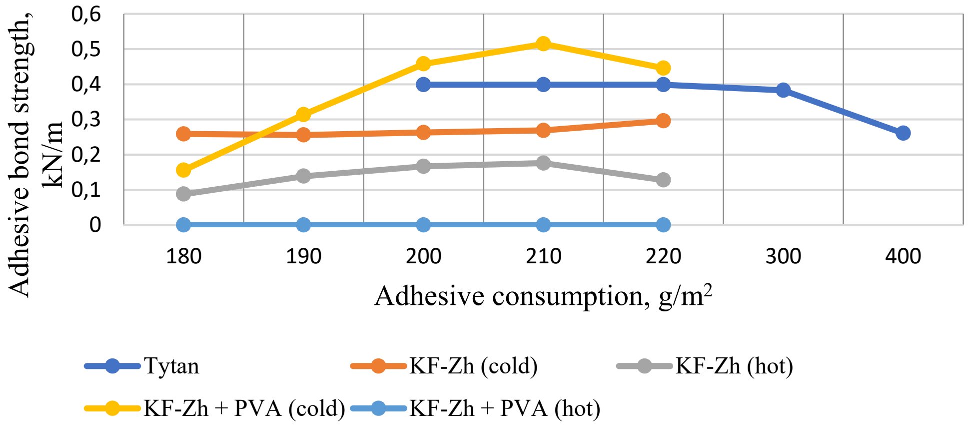


Figure 12. Dependence of the adhesive bond strength on the adhesive consumption (load groups D2)
Рисунок 12. Зависимость прочности клеевого соединения от расхода клея (по группе нагрузок D2)
Source: author's results
Источник: собственные результаты авторов

When gluing in a cold way using urea-formaldehyde and polyvinyl acetate adhesives, the adhesive bond strength is higher than when gluing in a hot way. Adhesives based on urea-formaldehyde resins and polyvinyl acetate have low viscosity. This does not allow to increase the consumption of glue, which is required by the insufficiently flat reverse surface of the flexible stone veneer. Therefore, the adhesive bond strength is low.

Discussion

The use of standard technologies and equipment for facing furniture boards with flexible stone veneer is not advisable, since flexible stone veneer has a significant thickness variation, which complicates pressing in flat presses. Therefore, it is possible to use flexible stone veneer when facing furniture boards only in the manufacture of individual orders manually.

Working with stone veneers has its specific features compared with other materials. It is rare in the natural world to find slates that have similar texture and colour. Therefore, every stone veneer is unique and unrepeatable. Designers will have to carefully approach the selection of colour and texture in a product and in the interiors. Stone veneer has a significant thickness variation and microcracks. It has to do with the characteristics of slates and marbles along with the manufacturing technology. Therefore, after cutting in order to obtain smooth joints, it is necessary to soften the edges by manual grinding. In order to prevent the surface from moisture absorption, it is recommended to treat it with special protective compounds. During the operation it is advisable to lay the stone sheets on a flat horizontal surface, with the stone surface facing upwards. In addition, before the facing procedure it is necessary to leave it in a heated area for at least 3 days. The curing can be carried out both in cold presses and without them, depending on the brand of adhesive. When using presses, it is necessary to set the specific pressing pressure in order to prevent the glue form squeezing out along the edges. During the facing procedure it is recommended to heat the stone veneer with a building dryer.

Conclusions

1. The use of standard technologies and equipment when lining furniture panels with stone veneer is impractical, since stone veneer has a significant thickness variation, which complicates pressing in flat presses.

2. Adhesives based on urea-formaldehyde resins and polyvinyl acetate have a low viscosity in order to carry out adhesive bonding without pressing.

3. Tytan adhesive showed good bonding strength for uneven separation and retains it both after technological exposure and according to the loading scheme D1 (the adhesive bond strength is 3.25 kN/m), according to the loading scheme D2 the strength is significantly reduced and is within 0 .4 kN/m. It should be noted that at an adhesive consumption of 400 g/m^2 or more, the strength characteristics decrease.

4. When cold method bonding with urea-formaldehyde and polyvinyl acetate adhesives, the bonding strength is higher than when hot bonding.

5. Stone veneer can be used as a facing material in an individual design of modern furniture, while contact assembly adhesives can be used to obtain a high-quality adhesive bond.

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