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 Niš, 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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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, poznat kao period intenzivne stambene izgradnje. Tada izgrađene fizičke strukture poseduju zadovoljavajuće performanse u konstrukтивnom 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).

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Znanja o tomu se ne značilo da su početkom 60-ih godina jedino siromašni stanari i pripadnici etničkih manjina bili voljni ili bili prisiljeni da žive u takvim naseljima, dok srednje klase nije bilo u ovom tipu stanova. U tom tipu naselja jasno je izražena socioekonomsko-ansjepnost njenih stanovnika [26]. Socijalni problemi kao rezultat masovnog doseljavanja stanovništva iz ruralnih krajeva, kao i etničkih manjina, onemogućili su izgradnju stalne društvene zajednice. Ta je bio trajni problem ovih naselja koja su postala stecishe ekonomski neaktivne potklase. Ta naselja postala su zapuštena urbana područja, s problemom primene zagađujućih građevinskih materijala kao što je ažbest [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 ovom vrsti smeštaja 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 nezadovoljne stanje u kome se nalazi većina zgrada koje su, iako prvobitno zamišljene kao privredne (rok trajanja od dvadeset do trideset godina), sada postale trajne. Za većinu objekata je iznenađujuće što su, s predviđenim rokostialama 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 projekta 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.

Koncept objekata bio je u minimalizovanu troškova izgradnje što je kasnije uslovljavalo visoke troškove održavanja [4,10,12]. Na raznovrsnom stambenom tržištu ovu 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 socioekonomsko-ansjepnost njenih stanovnika [26]. Socijalni problemi kao rezultat masovnog doseljavanja stanovništva iz ruralnih krajeva, kao i etničkih manjina, onemogućili su izgradnju stalne društvene zajednice. Ta je bio trajni problem ovih naselja koja su postala stecishe ekonomski neaktivne potklase. Ta naselja postala su zapuštena urbana područja, s problemom primene zagađujućih građevinskih materijala kao što je ažbest [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 ovom vrsti smeštaja među širom populacijom. To je rezultiralo ambivalentnim stavom javnosti prema ovoj vrsti stanovanja počev od ranih 70-ih godina XX veka.

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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.
This paper strives to obtain the basic data on the technical condition of implemented technologies of lightweight prefabricated construction of multi-family buildings [1].

2 SAMPLING METHOD AND DATA COLLECTION

The buildings in question are in: Mokranjčeva street, no. 35-37, Mokranjčeva street, access roads II and III and in Rasadnik neighborhood (Figure 2). The subjects of consideration were: six three-storey buildings, two two-storey buildings, seventeen ground level buildings having four apartments, ten buildings with two apartments and five individual houses. Many buildings were extended, which affected the status of facades (in terms of repairs), while many buildings were remediated or fully reconstructed using contact facades.

Tipske višespratnice (uzorci Tip 1 i 2) izgrađene su sa čeličnom nosećom konstrukcijom, unutrašnjom oblogom od drvenih panela, ispunom od drvolita (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).
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 to its structure resistant to mechanical action, damp, high temperatures, and aggressive chemicals, while exhibiting good thermal insulation properties and adhesion with cement binders. Facade and roof panels containing carcinogenic asbestos fibers are still found on these buildings after five decades.

### Table 1. Characteristic Bearing Structures of Analyzed Prefabricated Buildings

| Nosea konstrukcija | Façade walls | Pregradni zidovi | Krovna konstrukcija |
|---------------------|--------------|------------------|---------------------|
| Load bearing structure | Drveni paneli sa termo izolacijom+azbestni paneli | Drveni paneli | Dvovodni krov, drvena konstrukcija pokrivena azbestnim panelima |
|                      | Timber panels with thermo insulation+asbestos panels | Timber panels | Double-pitched roof, timber construction covered with asbestos plates |
|                      | Drveni okviri i paneli, zidani zidovi | Zidani zidovi 25cm i drveni paneli | |
|                      | Timber frames and panels, brick walls | Timber panels with thermo insulation+mortar | |
|                      | Čelični okviri | Drveni paneli | |
|                      | Steel frames | Timber panels | |
|                      | Apelovac P+3 | Apelovac P+1 | Apelovac P |
|                      | Apelovac P | Apelovac P | Apelovac P |

### 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) | Opis oštećenja | mali <30% | 30%< srednji < 60% | 60%< značajan |
|--------------------------------|-----------------|-----------|-------------------|---------------|
|                               | Description of damage | small <30% | medium < 60% | significantly |
|                               | prsline - pukotine cracks – fissures | 32 | 37 | 19 |
| Malertisane fasade | prsline u malteru usled skupljanja shrinkage cracks in mortar | 23 | 6 | 0 |
| Plastered facade           | oštećenja soklenog zida plinth wall damages | 36 | 15 | 4 |
|                               | iscvetavanje efflorescence | 42 | 23 | 3 |
|                               | Obloga od azbestnih ploča | 4 | 9 | 2 |
|                               | 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 primene 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 rabic-pletiva, otpadanje završnog sloja maltera, ljuškanje završnog sloja fasade, mrežaste prsline od skupljanja, pojava mahovine i lišaja, bujanje flore, prsline-pukotine, prsline-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).
Karakteristična oštećenja fasada od azbestcementnih panela klasifikovana su kao: potpuna dezintegracija zida, otpadanje panela, lom krajeva panela, uvrštanje u 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).

Strukturne 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 zbivenosti tla na različitim dubinama fundiranja. Na postojanost završnog sloja slike dominantan uticaj imali su mraz i pojava vlage usled propadanja vertikalne hidroizolacije u temeljnim zidovima. Najčešće evidentirana oštećenja su: otpadanje slike, kristalizacija soli, carbonatizacija, 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.
Oštećenja kalkanskih zidova, dimnjaka, ventilacionih kanala, streha i oluka svedoče o totalnom zanemaranju objekata od strane njihovih vlasnika. Na svim objektima izzev 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.

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 Sd=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

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

Slika 7. Oštećenja strehe (slika: P. Petronijević)
Figure 7. Damage to the eaves (photo: P. Petronijević)
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 čelićnom nosemom 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 preklop bez zaptivanja tako da je u kombinaciji s lošem 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 (kuhine i mokri čvorovi). Uzorci izgrađeni nakon 1962. godine na spoljnim zidovima imali su dodatni sloj termoizolacije sa ispravnim položajem parozaptivnog sloja tj. sa tople strane termoizolacionog sloja. Ter-hartija je uslovno rečeno preuzela ulogu 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].

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**Slika 8. Nastanak oštećenja fasadnog maltera usled bubrenja drvene građe (slika: P. Petronijević)**

*Figure 8. The appearance of damage to the façade 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. Koeficijent prolaska toplote, temperaturnog kašnjenja i faktor gušenja temperature višestruko su ispod danas zahtevanih vrednosti. Subjektivan 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 if 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 thickness. 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].

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]
Tablica 3. Broj defekata na malterisanim fasadama (2014 god.)

| Uzorak Specimen (zgrada i tip) | veličina uzorka number of specimen (broj rastera) 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           | 4x36                                        | 165 156 182 175               | 4.58 4.33 5.06 4.86                         |                               |                                 |
| 1-4 (Type 1) mortar          |                                             |                               |                                             |                               |                                 |
| 5, 6 (Tip 1) azbest          |                                             |                               |                                             |                               |                                 |
| 5, 6 (Type 1) asbestos       |                                             |                               |                                             |                               |                                 |
| 7-8 (Type 2)                 | 2x22                                        | 77 84                         | 3.50 3.82                                   |                               |                                 |
| 27-37 (Type 3-a)             | 17x16                                       | 45 52 39 46 51 59 47 57       | 2.81 3.25 2.44 2.88 3.19 3.63 2.94          |                               |                                 |
| 27-37 (Type 3-b)             | 10x10                                       | 21 28 38 22 24                | 2.10 2.80 3.80 2.20 2.40                   |                               |                                 |
| 38-42 (Tip 3-c)              | 5x6                                         | 0 3 1 0 1                    | 0.0 0.50 0.17 0.0 0.17                       |                               |                                 |
| 38-42 (Type 3-c)             |                                             |                               |                                             |                               |                                 |
|                                | ∑ = 1898                                    |                               |                                             | ∑ = 101.67 (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, ocjenjuje 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).
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 included 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: $n \neq \text{const}$ 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.

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

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

The upper control limit $UCL_u$ and the lower control limit $LCL_u$ 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.

$$UCL_u = \bar{u} + 3\sqrt{\left(\frac{\bar{u}}{n}\right)}$$  \hspace{1cm} (3)

$$LCL_u = \bar{u} - 3\sqrt{\left(\frac{\bar{u}}{n}\right)}$$  \hspace{1cm} (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. Adevratno održavanje i najveća materijalna ulaganja imali su objekti sa samo jednim vlasnikom.

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). Prosječan 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 meni 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 ukradene 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].
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.

Tipska 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, ljudsanje, probiranje vlage, pucanje maltera na mestu nosećih elemenata, oštećenje termoizolacije, biokorozija, …) po ustanovljenim fizičkim, hemijskim, mehaničkim ili biološkim uzrocima oštećenja [13,21].

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, oštećenje maltera na mestu drvenih stubova noseće konstrukcije, mrezaste 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 pozna da fasade su oštećene na veoma difuzan način, a prema slikama i istraživanjima, oštećenja fasada su karakteristična za ovu zonu.

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

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

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)
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 – 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.
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 vidame ili dodavanja slojeva [9]. Najmanje intervencija primenjena je na krovnom pokrivaču od salońit-ploča, koji je i nakon šest decenija zadržao skoro sve svoje karakteristike, osim estetskih.

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 nadzidživanjem i dozidživanjem preko postojećih gabašta objekta u potpunosti je narušen izgled i vizuelni identitet naselja.

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

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 održeni nesistematično, 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. Ova je takođe imalo uticaja na kasnije loše održavanje i izostanak periodičnog obravnavanja fasade. Iz grafika 10 nedvosmisleno se može zaključiti da i stepen zakačenosti objekata u sklopu sanacije fasada mahom odrađeni nesistematično, od slučaja do slučaja, i više se nije moglo učiniti uzrokom podrijetla oštećenja fasada. Uticaj razlika u spratnošću a tehnološki proces sanacije fasada i cena radova je međusobno približna (jedina razlika je u ceni radova na saniranju i remenjaju fasade). S povećanjem broja stambenih jedinica u okviru jednog objekta znatno se pogrjašava trenutno stanje fasada a stepen oštećenja raste. Ova pojava se objašnjava težim dogovorom većeg broja stanara. Uticaj razlike u spratnošću a tehnološki proces sanacije fasada i cena radova je međusobno približna (jedina razlika je u ceni radova).

U današnjoj savremenoj montažnoj gradnji većina nedostataka je korigovana izostanak periodičnog obnavljanja fasade. U periodu od 1960. do 1980. godine, postale su jasne nedostatke u kvalitetu 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. Ova je takođe imalo uticaja na kasnije loše održavanje i izostanak periodičnog obravnavanja fasade. Iz grafika 10 nedvosmisleno se može zaključiti da i stepen zakačenosti objekata u sklopu sanacije fasada mahom odrađeni nesistematično, od slučaja do slučaja, i više se nije moglo učiniti uzrokom podrijetla oštećenja fasada. Uticaj razlika u spratnošću a tehnološki proces sanacije fasada i cena radova je međusobno približna (jedina razlika je u ceni radova na saniranju i remenjaju fasade). S povećanjem broja stambenih jedinica u okviru jednog objekta znatno se pogrjašava trenutno stanje fasada a stepen oštećenja raste. Ova pojava se objašnjava težim dogovorom većeg broja stanara. Uticaj razlike u spratnošću a tehnološki proces sanacije fasada i cena radova je međusobno približna (jedina razlika je u ceni radova).

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.
7 LITERATURA

REFERENCES:

[1] American Society for Testing of Materials International. ASTM Standard E2270-05 Standard Practice for Periodic Inspection of Building Facades for Unsafe Conditions.

[2] Bartiaux, F. et al., Socio-technical factors influencing residential energy consumption (Serec). Part 1: Sustainable production and consumption patterns, Scientific support plan for a sustainable development policy (SPSD II), UCL, VITO and Danish Building Research Institute, January 2006.

[3] Curwell, S. et al., (2008), Hazardous Building Materials, Spoon Press, New York, USA.

[4] Folić, R. (2002) Održavanje konstrukcija pregled stanja i izveštaj o prispelim radovima. Građevinski atelijeri i konstrukcije, 45(3-4), 41-53.

[5] Folić, R., Kurtović - Folić, N., "Pouzdanost i održavanje stambenih zgrada" Tehnika – Naše građevinarstvo 49 (1995) 9-10, str. NG1-NG11

[6] Folić, R., Laban, M., Milanlo, V., Analiza pouzdanosti i održivosti krupno panelnih stambenih blokova u Sofiji, Skoplju i Novom Sadu, Fakultas universitats - series: Architecture and Civil Engineering, 9(1), 161-176. (2011)

[7] Godish, T., Sick Buildings: definition, diagnosis and mitigation. Lewis Publ. Boca Raton, USA, (1995)

[8] Gdlovski, B., Klasična ili montažna gradnja, Građevinar, 60 (1), pp. 81-94, (2008)

[9] Guidance: Securing parapets and facades on unreinforced masonry buildings. Advice for building owners, councils and engineers. Ministry of Business, Innovation and Employment. New Zealand, 85 p.: (2018)

[10] Hasan, A., (1999) Optimizing insulation thickness for buildings using life cycle cost, Appl Energy 63, pp. 115-124

[11] Hens, H., Ali Mohammed F., (1993) Thermal insulation quality and energy use in existing housing stock. CIB W64 Energy efficient energy symposium, Stuttgart

[12] Hens, H., Parjis, W. &Deurincck, M. (2009): Energy consumption for heating and rebound effects. Energy and Buildings, 42, 105-110

[13] Henshaw Justin, (2015), FAIA, FASTM, Analyzing Building Failures: Tools and Methodologies, pp 28-34

[14] Huovinen, S., Bergman, J., Hakkarainen, H., Development of a new methodology to analyse the durability of facade repair and retrofitting systems, Deterioration defects and repair methods of facades, Final report, Laboratory of structural engineering and building physics, Helsinki University of Technology, Finland, (1998)

[15] Itard, L, Meijer, F., Vrins, E., Hoiting, H., Building Renovation and Modernisation in Europe: State of the art review (2008) ERABUILD final report, OTB TU Delft, January 2008.

[16] Kimball, J., Beasley, P.E., and Mark K. Schmidt, S. E. Building Facades, (chapter 8), pp. 207-233.

[17] Laban, M. (2006). Kontrola kvaliteta prefabrikovanih betonskih fasadnih elemenata nakon višegodišnje eksploatacije. Građevinski materijali i konstrukcije, 49(1-2), 3-19.

[18] Martinez A, Patterson M, Carlson A et al (2015) Fundamentals in façade retrofit practice. Procedia Eng 118; pp. 934–941

[19] Milanko V., Laban M., Karabasil, D., (2006) Fire safety problems of residential towers, 2nd international scientific conference FIRE ENGINEERING, Lučenec, Slovakia, Proceedings, pp. 255 - 261

[20] Moghtadernejad, S., Design, inspection, maintenance, life cycle performance and integrity of building facades, Department of Civil Engineering and Applied Mechanics McGill University Montreal, Quebec, Canada Apr. 15, 2013

[21] Petronijević, P., Momčilović-Petronijević, A., (2019) Analysis of façade damage of prefabricated houses after long lasting use, 11th international conference Assessment, maintenance and rehabilitation of structures and settlements, Zlatibor, Serbia, 19-21. jun 2019. Conference proceedings, pp 73-82.

[22] Pehukuri, R., Vares, S., Pulakka, S., et al., (2012), Sustainable refurbishment of exterior walls and building facades, Final report, Part C – Specific refurbishment concepts, Espoo 2012. VTT Technology 35. 198 p. + app. 1 p.

[23] Romila, C. (2013), General principles for the design and construction of ventilated facades, bulletin-institutul politehnic Din Iași, Publicat de Universitatea Tehnică “Gheorghe Asachi” din Iași, Tomul LIX (LXIII), Fasc. 3, 2013, Secția Construcții. Arhitectură, pp. 161-169.

[24] Santos, P., Lemes, G.; Mateus, D. Thermal Transmittance of Internal Partition and External Facade LSF Walls: A Parametric Study. Energies 2019, 12, 2671.

[25] Saussay, A., Saheb, Y. &Quirion, P., (2012): The Impact of Building Energy Codes on the Energy Efficiency of Residential Space Heating in European Countries - A Stochastic Frontier Approach. International Energy Program Evaluation Conference, Rom

[26] Savov, R., Beloeva, V., Refurbishment of Social Buildings in Bulgaria – Specific problems and Solutions, The CRES conference proceedings "Retrofitting of Social Housing-Financing and Policy Options", 7-8 November 2006, Thessaloniki, Greece

[27] Schiessl, P., et al., (2003), Prediction of service Life of Existing Structures by Applying Probabilistic Service Life Design (SLD) Procedures, presented at the Proceedings of the International Conference ICACS 2003, China.

[28] Surface condition and mouldgrowth in traditionally-built dwellings (1990), BRE Digest 297.

[29] Ucar, A., Balo, F., (2010), Determination of the energy savings and the optimum insulation thickness in the four different insulated exterior walls Renew Energy 35, pp. 88–94.

[30] Viitanen, H. &Ritschkoff, A. 1991. Mould growth in pine and spruce sapwood in relation to air humidity and temperature. Uppsala. The Swedish University of Agricultural Sciences, Department of Forest Products. Report no 221. 40 p. + app 9 p

[31] Waldum A. M. Restoration of masonry facades. Renders and final coats in a severe climate. pp. 1128-1135
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