DE GRUYTER OPEN
CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

ISSN 2080-5187 CEER 2015; 17 (2): 83-95
DOI: 10.1515/ceer-2015-0024

RENOVATION OF LARGE-PANEL BUILDINGS IN CONTEXT OF URBAN RENEWAL

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Abstract

The article presents issues connected with renovating multi-storey precast concrete buildings, resulting from the consequences of construction defects occurring over the course of the building process and use of the buildings, as well as design flaws and construction defects when insulating external partitions. Analyses and conclusions which stem from them cover issues of renovation in the light of: damage in the vertical and horizontal joints, damage to the connection of layers in three-layer load-bearing and curtain walls, the effect of the damage on the possibilities of carrying out functional modernization of residential units, the effect of the damage on the effectiveness of thermo-modernization - new problems related to faulty insulation.

Keywords: precast concrete large-panel construction, revitalization

1. INTRODUCTION

Existing parts of cities or residential building complexes constructed in the precast concrete large panel system or so-called "housing projects", as a result of technical (and sometimes hidden construction flaws) and moral wear are partially losing their initial position in the functional, spatial and social structure of the modern-day city. Questions regarding the safety and comfort of using such building complexes in the future began to already arise in the early 90's of the XX century in public (social, political) discourse. Block housing

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projects are more and more often associated with degraded areas in need of revitalization. Current social expectations and the required safety of use have led to the initiation of the revitalization of existing precast concrete large-panel buildings in terms of: durability and thermo-modernization as well as construction possibilities of improving architectural-functional solutions.

2. THE SCOPE OF ANALYSIS OF AND RESULTS

The revitalization of precast concrete large-panel buildings usually comes down to: civil and structural construction renovation work, complex thermo-modernization, modernization of installation systems and ventilation, and functional and architectural modernization. This article has been limited to presenting renovation problems resulting from the consequences of: construction defects occurring over the course of the building process and use of the buildings, design flaws and construction defects when insulating the buildings, and the necessity of possible functional modernization. The analyses and conclusions drawn from them cover issues connected with renovation in light of: potential damage to construction joints (vertical and horizontal joints) and connections of three-layer walls, as well as the effectiveness of thermo-modernization in cases of improperly executed heating insulation work. These issues were analyzed in the context of precast concrete large-panel buildings constructed in the W-70 and Wk-70 systems (Fig. 1), made up of prefabricated load-bearing homogenous concrete walls (W), three-layer load-bearing walls (ZWS) and curtain walls (ZWO), and floor slabs (S). The means and quality of carrying out vertical and horizontal joint connections (Fig. 2, Fig. 3) as well as the means and quality of connecting the individual layers of wall elements (Fig. 4) were also accounted for.

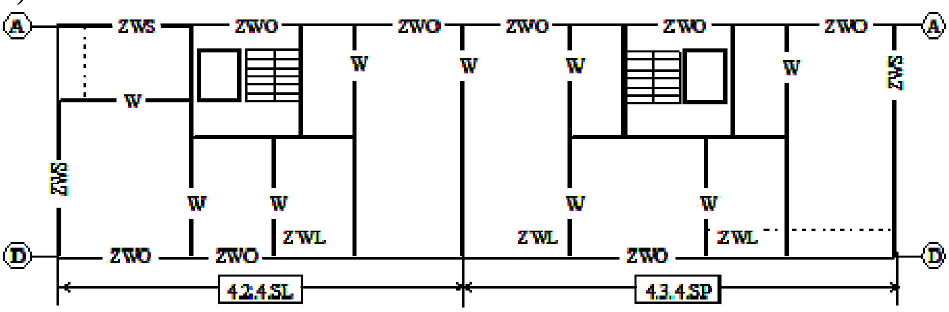
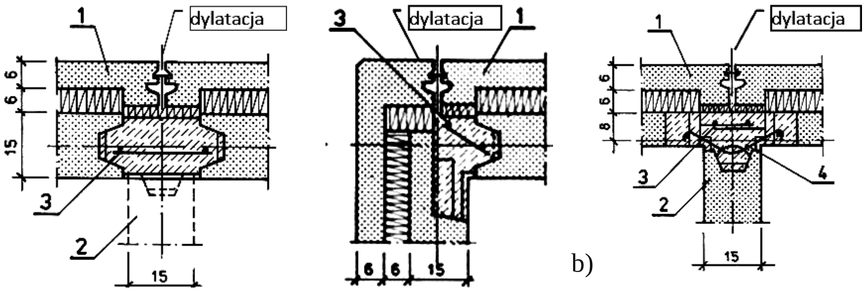
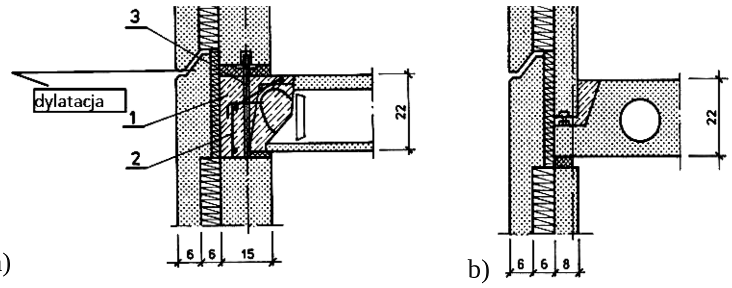


Fig. 1. Example of construction plan of an 11-storey precast concrete large-panel building



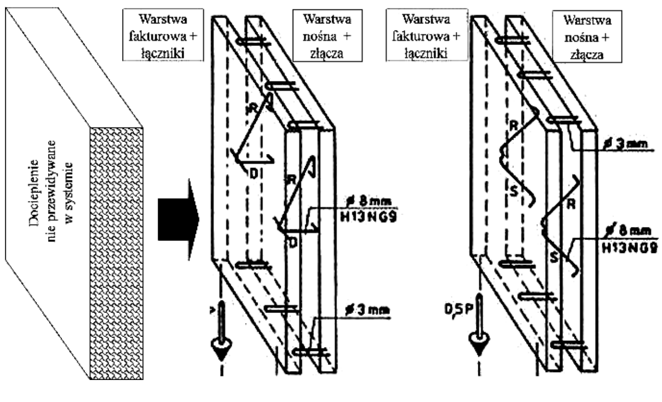
a) b)

Fig. 2. Connection of load-bearing layers in vertical joints and dilatation for texture layer: a) ZWS+ZWS joints in load-bearing walls b) ZWO+W+ZWO joint of load-bearing wall W with curtain walls ZWO; 1 - texture layer, 2 - load-bearing wall W, 3 - vertical reinforcement mesh, 4 - cramps



a) b)

Fig. 3. Horizontal joint and dilatation for texture layer: a) for ZWS load-bearing wall type and floor, b) for facade ZWO type walls and floor; 1 - concrete, 2 - horizontal reinforcement mesh, 3 - rectification screw



a)

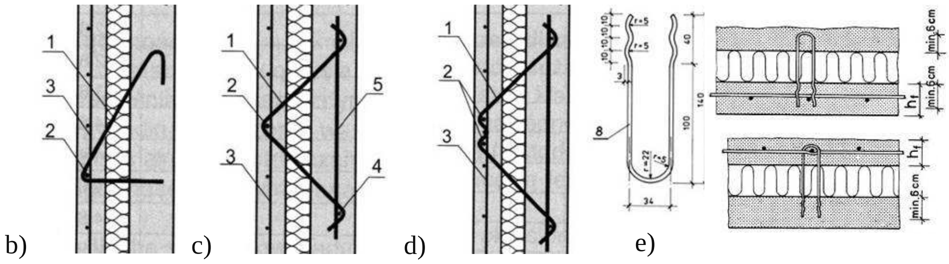


Fig. 4. Connection between load-bearing and texture layer in ZWS and ZWO type walls: a) model for joining with flexible connectors (hangers + pins), b) hanger with tensiled inclined arm, c) “one-humped” hanger, d) “two-humped” hanger, e) pins; 1 - hanger, 2 - element anchoring the hanger in the texture layer, 3 - reinforcing mesh for texture layer, 4), 5) - bar anchoring the hanger in the load-bearing layer

In Polish housing resources of precast concrete large-panel construction, there are buildings without damage as well as those which exhibit damage to the connections requiring repairs or reinforcement. An analysis of the results of the author's own studies "in situ" on pre-cast concrete large-panel buildings in-service for a over a dozen years revealed that their technical state depends, above all, on the quality of their execution. As of today, it can be said that, following many years of service, all construction defects which can potentially pose an accident risk have become apparent and such states removed [20, 25].

Thus, we are currently dealing only with buildings which may display damage that does not pose a risk to the safety of the load-bearing structure of the building, but only to the safety of their exploitation. Such damage is the result of the improper production of elements as well as construction defects and the faulty use of the buildings [2, 11, 12, 13, 14, 18, 19, 21, 23, 24]. The consequence of construction and/or in-service defects are three characteristic types of damage: a) damage/cracking in vertical joints - construction errors during the assembly process (Fig. 5), b) damage in horizontal joints in the area of window lintels with the wall being simultaneously pushed out of the building as a result of injecting the expansion gap between the ceiling and upper edge of the curtain wall - an in-service defect (Fig. 6), c) construction defects in the prefabrication plant in connecting the vapor-control layer with the load-bearing layer of wall components (Fig. 7, Fig. 8) and damage to the vapor-control layer (Fig. 9). Construction and in-service defects and their consequences in the joints of buildings are easy to identify [14]. On the other hand, the identification of technological defects which arise in the prefabrication plant when preparing three-layer wall elements is very difficult [12].

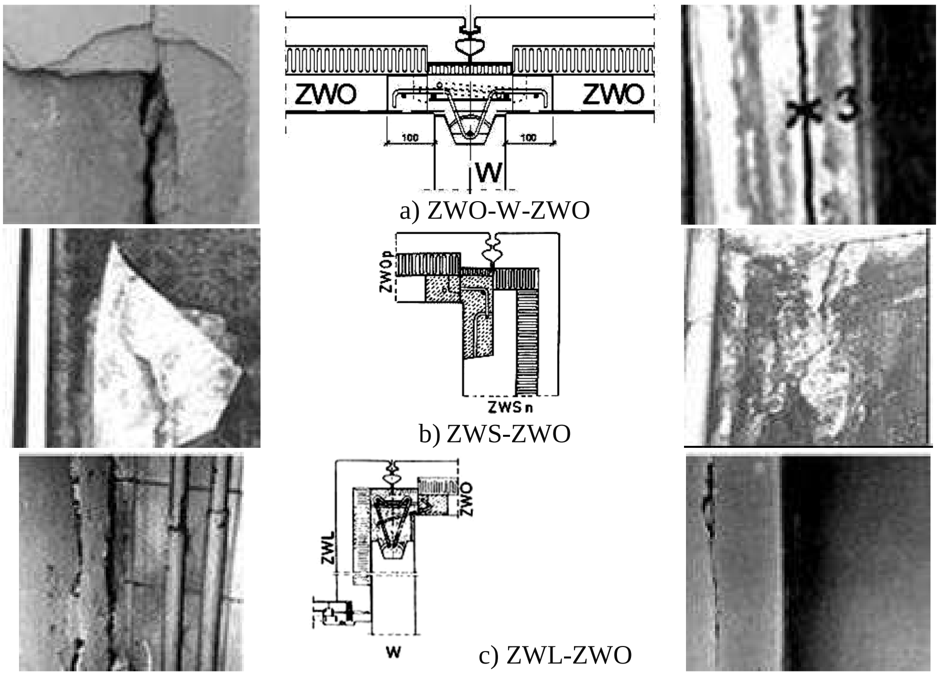


Fig. 5. Examples of cracking due to construction defects in the vertical joint

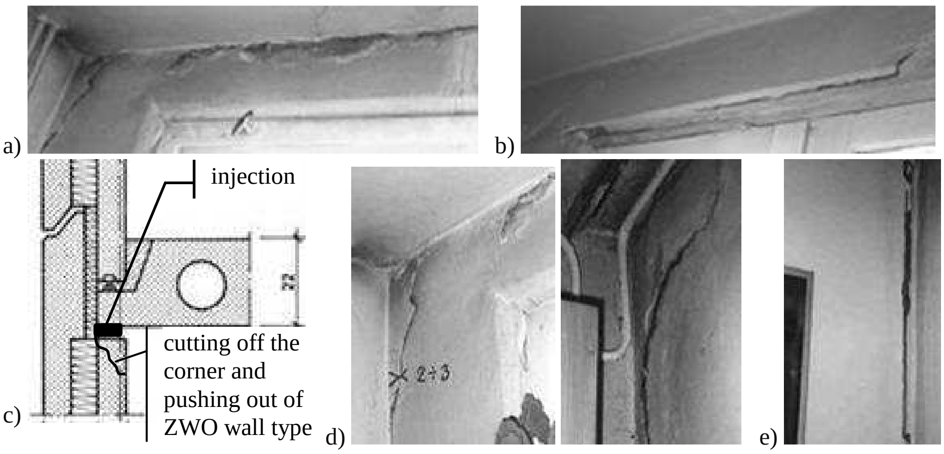


Fig. 6. Examples of damage in horizontal ZWO-S-ZWO wall type joints due to an in-service defect (injection of the gap beneath the floor): a), b), c) cutting off the upper corner of the load-bearing layer of wall and pushing out of ZWO type wall, d) inclination of wall and associated cracking in joints, e) gap with thickness of 5-8 mm between the ZWO type wall and partition wall

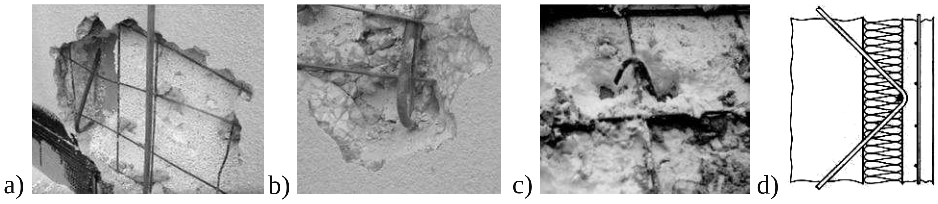


Fig. 7. Examples of faulty assembly of triangular hangers: a) photo by [26], b) photo by [In-westbud], c) photo by [J. Dębowski], d) lack of hanger within the texture layer

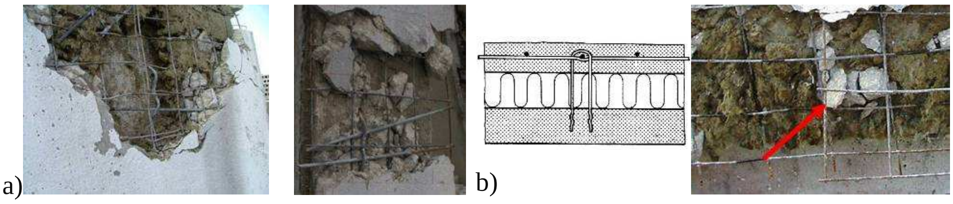


Fig. 8. Examples of faulty assembly of: a) two-humped hangers [photo by Inwestbud], b) pins in concrete slab with texture layer facing down [photo by Inwestbud]


Fig. 9. Examples of characteristic crack patterns in texture layer

Cracks in the vertical joints (Fig. 5), as shown in the work [16], do very little to reduce the planned carrying capacity of the load-bearing structure, as curtain walls were not accounted for in structural design calculations. Therefore, if cracks in the joints are of a stable nature and the load bearing contstruction of the building is intact, adapting the building to construction safety requirements comes down to standard renovation, returing the rooms to their full service potential. This most often involves filling the cracks with mortar or resin and covering them with plaster on a synthetic fiber mesh [8].

When cracks in vertical joints are structural or reveal a tendency to progress (active cracks), or when inclination of the curtain wall has taken place as a result of injecting the expansion gap underneath the ceiling (Fig. 6), it is necessary to remove the source of the cracking and then apply reinforcement in order for the building to meet safety requirments [10, 18]. Reinforcements should be made from the outside (from scafolding) and should not infringe on the structure of existing construction elements of the joint and the adjoining parts of prefabricated walls of the building (Fig. 10).

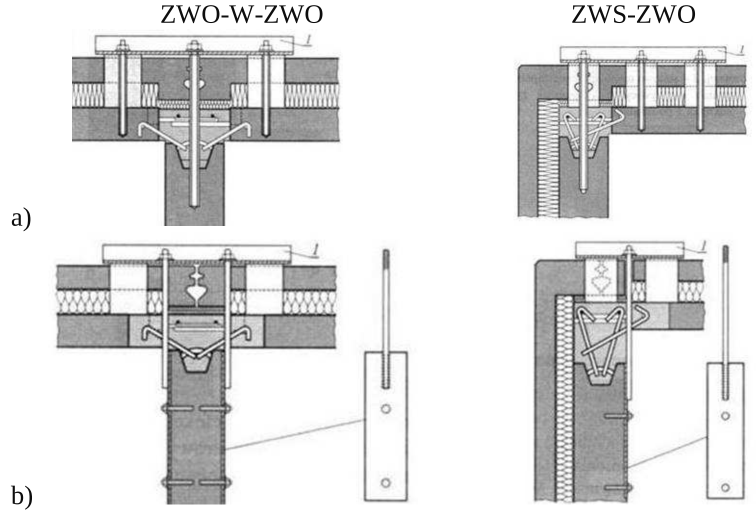


Fig. 10. Examples of mechanical strengthening of vertical joints from the outside of a building: a) with application of screws (for adequate concrete strength), b) with application of anchors (for inadequate concrete strength) [18]

An alternative solution minimizing the destruction of the vapor-control layer has been presented in Figure 11a. In the case of local damage, the joints can be reinforced from the outside of the building using angle plates attached with expansion bolts (Fig. 11b).

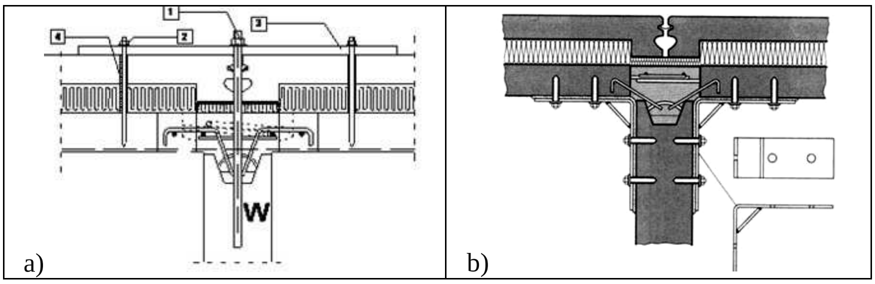


Fig. 11. Strengthening of vertical ZWO-W-ZWO type joints: a) alternative solution realized from the outside [15]; 1 - screw fastened to the W type wall, 2 - screws fastening the resistant element to the load-bearing layer of ZWO type wall, 3 - resistant element - steel flat bar (instead of C-shaped cross-section), 4 - distance-marking case (instead of concrete cork), b) strengthening realized from the inside of the building using angle plates [18]

Current knowledge indicates that the load-bearing construction of precast concrete large-panel buildings carried out in accordance with the technology called for by the project design is safe (meets the requirements set by the current norms) and ensures their long-term use [3, 6, 9, 16, 17, 27, 28, 29]. It can be assumed a priori that, following the many years that the existing buildings have been in service, all the construction defects which pose a risk of collapse have become apparent and such a state has already been removed [20, 22, 25]. Studies, however, continue to indicate that some of the housing resources of precast concrete large-panel construction include buildings which exhibit damage requiring repair or reinforcement. The number of building with construction defects is unknown and can vary largely within a given neighborhood, city, province and Poland, as the degree and range of damage depends on the contractor and cannot be generalized to encompass all precast concrete large-panel construction [10, 19]. In this context, it is important to ask how large the scale of such damage in the existing housing resources is. The answer to this question can be provided by the competent analyses of the technical state of precast concrete large-panel buildings in Poland, e.g. during mandatory technical inspections. A pool of such information will make it possible to assess the scale of the problem and next undertake professional activities in terms of assessing the level of risk and necessary repair work and reinforcements.

In the modernization process of precast concrete large-panel buildings, the need to connect individual residential units is known to arise (currently still not applied very often in practice), requiring new door openings to be made within inside load-bearing walls. Theoretical bases and technical recommendations as to the possibility of creating new openings are provided in the ITB guidebook [1], which proposes accounting only for the support of inside load-bearing walls. In work [4], however, it was revealed that the load-bearing layer of the ZWO curtain wall, in accordance with PN-EN 1992-1-1:2008, can also be treated as a support wall which increases the load-bearing capacity of the inside wall and makes it possible to create new openings of greater width within it as well as leave a narrower external strip at the edge.

Defects in connecting (hooks, pins) the vapor-control layer with the load-bearing layer of prefabricated ZWS and ZWO wall panels (Fig. 7, Fig. 8) and cracks in the vapor-control layer (Fig. 9) are not connected with damage (cracking) in the joints and do not pose a safety threat to the load-bearing construction of the building. However, they do pose a potential safety threat to its use as a result of the possibility of destruction occurring in the vapor-control layer and, in extreme cases, its separation (Fig. 12). The safety threat to the vapor-control layer (with technological defects) increases with added load of an additional heat-insulation layer.

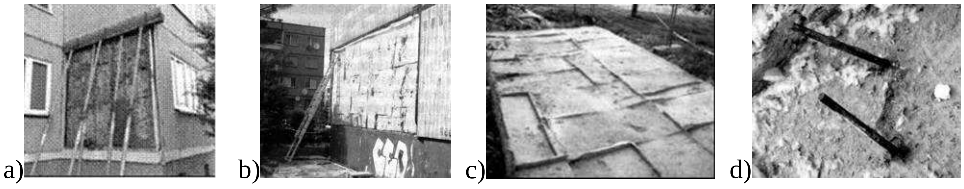


Fig. 12. Effects of the "hidden" construction defects in the joining of the layers: a), b) view of ZWS type walls after separation of texture layer [21, 26], c) view of inside surface of separated texture layer following the removal of mineral wool insulation [21], d) broken bars of hanger anchored within the texture layer [21]

The main problem as of currently is finding answers to the questions of: What is the actual safety risk to the vapor-control layer and how can it be assessed? Should the level of safety be assessed through invasive (non-invasive) methods of research? What about the safety of the vapor-control layer in insulated buildings? Perhaps it is better to resign from identifying defects in the connection of the vapor-control layer and load-bearing layer and instead choose to make it mandatory to mechanically connect these layers (Fig. 13) (or maybe remove these layers and insulate the load-bearing layer)?

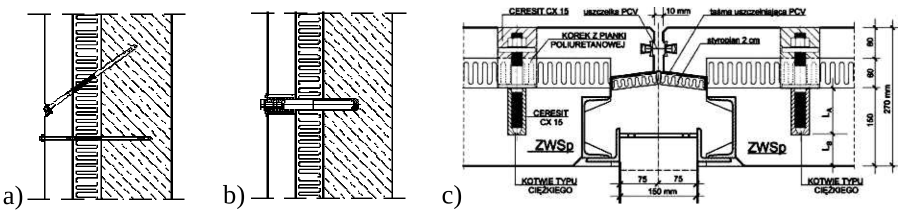


Fig. 13. Examples of additional anchoring of texture layer: a) scheme for band connector, b) scheme for shank connector, c) shank connector [5]

The author's own studies as well as findings reported in literature unfortunately indicate there to be numerous cases of the quick destruction of heating insulation caused by not adhering to the technical and technological conditions of carrying out insulation work. The result of construction defects, described among others in chapter 6 of this the work [15], is damage to the elevation of the building which occurs as soon as after a few years: cracking and destruction of the plaster coating and reinforced adhesive layer (Fig. 14), progression of biological corrosion and sporadically occurring separation of entire heat insulation (Fig. 15).

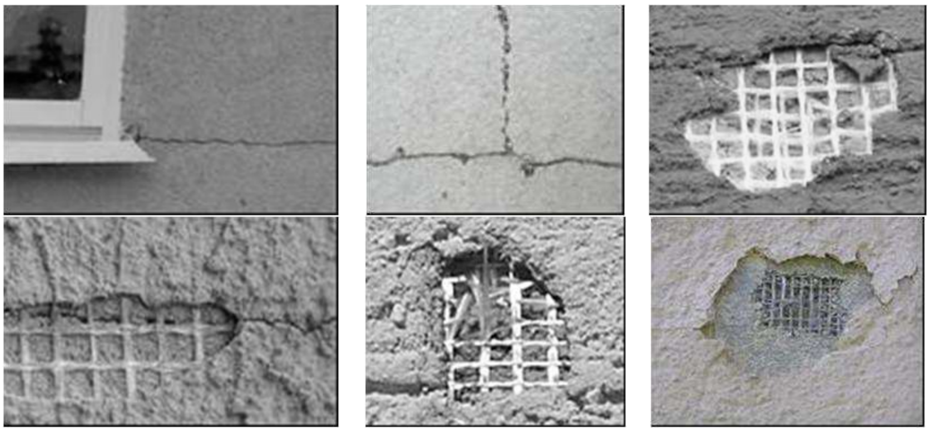
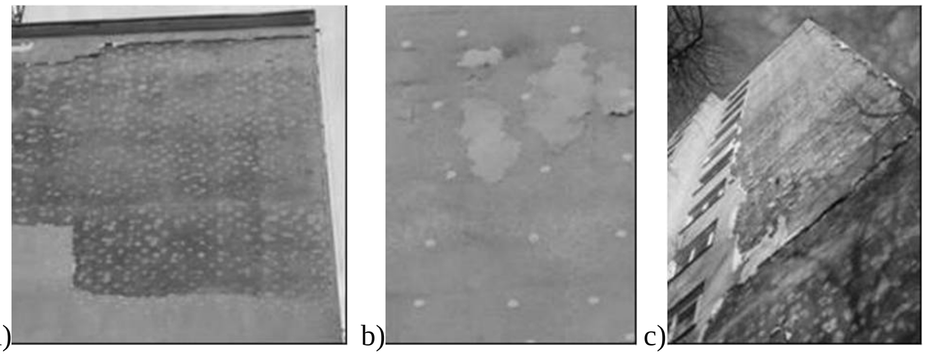


Fig. 14. Cracks and destruction of plaster and glue reinforced layer



a) b) c)

Fig.15. Effects of faulty insulation of two 11-storey buildings - view following the separation of the insulation layer: a) at the level of the top three floors, b) secondary dowelling of the remaining insulation, c) along the entire height of the building

3. CONCLUSIONS

Problems connected with the faulty execution of the thermo-modernization program are not restricted only to a technical scale but also to an economic and social one. The consequences of faulty building insulation contradict the results that are expected of thermo-modernization when it comes to heating energy savings and the social perception that block complexes will become a friendlier and accepted housing environment. It is estimated that as a result of heating energy savings, the cost of heating a building should be compensated for after 8-10 years of service. However, in cases where heating insulation work is faulty, the expected effect of obtaining savings will be negated, as the reconstruction of insulation layers and renovation of the entire surface of the elevation will be necessary after merely a few years of service. An inappropriately prepared thermo-modernization program and its realization result in set material losses which are, unfortunately, suffered by the inhabitants of the insulated building.

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REMONTY BUDYNKÓW WIELKOPŁYTOWYCH, JAKO ELEMENT REWITALIZACJI MIAST

S t r e s z c z e n i e

W artykule przedstawiono zagadnienia remontowe w budynkach wielkopłytowych wynikające ze skutków wad budowlanych powstałych w czasie budowy i eksploatacji oraz wad projektowych i wykonawczych przy realizacji docieplenia przegród zewnętrznych. Analizy i wynikające z nich wnioski obejmują zagadnienia remontowe w świetle: uszkodzeń w złączach pionowych i poziomych, uszkodzeń połączenia warstw w ścianach trójwarstwowych nośnych i osłonowych, wpływu uszkodzeń na możliwości modernizacji funkcjonalnej lokali mieszkalnych, wpływu uszkodzeń na skuteczność termomodernizacji - nowe problemy w aspekcie źle wykonanego ocieplenia.

Słowa kluczowe: budownictwo wielkopłytowe, remonty, rewitalizacja

Editor received the manuscript: 09.01.2015