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Adam RYBKA
Rzeszow University of Technology

REFURBISHMENT OF PREFABRICATED MULTIFAMILY DWELLING BUILDINGS IN POLAND

This paper discusses the main typologies of the multi-story residential building stock in the post WWII period and problems arising from the poor quality of the housing policy, the architectural and structural principles, and the construction work, as well as over 50 years of inappropriate exploitation.
Discussed was large-panel building technology evolution along with specification of the technical solution and description of thermal refurbishment methods.

1. Overview of building stock after Word War II in Poland

For Poland, it can be observed that the background to post – WW II housing construction was formed by the following:

1. Extensive destruction of building stock during WW II, including the destruction of ca 50% of dwellings, especially in towns.
2. Migration of people after the signing of the Yalta Pact, which resulted in the repatriation of people from the eastern parts of former Poland.
3. Industrialisation of the Polish economy after WW II, which resulted in the migration of about 30% of the population of rural areas to towns.
4. Significant population growth, which in the period 1945-1988 reached almost 14 million people.
5. The national urban planning and housing policy, which led to total standardization of perceived needs and the technical provisions in dwelling houses.
6. The social housing plan was almost entirely controlled by the state system, beginning with financing, production and ending with distribution.
7. State-owned firms for non-profit housing associations built most of the housing in Poland in the years 1945-1995. These associations constitute an instrument for realizing public housing and building policy. The associations have played an important role in the long-term development of industrialized housing in Poland.

8. During this construction there was not enough attention paid to the standard requirements of heating transfer.The mentioned above factors resulted in the acceptance of buildings that were of very low quality especially concerning physical aspects of the buildings. This was attributable to the demand for rapid, low-cost construction and to the poor quality of the workmanship, construction methods, equipment and materials (e.g. window frames, doors, piping, wiring lack of the thermal isolation and more).

The need for new dwellings has not been satisfied until now. Increases in the diversity and total number of dwellings have not kept pace with population growth, so there is still a shortage of dwellings. This situation will be probably changed in the future.

2. Dwelling standardization

From the mid-sixties onwards the construction of non-traditional dwelling housing started to develop rapidly with the general application of the national building policy and was based on the use of large-panel technology. In years 1967-1988 every year almost 200 000 dwellings were done. In the end of the seventies 2.04 million large-panel dwellings had been completed. In 1995, when the construction of dwellings in large-panel technology was almost finished, the total number of dwellings built in this technology was 3.5 million and the total number of dwellings reached 11.5 million in Poland. In 1995 the area of flats reached 430 million m^2 constructed by using large-panel technology and about 270-million m^2 m by using other methods.

The need for new dwellings resulted in formulation of an obligatory dwelling standard with 11 m^2 of usable floor space per inhabitant (including bath-room, lavatory and kitchen). In following years this standard was revised, even defining particular parts of the dwelling so strictly that it was possible to design only limited variants of dwelling systems. It was stated that every room should be assigned to provide sleeping accommodation for 1 or 2 residents. The personal and communal spaces within the dwelling were not separated. This standard with some changes was in force till 1987 [4].

From 1959, the compulsory standard prescribed rigorous limits for usable floor space within the dwelling and for its components. It was depending on the type: M-1, 20 m^2; M-2, 30 m^2; M-3, 38 m^2; M-4, 48 m^2; M-5, 57 m^2; M-6, 65 m^2; M-7, 71 m^2.

These requirements did not fit the modular system necessary for the use of industrialised technology based on precast elements, especially in the case of the large-panel buildings technology, which started in about 1967. For this reason, a new standard was introduced in 1972, extending the usable floor space per dwelling and improving the potential for design. Depending on the type of dwelling 3.0-4.0 m^2 usable floor space was added.

New standard, taking into account the structural and modular restriction of technology, were introduced in 1974. Enlarging the total usable floor space per every type of dwelling was made: M-1, 25-28 m^2; M-2, 30-35 + 1 m^2; M-3, 44-48 + 4 m^2; M-4, 56-61 + 2 m^2; M-5, 65-70 + 3 m^2; M-6, M-7, 75-85 m^2

The significant advantage gained from the application of this new standard was the increase of the floor area of kitchens and other rooms. The standards were adapted to the demands of technology but not to users needs. Standards analysis shows us what kind of living standard we can expect in such a kind of dwelling.

3. Technologies used in construction of dwelling buildings

3.1. Post-war period: 1947-1956

Up to mid 50s, housing was based on the use of traditional brick-walls, with concrete slabs on steel girders and ceramic or concrete filling. During this period there was little significant technical development. Gradually, improved transport equipment led to greater use of precast wall elements and also the first of the typical designs were elaborated. It made the building processes more efficient; this also led to more uniform architecture. As a result of the thoughtless execution of what would have been reasonable designs for cost-efficient building bearing in mind the limited technical possibilities and required standardisation, it was necessary to place, more limitations on the designs. In that period there In that period there were no outlines of any norms referring to the thermal preservation of the buildings.

3.2. First stage of prefabrication: 1956-1967

It can be observed that in this period many new industrial centres arose, and older centres were also growing rapidly in Poland. As previously indicated, the dwellings were strictly limited to a standard floor area (valid to 1987). The construction of typical residential blocks was based on a crosswise configuration of the structure with the wide use of large-block precast elements for walls as well as the use of slabs and the introduction of new materials: lightweight and cellular concrete. But traditional technology is still used, especially in smaller towns. This construction method demanded modular dimensioning of the entire building and of its parts. Typical residential buildings consisted of 3 to 6 stairways and 4 or 5 storeys, or higher up to 11 storeys with elevators. The number of dwellings and the floor areas varied, depending on the size of the families, which were to occupy them.

In that time, standard requirements of heat transfer coefficient (HTC) for buildings in Poland were based on 1964 norm (PN-64/B-03404), which was valid to 1984. Required HTC in W/m^2K for walls were 1,16 and for roofs 0,87.

3.3. Starting from 1967, large-panel buildings period

The first multi-family residential buildings have been constructed in large-panel technology from 1967 onwards.wo main, large-panel systems were elaborated: OWT-67 and WUF-T.

They were used all over Poland. After that a competition led to the selection of two methods (Szczecin and W-70) and number of local systems came into use [3].

Large-panel systems can be divided into two groups:

- Closed systems: OWT-67, WUF-T and Szczecin system; older systems in which most of walls are structural bearing walls, leading to the need for fixed floor-modules. With this system uniform dwelling units are arranged according a to uniform structural mesh. The largest floor-module was 540 x 480 cm, so all the dwellings in vertical rows were identical, and small.
- Open systems: W-70 and OWT-75; designed according to the dwelling standard of 1974, have a more flexible structural mesh and limited number of structural walls, which provides for greater flexibility in the layout of the dwellings units. Pressure on production capacity and the limitations of the standard requirements strictly limited flexibility in the size and layout of dwelling units and of the architectural design of the entire building.

In that time, standard requirements of heat transfer coefficient for residential buildings in Poland were change in 1984 (PN-82/B-02020) these requirements were valid to 1992. Required HTC in W/m^2K for walls were 0, 75 and for roofs 0,45. In 1992 requirements of heat transfer coefficient for residential buildings in Poland were changed another time (PN-91/B-02020) these requirements are Valid from 1992 till now. Required HTC in W/m^2K for walls is 0, 55 and for roofs 0, 30. From this time has started a huge movement of the thermal renovation of the existing residential buildings in Poland. This movement is still running.

4. Multifamily Dwelling Buildings Technology Evolution

4.1. Description of main non-traditional technologies

4.1.1. Large-block technology

One of the most popular large-block building systems was “Żerań brick”. That system was flexible because of the relative freedom of the spatial shaping and dwelling arrangement in design of the building. It was popular in small towns, for single buildings and also for social utility buildings such as schools and health hospitals. Typically it incorporates storey height external and internal wall blocks and hollow-core slabs units, with spans ranging from 240 to 600 cm, with step of 60 cm. In this system, the precast elements were hollow-core 24 cm thick panels made of plain concrete B20 class. External wall panels had 12 cm thick thermal insulation layer made of cellular concrete. The main width of wall and slab elements was 120 cm. Typically transverse structure building was constructed up to 11 storeys high in this system [2].

4.1.2. Large-panel technology

There was a number of popular large-panel systems. In that case, wall elements were storey-high, and their maximum length extends to 6.0 m, which was the maximum for a single room. Ceiling slabs had a corresponding span – up to 6.0 m. External walls were precast as three layer sandwich panels, with an internal structural concrete layer, central thermal insulating layer and external surface quality layer. Wall openings were fitted with assembled windows and doors.

Foundations

In all systems there were usable single storey basements, which were used for resident's storerooms and technical-rooms. Depending on local soil structure and conditions, shallow foundations were usually used, with concrete or reinforced strips under the basement walls, while for soils of poorer bearing quality reinforced concrete slabs were used. Exceptionally, deep foundations were made. Sometimes system-built precast basement walls (thickness of concrete walls 14-20 cm, cellular concrete walls 26-30 cm), were used.

Overground structure

Three types of structural form can be distinguished: transverse, longitudinal and mixed-depending on the construction system chosen for the building. All elements were prefabricated for standard dimensions.

Bearing internal walls were made of precast concrete with reinforcements; of uniform thickness ranging from 12 to 24 cm. Wall elements with openings had an appropriate reinforcement system. Bearing external walls were made of lightweight concrete with thickness up to 40 cm (Szczecin system). Typically, three-layer walls with an internal bearing layer made of reinforced concrete 12 to 15 cm thick, thermal insulating (foamed polystyrene or mineral wool 5 to 6 cm (in later years upgraded to 8 cm) and a surface reinforced concrete layer 6 or 7 cm thick with finishing structure. Curtain walls (self-bearing) have the same structure with the thickness of the bearing layer reduced to 8-12 cm. Ceiling slabs were made of reinforced concrete as hollow-core 24 cm thick or solid 16 cm. Elements of stairs and landings were made as precast reinforced concrete elements. There also were the three dimensional elements of elevator shafts. Flat roofs, with slopes inclined to the interior, were separated from the top storey ceiling by a space and constructed from concrete panels supported on brick walls.

External Walls

The most popular dwelling house technology in Poland in period 1967-1989 is based on large panel precast elements. Typical external bearing walls, for most of building systems, were three-layer panels with internal bearing layer made of plain or reinforced concrete 12 to 15 cm thick, thermal insulating (foamed polystyrene or mineral wool 5 to 6 cm, in later years upgraded to 8 cm) and surface (facade) reinforced concrete layer 6 or 7 cm thick with finishing. Curtain walls (self-bearing) have the same structure with thickness of bearing layer reduced to 8-12 cm. Facade layer is fixed to structural one by bearing steel hangers and stirrup pins. This connection is flexible to compass thermal strain differences in both concrete layers. In wall openings doors and windows were installed. Most typical of large-panel systems was the rough cast finishing of the external concrete layer of the elements, with sealed fronts for the element joints. In some systems, where external longitudinal strip walls were used, spaces between openings (windows or balcony doors) were filled with sandwich panels. These panels with timber frames were made of asbestos-cardboard sandwiching a thermal insulating layer and chipboard. Sometimes precast concrete panels were used [6].

4.2. Specification of the technical solution, principal thermo modernization technologies used to change existing multifamily large-panel dwelling buildings

4.2.1. Dry System of External Thermal Insulation (DSETI)

Dry System of External Thermal Insulation (DSETI) for refurbishing the three-layers external wall panels in large panel buildings became most popular in second part of 80th decade. It is a “simplified version” of ventilated facade systems popular in Western Europe. Its advantage lay in simple and fast installing works based on easy to reach materials. The additional facade consists of heat-insulating layer made of mineral wool sheets 40, 60 or 80 mm thick, and a covering layer of folded steel sheets T35 or T55 made of 0,75 mm steel protected with zinc coating and painted. Horizontal bearing strips spaced resulting from insulation sheets (1000, 2000 or 3000 mm) made of steel “Z” or “C” shape zinc covered profiles are mechanically fixed to concrete facade layer with expansion bolts spacing ca 1000 mm. Then, mineral wool sheets are put on the wall and mechanically fixed with plastic hat-nails. Folded steel covering layer is then fixed to bearing strip with self-drilling screws or blind rivets. Sheets have appropriate horizontal and vertical laps. Top, bottom and side edges as well as openings were covered with additional plain steel sheets or strips covering old facades [1].

4.2.2. Light Wet System of External Thermal Insulation (LWSETI)

Another way of refurbishing the three-layers external wall panels in large panel buildings was to use Light Wet System of External Thermal Insulation (LWSETI).

Additional facade consist of heat-insulating layer made of foamed polystyrene sheets or mineral wool sheets 40, 60 or 80 mm thick, and a covering layer of light, thin cement glue layer about 5,0 mm thick with plastic netting reinforcement layered with paint Starting horizontal bearing strips spaced resulting from insulation sheets) were made of steel “Z” or “C” shape zinc covered profiles are mechanically fixed to old concrete façade by screws. Then, foamed polystyrene or mineral wool sheets are put on the wall and mechanically fixed with plastic hat-nails. Sheets have appropriate horizontal and vertical laps. Top and side edges as well as openings were covered with additional layer of light, thin cement glue layer about 5,0 mm fat with plastic netting reinforcement and coloured, covering old facades. Foamed polystyrene sheets were used till 12.0 m facade height and mineral wool sheets were used above to 12.0 m height because of fire regulations [5].

5. Conclusions

In years 1967-1988 every year almost 200 000 dwellings were built in Poland. In the end of the seventies 2.04 million large-panel dwellings had been completed. Many factors have shown that prefabricated multifamily dwelling buildings were very low quality especially according to physical aspects of the buildings.

Due to change of thermal norms such number of residential buildings were in need of thermal refurbishing, especially their external walls. This work is still in progress.

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ODNAWIANIE PREFABRYKOWANYCH WIELORODZINNYCH BUDYNKÓW W POLSCE

Streszczenie

W artykule przedstawiono typologię wielorodzinnych prefabrykowanych budynków wznoszonych w okresie po drugiej wojnie światowej i problemy wynikające ze złej jakości realizacji tych domów. Wskazano na problemy architektoniczne i konstrukcyjne oraz na problemy pracy konstrukcji budynków, jak również ponadpięćdziesięcioletniej, niewłaściwej ich eksploatacji. Omówiono rozwój technologii budynków wielopłytowych wraz ze specyfikacją technicznych rozwiązań i opisem metod ocieplenia tych budynków.

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