ANALIZA OŠTEĆENJA FASADA ZGRADA LAKOG MONTAŽNOG SISTEMA NAKON DUGOGODIŠNJE EKSPLOATACIJE

ANALYSIS OF FACADE DAMAGE OF LIGHTWEIGHT PREFABRICATED HOUSES AFTER LONG LASTING USE

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1 UVOD

U ovom radu analizirana su oštećenja fasada individualnih i kolektivnih stambenih objekata u naseljima u Apelovcu i Rasadniku u Nišu, građenih početkom 60-tih godina XX veka u lakomontažnom sistemu. U ovom periodu, s naglom industrijalizacijom grada paralelno je došlo do brze izgradnje čitavih naselja na periferiji grada Niša. Razmatrani objekti izgrađeni su po fazama, od 1958. do 1964. godine, u sistemu fabrike Krivaja iz Zavidovića iz Bosne u tadašnjoj SFRJ. U tom periodu, nisu postojale tehničke norme i standardi za izgradnju objekata tog tipa, tako da podaci pokazuju da kvalitet omotača tada izgrađenih objekata ne zadovoljava današnje zahteve, naročito u pogledu termoizolacije [25]. Poseban problem predstavlja značajan fond izgrađenih višespratnih zgrada u drugoj polovini XX veka, poznatoj kao u periodu intenzivne stambene izgradnje. Tada izgrađene fizičke strukture poseduju zadovoljavajuće performanse u konstruktivnom smislu, ali usled brzine gradnje, malo pažnje je posvećeno kreiranju omotača zgrade [17]. Standardni tipovi fasada lakomontažnih objekata građenih u tom periodu bili su: malterisane fasade, fasade od azbestnih ploča, objekti sa oblogom od lima, od iverice, prirodnog drveta i panela od lakog betona (slika 1).

1 INTRODUCTION

This paper analyzes the damage of facades of individual and collective housing buildings in lightweight prefabricated neighborhoods on Apelovac hill and Rasadnik in Nis, built in the early 1960s. In this period, with the rapid industrialization of the city, there was an accelerated construction of entire neighborhoods on the outskirts of the city of Niš. The considered buildings were built in phases in the period from 1958 to 1964 using the system of the Krivaja factory from Zavidovići, Bosnia in Former Yugoslavia. At the time there were no technical norms and standards for construction of buildings of this type, so the data show that the quality of cladding of the buildings constructed in that period fails to meet the present day standards, especially in terms of thermal insulation [25]. A special problem is a sizeable stock of built multi-storey buildings constructed in the second half of the 20th century, which is known as a period of intensive housing construction activity. Physical structures built in this period have satisfactory performances in structural sense, but due to the rapid construction process, little attention was paid to creation of building cladding [17]. The standard types of lightweight building facades built in this period were: plastered facades, asbestos panel facades, sheet-metal clad facades, plywood facades, natural timber and light concrete panel facades (Figure 1).

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Slika 1. Tipovi fasada lakih montažnih objekata: a) malterisana fasada, b) azbestne ploče, c) limena obloga, d) paneli odiverice, e) drvena obloga, f) paneli od lakog betona

Figure 1. Types of facades of light prefabricated buildings: a) plastered façade, b) asbestos plates, c) metal sheet, d) plywood façade panel, e) timber cladding, f) lightweight concrete panel

Koncept objekata bio je u minimalizovanju troškova izgradnje što je kasnije uslovljavalo visoke troškove održavanja [4,10,12]. Na raznovrsnom stambenom tržištu ovo je značilo da su početkom 60-ih godina jedino siromašni stanari i pripadnici etničkih manjina bili voljni ili bili prinuđeni da žive u takvim naseljima, dok srednje klase nije bilo u ovom tipu stanova. U tom tipu naselja jasno je izražena socioekonomska pripadnost njenih stanovnika [26]. Socijalni problemi kao rezultat masovnog doseljavanja stanovništva iz ruralnih krajeva, kao i etničkih manjina, onemogućili su izgradnju stabilne društvene zajednice. To je bio trajni problem ovih naselja koja su postala stecište ekonomski neaktivne potklase. Ta naselja postala su zapuštena urbana područja, s problemom primene zagađujućih građevinskih materijala kao što je azbest [3,7] i loših mera zaštite od požara [19]. Problem lošeg imidža i društvenih nevolja u ovim naseljima, doveo je do veoma negativne slike o ovoj vrsti smještaja među širom populacijom. To je rezultiralo ambivalentnim stavom javnosti prema ovoj vrsti stanovanja počev od ranih 70-ih godina XX veka.

Temeljna analiza naselja pokazala je nezadovoljavajuće stanje u kome se nalazi većina zgrada koje su, iako prvobitno zamišljene kao privremene (rok trajanja je od dvadeset do trideset godina), sada postale trajne. Za većinu objekata je iznenađujuće što su, s predviđenim rokom trajanja od dvadeset godina, uopšte trajali šezdeset godina [27]. Problem ovih, kao i mnogih drugih naselja, jeste u njihovom neadekvatnom održavanju [5]. Ljudi lošeg materijalnog stanja vremenom su postali privatni vlasnici socijalnih stanova, bez dovoljno sredstava za njihovu obnovu i adekvatno održavanje [2]. Stanari su samoinicijativno i bez projekata menjali fasade, uništavajući ih, iako to ne bi smeli, jer je fasada zajednička, a za radove bilo koje vrste neophodna je saglasnost većine stanara. U višestambenim zgradama u analiziranim naseljima trenutno živi više stotina ljudi.

The concept of the buildings was to minimize construction costs, which later caused high maintenance costs [4,10,12]. In the diverse housing market at the beginning of 60's, this meant that only the poor tenants and ethnic minorities were willing or compelled to live in such neighborhoods, while the middle class did not live in such type of housing. This type of neighborhoods clearly reflects the socio-economical stratum of its residents [26]. Social problems, as a result of mass influx of population from rural areas and ethnic minorities, prevented building of a stable social community. This became a durable problem of such neighborhoods, which became residences of economically inactive subclass. These neighborhoods became derelict urban areas, plagued by the polluting building materials such as asbestos [3,7] and poor fire prevention measures [19]. The problem of bad image and social problems in these neighborhoods resulted in a very negative picture of this type of housing among the wider population. This resulted in a very ambivalent public opinion of this kind of housing since the early 70's of 20th century.

A thorough analysis of the neighborhood revealed a sorry state of most of the buildings which were originally conceived as temporary (service life from 20 to 30 years), and which now became permanent. Through the lack of maintenance, many of the buildings are now in very poor repair, and it is unbelievable how they survived for 60 years, at all [27]. The problem with this, as with many other neighborhoods is that they are inadequately maintained [5]. People became private owners of social apartments, but nowadays they have no resources to restore them [2]. The residents change the facades according to their own fashion, and destroy them, even though they should not do it because the façade is a common property, and for any kind of repair works, consent of majority of residents is required. Several hundred people currently live in the multi-family buildings in the mentioned neighborhood.

Ovaj rad ima za cilj dobijanje osnovnih podataka o tehničkom stanju primenjenih tehnologija montažne gradnje višeporodičnih stambenih zgrada u lakomontažnom sistemu [1].

2 NAČIN ODABIRA UZORKA I PRIKUPLJANJE PODATAKA

Predmetni objekti se nalaze u: ul. Mokranjčeva 35–37, ul. Mokranjčeva, prilazi II i III i u naselju Rasadnik (slika 2). Analizirano je: šest trospratnih zgrada, dve dvospratne, sedamnaest prizemnih kuća sa po četiri stana u osnovi, deset dvojnih kuća i pet individualnih kuća. Na određenom broju objekata izvršena je dogradnja, što je bitno uticalo na stanje fasada u smislu popravki, dok je na mnogim objektima izvršena sanacija ili potpuna rekonstrukcija u vidu kontaktnih fasada.

Slika 2. Dispozicijamontažnihnaseljaizgledtipskihobjekata

Figure 2. Disposition of prefabricated neighborhoods and appearance of standardized buildings

Tipse višespratnice (uzorci Tip 1 i 2) izgrađene su sa čeličnom nosećom konstrukcijom, unutrašnjom oblogom od drvenih panela, ispunom od drvoluta (heraklit) i fasadom od ravnih azbestcementnih ploča ili od maltera (Tabela 1). Prizemni objekti (Tip 3-a, b, c) izrađeni su s drvenim skeletom, drvenom oblogom sa unutrašnje strane i malterom sa spoljne. Krovni pokrivač svih objekata jesu salonit-ploče. Podrumski zidovi i tavanice podruma svih uzoraka od armiranog su betona. U svim objektima su stanovi male kvadrature, a struktura stanova je jednosobna i dvosobna (slika 3).

Standardized multi-storey buildings (Specimen Type 1 and 2) were constructed using steel supporting structure, with interior lining of timber panels, with heraklit infill and a façade of flat asbestos-cement panels or mortar (Table 1). Ground level buildings (Type 3-a,b ,c) were constructed using timber frame, interior timber lining, and they are plastered from the outside. The roof covering of all buildings is everite. Basement and basement ceiling of all buildings is made of reinforced concrete. All buildings contain small apartments, having one or two rooms (Figure 3).

Slika 3. Šeme osnove uzoraka
Figure 3. Specimen floor plans

U periodu nakon Drugog svetskog rata uporedo s naglom ekspanzijom montažne gradnje kreće se u intenzivnu upotrebu azbestnih mineralnih vlakana na prostoru bivše SFRJ. Azbest zbog svoje strukture otporne na mehanička dejstva, vlagu, visoke temperature, agresivne hemikalije a dobre termičke izolacije i athezije s cementnim vezivima, našao je široku primenu. Salonitne fasadne i krovne ploče koje sadrže kancerogena azbestna vlakna i nakon više od pet decenija nalaze se na ovim objektima.

In the period after WWII, simultaneously with the booming prefabricated building construction, asbestos mineral fibers were intensively used in former SFRY. Asbestos became widely used due its structure resistant to mechanical action, damp, high temperatures, and aggressive chemicals, while exhibiting good thermal insulation properties and adhesion with cement binders. Façade and roof panels containing carcinogenic asbestos fibers are still found on these buildings after five decades.

Tabela 1. Karakteristike noseće konstrukcije analiziranih objekata
Table 1. Building structure characteristics of analysed prefabricated buildings

Karakteristike noseće konstrukcije Building structure characteristics				
	Noseća konstrukcija <i>Load bearing structure</i>	Fasadni zidovi <i>Facade walls</i>	Pregradni zidovi <i>Partition walls</i>	Krovna konstrukcija <i>Roof structure</i>
Apelovac P+3	Čelični okviri <i>Steel frames</i>	Drveni paneli sa termo izolacijom+azbestni paneli <i>Timber panels with thermo insulation+asbestos panels</i>	Drveni paneli <i>Timber panels</i>	Dvovodni krov, drvena konstrukcija pokrivena azbestnim panelima <i>Double-pitched roof, timber construction covered with asbestos plates</i>
Apelovac P+1	Čelični okviri <i>Steel frames</i>	Drveni paneli sa termo izolacijom+malter <i>Timber panels with thermo insulation+mortar</i>	Zidani zidovi 25cm i drveni paneli <i>Brick walls 25cm and timber panels</i>	
Apelovac P	Drveni okviri i paneli, zidani zidovi <i>Timber frames and panels, brick walls</i>			

3 DEFINISANJE METODOLOGIJE

Izbor uzorka konkretnih objekata izvršen je na osnovu približnog perioda izgradnje (1958–1962). Starost objekata je oko šezdeset godina i upotrebnim im je odavno istekao. Podaci su dobijeni opservacijom, odnosno posmatranjem, uočavanjem, registracijom i mapiranjem uočenih defekata. Zbog male spratnosti opserviran je celokupan fasadni omotač. Za svaki posmatrani objekat je, u okviru posmatranog uzorka, izvršena identifikacija vrste fasadne obloge kao i prebrojavanje zastupljenih oštećenja. Svi uočeni defekti na fasadama odabranih objekata precizno su opisani i razvrstani [18]. Sabiranjem ukupnog broja defekata na svim fasadama (u okviru jednog uzorka) dobijen je ukupan broj oštećenih fasada po uzorku. Oštećenja su zasebno evidentirana i klasifikovana za: fasadne zidove, temeljne zidove, strehe i ivice krova.

Prebrojavanje klasifikovanih defekata radi se za svaki uzorak, posmatrajući fasadnu površinu jednog trakta kao primerak, odnosno od šest do trideset šest takvih primeraka po uzorku. Konfiguracije fasada posmatranih objekata su gotovo identične bez obzira na veličinu i spratnost objekta. Defekti svakog pojedinačnog elementa evidentirani su po vrsti i nivou oštećenja konkretnog elementa prema [17]. Nivo oštećenja fasade pojedinačnog trakta u odnosu na njegovu ukupnu površinu klasifikovan je kao: manji (oštećena površina iznosi manje od 30% ukupne površine trakta), srednji (oštećena površina iznosi od 30% do 60% ukupne

3 DEFINING OF METHODOLOGY

The selection of specific buildings was performed based on the approximate construction period (1958–1962). The age of the structure is around 60 years, and their service life expired long ago. The data were obtained by observation, monitoring, registering and mapping of the observed defects. Since the buildings were low, entire façade cladding was observed. Façade cladding and counting of damage was performed for each observed building, within the observed sample. Classification of the type of façade cladding and counting of the found damage was performed for each observed building, within the observed sample. All the observed defects on the facades of the selected buildings have been described in detail and classified [18]. By summing up the total number of defects on all the facades (within one sample) a total number of damaged facades per sample was obtained. The damage was separately recorded and classified for: façade walls, foundation walls, eaves and roof edges. Counting of classified defects is performed for each sample, observing the façade surface of tract as a specimen, i.e. 6 to 36 such specimens per sample. Façade configurations of the observed structures are almost identical, regardless of the size and height of the buildings. Defects of each individual element are recorded by type and level of damage of the specific element according to [17]. The level of damage of individual tracts in comparison to its total surface area is

površine trakta) i značajan (oštećena površina iznosi preko 60% ukupne površine trakta) (Tabela 2).

classified as: small (damaged surface is less than 30% of total tract surface area), medium (the damaged surface is 30% to 60% of total tract surface area) and significant (the damaged surface is exceeding 60% of the total tract surface area) (Table 2).

Tabela 2. Evidentiranje defekata na fasadama zgrada Tip 1, Mokranjčeva i Rasadnik, 2014. god.
Table 2. Recording of defects on the facades of buildings Type 1, Mokranjceva and Rasadnik, 2014 year

		Nivo oštećenja (2014. godine) Damage level (2014. year)		
	Opis oštećenja Description of damage	mali <30% small <30%	30%< srednji < 60% 30%< medium< 60%	60%< značajan 60%< significantly
Malterisane fasade Plastered facade	prslina - pukotine cracks – fissures	32	37	19
	odlomljene ivice broken edges	17	5	4
	prslina u malteru usled skupljanja shrinkage cracks in mortar	23	6	0
	odvajanje završnog sloja separation of the final layer	36	15	4
	oštećenja soklenog zida plinth wall damages	42	23	3
	iscvetavanje efflorescence	4	9	2
Obloga od azbestnih ploča Asbestos-tiles cladding	krivljenje panela panel bending	12	2	0
	lom panela panel fracture	17	4	0
	otpadanje panela panel falling off	5	0	0

Fasadne obloge u razmatranom uzorku mogu da se podele na fasade od maltera i fasade od azbest-cementnih ploča. Dalja podela izvršena je na pune fasade (bez otvora) i one sa otvorom. Za svaki posmatrani objekat u okviru posmatranog uzorka fasadne površine izvršena je identifikacija vrste fasade i oštećenja na njima. Usvojena je klasifikacija defekata prema [17] i prilagođena – dopunjena je oštećenjima primećenim tokom opservacije konkretnih primera. Klasifikacija koja se primenjuje u ovom istraživanju data je u (Tabela 2). Zbog ograničenog prostora rezultati analizirani u ovom radu dati su zbirno za presek stanja oštećenja opserviran 2014. godine.

Defekti malterisanih fasada [16] u ovom istraživanju klasifikovani su kao: dezintegracija sloja maltera, totalno odvajanje fasade od potkonstrukcije, otpadanje maltera i korozija rabc-pletiva, otpadanje završnog sloja maltera, ljuštenje završnog sloja fasade, mrežaste prslina od skupljanja, pojava mahovine i lišajeva, bujanje flore, prslina-pukotine, prslina-pukotine predisponirane geometrijom potkonstrukcije, otpadanje delova fasade (slika 4).

Façade cladding in the observed sample can be classified into the mortar facades and asbestos-cement facades. Further classification comprises monolithic facades (without openings) and those with openings. Façade type and damage on them was performed for each observed structure within the observed sample of façade surface. Classification of defects according to [17] was adopted and adapted – amended with damage perceived during the observation of specific examples. The classification implemented in this research is provided in (Table 2). Because of the limited space results analyzed in this paper are presented as summation for the damage status observation of 2014.

Defects of the plastered facades [16] in this research were classified as: disintegration of the mortar layer, total separation of the façade from substructure, falling off of the mortar and corrosion of the wire mesh, falling off of the finish mortar layer, flaking of the façade finish layer, network of cracks from shrinkage, occurrence of moss and lichen, flora development, cracks and crevices resulting from the geometry of substructure, falling off of façade parts (Figure 4).

Slika 4. Karakteristična oštećenja malterisanih fasada (slika: P. Petronijević)
Figure 4. Characteristic damage of plastered facades (photo: P. Petronijević)

Karakteristična oštećenja fasada od azbestcement-nih panela klasifikovana su kao: potpuna dezintegracija zida, otpadanje panela, lom krajeva panela, uvrtnje i krivljenje panela, pukotine i prsline panela, odvajanje panela od drvene potkonstrukcije, oštećenja ter-hartije (slika 5).

Characteristic damage of asbestos panel façade are classified as : complete disintegration of the wall, falling off of panels, panel edge breaking, warping of panels, cracks and crevices of panels, separation of panels from the substructure, roofing paper damage (Figure 5).

Slika 5. Karakteristična oštećenja fasadnih panela od azbesta (slika: P. Petronijević)
Figure 5. Characteristic damage to the asbestos panels (photo: P. Petronijević)

Strukturalne pukotine u temeljnim zidovima evidentirane su kod većeg broja uzoraka. Podužne pukotine u visini tavanice podruma i vertikalne pukotine čoškova objekata posledica su neadekvatnog armiranja podrumskih zidova (slika 6-a). Kose pukotine evidentirane su kod objekata fundiranih na kosom terenu i posledica su nejednakog sleganja. S obzirom na malu masu ovog tipa objekata, nejednako sleganje je uzrokovano različitim stepenom zbijenosti tla na različitim dubinama fundiranja. Na postojanost završnog sloja sokle dominantan uticaj imali su mraz i pojava vlage usled propadanja vertikalne hidroizolacije u temeljnim zidovima. Najčešće evidentirana oštećenja su: otpadanje sokle, kristalizacija soli, karbonatizacija, biodegradacija, oštećenja završnog dekorativnog premaza i druga.

Structural cracks in the foundation walls were recorded in a number of samples. Longitudinal cracks at the level of the basement ceiling and vertical cracks of the corners of the buildings are the result of the inadequate reinforcing of basement walls (Figure 6-1). Diagonal cracks are identified in the structures founded on an inclined ground as the consequence of irregular settling. Regarding small mass of this type of buildings, irregular settling was caused by the different ground compaction degree at various depths of founding. The durability of the finish layer of the plinth was affected by the frost and damp due to dilapidation of vertical waterproofing in the foundation walls. Most often recorded damage was: falling off of the plinth, salt crystallization, carbonation, biodegradation, damage of the finish decorative coating.

Slika 6. Oštećenja temeljnog zida: a) strukturalne pukotine, b) otpadanje obloge, c) iscvetavanje, d) karbonatizacija
Figure 6. Plinth wall damages: a) structural cracks, b) wall cover falling off, c) salt crystallization, d) carbonation

Oštećenja kalkanskih zidova, dimnjaka, ventilacionih kanala, streha i oluka svedoče o totalnom zanemarivanju objekata od strane njihovih vlasnika. Na svim objektima izuzev Tip 3-c i posle 60 godina nalaze se izvorno ugrađeni elementi. Evidentirana su oštećenja opšiva krova bez obzira na primenjenu vrstu materijala (slika 7-b,c). Na mnogim objektima nedostaju: delovi kalkanskih zidova, limeni opšiv krova, delovi oluka, ploče krovnog pokrivača i drugo.

Damage to gable walls, chimneys, ventilation ducts, eaves, downpipes give evidence of the total neglect of the buildings by their owners. On all the buildings, except Type 3-c there are original elements after 60 years. The roof flashing damage was recorded, irrespective of the used type of material (Figure 7-b,c). Many buildings lack: parts of gable walls, sheet-metal flashing of the roof, parts of gutters, roofing panels etc.

Slika 7. Oštećenja strehe (slika: P. Petronijević)
Figure 7. Damage to the eaves (photo: P. Petronijević)

Tokom više decenija od kada su izrađene, u najvećem broju uzoraka stambenih zgrada pojavila se realna potreba za njihovom adaptacijom, renoviranjem ili rekonstrukcijom [6,15]. S obzirom na specifičnost tehnologije izrade spoljnih zidova montažnih kuća, tada važećim propisima o termičkoj zaštiti objekata i primenjivanim materijalima, javio se problem adekvatnog saniranja dotrajalih fasada. Osnovni nedostatak ovog tipa montažnih zgrada jeste nizak stepen stambene ugodnosti unutrašnjih prostorija koji je posledica loše izolacije, loše zaptivenosti i paronepropustljivosti spoljašnjih zidova.

Nedovoljno poznavanje fenomena građevinske fizike uzrokovalo je postavljanje parne brane (paronepropusne lepenke $S_d=40-50m$) na pogrešnom mestu. Na ispitanim uzorcima izgrađenim u periodu od 1958. do 1962. godine, ter-hartija je postavljana na spoljnoj strani heraklit-ploča bez ikakvog dodatnog termoizolacionog sloja, što je na velikim fasadnim površinama bez otvora prouzrokovalo umerena do značajna oštećenja (slika 8-a,b). Ovim je izazvana pojava kondenzata u sloju heraklit-ploča, značajan porast koeficijenta prolaska toplote i pojava površinske kondenzacije na unutrašnjoj strani zida. Usled povećanja vlažnosti, bubrili su drveni

In the course of decades that passed since the buildings were built, a real need arose to adapt, renovate or reconstruct the majority of housing building samples [6,15]. Regarding the specific technology of construction of external walls of prefabricated houses suited to the regulations of thermal insulation of buildings and materials available at the time, there arose the problem of adequate remediation of decrepit facades. The fundamental shortcoming of this type of prefabricated buildings is the low indoor living comfort level which is the consequence of poor insulation, sealing and vapor impermeability of external walls.

Lack of understanding of building physics phenomena resulted in construction of the vapor barrier (vapor impermeable plywood $S_d=40-50m$) in a wrong position. On the observed samples, built in the period 1958-1962 the roofing paper was placed on the external side of heraklit panels without any additional thermal insulation layer, which caused moderate to considerable damage to the large façade areas without openings (Figure. 8-a,b). This caused condensation in the layer of heraklit panels, considerable increase of passage of heat and onset of surface condensation on the interior side of the wall. Due to the increase of dampness, the timber

elementi u sastavu noseće konstrukcije zida. Povećanje zapremine drvenih stubova i greda uticalo je na dezintegraciju maltera fasade (slika 9-a,b). Kod uzorka Tip 1 sa čeličnom nosećom konstrukcijom, oštećenja ovog tipa nisu registrovana osim vizuelnih nedostataka fasadnih zidova (slika 9-b,c). Ovaj tip objekata imao je značajno nepovoljnije termičke karakteristike u vidu izraženih termičkih mostova [24]. Povećanje vlažnosti fasadnog roštilja i heraklit-ispune stvorilo je uslove za pojavu buđi i plesni na unutrašnjoj strani zida [28,30].

Postupak nastavljanja ter-hartije je na preklap bez zaptivanja tako da je u kombinaciji s loše ugrađenom stolarijom stvorena mogućnost za izvestan protok vodene pare. Na fasadama s velikim brojem otvora, oštećenja usled bubrenja drvene građe su evidentirana ali u znatno manjoj meri. Oštećenja fasada su intenzivnija na mestu prostorija s povećanom vlažnošću vazduha (kuhinje i mokri čvorovi). Uzorci izgrađeni nakon 1962. godine na spoljnim zidovima imali su dodatni sloj termoizolacije sa ispravnim položajem parozaptivnog sloja tj. s tople strane termoizolacionog sloja. Ter-hartija je uslovno rečeno preuzela ulogu parne brane sprečavajući prodor vodene pare u zonu termoizolacionog sloja. Time je ostvarena povoljnija raspodela parcijalnog pritiska i pritiska zasićenja u slojevima sklopa zida (slika 8-a,b) [20].

elements within the bearing structure of the wall swelled. Increase of volume of the timber posts and beams had effects on disintegration of the façade mortar (Figure 9-a,b). In the Type 1 samples with the steel supporting structure, damage of this type were not registered except the visual defects of façade walls (Figure 9-b,c). This type of buildings had considerably more unfavorable thermal characteristics demonstrated by the evident thermal bridges [24]. The increase of dampness of façade bearing sub-structure and heraklit infill created conditions for onset of mould on the interior side of the wall [28,30].

The roofing paper was installed with overlapping without sealing, so in combination with the poorly fitted joinery, there occurred potential for a certain water vapor flow. Damage was found also on those façades with a large number of openings, but to a much lesser degree. Façade damage is more intensive where the rooms have increased air humidity (kitchens and bathrooms). Those samples constructed after 1962 had an additional layer of thermal insulation on the external walls, with a correct position of vapor barrier layer, on the warm side of thermal insulating layer. Roofing paper assumed the role of a vapor barrier preventing penetration of water vapor into the zone of thermal insulation layer. This created a better distribution of partial pressure and saturation pressure in the wall layers (Figure. 8-a,b) [20].

Slika 8. Nastanak oštećenja fasadnog maltera usled bubrenja drvene građe (slika: P. Petronijević)
Figure 8. The appearance of damage to the facade mortar due to swelling of timber (photo: P. Petronijević)

Delimično poboljšani poprečni presek spoljašnjeg zida s dodatnom izolacijom od 5 cm i dalje je bio loš zbog loše zaptivenosti. Koeficijenti prolaska toplote, temperaturnog kašnjenja i faktor gušenja temperature višestruko su ispod danas zahtevanih vrednosti. Subjektivni ugođaj boravka u ovim stanovima jako je loš zbog slabe izolovanosti, kratkog faznog pomeranja i odsustva značajnijeg faktora prigušenja temperature [29]. Koeficijent prolaska toplote smanjen je povećanjem sloja termoizolacije, dok su koeficijent temperaturnog kašnjenja i faktor gušenja temperature i u savremenoj montažnoj gradnji teško ostvarivi. Veće temperaturno kašnjenje može se postići dodatnom masom materijala i rasporedom slojeva (Slika 8-c), što u slučaju montažne gradnje značajno povećava cenu fasadnih panela [22,23]. Spoljna temperatura vazduha i temperatura spoljne površine zida osciluje tokom dana. Amplituda temperaturnog talasa prodire kroz slojeve zida i pri tome se smanjuje – guši. Gušenje temperature je karakteristična vrednost kojom se opisuje toplotna stabilnost konstrukcije. Faktor gušenja je odnos amplitude temperaturne oscilacije spoljašnjeg vazduha i amplitude unutrašnje površine zida [8].

Partially improved cross section of the external wall with additional insulation of 5 cm was still bad because of poor sealing. Heat passage coefficients, temperature retardation and temperature damping factor are many times below the values required nowadays. Subjective feel of living in such apartments is very low because of poor insulation, short phase shift and absence of any considerable temperature damping factor [29]. Heat passage coefficient is reduced by the increase of thermal insulation layer thickens. Whereas, the temperature retardation coefficient and temperature damping factor are hard to achieve even in the contemporary prefabricated construction. A higher temperature retardation can be achieved with additional mass of material and arrangement of layers (Figure 8-c). In case of prefabricated construction this considerably increases the cost of façade panels [22,23]. The external air temperature of the external wall surface oscillates during daytime. The amplitude of the temperature wave penetrates through the wall layers and gets decreased – damped. Temperature damping is a characteristic parameter used to describe heat stability of the structure. Damping factor is the ratio of amplitude of temperature oscillation of outside air and amplitude of interior wall surface [8].

Slika 9. Oštećenja fasadnog maltera usled bubrenja drvene građe, mrlje na mestima termičkih mostova (slika: P. Petronijević), Efeka termičkog mosta na mestima čeličnih profila kod zidova lakih montažnih konstrukcija [24]

Figure 9. The damage to the facade mortar due to swelling of timber, stains at thermal bridge sites (photo: P. Petronijević), Thermal bridge's effect due to vertical steel studs in a light steel framed walls [24]

4 ANALIZA PRIKUPLJENIH PODATAKA

Sabiranjem ukupnog broja defekata na svim primercima (u okviru jednog uzorka), dobija se ukupan broj oštećenja fasadnih traktova po uzorku. Deleći ukupan broj oštećenja s brojem posmatranih primeraka, dobija se broj oštećenja po jednom fasadnom traktu, tj. po primerku. Rezultati su prikazani primenom u-kontrolne karte za attribute. Podaci su grupisani prema pojedinačnim objektima i prema vrsti fasade, kako bi kontrolne karte imale smisla (Tabela 3).

4 ANALYSIS OF ACQUIRED DATA

By adding up the total number of defects on all specimens (within one sample), a total number of damage of façade tracts per sample is obtained, and by dividing the obtained number with the number of the observed samples, the number of damage per one façade tract, i.e. specimen is obtained. The results are displayed using in the u- control chart for attributes. The data are grouped according to the individual structures and type of the façade, so that the control charts would make sense (Table 3).

Tabela 3. Broj defekata na malterisanim fasadama (2014 god.)
Table 3. Number of defects on plastered facades (2014 year)

Uzorak Specimen (zgrada i tip) (building and type)	veličina uzorka number of specimen (broj rastera) n (facade pattern) n	ukupan broj defekata u uzorku c the total number of defects in the specimen c	broj defekata po primerku $u=c/n$ number of defects per specimen $u=c/n$
1-4 (Tip 1) malter 1-4 (Type 1) mortar	4x36	165 156 182 175	4.58 4.33 5.06 4.86
5, 6 (Tip 1) azbest 5, 6 (Type 1) asbestos	-	-	-
7-8 (Tip 2) 7-8 (Type 2)	2x22	77 84	3.50 3.82
9-26 (Tip 3-a) 9-26 (Type 3-a)	17x16	45 52 39 46 51 58 47 57 42 50 48 53 47 55 41 37 51	2.81 3.25 2.44 2.88 3.19 3.63 2.94 3.56 2.63 3.13 3.01 3.31 2.94 3.44 2.56 2.31 3.19
27-37 (Tip 3-b) 27-37 (Type 3-b)	10x10	21 28 38 22 24 26 28 18 14 16	2.10 2.80 3.80 2.20 2.40 2.60 2.80 1.80 1.40 1.60
38-42 (Tip 3-c) 38-42 (Type 3-c)	5x6	0 3 1 0 1	0.0 0.50 0.17 0.0 0.17
		$\Sigma = 1898$	$\Sigma = 101.67 (\bar{u}=3.22)$

Kontrolna karta je urađena po uzoru na istraživanje [17]. Na kontrolnim kartama je neophodno utvrditi centralnu liniju i kontrolne granice. Centralna linija kontrolne karte definiše standard kvaliteta za posmatrane uzorke – zgrade, u pogledu oštećenja posmatranih fasadnih elemenata. Kontrolne granice definišu granice tolerancije kvaliteta, a vrednosti koje prelaze gornju granicu ukazuju na broj oštećenja po primerku (jednom modularnom fasadnom rasteru), odnosno po uzorku (objektu), koji nije posledica normalne standardne eksploatacije zgrade i uobičajenih spoljašnjih uticaja. Razlozi koji su doveli do takvog stanja zahtevaju posebne postupke ispitivanja i analize.

Stabilnost kvaliteta izvedenih radova fasade nakon isteka određenog vremenskog perioda, ocenjuje se pomoću ovako formiranih kontrolnih karata, utvrđivanjem broja tačaka koje se nalaze van kontrolnih granica (slika 10).

The control chart was made using the research as a model[17]. It is necessary to determine the central line and control boundaries on the control charts. The central line of the control chart defines the quality standard for the observed samples – buildings; in terms of damage of façade elements. Control boundaries define the boundaries of quality tolerance, and the values exceeding the upper limit indicate the number of damages per specimen (one modular façade pattern), i.e. per sample (building), which is not the result of normal and standard use of the building and usual external impacts. The reasons causing such state require special research procedures and analyses.

Stability of quality of executed works on the façade after the lapse of a specified time period is assessed using such control charts, by finding the number of points outside the control boundaries (Figure 10).

Slika 10. U kontrolna karta
Figure 10. U control chart

S obzirom na to što je za uzorak konstatovan broj grešaka po primerku i da je broj primeraka po uzorku promenljiv, sračunat je udeo defekata po uzorku i upotrebljena je u-kontrolna karta. Primena u-kontrolne karte skoro je identična primeni c-kontrolne karte, s tim što se ova karta može koristiti i za praćenje broja defekata po jedinici mere uzorka. U-kontrolna karta primenjuje se na primercima koji nemaju za jedinicu komad. Uslovi za primenu u-kontrolnih karti su: $n \neq const$ i $k \geq 15$, a kontrolne granice variraju.

U je količnik između ukupnog broja defekata u uzorku i ukupnog broja primeraka u uzorku.

Regarding that for a sample, a number of errors per specimen has been specified, and that the number of specimens per sample is variable, the share of defects per sample was calculated and used in the research. Use of an u -control chart is almost identical to the use of a c -control chart, but this chart can be used for monitoring the number of defects per sample measurement unit. U -control chart is used for the specimens which are not measured in pieces. Conditions for use of the u -control chart are: $n \neq const$ and $k \geq 15$, and the control limits are variable.

U is the quotient of the total number of defects in the sample and the total number of specimens in a sample.

$$u = \frac{c}{n} = \frac{\text{number of defects found in the subgroup}}{\text{subgroup size}} \quad (1)$$

$$\bar{u} = \frac{\sum_{i=1}^k c_i}{\sum_{i=1}^k n_i} = \frac{1898}{590} = 3.22 \quad (2)$$

Gornja kontrolna granica UCLu i donja kontrolna granica LCLu date su formulama 3 i 4. Važno je istaći da ukoliko se promeni veličina podgrupe, menjaju se i kontrolne granice.

The upper control limit UCLu and the lower control limit LCLu are given by formulas 3 and 4. It is important to note that if the subgroup size changes from subgroup to subgroup, the control limits will change.

$$UCLu = \bar{u} + 3\sqrt{(\bar{u} / n)} \quad (3)$$

$$LCLu = \bar{u} - 3\sqrt{(\bar{u} / n)} \quad (4)$$

Stabilnost kvaliteta fasadnih površina kod objekata Tip 1 i Tip 3-c van statističke je kontrole. U ovim slučajevima stanje fasada je izvan specifikacionih granica. Uzrok varijacije je stepen kolektivizacije stanovanja. Stanje fasada objekata Tip 1 pokazuje oštećenja iznad uobičajenog nivoa oštećenja. Sa u-kontrolne karte uočava se da smanjenje broja stanova u okviru jednog objekta direktno utiče na poboljšanje opšteg stanja fasade objekta. Adekvatno održavanje i najveća materijalna ulaganja imali su objekti sa samo jednim vlasnikom.

The Stability of the quality of façade surfaces in the Type 1 and Type 3-c buildings is outside the statistic control. In these cases the condition of the facades is outside the specified limits. The cause to this variation is the degree of collectivization of the housing. The Type 1 façade condition shows damage above the usual damage level. From the U-chart, it can be observed that reduction of a number of apartments within one building directly causes improvement of the general condition of the building façade. Adequate maintenance and highest investments was recorded in the buildings with only one owner.

5 DISKUSIJA REZULTATA ISTRAŽIVANJA

Evidentirani defekti na fasadama su statistički podaci dobijeni istraživanjem. Prikazani su u Tabeli 2 i 3. Veličina uzorka je ukupan broj objekata (zgrada). Prosečan broj defekata po tipu objekata dobija se deljenjem ukupnog broja defekata s brojem ispitanih primeraka. Kvalitet fasadnih površina razmatranih uzoraka montažnih objekata ocenjen je analizom dobijenih u-kontrolnih karti. Ustanovljeno je da je potrebno odrediti meru oštećenja, do koje je moguće izvršiti popravke, tako da se dobiju optimalni rezultati u pogledu troškova i trajnosti izvršenih radova. Istraživanje je rađeno s ciljem doprinosa mogućnosti eventualnog otklanjanja oštećenja nastalih na fasadnim površinama nakon više od šezdeset godina eksploatacije objekata. Totalna rekonstrukcija fasadnih zidova neophodna je zbog nedovoljne termičke izolovanosti [11].

Primećeno je da su neke intervencije urađene prekasno jer je nakon kratke stabilizacije stanja izazvalo

5 RESEARCH RESULTS DISCUSSION

The recorded data – defects on the facades are statistical data obtained by the research. They are presented in Tables 2 and 3. The size of the sample is the total number of structures (buildings). The average number of defects per type of structure is obtained by dividing the total number of defects with the number of researched specimens. The quality of façade surfaces of the observed samples of prefabricated structures is evaluated by analyzing the obtained u -control charts. It was established that it is necessary to determine the degree of damage up to which it is possible to perform repairs, so that optimum results in terms of costs and durability of executed works are obtained. The research was performed with the goal of contributing to potential repair of damage occurring on the façade surfaces after more than 60 years of building service. The total reconstruction of façade walls is necessary for the reasons of inadequate thermal insulation [11].

ubranu devastaciju fasada. Klasifikovani su izgrađeni objekti i ustanovljena je tipologija fasadnih zidova, zasnovana na konstrukciji i materijalizaciji fasade. Istraženi su uzroci defekata i dati su tipični primeri oštećenja na betonskim (soklenim) zidovima i fasadnim zidovima. Posebno je analiziran uticaj neadekvatno saniranih fasada i nadograđenih delova objekata na loš vizuelni identitet naselja.

It was noticed that some interventions were made too late, because after a short stabilization, they caused an accelerated devastation of facades. The built structures are classified and the typology of façade walls based on the structure and materialization of facades was established. The causes of defects were explored and typical examples of damage on the concrete (plinth) walls and clad facades were provided. The detrimental impact of inadequately remediated facades and extended sections of structures on the visual identity of the neighborhood was separately analyzed.

Slika 11. Aktivnosti na održavanju zgrada
Figure 11. Building maintenance activities

Tipiska grupa fasada podeljena je na zidove obložene malterom i azbestcementnim pločama. Za obe vrste fasadnih zidova data je klasifikacija defekata (pukotine, pukotine usled skupljanja, krivljenje elemenata, razdvajanje azbestnih ploča, korozija armature, ljuštenje, prodiranje vlage, pucanje maltera na mestu nosećih elemenata, oštećenje termoizolacije, biokorozija,...) po ustanovljenim fizičkim, hemijskim, mehaničkim ili biološkim uzrocima oštećenja [13,21].

The standardized group of facades is classified into the walls clad with mortar and with asbestos-cement panels. For both types of façade walls, classification of defects is provided (cracks, shrinkage cracks, bending of elements, delaminating of asbestos panels, reinforcement corrosion, flaking, dampness penetration, cracking of mortar where the structural elements are located, thermal insulation damage, biocorrosion...) according to the established physical, chemical, mechanical or biological damage causes [13,21].

Slika 12. Tipična oštećenja i njihov relativni udeo na omalterisanim fasadama (Apelovac, 2014)
Figure 12. Typical defects and their relative share in plastered façade (Apelovac, 2014)

Defekti fasada podeljeni su u dve grupe: one koje su nastale usled grešaka pri izvođenju i one koje su nastale kao posledica neadekvatnog održavanja ili prekomernog naprezanja. Uzroci karakterističnih oštećenja fasada su identifikovani kao sledeći: neadekvatna termoizolacija, otpadanje maltera na mestu drvenih stubova noseće konstrukcije, mrežaste pukotine usled skupljanja, oštećenja maltera usled prodora vode u termoizolacioni sloj. Na osnovu sprovedenih istraživanja oštećenja montažnih objekata u naselju Apelovac u Nišu, može se

Façade defects are divided into two groups: those occurring due to the construction errors and those occurring as a consequence of inadequate maintenance or overloading. Causes of characteristic façade damage are identified as: inadequate thermal insulation, falling off of mortar at the location of timber posts of the bearing structure, mesh crack resulting from shrinking, mortar damage due to the water penetration into the thermal insulation layer. On the basis of the conducted research of prefabricated buildings damage in the neighborhood

zaključiti da su osnovni uzroci oštećenja veoma slični, mada su strukture fasada različite.

Stabilnost kvaliteta fasadnih površina ocenjena je analizom dobijenih grafika u-kontrolnih karti za attribute. Kako ne postoji podatak koji bi ukazivao na očekivana ili uobičajena oštećenja fasadnih površina montažnih objekata nakon višedecenijske eksploatacije, početni podatak predstavljaju centralne linije kontrolnih karata [17].

Prosečna vrednost oštećenja usvojena je kao očekivana. Fasadne površine uzoraka Tip 3-c imaju oštećenja znatno ispod uobičajenog nivoa. Analizom gornjeg nivoa oštećenja zaključuje se da su fasade na zgradama Tip 1 oštećene preko uobičajenog nivoa oštećenja i svi uzorci prelaze gornju kontrolnu granicu. Ovakvo grupisanje podataka pokazuje da postoji više aritmetičkih sredina, koje su posledica neujednačenog kvaliteta tehničkog stanja fasada za ove tri grupe uzoraka. Za dalju analizu, neophodno je stanje fasada razmatrati u zavisnosti od stepena kolektivizacija stanovanja. Evidentno je da je isti tip fasade na objektima veće spratnosti i s većim brojem stambenih jedinica u značajno lošijem stanju u odnosu na pojedinačne i dvojne kuće. Uzrok ove pojave je nemogućnost usaglašavanja svih stanara oko radova na održavanju i saniranju fasada.

of Apelovac in Niš, it can be concluded that the basic causes of damage are very similar, although the façade structures are different.

The stability of quality of façade surfaces is assessed through the analysis of the obtained graphs u- control charts for attributes. Since there are no data indicating the expected or common damage of façade surfaces of prefabricated buildings after a service lasting several decades, the baseline data are the central lines of control charts [17].

The average value of damage is adopted as expected. Façade surfaces of Type 3-c samples have damage considerably below the usual level. By analyzing the upper level of damage, it is concluded that the façades on the Type 1 buildings are damaged past the usual damage level and that all the samples exceed the upper control limit. Such grouping of data indicates that there are multiple arithmetic means which are the consequence of the uneven quality of technical condition of façades of these three groups of samples. For further analysis, it is necessary to consider the façade condition in dependence of the degree of collectivization of housing. It is evident that the same type of façade on the higher buildings with a large number of housing units is in a considerable poorer state of repair in comparison with individual and semi-detached houses. The cause of this is that the tenants could not reach the agreement about necessary maintenance and repair works on the façades.

Slika 13. Intervencije na fasadama objekti Tip 1 (Apelovac, 2014-2019)
Figure 13. Facade interventions on Type 1 structures (Apelovac, 2014-2019)

Upoređenjem stanja omalterisanih fasada u odnosu na prefabrikovane montažne elemente, zaključujemo da je devastacija fasadnih elemenata od azbestcimenta izraženija. Direktna izloženost fasadnog sloja od azbestcementnih ploča atmosferskim i drugim uticajima tokom eksploatacije objekata dovela je do masivnih oštećenja elemenata, pukotina, krivljenja ploča, odlamanja delova, propadanja drvene potkonstrukcije i odvajanja ploča od potkonstrukcije usled korozije zavrtnjeva. Malterisane fasade u zgradi s parnom branom i dodatnom termoizolacijom, prosečno pokazuju za trećinu manje oštećenja od preostalih njoj identičnih zgrada.

S obzirom na to što je ovaj tip fasade koji je analiziran u istraživanju najzastupljeniji u objektima

By comparing the condition of plastered facades with prefabricated elements, it can be concluded that deterioration of façade elements made of asbestos-cement is more pronounced. Direct exposure of the façade layer made of asbestos-cement panels to atmospheric and other impacts during building service led to massive damage of elements, to onset of cracks, panel bending, chipping of parts, decay of timber substructure, separation of panels from the substructure due to the corrosion of bolts. Plastered facades in buildings with vapor barrier and additional thermal insulation, demonstrate on average a third less damage than the other buildings identical to it.

Considering that this type of façade analyzed in the research is most widely present in the lightweight

lakog montažnog tipa, realizovanim u drugoj polovini dvadesetog veka, na osnovu posmatranih uzoraka i dobijenih rezultata, može se zaključiti da su generalno potrebne investicije u vidu popravke, obnove i termičke sanacije fasada.

Danas je već uveliko razvijena metodologija reparacije fasada koja donosi trajne rezultate. Razvijeni su modeli analiza koje kombinuju uticaje toplote, vlage i drugih merodavnih faktora, koji omogućavaju valorizaciju kvaliteta fasadnih zidova s funkcionalnog aspekta, pre i posle izvršenih radova [14].

Dosadašnje mere, preduzete u tom pravcu, obuhvataju više arhitektonskih rešenja kao što je dogradnja, dok se u mere poboljšanja kvaliteta omotača zgrade mogu ubrojati razni vidovi zamene ili dodavanja slojeva [9]. Najmanje intervencija primenjeno je na krovnom pokrivaču od salonit-ploča, koji je i nakon šest decenija zadržao skoro sve svoje karakteristike, osim estetskih.

prefabricated buildings built in the second half of the 20th century, based on the observed samples and obtained results, it can be concluded that in general it is necessary to invest in repairs, renovations and thermal renovations of facades.

Nowadays, the façade repair methodology with durable results is well developed. The models of analyses which combine the effects of heat, damp and other relevant factors are developed as well which facilitate assessment of the quality of façade walls from the aspect of function, prior and after the performed works [14].

The current measures, to this end, include multiple architectonic designs such as extensions, while the measures of improvement of building cladding quality may include various forms of replacement or addition of layers [9]. There were the least interventions on the roofing cover made of everite panels. After six decades, it retained all its characteristics, except esthetic appearance.

Slika 14. Dogradnja objekata Tip 3-b (Apelovac, 2019)
Figure 14. Upgrades of buildings Type 3-b (Apelovac, 2019)

S obzirom na to što se analizirana naselja nalaze na rubnim delovima grada, poslednjih dvadeset godina su izložena intenzivnoj nelegalnoj gradnji. Dogradnje su izgrađene u potpunom neskladu s postojećim objektima, bez ikakve međusobne usaglašenosti i tipizacije. Novoizgrađeni delovi po gabaritima prevazilaze i nekoliko puta postojeće objekte (Slika 14). Bespravnim nadziđivanjem i doziđivanjem preko postojećih gabarita objekta u potpunosti je naružen izgled i vizuelni identitet naselja.

Regarding that the analyzed districts are on the periphery of the city, they have been exposed to intensive illicit building in the last 20 years. Upgrades were constructed in a total disharmony with the existing buildings, without any mutual coordination and typifying. Newly constructed sections exceed the existing buildings for several times, in terms of their size (Figure 14). Illicit extensions and additions of floors over the existing building dimensions entirely marred the visual identity of the district.

Slika 15. Neadekvatne intervencije na fasadi Type 3-b (Apelovac, 2019)
Figure 15. Inadequate interventions on the façade Type 3-b (Apelovac, 2019)

Na osnovu analiziranih rezultata sprovedenog istraživanja može se zaključiti da su radovi na sanaciji fasada mahom odrađeni nesistematично, od slučaja do slučaja i da su se pokazali kao nezadovoljavajući zbog nedovoljnih prethodnih saznanja o uzrocima i vrstama oštećenja fasada. Dominantan vid saniranja fasada bio je dodavanje kontaktne fasade bez ikakvih prethodnih radova na saniranju oštećenja postojećeg fasadnog omotača (Slika 15). Time su problemi samo sakriveni, ali ne i rešeni [31].

6 ZAKLJUČAK

Nakon kratkog perioda euforije tokom šezdesetih godina, postali su jasni negativni aspekti ove forme montažnih objekata namenjenih kolektivnom stanovanju. Fizički i ekološki problemi, upotreba zagađujućih i materijala za građenje koji nisu trajni, problemi sa održavanjem, prerano propadanje zgrada nakon veoma kratkog perioda – sve ovo je vodilo rastućoj sumnji u kvalitet montažnih objekata. Jedna od posledica slabih karakteristika i lošeg održavanja jeste nezadovoljavajući kvalitet fasada po današnjim merilima. Bitan faktor koji se ne sme izostaviti prilikom analiza jeste relativno nizak socioekonomski položaj stanara. Slab materijalni status stanara je uslovio odabir montažnog tipa objekta u odnosu na klasičnu gradnju koja je skuplja. Ovo je takođe imalo uticaja na kasnije loše održavanje i izostanak periodičnog obnavljanja fasade. Iz grafika 10 nedvosmisleno se može zaključiti da i stepen kolektivizacije ima direktan uticaj na pad održavanja objekata. S povećanjem broja stambenih jedinica u okviru jednog objekta znatno se pogoršava trenutno stanje fasada a stepen oštećenja raste. Ova pojava se objašnjava težim dogovorom većeg broja stanara. Uticaj razlike u spratnosti je mali jer su svi objekti s malom spratnošću a tehnološki proces sanacije fasada i cena radova je međusobno približna (jedina razlika je u ceni skele).

U današnjoj savremenoj montažnoj gradnji većina nedostataka je korigovana striktnim poštovanjem pravila građevinske fizike. Najbitnije razlike su primena gipskarton ploča umesto drvenih, pravilna upotreba parnih brana tj. sprečavanja difuzije vodene pare, azbestcementni paneli su u potpunosti izbačeni zbog svoje kancerogenosti a značajna su i poboljšanja hidro i termoizolacionih svojstava savremenih fasadnih obloga.

Based on the analyzed results of the conducted research, it can be concluded that the facade remediation works were mostly performed unsystematically, in a case-by-case fashion, and they proved to be unsatisfactory due to insufficient preliminary knowledge about the causes and types of facade damage. The prevalent form of remediation of facades was adding a contact facade without any previous work on remediating the damage on the existing facade cladding (Figure 15). This only concealed the problems, and failed to solve them [31].

6 CONCLUSION

After a short period of euphoria during the 60's the negative aspects of this form of prefabricated buildings intended to collective housing became evident. Physical and environmental problems, usage of polluting and non-durable building materials, problems with maintenance, excessively early deterioration of buildings after a very short period – all this led to a growing distrust in the quality of prefabricated buildings. One of the consequences of weak characteristics and poor maintenance are unsatisfactory quality of facades by the contemporary standards. An important factor which should be included in the analysis is a relatively low socio-economic position of the tenants. The low financial status of the tenants necessitated the selection of the prefabricated type of buildings as opposed to the classical construction which is more expensive. This also had effects on the later poor maintenance and lack of periodical renovation of the façade. In reference to the chart 10 it can undoubtedly be concluded that the degree of collectivization has a direct impact on the low level of building maintenance. Increased number of housing units in a single building considerably aggravates the current condition of facades, and the degree of damage increases. This phenomenon is explained by the failure of a large number of tenants to reach an agreement on maintenance works. The number of floors makes a small difference, because all the buildings have few floors and the technological process of remediation of facades and works cost is approximately the same (the only difference being in the cost of scaffolding).

In the contemporary prefabricated construction most of the defects is corrected by strict observation of the building physics rules. The most prominent differences are usage of gypsum-cardboard panels instead of timber ones, correct utilization of vapor dams, i.e. prevention of water vapor diffusion; asbestos-cement panels are completely cancelled because of their carcinogenic properties, and considerable improvements of water and thermal insulation properties of contemporary façade claddings have been made.

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REZIME

ANALIZA OŠTEĆENJA FASADA ZGRADA LAKOG MONTAŽNOG SISTEMA NAKON DUGOGODIŠNJE EKSPLOATACIJE

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U ovom radu analizirana su oštećenja fasada individualnih i kolektivnih stambenih objekata u montažnom naselju Apelovac u Nišu. Sprovedena je evaluacija tehničkih i konstruktivnih karakteristika fasadnih zidova prema kriterijumima trajnosti i održivosti. Nakon više od pedeset godina eksploatacije, ovi objekti u većini slučajeva i dalje ispunjavaju svoju osnovnu namenu, ali njihove fasade više ne zadovoljavaju zahteve kvaliteta, što je u jednoj meri posledica oštećenja tokom vremena ali i strožih zahteva u pogledu tehničkih karakteristika i izgleda zgrada. Fasadni zidovi, urađeni po tadašnjoj građevinskoj praksi, u potpunosti su izgubili svoje fizičko-tehničke i likovno-estetske funkcije.

Ključne reči: Oštećenje fasada, montažne kuće, trajnost, održivost, obnova

ABSTRACT

ANALYSIS OF FACADE DAMAGE OF LIGHTWEIGHT PREFABRICATED HOUSES AFTER LONG LASTING USE

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This paper analyzed the damage of facades of individual and collective housing buildings in prefabricated neighborhoods on Apelovac hill in Nis. An evaluation of technical and structural characteristics of facade walls according to the durability and sustainability criteria has been conducted. After over 50 years of service, these buildings, in most cases are still fit for their primary purpose, but their facades fail to meet the quality standards any longer. It is in part the result of damage sustained in time, but also of more stringent requirements regarding technical characteristics and building appearance. Facade walls constructed according to the building practice of the day completely lost their physical-technical and visual-esthetic functions.

Key words: Façade damage, prefabricated houses, durability, sustainability, restoration