WARSAW UNIVERSITY OF TECHNOLOGY Index 351733
FACULTY OF CIVIL ENGINEERING
COMMITTEE FOR CIVIL AND WATER ENGINEERING
POLISH ACADEMY OF SCIENCES ISSN 1230-2945

DOI: 10.24425/ace.2025.154121

ARCHIVES OF CIVIL ENGINEERING

Vol. LXXI ISSUE 2 2025

pp. 279 – 293

Research paper

Experimental tests of steel balcony connections – Part 1

Maciej Tomasz Solarczyk[1], **Paweł Piotrkowski**[2], **Maciej Niedostatkiewicz**[3]

Abstract: Paper presents theoretical analysis and results of experimental tests of three prefabricated balcony sets in natural scale with dimensions (width × length × height): 2.0 m × 2.78 m × 0.186 m (in a slope to 0.17 m) and one with dimensions: 2.0 m × 2.78 m × 0.2 m, consists of reinforced concrete slabs connected with each other with steel balcony connections. The impact of variable parameters (elongation of anchorage of balcony connections in ceiling slab, concreting of test elements in two stages, using of muffs as couplers to connect the longitudinal reinforcement bars in balcony sets and different height of the balcony slab) on the load bearing capacity of the elements are analysed. In the paper also the test stand was described. During the experimental tests, the crack morphology was determined, displacements and crack widths were measured. The paper contains a review of the scientific papers in the field of balcony connections.

Keywords: balcony, balcony connections, experimental tests, reinforced concrete structures

[1]MSc., Eng., Gdansk University of Technology, Faculty of Civil and Environmental Engineering, Gabriela Narutowicza 11/12, 80-233 Gdansk, Poland, e-mail: maciej.solarczyk@pg.edu.pl, ORCID: 0000-0001-6070-0736
[2]DSc., PhD., Eng., Gdansk University of Technology, Faculty of Civil and Environmental Engineering, Gabriela Narutowicza 11/12, 80-233 Gdansk, Poland, e-mail: piotrkow@pg.edu.pl, ORCID: 0000-0001-7860-673X
[3]DSc., PhD., Eng., Prof. GUT, Gdansk University of Technology, Faculty of Civil and Environmental Engineering, Gabriela Narutowicza 11/12, 80-233 Gdansk, Poland, e-mail: mniedost@pg.edu.pl, ORCID: 0000-0002-6451-6220

1. Introduction

Balcony connections are used to connect the ceiling slab with the cantilevered balcony slab. The basic function of such an elements is to transfer transverse forces and bending moments from the balcony to the construction of building. Additionally the connection of the floor and balcony slabs is one of the most important thermal bridges in the building – if it is not properly secured, it will result in significant heat losses and deterioration of serviceability conditions by increasing heating costs. The fire resistance of the balcony connection is also an essential condition. Another important factor is the durability of the structure over a long period of serviceability. The main reinforcement bars in the balcony should be adequately protected against the unfavorable effects of the external environment, which may lead to corrosion. If renovation works are abandoned in this regard, they may lead to a disaster or construction failure [1]. For this reason, stainless steel bars are most often used in connections. Another solution is to use an increased concrete cover of the main reinforcement. The structural designer should also consider the influence of dynamic and multiple-variable loads on the load-bearing capacity of a balcony connections. Often, when choosing a technical solution, the decisive is the economic aspect – assessing the costs of connecting between the balcony and the ceiling, the speed of assembly of the structure, the complexity of its implementation or the limitation of assembly works, for both: newly constructed and modernized buildings [2].

In this paper, the authors decided to present an alternative solution for system balcony connections. The construction solution of the connectors used in the tested balcony slabs results from the need to use materials easily available in the production of other structural elements, which allows for reducing the costs of the balcony-ceiling connection and is an ecological solution, limiting the amount of post-production waste and, consequently – reducing the carbon footprint.

The paper analyzed the impact of variable parameters (elongation of anchor-age of balcony connections in ceiling slab, concreting of test elements in two stages, using of muffs to connect the longitudinal reinforcement bars in balcony sets and different height of the balcony slab) on the load-bearing capacity of a steel balcony connections consisting of a tension bar and a shear plate ended with a two transverse plates (see Fig. 1). This paper is the first part of investigation. In [3] the results of deformations in the balcony connection using strain gauge sensors and numerical model of balcony connection is presented.

2. Literature

There are a number of papers in the scientific literature related to thermal issues in balcony-to-slab connections.

In [4] the impact of modifying the ceiling slab by making 12.5 mm depression (curb) in the concrete balcony slab right beneath the sliding door/spandrel panel frame and filled with a 25.4 mm thick Extruded Expanded Polystyrene (EPS) rigid insulation was analyzed. A special case – a multi-unit residential building in Canada was presented in [5], where the authors proved that overall thermal transmittance (U-value) in a 2D heat transfer is improved by 9–18% depending on the thermal performance of the above and below balcony components. In [6] potential effects of high-performance fiber-reinforced polymer thermal breaks for balcony connections on the thermal losses and heating needs of a typical residential building in Switzerland were investigated. In [7] the authors uses a combination of field measurements and models to investigate the effects of installing balcony thermal breaks on the interior surface temperatures, effective thermal resistance, and annual building energy consumption. For the field experiment, yearlong measurements were conducted on the 13th floor of a 14-story multi-family building in Chicago, in which thermocouple sensors were embedded into eight balconies and their adjacent interior floor slabs just before concrete was poured to complete the construction. The results demonstrate that the thermal breaks in the balcony reduce the linear thermal bridge, but the predicted effect on annual energy consumption in all modelled building types was small (less than 2%). The thermal aspects of the reinforced concrete balcony – floor connection were presented in [8]. The thermal behavior of a balcony board with integrated reinforced insulating elements was investigated by means of measurement as well as numerical analysis was realized using Fluent ANSYS workbench.

Experimental tests of full-scale balcony slabs connected to the ceiling slab using balcony connections in terms of acoustic behavior were presented in [9]. Conclusions to reduce vibrations of such structures were formulated.

In [10] a specific solution that guarantee a load capacity connection for balcony slab and at the same time a thermal efficiency was analyzed. Moreover the design model and the thermal performance analysis in winter and summer situation was described. In [11] selected results of experimental and numerical investigations of the structural behaviour and deformation behaviour of slap connections with compression shear bearings were presented. In particular, the different failure modes and the developed design method were described. In [12] the authors describes a floor to balcony junction made as a thermal connection with a special construction element – stainless steel Z-shaped profile. The authors of the paper draw attention to the complex work of such an element and thus to experimental studies covering different M/V ratios varying from 0.1 to 0.8. An analytical model have been deduced in order to predict the resistance at Ultimate Limit State of the balcony connection. Authors in [13] summarises the experimental tests of balcony connections subjected to vertical actions. An analytical formulation for determining the ultimate load and an analytical model for computing the flexural stiffness have been proposed and validated using the experimental results. Experimental tests of special balcony connections under cyclic load to determine their fatigue strength were presented in [14]. In [15] authors investigates experimentally and numerically the behaviour of a balcony-to-slab connection made by an H-profile embedded in the concrete slab. Overview of system solutions for balcony connections is described in [16]. Preliminary experimental tests of steel balcony connections in the aspect of load bearing capacity of balcony – slab joint is presented in [17]. Experimental tests of full-scale prefabricated balcony sets consist of reinforced concrete slabs (balcony and ceiling) connected with each other with double-type balcony connections is described in [18].

3. Materials and methods

In [17] the results of test carried out during Stage I were presented. In this case balcony connection consisted of an undercut plate with dimensions 180 mm × 90 mm, 20 mm thick with welded on top (in tension zone) one reinforcement bar ϕ12 mm with a mean yield strength of 533 MPa. At the bottom of the plate (in compression zone), on the balcony and the ceiling side of set, transverse plates with dimensions 80 mm × 35 mm, 12 mm thick were welded. The components of the balcony connection (1 and 2 in Fig. 1) were made of S355J2G3 steel. The balcony set was marked as I_ZB_1_1.

In Stage II balcony connections presented in Fig. 1 (marked as II_ZB_1_2 and II_ZB_1_3) and in Fig. 2 with modified geometry (marked as II_ZB_1_4) were tested. In this case (II_ZB_1_4), a symmetrical balcony connection was assumed, with 240 mm length, connected at the bottom with two transverse plate of 35 mm height, width of 80 mm and 12 mm thick, located 30 mm from the bottom of balcony connection. This resulted in the reduction of the effective depth of the cross-section (by lifting of transverse plate up on the ceiling slab side) and the elongation of the anchorage length in the ceiling slab.

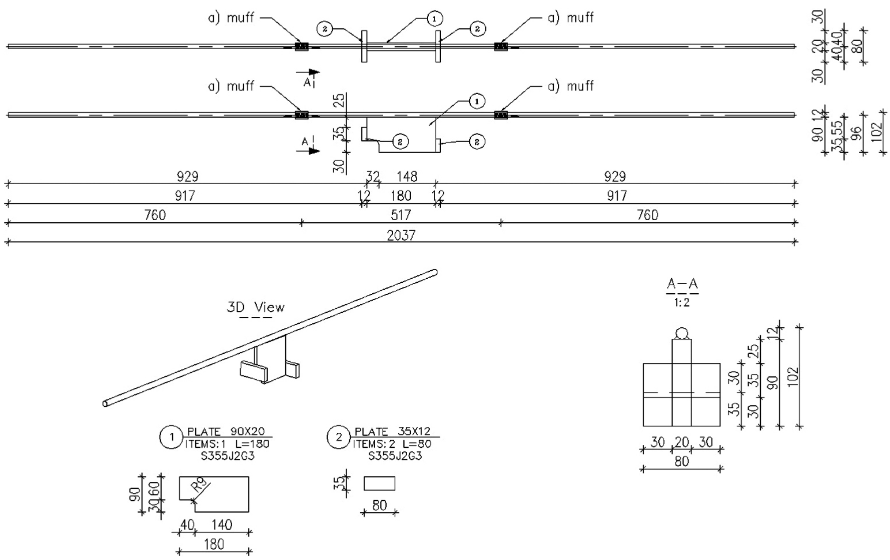

Fig. 1. The geometry of balcony connection: in Stage I (without muff) – set I_ZB_1_1 and in Stage II (with muff – element a)): II_ZB_1_2 and II_ZB_1_3

The variable parameters in the analysis were:

– use of a muff to connect the longitudinal reinforcement bars in balcony sets: II_ZB_1_2, II_ZB_1_3 and II_ZB_1_4 – see Fig. 4 (no muff in Stage I of tests – described in [17] – I_ZB_1_1 – see left photo on Fig. 3); muffs located on two sides of the balcony connections: approximately 20 cm from the edge of ceiling slab and 25 cm from the edge of balcony slab; total distance between muffs – 51.7 cm;

– two-stages of concreting – balcony slab build two days earlier than ceiling slab (in balcony set II_ZB_1_2);
– modified geometry of balcony connection – application of symmetrical balcony connection (to eliminate assembly problems) and elongation of anchorage length in ceiling slab (in balcony set II_ZB_1_4) (Fig. 2);
– different height of balcony slab – 1.4 cm thicker than in other sets: 18.6 cm (for I_ZB_1_1, II_ZB_1_2 and II_ZB_1_3) and 20 cm (for II_ZB_1_4).

In Stage II of the tests, muffs on the longitudinal reinforcement bars were used to simplified the assembly of the balcony connections (see the geometry at Fig. 1 and Fig. 2). Additionally, the balcony connection with a muff to enable corrosion protection by hot-dip galvanizing (with a minimum galvanized coating thickness of 85 µm) was made.

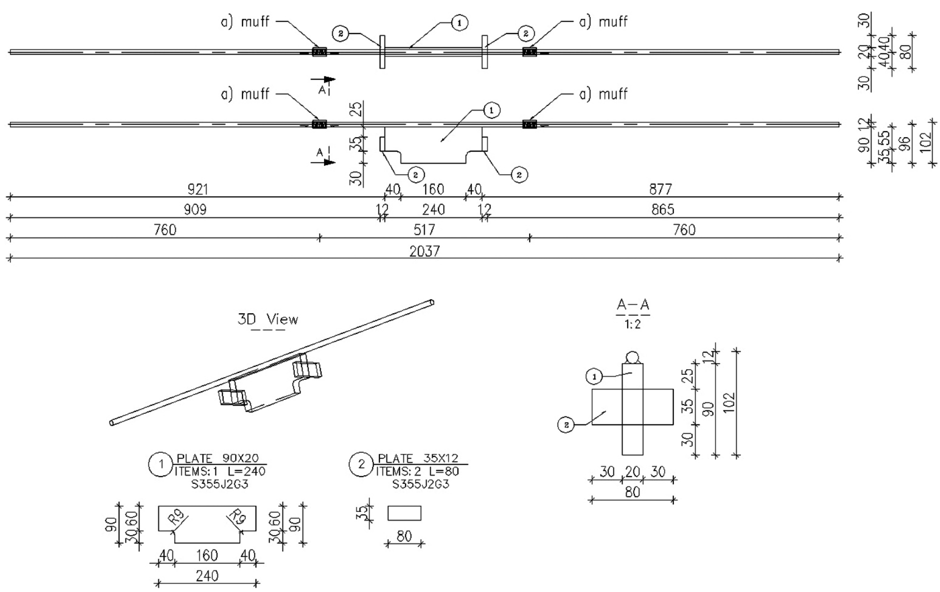

Fig. 2. The geometry of the balcony connection in Stage II (with muff – element a)) – set II_ZB_1_4 (the geometry of balcony connection has been modified in relation to Stage I)

The authors tested full-scale prefabricated balcony sets: three with dimensions (width × length × height): 2.0 m × 2.78 m × 0.186 m (in a slope to 0.17 m) and one with dimensions: 2.0 m × 2.78 m × 0.2 m. The assumed differences between the sets are discussed above. The sets consists of reinforced concrete slabs (balcony and ceiling) connected with each other by balcony connections. In each set, 12 balcony connections were used to connect slabs (one connection – a plate with welded reinforcing bar ϕ12 mm), divided into two packages of 6 connections, 0.5 m length, spaced every 0.10 m. The overhang of the cantilever (measured to the edge of ceiling slab) equals L_{eff} = 1.78 m. Concrete C30/37 and reinforcement steel K500-B-T were used to build the balcony sets.

Experimental tests were carried out on a specially designed test stand (right photo on Fig. 3 and Fig. 5), which was adapted to the Zwick-Roell 500 kN testing machine. The two hydraulic jacks of testing machine were placed at a spacing of 2.0ḿ (one act as a ballast). It was assumed that balcony sets would be loaded quasi linearly, parallel to the outer edge of balcony slab by use of set of beams on which the concentrated load (F) of the hydraulic jack of the testing machine was applied.

Fig. 3. Balcony connection with glued strain gauges before assembly of reinforcement in set I_ZB_1_1 – without muff on longitudinal reinforcement bars (Stage I) (on the left) and photo of the test stand during research (on the right)

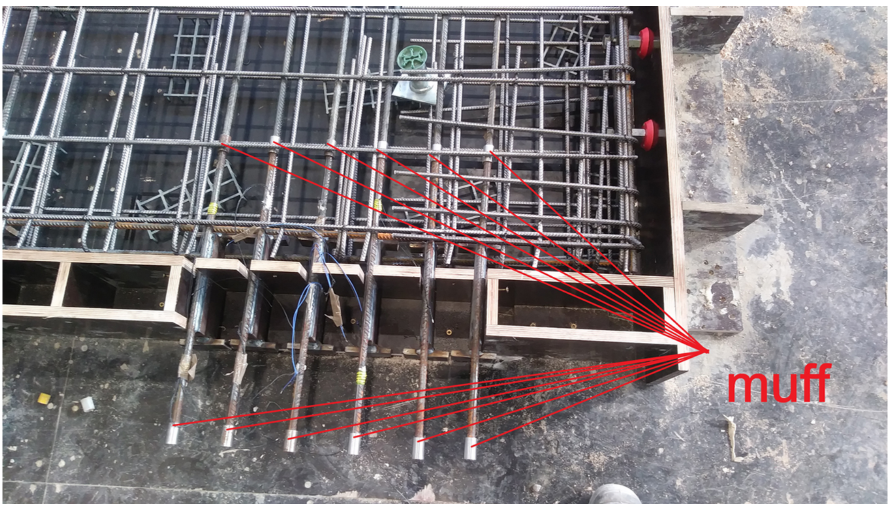

Fig. 4. Balcony connection with glued strain gauges before concreting set II_ZB_1_2 – muff on longitudinal reinforcement bars (Stage II)

Loading scheme during experimental tests corresponded to the theoretical (standard) loading scheme of the balcony slab. During tests, deflections in three points at the end of cantilever were measured using displacement sensors with an limit error of 0.01 mm. Additionally, crack morphology with measurement of crack width (by microscope with limit error of 0.02 mm) were tested.

The maximum value of load obtained in tests was assumed as the failure force (F_u). During testing, the value of the force was taken as the load from the hydraulic jack of the Zwick–Roell 500 kN testing machine (Fig. 5), given with an limit error of 0.1 kN.

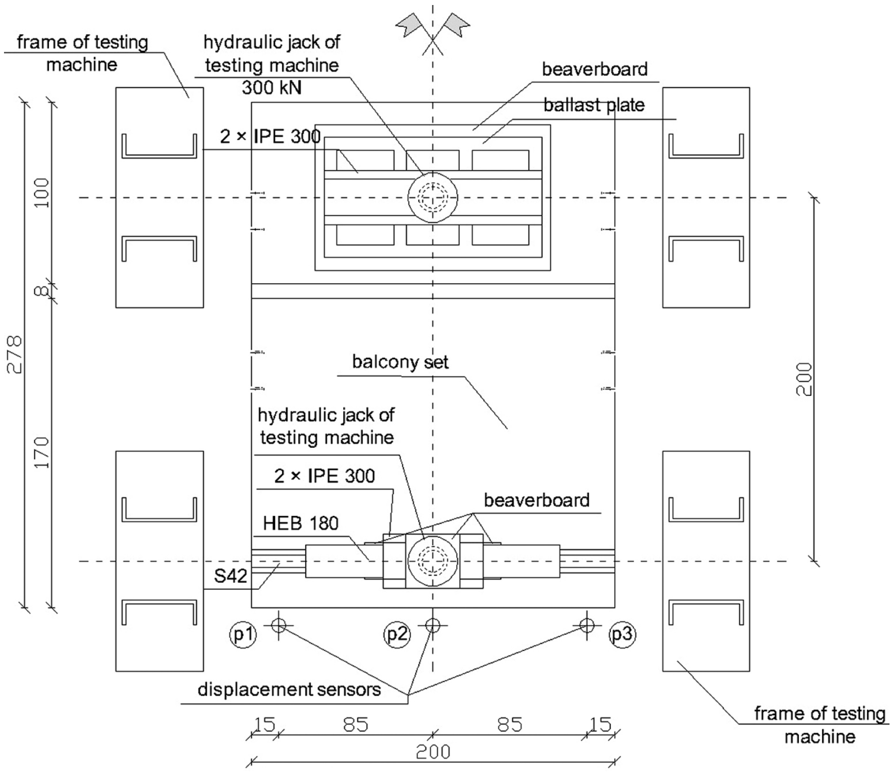

Fig. 5. Plan view of test stand

4. Experimental results

Deflections of balcony sets on Fig. 6 (I_ZB_1_1), Fig. 8 (II_ZB_1_2), Fig. 10 (II_ZB_1_3) and Fig. 12 (II_ZB_1_4) were presented. Crack morphology of balcony sets on Fig. 7 (I_ZB_1_1), Fig. 9 (II_ZB_1_2), Fig. 11 (II_ZB_1_3) and Fig. 13 (II_ZB_1_4) were shown.

4.1. Balcony set I_ZB_1_1

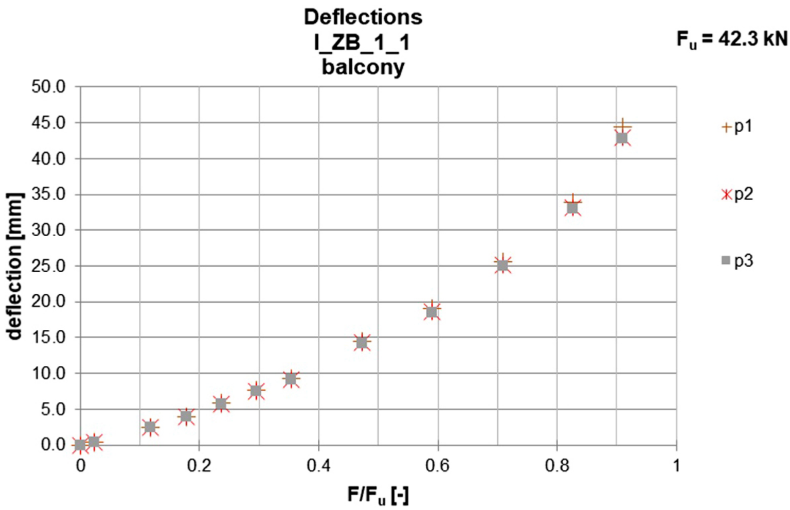

Fig. 6. Deflection of balcony set I_ZB_1_1 during Stage I of tests

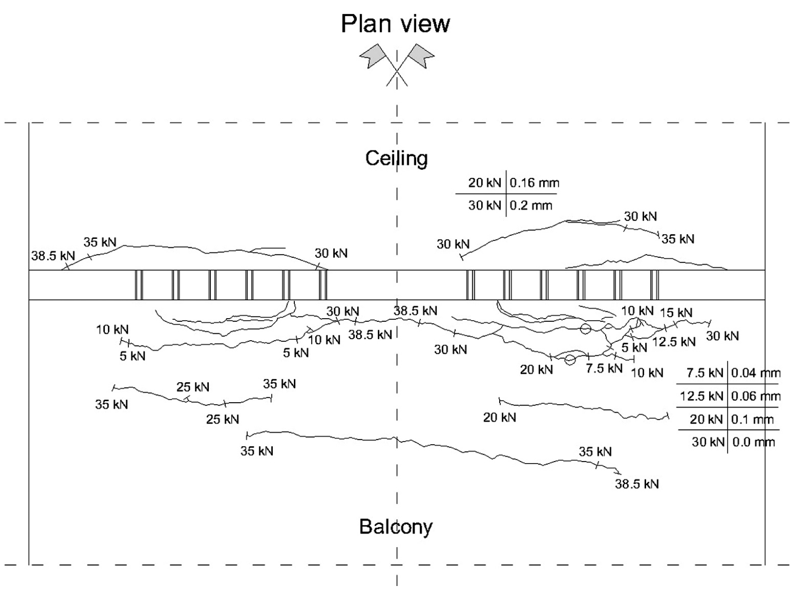

Fig. 7. Crack morphology of balcony set I_ZB_1_1 during Stage I of tests

4.2. Balcony set II_ZB_1_2

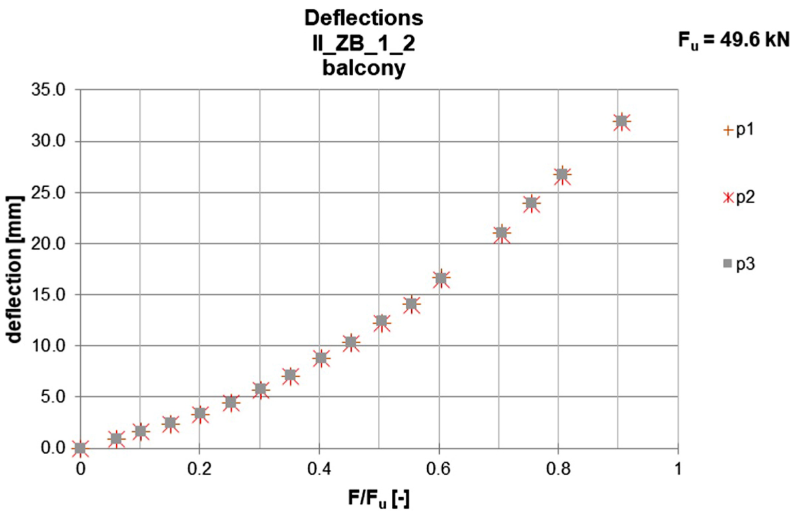

Fig. 8. Deflection of balcony set II_ZB_1_2 during Stage II of tests

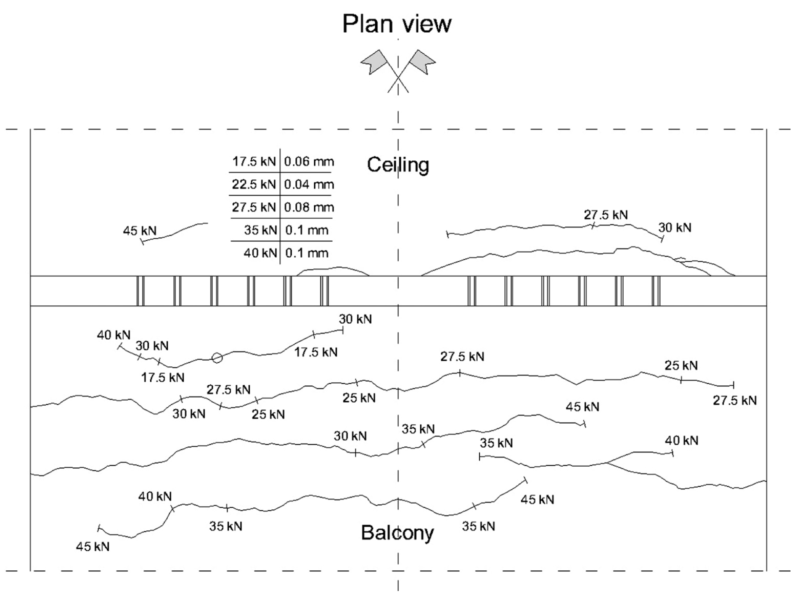

Fig. 9. Crack morphology of balcony set II_ZB_1_2 during Stage II of tests

4.3. Balcony set II_ZB_1_3

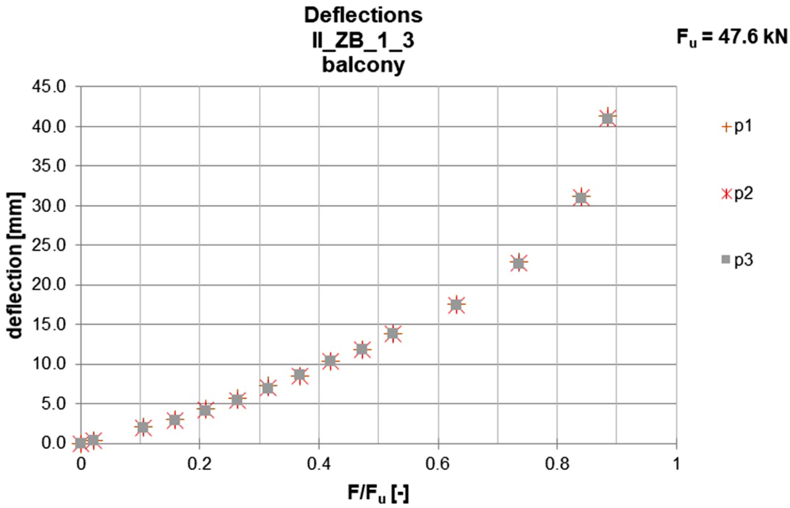

Fig. 10. Deflection of balcony set II_ZB_1_3 during Stage II of tests

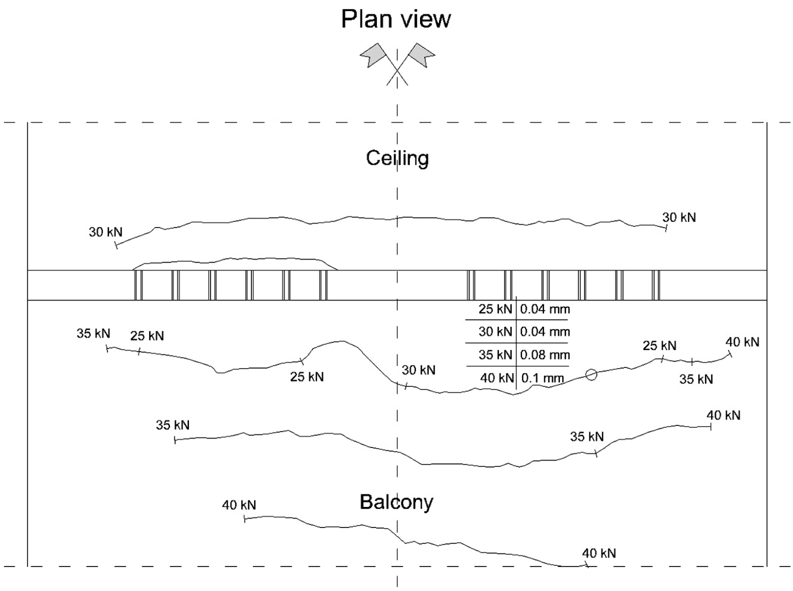

Fig. 11. Crack morphology of balcony set II_ZB_1_3 during Stage II of tests

4.4. Balcony set II_ZB_1_4

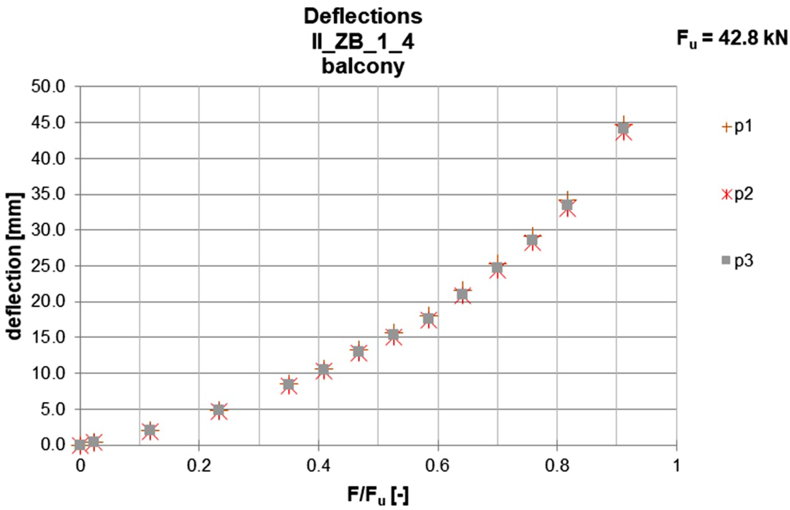

Fig. 12. Deflection of balcony set II_ZB_1_4 during Stage II of tests

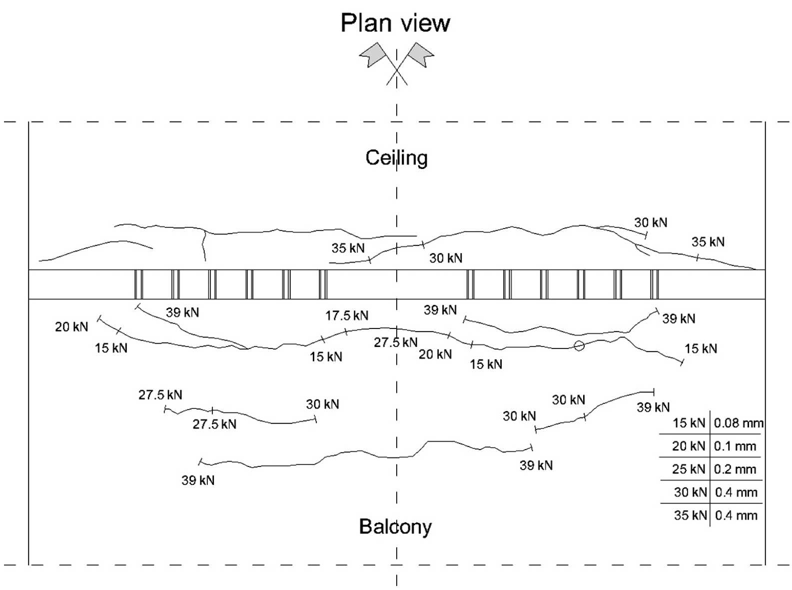

Fig. 13. Crack morphology of balcony set II_ZB_1_4 during Stage II of tests

5. Static calculations

The values of internal forces were determined from standard actions [19].

Overhang of cantilever (balcony): $L_{\mathrm{eff}} = 1.78$ m. Permissible value of deflection (according to 7.4.1 (4) in [20]): $f_{\mathrm{dop}} = \frac{1}{250} \cdot L_{\mathrm{eff}} = 0.71$ cm. According to Table 8 in [21] the limit deflection for cantilever equals: $f_{\mathrm{dop,PN-B}} = \frac{L_{\mathrm{eff}}}{150} = 1.19$ cm.

Width of balcony slab and design strip: $B = b = 2.0$ m. Thickness of balcony slab: $h = 18.6$ cm $= 0.186$ m (0.2 m for II_ZB_1_4).

Dead load of balcony slab: $g = \gamma_c \cdot h = 25\ \frac{\mathrm{kN}}{\mathrm{m}^3} \cdot 0.186\ \mathrm{m} = 4.65\ \frac{\mathrm{kN}}{\mathrm{m}^2}$ ($5\ \frac{\mathrm{kN}}{\mathrm{m}^2}$ m for II_ZB_1_4).

Additional load from finishing layers (estimation): $g_d = 1.0\ \frac{\mathrm{kN}}{\mathrm{m}^2}$. Characteristic value of a uniformly distributed load on balcony area: $q = 5.0\ \frac{\mathrm{kN}}{\mathrm{m}^2}$. Characteristic value of the line vertical load acting from the dead load of railing: $P = 1.0\ \frac{\mathrm{kN}}{\mathrm{m}}$. Characteristic value of the line horizontal load acting on the balcony railing: $P_1 = 1.0\ \frac{\mathrm{kN}}{\mathrm{m}}$. Minimum railing height (according to §298. 2. in [22]): $x = 1.1$ m.

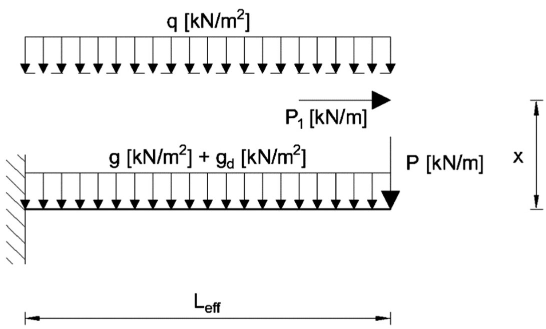

Fig. 14. Static scheme and loading scheme of balcony

Characteristic value of total bending moment determined from standard [19] actions (Fig. 14): $M_{\mathrm{Ek}} = 39.5\ \ \mathrm{kN \cdot m}$ ($40.6\ \ \mathrm{kN \cdot m}$ for II_ZB_1_4).

6. Analysis of experimental results and conclusions

In Table 1 summary of characteristic values obtained from tests and analysis of results was presented.

Maximum crack width measured before failure equals $w_{\max} = 0.4$ mm (see Fig. 13 – set II_ZB_1_4). In other cases, crack width does not exceed the standard limiting value [20, 21]: $w_{\lim} = 0.3$ mm.

Under the applied standard actions [19] (see force F_{Ek}) the maximum measured deflection (I_ZB_1_1) was $f = 9.3$ mm and was lower than the permissible value of deflection limited to 1/150 of cantilever. Due to the creep coefficient in quasi-permanent combination of actions, it may happen that the permissible deflection of the element will determine the quantity or type of used balcony connections or the execution of the upward deflection of the balcony.

Table 1. Summary of characteristic values obtained from tests and analysis of results

Description	**Test / calc**	**Symbol [unit]**	**I_ZB_1_1**	**II_ZB_1_2**	**II_ZB_1_3**	**II_ZB_1_4**
				– muff – two-stage concreting	– muff	– muff – modified geometry of balcony connection – height of balcony slab: 20 cm
force from the hydraulic jack of testing machine at which an equivalent bending moment due to standard actions was obtained	test	F_{Ek} [kN]	14.0	14.4	14.5	14.3
bending moment determined from standard actions (load level)	calc	M_{Ek} [kNm]	39.5 (0.47)	39.5 (0.43)	39.5 (0.45)	40.6 (0.49)
deflection at force F_{Ek}	test	f_{Ek} [mm]	9.3	5.7	7.3	8.5
cracking force	test	F_{cr} [kN]	5.0	27.5	25	15
maximum measured deflection before failure (load level)	test	$f_{\mathrm{max,test}}$ [mm]	44.5 (0.91)	31.9 (0.91)	41.3 (0.88)	44.8 (0.91)
maximum measured crack width before failure	test	[mm]	0.2	0.1	0.1	0.4
failure force	test	F_u [kN]	42.3	49.6	47.6	42.8
failure moment	test	M_u [kNm]	82.3	92.7	88.7	83.5

Deflections measured before reaching the maximum force – before failure (at the load level $\eta = 0.9$) did not exceed $f = 45$ mm (Fig. 15).

Based on the test results, it can be concluded that all tested balcony sets behave in a similar way. The solution presented in the paper allows to meet the Ultimate Limit State (ULS) and Serviceability Limit State (SLS) conditions. This also allows to conclude that steel balcony connections may compete with system balcony connections. An interesting behavior observed in the tests was the rotation of balcony connection on the ceiling slab side of balcony set as rigid element.

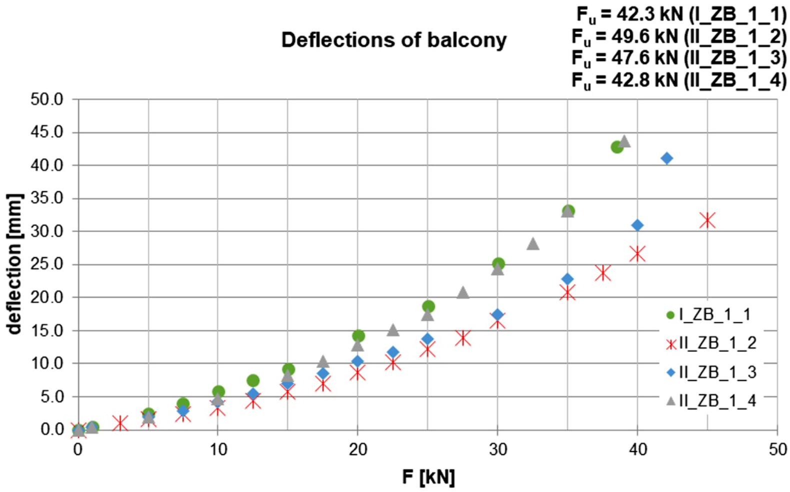

Fig. 15. Comparison of deflections of balcony sets during Stages I and II of tests

References

[1] Ł. Drobiec, "Uszkodzenia i sposoby napraw balkonów oraz stropów z belkami stalowymi i murowanym wypełnieniem", in *Awarie budowlane: Zapobieganie, diagnostyka, naprawy, rekonstrukcje*. Zachodniopomorski Uniwersytet Technologiczny w Szczecinie, 2017, pp. 273–282.

[2] R. Bucoń and A. Czarnigowska, "Decision support method for optimal modernization of residential buildings", *Archives of Civil Engineering*, vol. 70, no. 1, pp. 219–237, 2024, doi: 10.24425/ace.2024.148908.

[3] M.T. Solarczyk, P. Piotrkowski, and M. Niedostatkiewicz, "Experimental tests of steel balcony connecions – part 2", *Archives of Civil Engineering*, 2025 (in print).

[4] C. Murad, H. Doshi, and R. Ramakrishnan, "Impact of Insulated Concrete Curb on Concrete Balcony Slab", *Procedia Engineering*, vol. 118, pp. 1030–1037, 2015, doi: 10.1016/j.proeng.2015.08.545.

[5] H. Ge, V.R. McClung, and S. Zhang, "Impact of balcony thermal bridges on the overall thermal performance of multi-unit residential buildings: A case study", *Energy and Buildings*, vol. 60, pp. 163–173, 2013, doi: 10.1016/j.enbuild.2013.01.004.

[6] K. Goulouti, J. Castro, A.P. Vassilopoulos, and T. Keller, "Thermal performance evaluation of fiber-reinforced polymer thermal breaks for balcony connections", *Energy and Buildings*, vol. 70, pp. 365–371, 2014, doi: 10.1016/j.enbuild.2013.11.070.

[7] I. Susorova, B. Stephens, and B. Skelton, "The Effect of Balcony Thermal Breaks on Building Thermal and Energy Performance: Field Experiments and Energy Simulations in Chicago, IL", *Buildings*, vol. 9, no. 9, pp. 1–24, 2019, doi: 10.3390/buildings9090190.

[8] K. Dikarev, A. Berezyuk, O. Kuzmenko, and A. Skokova, "Experimental and numerical thermal analysis of joint connection "floor slab – balcony slabe" with integrated thermal break", *Energy Procedia*, vol. 85, pp. 184–192, 2016, doi: 10.1016/j.egypro.2015.12.325.

[9] M. Schneider and H-M. Fischer, "Vibration reduction of thermal break balcony connections", *Journal of the Acoustical Society of America*, vol. 123, 2008, doi: 10.1121/1.2935551.

[10] T. Heidolf, E. Nusiner, S. Terletti, and D. Carminati, "Application and Advantages of a Balcony Thermal Insulation Element", in *Proceedings of Italian Concrete Days 2016*. Springer, 2016, doi: 10.1007/978-3-319-78936-1_6.

[11] T. Heidolf and R. Eligehausen, "Bemessungskonzept für wärmedämmende Plattenanschlüsse mit Druckschublagern", *Beton- und Stahlbetonbau*, vol. 108, no. 3, pp. 179–187, 2013, doi: 10.1002/best.201200073.

[12] G. Le Bloa, H. Somja, and F. Palas, "Experimental Study on the M-V Interaction of a Hybrid Steel Connection Used in Concrete Floor-to-Balcony Junction", in *High Tech Concrete: Where Technology and Engineering Meet Proceedings of the 2017 fib Symposium*. Springer, 2018, pp. 2407–2414, doi: 10.1007/978-3-319-59471-2_274.

[13] P. Keo, B. Le Gac, H. Somja, and F. Palas, "Experimental study of the behavior of a steel-concrete hybrid thermal break system under vertical actions", in *High Tech Concrete: Where Technology and Engineering Meet Proceedings of the 2017 fib Symposium*. Springer, 2018, pp. 2573–2580, doi: 10.1007/978-3-319-59471-2_293.

[14] B. Le Gac, P. Keo, H. Somja, and F. Palas, "Resistance of a steel-concrete hybrid thermal break system to low cycle fatigue under thermal actions", presented at *12th International Conference on Advances in Steel-Concrete Composite Structures (ASCCS 2018),* València, Spain, 2018, doi: 10.4995/ASCCS2018.2018.6990.

[15] P. Heng, H.H. Le, H. Somja, F. Palas, and C. Lepourry, "Behaviour of embedded H-profile balcony-to-slab connection", *Journal of Constructional Steel Research*, vol. 213, 2024, doi: 10.1016/j.jcsr.2023.108337.

[16] M.T. Solarczyk, P. Piotrkowski, and M. Niedostatkiewicz, "Przegląd rozwiązań systemowych łączników balkonowych", *Przegląd Budowlany*, no. 9, pp. 15–23, 2021.

[17] M.T. Solarczyk, P. Piotrkowski, and M. Niedostatkiewicz, "Wstępne badania eksperymentalna stalowych łączników balkonowych w aspekcie nośności złącza balkon – strop", in *Wybrane problemy naukowe budownictwa 65. Konferencja Naukowa Komitetu Inżynierii Lądowej i Wodnej PAN oraz Komitetu Nauki PZITB*, W. Drozd, P. Kozioł, K. Zima, Eds. Warszawa: Wydawnictwo Naukowe PWN, 2020, pp. 10–29.

[18] M.T. Solarczyk, P. Piotrkowski, and M. Niedostatkiewicz, "Experimental tests of steel double-type balcony connections", *Technical Transactions*, vol. 121, no. 1, 2024 doi: 10.37705/TechTrans/e2024001.

[19] EN 1991–1-1:2002 Eurocode 1: Actions on structures – Part 1–1: General actions – Densities, self-weight, imposed loads for buildings.

[20] EN 1992-1-1:2004 Eurocode 2: Design of concrete structures – Part 1–1: General rules and rules for buildings.

[21] PN-B 03264:2002 Konstrukcje betonowe, żelbetowe i sprężone – Obliczenia statyczne i projektowanie.

[22] Rozporządzenie Ministra Infrastruktury z dnia 12 kwietnia 2002 r. (wraz ze zmianami) w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie, (Dz.U. 2002 nr 75 poz. 690).

Badania eksperymentalne stalowych łączników balkonowych – część 1

Słowa kluczowe: badania eksperymentalne, balkony, łączniki balkonowe, konstrukcje żelbetowe

Streszczenie:

W artykule przedstawiono analizę teoretyczną oraz wyniki badań eksperymentalnych dotyczących prefabrykowanych zestawów balkonowych w skali naturalnej: trzech o wymiarach (szerokość × długość × wysokość): 2.0 × 2.78 × 0.186 m (w spadku do 0.17 m) oraz jednego o wymiarach: 2.0 × 2.78 × 0.2 m, składających się z żelbetowych płyt połączonych ze sobą za pomocą stalowych łączników balkonowych. W publikacji przeanalizowano wpływ parametrów zmiennych (zwiększona długość kotwienia łączników, betonowanie elementów badawczych w dwóch etapach, zastosowanie muf na prętach zbrojenia podłużnego oraz zwiększona grubość płyty balkonowej) na nośność elementów. W artykule opisano stanowisko badawcze. W trakcie badań określono morfologię zarysowania, mierzono przemieszczenia oraz szerokość rys. Artykuł zawiera przegląd literatury naukowej z zakresu łączników balkonowych.

Received: 2024-02-12, Revised: 2024-06-11