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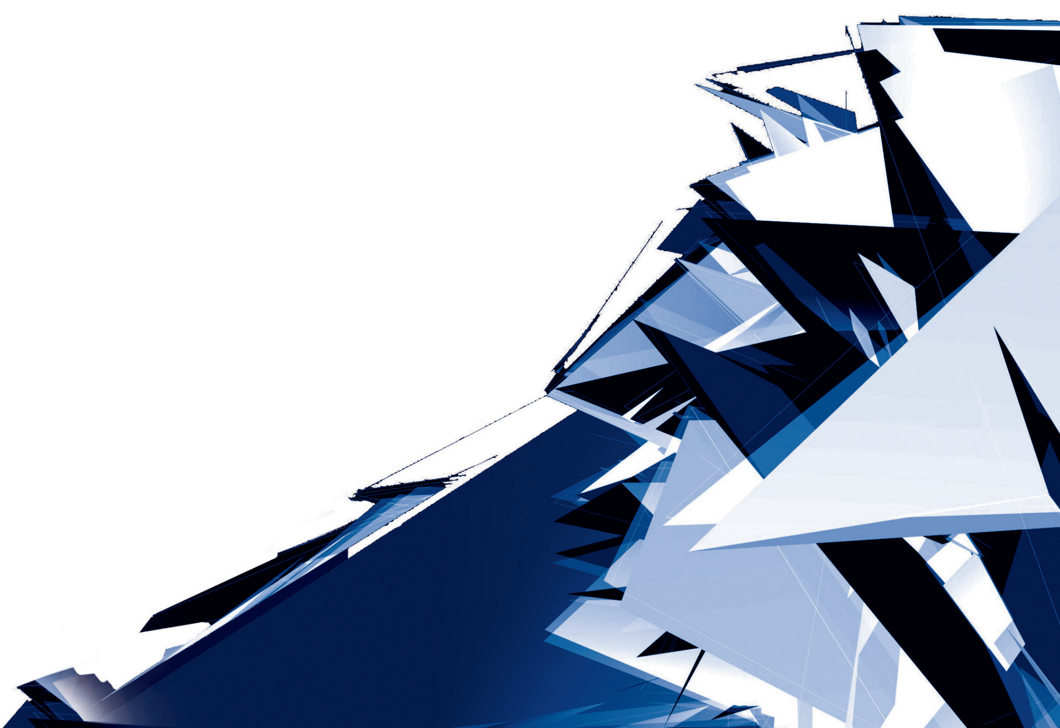

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# Multiple-use performing arts halls

## Sale widowiskowe o wielofunkcyjnym charakterze

**Abstract**

Performing arts halls are increasingly becoming multi-purpose halls. Purpose-built venues that serve purely as concert halls or opera houses are rather rare today. Multi-purpose halls, conversely, can be used for different types of stage presentations inside a single building, under one roof with proportionally lower costs; furthermore, they can also be used for activities which are not related to the performing arts. The paper discusses functional and spatial adaptability and flexibility in multiple-use halls, and presents possible forms and arrangements of the stage and the auditorium as well as their spatial interrelations. Attention is focused upon acoustics and their impact on the functioning of multi-purpose performance spaces. The paper also presents multi-use and multi-format facilities. The author attempts to determine the best possible conditions for various types of theatre arrangement.

**Keywords:** performing arts halls, functional adaptability, multiple-use

**Streszczenie**

Obiekty widowiskowe w coraz większym stopniu stają się ośrodkami wielofunkcyjnymi. Obiekty przeznaczone tylko dla jednego rodzaju prezentacji, takie jak sale koncertowe lub gmachy operowe nie są współcześnie bardzo liczne. Sale wielofunkcyjne z kolei mogą służyć różnym rodzajom prezentacji scenicznych, a także innym widowiskom, wewnątrz jednej przestrzeni, w jednym budynku, przy proporcjonalnie niższych kosztach. Niniejszy artykuł rozważa funkcjonalne i przestrzenne możliwości przekształceń sal wielofunkcyjnych oraz przedstawia możliwe wzajemne konfiguracje sceny i widowni wraz z ich powiązaniem przestrzennym. W opracowaniu autor uwzględnia również problematykę akustyki i jej wpływu na przestrzenie wielofunkcyjne. Bada on poszczególne formy i rodzaje aranżacji sceny i widowni pod względem ich optymalnego funkcjonowania.

**Słowa kluczowe:** obiekty widowiskowe, zmienność funkcjonalna, wielofunkcyjność

## 1. Introduction

Single purpose halls have the advantage of being able to provide optimum acoustics and artistic environments for each form of stage presentation; however, only large and wealthy institutions are able to afford them. Today, buildings for the performing arts with a single, dominant function are being increasingly replaced by structures combining many forms of stage presentation in a single building. Multi-purpose halls are intended to respond to changing situations in their use. In this paper, the author does not discuss all forms and functions of performance spaces; he wishes only to indicate how spaces in such structures can become functionally adaptable. Contemporary buildings for the performing arts are primarily distinguished by the functional adaptability of the auditorium, the stage and support facilities (public spaces). In many cases, they may have flexible auditoria and stage arrangements and also multi-purpose public spaces. Multiple-use of such buildings is associated with the adequate design of those facilities and also with such solutions which can enable the appropriate conditions for different types of productions. Each of the alternative uses requires specific provisions to be made in its design and equipment. Multiple-use auditorium design must involve aspects relating to their profitable functioning. This may be limited to architectural factors, technical issues and acoustics, but it may also lead to the wide range of potential uses of the building [1]. This paper explores the types and characteristics of multi-purpose buildings and presents the possible applications of elements of functional adaptability in performance spaces.

## 2. Types of Buildings for the Performing Arts

Performance spaces are very diverse. The differences lie not only in the types of stage presentation they are suitable for but also in the arrangement of the auditorium, the stage and areas for the audience members (public spaces) and their adaptability. The main types of buildings for the performing arts are defined by the types of stage presentations for which they are designed; these include: drama theatres, concert halls, opera halls, halls intended for dance performances (ballet and others) and multi-purpose halls, e.g. combining various forms of presentation in one space. ***Drama theatres*** can be divided into categories with regard to the types of stage and seating arrangements in the auditorium: *theatre in the round* - a central stage surrounded by audience from all sides; *thrust stage theatre* - a theatre in which the stage is extended so that the audience surrounds it on three sides, characteristic of Shakespearian performances; *traverse stage* halls with the audience on two opposite sides; *open stage theatre* and its variants (e.g. *end stage theatre*); *proscenium stage theatre* – the most popular type; *flexible theatre* with a variable structure of the stage and of the auditorium (e.g. *black box theatre, studio theatre, courtyard theatre, promenade theatre*)[1]. Drama theatres can be further

1 One example that combines drama theatres of different sizes and forms is the National Theatre in London. The large theatre (Olivier Theatre) has an open stage and houses 1,160 seats. The medium-size theatre (Lyttelton

classified with regard to: character of the presentations (formal or informal); the methods of financing the theatre institutions (public theatre, commercial theatre, etc.). With regard to their plans, drama theatres can assume various forms from square and rectangle formats through to polygon and fan shapes.

***Opera theatres*** are distinguished by both their greater dimensions than drama theatres and also by their smaller diversity of forms. A prevailing solution for a 'playing space' in such buildings is a proscenium stage equipped with a fly tower, a stage basement and side stages. In fact, every opera has an orchestra pit. The auditorium layout in buildings of this type mostly repeats the historical solutions with a horse shoe form[2], a semicircle or fan shape.

***Concert halls*** also vary in size and the ways in which the auditorium and the stage platform are arranged. They include very small recital halls and also large halls with capacities as high as 2,500 seats in the auditorium. With regard to the auditorium and stage layout, one may distinguish among concert halls: *single direction relationship* - popular arrangements based on a rectangular plan, with an auditorium situated opposite the stage (*shoebox format*; *rectangular box*); *vineyard formats*, with an auditorium surrounding the stage; arrangements of polygonal shape, fan shape and even an elliptical shape, with an auditorium surrounding either the entire stage or a part of it.

***Multi-purpose halls*** are characterised by their large diversity, both with regard to size and the manner of arranging the auditorium and the stage. There is an emergence of halls with a fixed configuration of the auditorium and variability only within the stage and forestage, and there are also halls with a completely variable space, adjusted to various types of presentations, both onstage and offstage.

## 3. Historical Development of Multi-Purpose Theatres

Until the beginning of the 20$^{th}$ century, cultural facilities usually had a single, specific function: an opera house was for opera and a cinema was used almost exclusively to show films. The multi-use of buildings for the performing arts originates from the concept of the 'synthesis of the arts', which appeared around the end of the nineteenth century or, more precisely, which re-emerged around that time[3]. The primary promoter of the 'synthesis of the arts' at that time was Richard Wagner, who wanted to create a musical drama combining poetry, music, dance, architecture, painting and sculpture to form the *Gesamtkunstwerk* – the total work of art. The

Theatre) with the proscenium stage offers 890 seats in the auditorium. The smallest theatre is a studio theatre (Dorfman Theatre, formerly Cottesloe Theatre) with a variable space and a maximum capacity of 400 seats. The smallest theatre is also an example of a courtyard theatre.

2 A horse shoe form of an auditorium was a solution characteristic of historic opera houses; however, it did not always meet the requirement of good visibility in the horizontal plane. Such a construction of an auditorium (concave wall surfaces, theatre boxes and balconies) also affected the uneven distribution of the acoustic field in the theatres of this type.

3 This is because the concept of the synthesis of the arts dates back as far as ancient Greece, particularly to the archaic period, when art was syncretic. It was referred to as *triune choreia*, and it was a combination of sound (music), words (poetry) and movement (dance).

first modern buildings with functionally adaptable auditoriums were constructed around the end of the nineteenth century and beginning of the twentieth century. Examples of theatres and concert halls with adaptable auditoria and stage areas include the Auditorium Theatre in Chicago, erected in 1889 and Grosses Schauspielhaus in Berlin of 1919. In 1926, a German theatre reformer and director, Erwin Piscator, together with the architect Walter Gropius, proposed a solution for the theatre space that was referred to as 'Total Theatre'. Their project, which never came to life, involved a revolving auditorium and stage (proscenium stage with the auditorium located opposite the stage and an open stage with the auditorium located on three sides and also a central stage with a surrounding auditorium), and it was supposed to combine architectural functionalism with elements of other arts. Piscator required the elimination of the proscenium in order to bring the actors and the audience closer together and in addition 'convertibility, flexibility and anonymity' in the drama theatre design. The aim of Gropius and his 'Total Theatre' design was to draw the spectator into the drama. He wrote about his design: "I have tried to create an instrument so flexible that a director can employ any one of the three stage forms by the use of simple, ingenious mechanisms. The expenditures for such an interchangeable stage mechanism would be fully compensated for by the diversity of purposes to which such a building would lend itself: for the presentation of drama, opera, film and dance; for choral or instrumental music, for sports events or assemblies" [11]. The building was designed to be a really multiple-use venue.

Avant-garde concepts for theatre reform also appeared in Poland in the interwar period, challenging the dominant solutions used in opera and theatre buildings in the eighteenth and nineteenth centuries. The domination of the proscenium stage was abandoned and replaced by bold solutions concerning the area of the stage and the auditorium. The Stefan Żeromski Theatre in Warsaw (1932-33, designed by Sz. Syrkus) was equipped with changeable units, a system of portable platforms with a size of 2.0 x 0.9 m, which could be rearranged to fit the needs of a particular stage presentation. Consequently, it was the first theatre hall with a completely adaptable space in Poland and, most likely, in the entire world [4]. In the design of another structure, the Simultaneous Theatre, also referred to as the 'Theatre of the Future' (1928–29), the designers, Sz. Syrkus and A. Pronaszko, replaced the proscenium stage with a circular (ring) moving stage, which was designed to consist of two revolving circles with lifts and small revolving stages[4].

The designs of experimental theatres that appeared in the nineteen-twenties and nineteen-thirties revolutionised buildings for the performing arts. The proscenium stage and the auditorium located opposite no longer constituted the only possible spatial arrangement for theatre performances. Efforts were made to come up with solutions that would alter the audience member's perception of the performance, transforming it into an aesthetic and spiritual experience. Most cultural centres and other multi-purpose buildings in the twentieth century were of local significance only. This was also the case in France, where the first cultural centre projects were created. Over a dozen cultural centres were built in France in 1961-1971 [6], and the idea of multi-purpose buildings re-emerged in that country in later years (despite the partial failure of cultural centre financing), as demonstrated by the Pompidou Centre in

4 The designers modified the Gropius design and Oskar Strandt's concept of the 'circular stage'.

Paris. It should be noted that multi-purpose structures had already existed in ancient times; buildings constructed in that period – odeons – also included stage facilities designed for various musical, theatrical and oratorical presentations.

## 4. The Multiple-Use Theatre Design

'Multi-purpose' is a very broad term that can be interpreted in several different ways. In buildings for the performing arts, functional adaptability primarily relates to transformations on the stage and in the seating areas that enable the presentation of different stage forms in a single space. A concert hall has a different interior layout and different acoustics to a drama theatre hall. Most multi-purpose halls can be characterised by such arrangements that are, on the one hand, typical for concert halls (with regard to the auditorium form and the seating layout), and on the other, for drama theatres and opera houses (with regard to the form of the stage area). Functional adaptability is usually found in structures with a proscenium stage which can be transformed within the proscenium zone (e.g. through the use of an adaptable orchestra pit with lifts) and also in the area of the main stage (adjustable height and width of the proscenium opening, lifts and bridges, acoustic shells or suspending reflectors, revolving platform, etc.), Fig. 1.

A forestage area can be adapted for multiple activities. A permanent orchestra pit can hinder the relationship between the audience and the performance by increasing the distance between the two. Therefore, it is a common practice to cover over the orchestra pit and use it as a forestage. This can be done manually by assembling panels and framework, but the upraised hydraulic lift can also form an apron stage [7, p.56], Fig. 2.a. A lift or lifts can be lowered to the seating area for extra seating rows, Fig. 2.b. A lift in the lowest position forms the orchestra pit, Fig. 2.c. Open or apron stages can also be retractable or comprised of moveable platforms [10, p. 143]. Lifts and bridges within the stage area can be used not only for scenic devices, but also as platforms for musicians and the choir, Fig. 2.e. Sometimes, lifts and bridges can be used for additional audience seating, Fig. 2.d. A wide proscenium opening is usually used for musical performances, especially for orchestral concerts, Fig. 3.a, b, c. A reduced width of the proscenium opening can be applied for drama theatre productions [2, p. 156], Fig. 3.d.

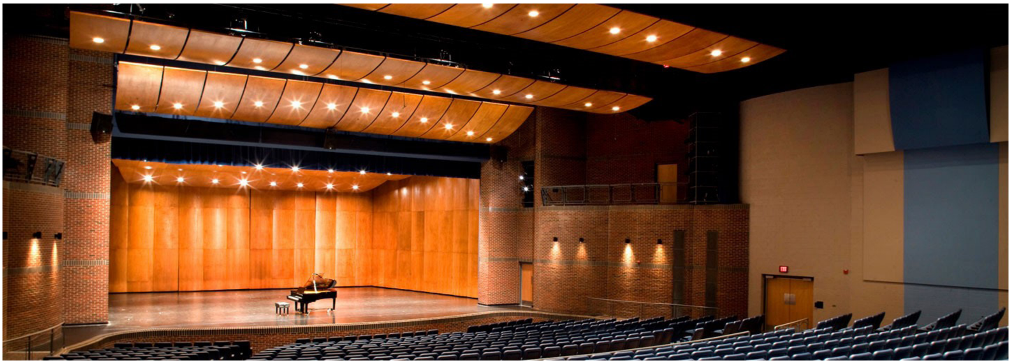

Fig. 1. A multi-use proscenium stage with acoustical shell and ceiling panels (reflectors) (source: [12])

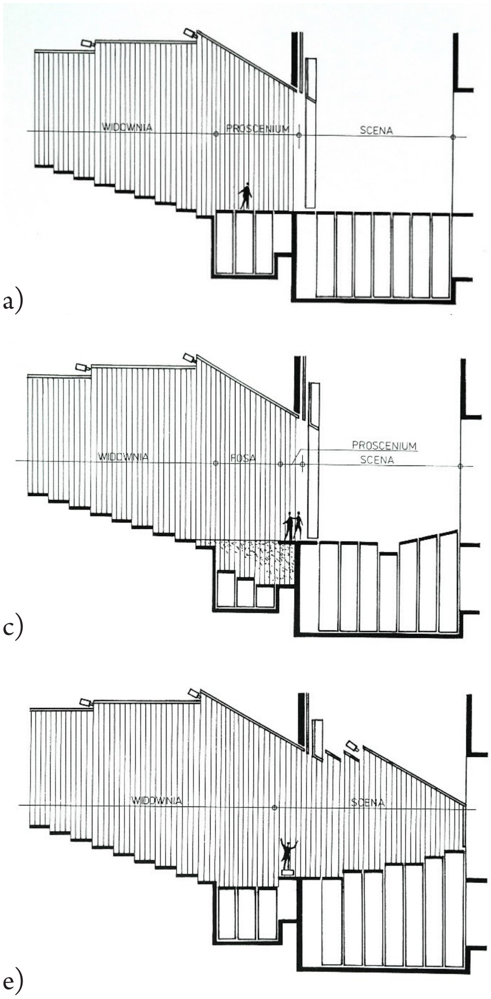


Fig. 2. A multi-use proscenium stage with a fly tower and a flexible proscenium zone – lifts and bridges within the stage and a forestage area: a) drama theatre arrangement with the forestage in position over orchestra pit; b) drama theatre configuration with additional seating rows – orchestra pit lifts are lowered to the auditorium level; c) opera and musical arrangement – lifts at the lowest position form an orchestra pit; d) central stage with additional seating for the audience on the main stage; e) concert hall configuration with platforms and an acoustic shell (prepared by: A. Grudziński, P. Amałowicz)

In addition to having different options with the stage and the forestage area, the auditorium can also be adaptable, both in terms of layout (folding or movable seat rows or rotating such rows using platforms) and the division of the space through movable partitions to create separate areas. Another possibility is the adaptation of the auditorium size and cubic volume of the hall to meet the requirements of current stage presentations. Some performances are suitable for smaller audiences than the full capacity of the house, and it is therefore useful to be able to reduce the size of the auditorium in the best possible way– this is very difficult to achieve in

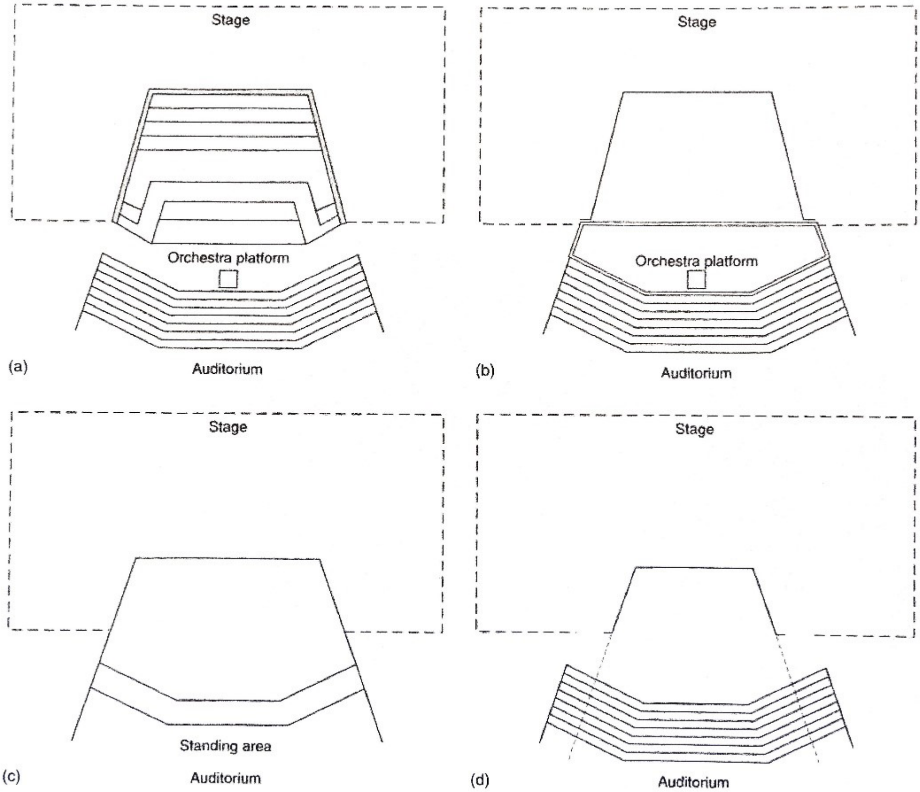


Fig. 3. Possible layouts of a multi-use proscenium stage with a changeable proscenium zone: a) concert hall configuration with an acoustic shell and the widest proscenium opening; b) opera and musical arrangement with an orchestra pit and a wide proscenium opening; c) pop/rock music layout with a forestage in position over the orchestra pit; d) drama theatre arrangement with a forestage in position and reduced width of proscenium opening (source: [2, p. 156])

a single-tier auditorium [7, p.19]. Moving walls or curtaining off the rear of the auditorium is not very satisfactory because the audience usually have to approach through the curtained-off area. With a multi-tier auditorium, on the other hand, it is relatively easy to close off the balcony level, but a more sophisticated development is to lower the auditorium ceiling to rest on the front of the balcony [7, p.19]. Acoustic elements that adjust the cubic volume in functionally adaptable halls are important to ensure suitable reverberation time for particular events [3]. This is usually accomplished with movable ceilings, which can be lowered or raised as necessary, Fig. 4. Acoustic panels can also be placed at suitable angles to correctly direct the sound (acoustic wave). The walls may also have variable acoustic properties, e.g. they may be covered with an sound-absorbing material (curtains) to shorten the reverberation time where necessary.

The most popular plan arrangement for multi-purpose halls is a rectangular form. The adaptable auditorium forms include polygonal shapes, square and fan configurations. For practical reasons, rectangular halls with a flat floor (and retractable or removable seating) with a ratio of width to length 1:2 can be easily divided into two or three parts. In this case,

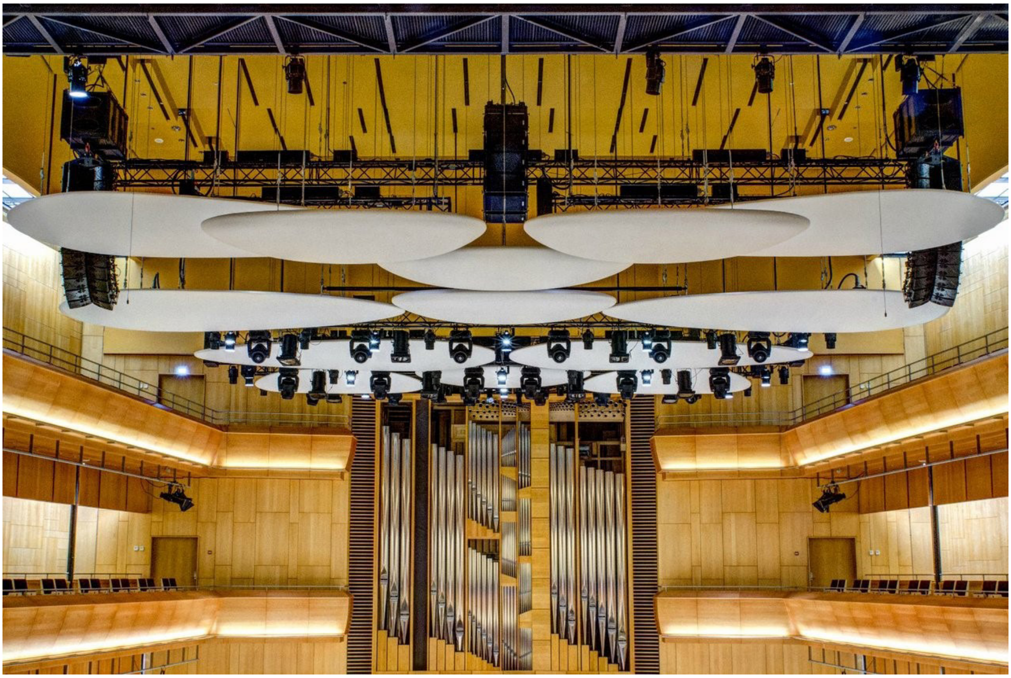

Fig. 4. Movable acoustic ceiling elements in Stavanger Concert Hall (source: [13])

each part of the hall can serve different purposes. If the room is divided into three parts, the middle part is often used as a sound buffer. Rectangular forms are used for orchestral music and drama theatre plan arrangements, especially when the audience is placed in front of the platform – this is a single-direction relationship between the audience and the performers. Straight rows of seats and also straight rows with side blocks of seats angled and focused towards the platform/stage are used in such configurations.

For some concert hall configurations and also for drama theatre arrangements, the audience is located on three sides of the platform/stage. In this case, the auditorium forms include a rectangle, a polygon and a fan. The audience can also surround the stage. The performance area may be placed in the centre of the seating or along the long axis. The audience can surround the stage through the use of galleries or by sub-division into terraces [2, p. 106]. For such configurations, the auditorium formats include rectangular, polygonal, elliptical (oval) and circular shapes and the seating geometry can provide curved and angular rows. Distinct blocks of seating focused towards the platform/stage can also be used.

Multi-purpose halls can be subdivided into the following categories:

1. 1. Halls with adaptable stage and auditorium areas, designed for a single form of stage presentation;
2. 2. Halls with adaptable stage, proscenium areas and front parts of the auditorium, designed for various types of production;
3. 3. Halls with adaptable stage, proscenium and auditorium areas, designed for various types of production;

4. 4. Multi-use halls, used not only for stage presentations but also for other functions, such as conferences, lectures or sports [2, p. 110].

The first category includes, for example, drama theatre halls, which can be adapted for different types of dramatic productions. It is a multi-format with a single production type. A stage can be changed from a proscenium format, with a proscenium arch and a fly tower to an open stage form or a thrust stage form. A theatre in the round could be also arranged (with a central stage). The Gdańsk Shakespeare Theatre, opened in 2014, is a perfect example of such a facility. It is a functionally flexible theatre, which enables different variants of stage and auditorium configuration for the purpose of theatrical and extra-theatrical presentations. There are two main arrangements in the GST hall. The first is the Italian configuration with a traditional proscenium stage, Fig. 5. The stage movement technology located in the base below the floor slab enables transformation of the stage into the Elizabethan configuration, Fig. 6. It is a mobile stage. The roof above this stage is retractable. The ground floor seating is also changeable and the flat floor can be arranged for standing audience members, in addition to the fixed three storeys of wooden galleries in the perimeter areas for 680 people. In this configuration, the Shakespeare stage is surrounded on three sides by the seating. The other possible arrangements are: experimental configuration with a central stage, ceremony configuration with a flat floor and a fencing arrangement with a fencing strip. The Yard at Chicago Shakespeare is an even more flexible theatre example. The design features nine mobile audience 'towers' that can be arranged in a wide variety of ways (twelve different configurations). Compressed air skid technology lifts each of the 16 tonne towers off the ground on a bed of air, allowing them to be moved by a three persons. The capacity of the hall ranges from 150 to 850.

The second category could be described as a single format with flexibility [2] – a space which accommodates more than one type of production and requires physical adaptation, e.g. a concert hall arrangement with an acoustic shell, an opera and dance arrangement with an

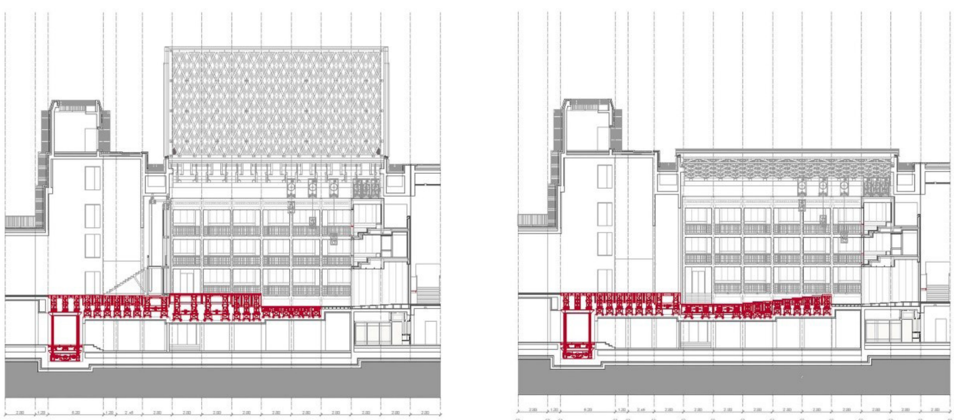

Fig. 5. 6. The Gdańsk Shakespeare Theatre, the main hall: sections of the Italian configuration (left) and the Elizabethan configuration (right) (source: [14])

orchestra pit and a proscenium frame, and a drama theatre arrangement with a forestage – all in one space. A recent example of this type is the functionally adaptable hall of the Podlasie Opera and Philharmonic in Białystok, Poland, designed under the guidance of the architect Marek Budzyński. It is an opera house, a concert hall and a drama theatre, all in one space. The stage is a multi-use proscenium form with a large proscenium opening – 16.0 x 16.5 m. The height of the opening can be reduced to 11 m, especially for opera and drama theatre productions. For concert purposes, the acoustic shell must be placed on the stage to enhance acoustics in the stage house and the auditorium. The seating layout is different for different types of production. The basic size of the auditorium is 824 seats, but it can be reduced to 652 seats or even 570 seats for small scale productions or increased to 1016 seats (with additional seating onstage). Special curtains are used to separate and isolate balconies, if necessary. Acoustic properties are also adjustable within this auditorium. Reflective panels suspended above the audience seating can be raised or lowered to increase or reduce reverberation time,

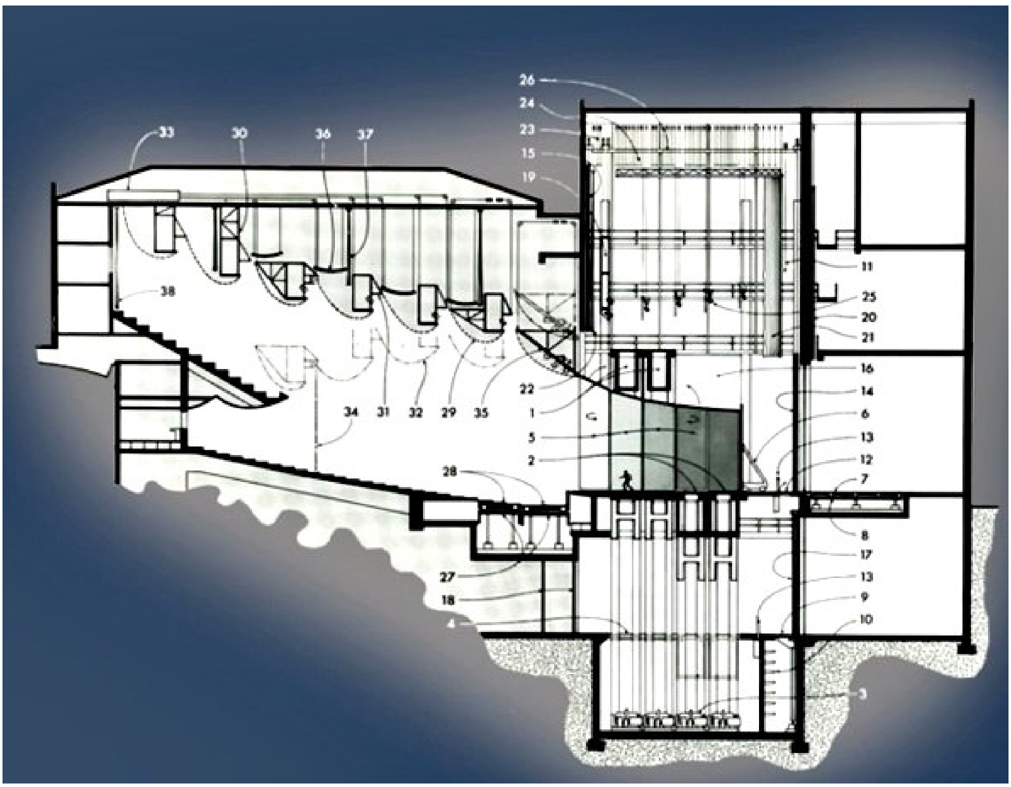


Fig. 7. A multi-purpose theatre project by Olaf Soot Design for Maracaibo, Venezuela – the longitudinal section shows possible conversion from concert hall with 2,100 seats to an opera house (1,740 seats) or a drama theatre (750 seats). The main adjustable elements are: an orchestra shell (5) in position onstage – panels of the shell are a part of downstage lifts for quick conversion from a theatre to a concert hall; a movable ceiling located at a high (29) or low (32) position; auditorium partition curtain (34); orchestra pit lift (27) with seating wagons (28); ceiling acoustical absorptive curtains (37) and wall acoustical curtains (38). (source: [15])

and their rake angle is also variable. The reverberation time should be longer for orchestral and choral music performances, slightly shorter for opera and much shorter for dramatic and electroacoustic performances; therefore, the volume of the auditorium must be changed. The acoustic properties of internal walls can also be transformed from reflective to absorptive when plush curtains are dropped.

The third category refers to multi-form halls, where various productions take place within the same enclosure. It is similar to the second category, but the seating layout and the capacity can also be modified, Fig. 7.

The last category combines a provision for performing arts productions with other activities, e.g. indoor sports facilities, conferences and lectures. Usually, the auditorium in such buildings can be reconfigured into different seating arrangements to change the performer – audience relationship. By moving large architectural elements, one form of the theatre can be transformed into another. In this case, the halls frequently have a flat floor used to place movable inclined seating. Such seating can be retractable, telescopic, moved on trolleys (wheeled units), removable or hydraulically raised and retracted[5] [10, pp. 142-143], Figs. 8 & 9. The Derngate Auditorium in Northampton, England, is a good example of this category[6]. Another example, however, not a perfect example, is the Schaubuhne in Berlin; this is a building with a vast central nave – an open space in which the position of the acting area is not predetermined. The convertible space can be adapted to each production by combining or adding mobile facilities located on the walls, floor and ceiling. The space can be divided into three auditoriums that can be used together or separately[7] [5, p. 64].

Fixed seating in multi-use halls is usually located in stepped perimeter areas and the central part of the auditorium is often flat and equipped with movable chairs. Rectangular and square box forms are often used in this category, both with fixed perimeter seating and removable central seating, and also with fixed rear seating and removable front seating on a flat floor. Adaptability from one format to another is sometimes simple, when the level of adaptation is relatively small, such as the formation of the forestage over an orchestra pit, and when it does not interfere with sightlines. Sometimes, however, adaptability means alterations of seating and staging, Fig. 10. On a small scale, such changes can be achieved manually or mechanically without serious problems, but on a large scale, the problems become more challenging, both technically and economically, if all formats are to perform satisfactorily [2, p. 124, 125].

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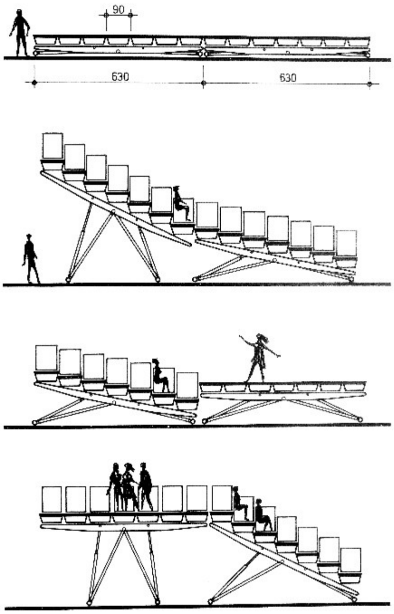
5 In retractable or telescoping seating, each row retracts into the row behind until the stored unit is one rear row deep. Complete inclined units on wheels can also be easily moved into storage areas. In some cases, removable seats are placed on a units built up on a set of boxes. Hydraulic lifts are also used to form a stepped floor [2, p. 127].

6 The Derngate Theatre in Northampton is a multiple-use building. the auditorium and stage space of which can be changed and shaped in accordance with the need of theatrical, opera, musical and dance performances, and even sporting events.

7 The Schaubuhne in Berlin was refurbished in 1981 and a flexible space was built. The machinery was sufficiently variable to enable a wide variety of configurations. The building was filled with lifts, mobile units, winches and acoustic movable curtains but this was not without other constraints. Three auditoriums, each of a different size, could be combined together with a total capacity of 2,000 seats.



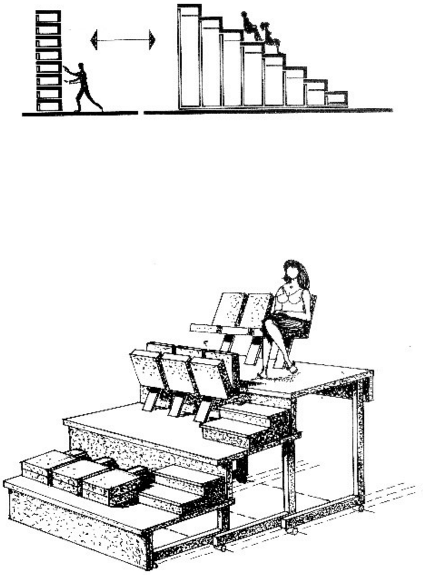
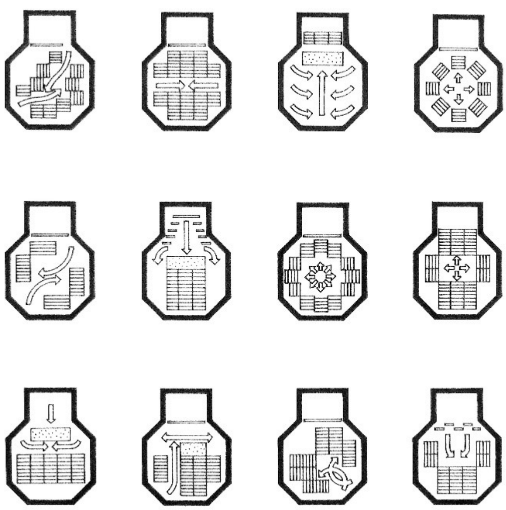



Fig. 8. 9. Movable seating and stage platforms (left), retractable seating (right) (prepared by: A. Grudziński)



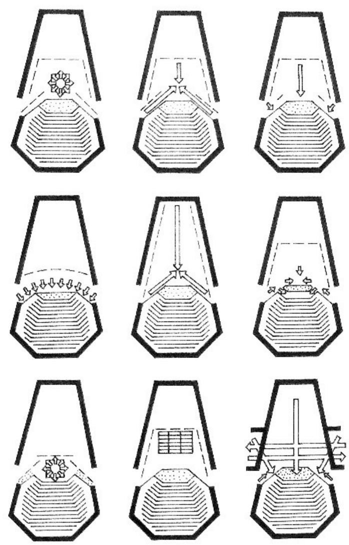


Fig. 9. Fig. 10. Adjustable auditorium plan arrangements – changeable seating and stage examples (left) and a multi-use stage with a flexible proscenium zone (right) (prepared by: A. Grudziński)

## 5. Acoustic Arrangements of Multiple-Use Auditoriums

Acoustic elements are crucial for multi-use halls. The ideal sound environment for performing arts halls depends on three variables: room acoustics, sound system and quietness. To achieve a quiet environment, enclose constructions must isolate external sounds and vibrations. Sometimes double or even triple walls are used to separate the main hall. Noise control within the hall is also important. Several conditions must be realised in the design of a multiple-use auditorium that is to have optimal room acoustics. Firstly, the hall must have the best possible shape and dimensions to provide the most favourable generation and distribution of sounds for both performers and the audience [9, p. 460]. Secondly, it should have the proper diffusion of reflected sound, so that the direct sound heard by the audience is enhanced by reflections of the sound, which flows to all listeners from all directions [9, p. 460]. The multiple-use auditorium must have provision for acoustic adjustability.

The main acoustic elements in multi-purpose halls are:

- acoustic enclosures (shells);
- reflective, diffusive and absorptive panels;
- movable, changeable ceilings which can adjust the cubic volume of the hall;
- adjustable acoustic properties of internal walls.

In most multi-purpose auditoriums, the stage area is separated from the seating by a proscenium opening. The proscenium stage used in drama and opera performances is not a sound reflector for orchestral and choral music performances. The fly tower is usually high and absorbs too much sound. Sound is absorbed by curtains, scenery and rigging systems. This space reduces the quality of sound, especially for concert arrangements. Therefore, ***acoustic shells*** must be used onstage. These should convert the theatrical stage to a concert hall platform that is acoustically coupled to the auditorium [9, p. 308]. These structures shield onstage sound absorption and acoustically connect the stage area to the auditorium. Acoustic enclosures enhance the ability of performers to hear each other (by providing early reflections), project sound toward the audience and increase sound intensity. Sound-reflective shell towers are placed on the stage floor, forming back and side walls that enclose the performers, and overhead panels are suspended above the stage using the rigging system. A full-stage acoustic shell is the ideal solution for musical performances on a proscenium stage, Fig. 11.

A high ceiling in the audience area could be also a sound trap (i.e. it can absorb too much sound). ***Reflective ceiling panels*** ('acoustic clouds') suspended above the audience seating area reflect sound down towards the audience, Fig. 12. The panels are spaced apart to enable sound to enter the volume above the panels. The later reflections from this volume enhance reverberation and create envelopment of the acoustic space.

***Acoustic wall panels*** within the seating area are mainly diffusers and absorbers. The front one-third of the auditorium walls are usually diffuser panels. Aa combination of diffuser and absorber panels is generally placed on the middle third of the auditorium walls.. The rear sections of the side walls and the entire back wall are normally covered with absorber panels. The shapes of the reflective and diffusive panels include convex and pyramidal forms, and wavy patterns etc. Their construction materials are usually wood and gypsum boards (sometimes

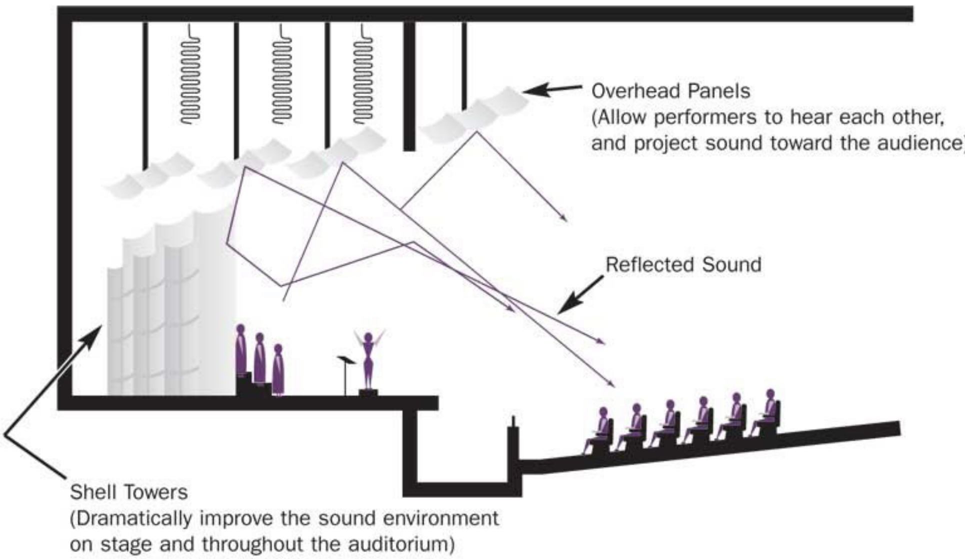



Fig. 11. Acoustic shell – sound-reflective shell towers and overhead panels surrounding the performers (source: [16])

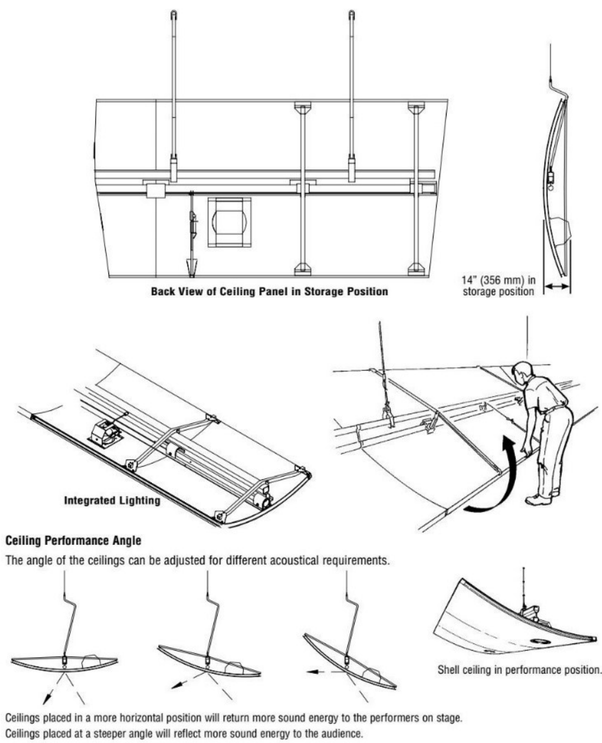



Fig. 12. Reflective ceiling panels (source: [17])

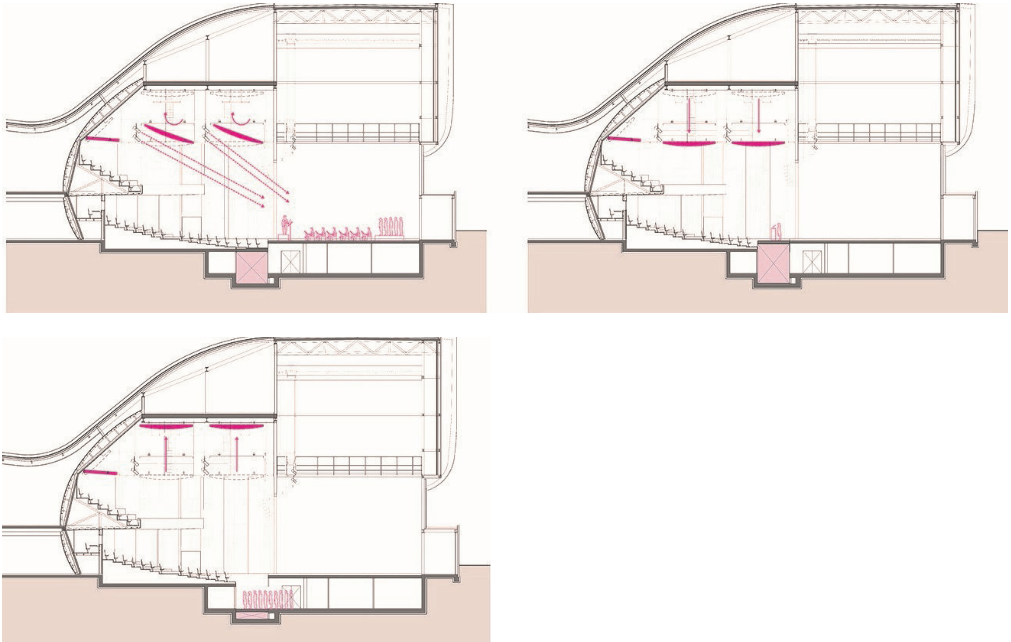


Fig. 13. Movable and retractable ceiling. Theatre de Stoep / UN Studio, the Netherlands(source: [18])

glass), which can be characterised as hard-surfaced. Absorptive panels, reversely, are made of soft and porous materials.

Reverberation time should be short for speech and long for music. Variations in volume and reverberation times typically cause difficulties when combined in a single auditorium. ***Movable ceilings*** can adjust the cubic volume of the auditorium for the given performance, Fig. 13. Mechanical, retractable elements can change the volume of the hall. Electronic devices like "assisted resonance" can also adjust reverberation time [2, p. 115]. Volume could be adjusted by dropping sound-absorbent banners or panels. Such an approach transforms the way in which ceilings and walls can be treated. It is also possible to curtain off a section(s) of the seating [2, p. 115], for example, balconies.

The requirements for some types of performance are akin to other types, whereas others can be vastly different. A concert hall has a different interior layout and different acoustics to drama theatre auditorium. A multiple-use hall must provide sufficient auditorium volume for use as a concert hall and means by which it can be reduced: by closing off balconies and other spaces of the auditorium to lower reverberation time and the seating capacity to an appropriate value for speech or by maintaining the volume constant and adding sufficient absorption to offset excessive volume [9, p. 308].

## 6. Summary and Conclusions

Multi-purpose performance spaces can be used for a variety of functions. The diversity of stage productions that can be presented in a single space is the main advantage of such facilities that can be configured and adapted to meet the needs of the current presentations. Another advantage they present is the diversity of support facilities for public. Buildings for the performing arts are often flexible in order to improve their functioning. However, it is necessary to consider all their main, changeable functions during the design work. It is also necessary to consider the balance between the costs and benefits of the flexibility. Venues that are multiple-use are associated with certain limitations. Too much machinery can generate very high costs and create other constraints. Acoustic arrangements can be quite complex, but they are also necessary when multi-form strategies are applied.

The multi-purpose idea has in some cases been the expression of the clients' unusual and unrealistic aims, not based on a reliable and comprehensive feasibility study. In attempting to cater for every use, even incompatible uses, designs of multiple-use buildings have occasionally failed. They have been too expensive and not suitable for any types of production that are very different from each other.

The optimum solution for multiple use seems to be such an approach to architectural design and construction that ensures maximum utilisation of the potential of buildings for the performing arts and their very high functionality. Therefore, the study of the design decisions that lead to flexible buildings is important. Features such as the incorporation of changeable elements and the creation of multi-purpose spaces must be examined. Flexibility of theatre buildings and the functional adaptability of the stage and auditorium area should be considered at an early stage of design work, and future spectators and the persons who manage the cultural institutions should be consulted. Design requirements are much more complicated for multiple use than for single use facilities, but a well-designed and efficiently operated multiple-use building for the performing arts offsets other more serious disadvantages, simply because of the increased use factor and the more stable income they are likely to provide [9, p. 306]. Multiple-use also broadens the range of services that can be provided by cultural institutions.

## References


[1] Amałowicz P., *Cultural Centre as a Friendly Place. On the Basis of Projects and Realisations of the Lower Silesian Philharmonic Hall and the Karkonoska Library in Jelenia Góra,* [in:] *The Urban Landscape Reneval,* International Scientific Conference ULAR 6, Monograph Vol.2, The Silesian University of Technology, Gliwice 2012.

[2] Appleton I., *Buildings for the Performing Arts. A Design and Development Guide,* Butterworth Architecture, Oxford 2008.

[3] Beranek L., *Concert Halls and Opera Houses. Music, Acoustics, and Architecture*, Springer, New York 2004.

[4] Braun K., *Przestrzeń teatralna*, PWN, Warszawa 1982.
[5] Breton G., *Theatres*, Editions du Moniteur, Paris 1989.
[6] Charpentier Ch., *The Maisons de la culture*, [In:] *Place for the Arts*, eds. A. Schouvaloff, Seel House Press, Liverpool 1970.
[7] Ham R., *Theatres. Planning Guidance for Design and Adaptation*, Butterworth Architecture, London 1988.
[8] Holden M., *Acoustics of Multi-Use Performing Arts Centers*, CRC Press, Boca Raton, 2016.
[9] Izenour G. C., *Theater Design*, Yale University Press, Yale 1997.
[10] Lawson F., *Conference, Convention and Exhibition Facilities, A Handbook of Planning, Design and Management*, The Architectural Press, London 1981.
[11] Schlemmer O., *Theater of the Bauhaus*, Wesleyan University Press, 1961.
[12] https://www.wengercorp.com (online: 1.06.2019).
[13] https://www.stavanger_waagner-biro.com (online: 1.06.2019).
[14] https://www.archdaily.com (online: 1.06.2019).
[15] http://www.olafsoot.com (online: 1.06.2019).
[16] https://www.constructioncanada.net (online: 1.06.2019).
[17] https://www.issuu.com/wengercorp/docs/wenger_data_book_2014/1590 (online: 1.06.2019).
[18] https://www.archdaily.com (online: 1.06.2019).

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# The cultural landscape of Nowy Wiśnicz – a study of visual exposure as a basis for the development and management of the surroundings of the castle hill

# Krajobraz kulturowy Nowego Wiśnicza – studium ekspozycji jako podstawa zagospodarowania i zarządzania otoczeniem wzgórza zamkowego


## Abstract

The landscape of Nowy Wiśnicz is a unique example of the preservation of Baroque cultural landscape. Changes in the manner in which the castle surroundings are used and a lack of care resulted in overgrown greenery which then began to interfere with precious spatial relations. The landscape currently requires intervention. Conservation has been protecting the site against investment plans. However, it must be integrated with active protection in the form of caring for the vast area in order to preserve the spatial meaning of the entire complex. A study of the exposure of the castle hill indicated further actions that are required for the landscape framework . With use of contemporary methods of a visual analysis, the main exposure links were identified. Two options of specific guidelines for land cover were then defined. These were considered with regard to the current state and then against the future state in the case of no intervention. These guidelines constitute the basis for further steps for the development and management of the surroundings of the castle hill.


**Keywords:** visual analysis, visibility degree, landscape legibility, Baroque landscape


## Streszczenie

Krajobraz Nowego Wiśnicza to unikatowy przykład zachowanego barokowego krajobrazu kulturowego. Zmiany sposobu użytkowania otoczenia zamku i brak jego pielęgnacji spowodowały nadmierny rozwój roślinności, który zakłócił cenne powiązania przestrzenne. W chwili obecnej krajobraz wymaga interwencji. Ochrona konserwatorska zapewniła bezpieczeństwo ze strony zakusów inwestycyjnych, należy ją jednak zintegrować z czynną ochroną w postaci pielęgnacji rozległego obszaru w celu zachowania wyrazu przestrzennego całego zespołu. Studium ekspozycji Wzgórza Zamkowego wskazało krajobrazowe ramy dalszych działań. Za pomocą współczesnych metod analizy widokowej zidentyfikowano główne powiązania ekspozycyjne. Następnie określono szczegółowe wytyczne dotyczące pokrycia terenu w postaci dwóch wariantów ukazując je na tle stanu obecnego i stanu jak nastąpi w wyniku braku interwencji. Wytyczne te stanowią podstawę dalszych kroków mających na celu zagospodarowanie i zarządzanie otoczeniem wzgórza zamkowego.


**Słowa kluczowe:** analiza widokowa, stopień widoczności, uczytelnienie krajobrazu, krajobraz barokowy

## 1. Introduction

The notion of cultural landscape contains the word *culture* which stands for cultivation[1]. A lack of cultivation and care leads to natural processes returning the landscape to its original condition. These processes take on a form of secondary natural succession, i.e. gradual changes of forms of shaping and covering as subsequent stages proper for the conditions of a given place. In Poland, this is common practice and results from both natural and cultural transformations, including *atlantisation* of climate or reducing the existing active agricultural use (Fig. 1).

This process does not spare protected areas and this is demonstrated in significant transformations that lead to the loss of legibility of past landscape assumptions. The landscape of Nowy Wiśnicz has fallen prey to this phenomenon. A high number of forms of protection for the castle and its surroundings have failed to protect it from the significant weakening of landscape values [20]. Little interest in the surroundings of the site results in the advancement of processes which led to the deformation of the local cultural landscape and created a situation of conflict between the protection of the natural environment and the protection of the site of historic value [10]. The accumulation of uncontrollable phenomena currently makes it difficult to provide adequate protection of the historically valuable site and it requires immediate regulation. The initial step for outlining the framework for action was a study of visual exposure of the castle hill. It was aimed at defining the main visual links and the possibilities for making them more readable. It outlined the spatial framework for further work while identifying the conditions for achieving a specific landscape effect in the form of guidelines [21].

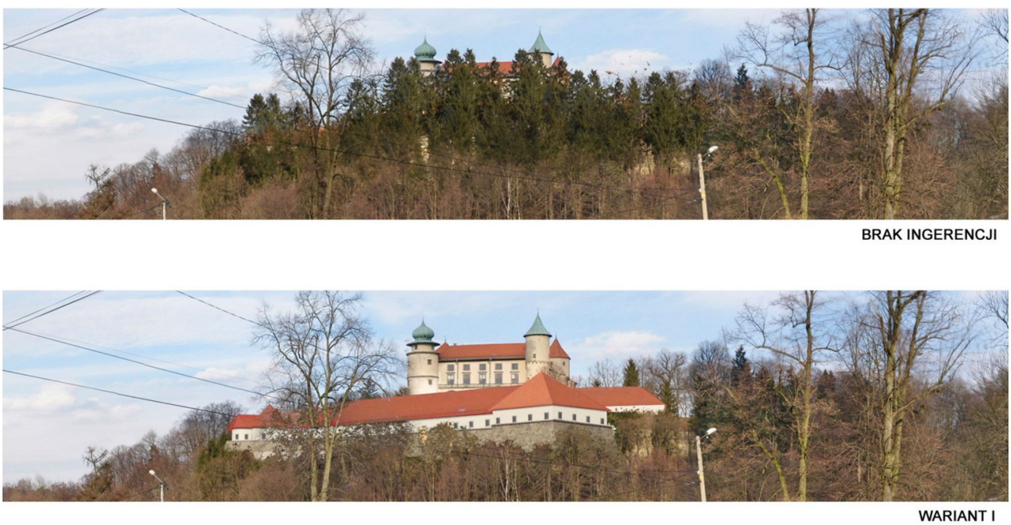


Fig. 1. A study of visual exposure to identify possibilities of making the castle hill more legible in the landscape of Nowy Wiśnicz [21]

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1 The word *culture* originates from the Latin word for *cultivation, i.e. Kultus agri* – agriculture

## Materials–transformations of the cultural landscape of Nowy Wiśnicz

The landscape of Nowy Wiśnicz is a unique example of the preservation of a Baroque cultural landscape. It is based on a trio of the castle, the monastery, and the town, and it reflects the ideas characteristic of its époque. This unique combination covering a considerable area has been preserved in exceptionally good condition. Although it has been slightly transformed, it remains a balanced composition with a clear spatial message [9].The story of settlement in Nowy Wiśnicz goes back to medieval times. Its form took on a special meaning in the seventeenth century when the castle was surrounded with fortifications based on a pentagon. The fortifications were designed and built on a grand scale with five bastions and curtains. This redevelopment made Wiśnicz one of the strongest noble fortresses in Poland at that time [7,8,9]. Cartography and historical iconography shows the former method of managing the surroundings. The residence was initially surrounded by lavish gardens and animal compounds [15]. When the times of the former grandeur were over, distinctive forms of outstanding architectural and cultural items remained landmarks in the local landscape and defined it in accordance with their own composition rules. A wide context in the form of arable land exposed the whole complex comprising the castle, the monastery, and the town while providing a strong basis for the dominants [8,9]. Reducing agriculture which has been observed for several decades now is gaining on strength in the contemporary landscape of Wiśnicz. This pulling back and reducing the agricultural area has gradually given in to natural succession. Although transforming parks and animal compounds into arable land did not have a significant impact on the basic spatial structure, growing trees are making its visual impact weaker and might even make it invisible.

Fig. 2. The beginnings of planting forest on the slopes of the castle hill; photo by A. Bochenek, 1918; archives of OT NID in Kraków

In the interwar period, there were spruce planted on the hill slope facing the town (Fig. 2). Growth of these evergreen species permanently transformed the character of the hill. They have become a key element of the landscape while having an impact on the visual perception of the castle itself. This seemingly insignificant intervention is marked strongly today in the hill's exposure. The trees that are present there in accordance with the habitat are predominantly deciduous. They are characterised by change in accordance with the seasons. They become semi-transparent once they lose their leaves. Moreover, they usually have a positive influence on the slopes by strengthening them with their roots. The spruces were planted deliberately. They have adverse effects on the greenery in their proximity and introduce a permanent cover for the castle regardless of the season (Fig. 3). Furthermore, spruce trees might have a very negative impact on the stability of the slopes [13, 14].

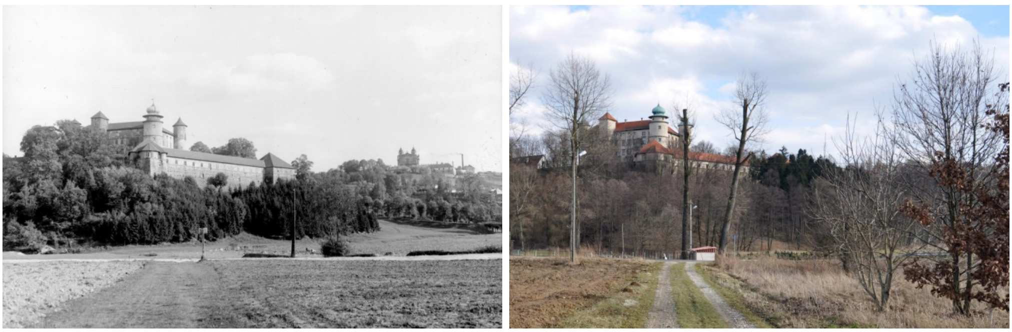

Fig. 3. Transformation of the landscape of the castle hill. View from Mickiewicza street [21]

The development of flora has prepared a good basis for favourable conditions for fauna. They have proven to be so beneficial that there is currently a large population of the lesser horseshoe bat, which is under constant observation. Because of the lesser horseshoe bat habitat, the area has been protected under the Natura 2000 project.

Despite many years of negligence, the spatial complex of Nowy Wiśnicz still possesses the model characteristics to be one of the greatest and best preserved landscapes of its era [9,20]. Currently, it qualifies for conservation and the castle plus its surroundings have been listed in the register of objects of cultural heritage in the Małopolska province. It is also included in the area register of the urban design of Nowy Wiśnicz. In the existing spatial development plan, it is listed within the area of strict and indirect conservatory protection[2] [19]. Furthermore, it is located in the Wiśnicz-Lipnica Landscape Park as well as the area covered by Natura 2000 Nowy Wiśnicz. As a result of existing forms of protection, it was not irreversibly destroyed by new construction investment; neither was it deformed or irrecoverably disrupted. Due to studies and conservation works that have taken place over the years, the objects have

[2] The castle hill and the castle itself were already under protection in the interwar period. The decisions from 1930 and 1936 confirmed the castle's value on the heritage site list when placing it there together with its surroundings. After WW2,it was listed there again on 17 May 1947. The castle with the surroundings were present in the register of the heritage sites of the former Kraków province. The castle is also a part of an entry into the spatial urban layout of Nowy Wiśnicz, under decision from 27 July 1976.

been preserved in good condition with no significant changes of form or layout. However, conservation works focused mainly on the buildings which resulted in effective protection and the current state of preservation of the buildings [7, 8]. However, in the case of the surroundings, neither the gardens nor the greenery composition have ever been subject to this kind of care. These were limited to an entry in the register of protected areas to keep them safe from construction investment [17–19]. However, a lack of active protection froze the area in terms of any resources for its proper management [16].

Passive area protection failed to stop natural processes that were missed by static planning records. In the place without proper care, the role was taken over by the nature and more or less successful actions of the managers of this area. The current direction of the landscape changes of the castle hill calls for intervention and long term management. This activity must be based on the conscious shaping of greenery taking into account both natural and cultural qualities.

## 2. Study method for exposure of the castle hill

*A study of the visual exposure of the castle hill in Nowy Wiśnicz in terms of its greater legibility in the landscape* [21] was conducted in order to outline the spatial framework for future activity. The study was designed to determine the possibilities for restoration of the visual exposure of the castle hill while preserving its natural qualities. The research was based on an active and passive exposure analysis as well as panorama and cross section analyses. The coefficient of the visibility degree [4,5] was used for verification of the findings. The results were presented as plans and visualisations. The research was conducted on the basis of the digital model of the terrain (DTM) and the digital model of the land cover (DLM) [11, 21]. Additionally, the body of the castle and its surrounding fortifications also required modelling to facilitate detailed research regarding the visibility range of the building. An analysis of passive exposure allowed identification of areas within the visual range of the studied object. An analysis of active exposure allowed locating exposure elements in the form of points, sequences, and visual planes [2]. An on-site inspection, historical materials and their verification became the basis for the prioritisation of elements of active exposure which led to singling out key, specific and complementary elements [5].

The prioritisation of elements of active exposure became the basis for locating the main directions of this exposure. These directions set the lines for cross sections across the terrain which then became the basis for defining acceptable sizes of land cover. As a result, a map was designed to define the acceptable sizes of forms of the castle hill cover. The findings were either presented as two options or as two phases of activity O1 and O2. An analysis of exposure and the range of greenery correction strategies defined there were verified with use of the coefficient of the exposure degree which determines the tangible effects of the transformed exposure in the form of charts, diagrams, and figures [4, 5]. This analysis was supplemented with panoramas [1]. The work was simultaneously performed on the plans, cross sections and panoramic views. As a result, the panoramas illustrate the existing state, the state that would occur in the case of no intervention and two options of care activity (O1 and O2). Presenting the future state in the case of no intervention, the so-called *do nothing scenario* is a reference point commonly used in landscape research methodology when the subject of research is living matter in the form of natural land cover, the condition of which being subject to change [5]. The depiction of the future state in the case of no intervention takes into account the continuation of processes that have already begun and it clearly presents their results [6]. A time horizon of ten years has been adopted for the purpose of the study.

## 3. Research results

### 3.1. Passive exposure

The exposure of the castle hill is highly diverse; it changes depending on the location of the observer. This results from the complex topography of the hill, the different green cover and the very body of the castle that is shaped differently in different parts. An initial analysis confirmed in the model study demonstrated the most favourable views to be from the north to the west and with a slight move towards the south west (Fig. 4). These are mainly the exposures that link the castle to the town. Putting together the area from which the castle is seen with the possibility of observing this view from a network of roads, routes and paths used by people allowed us to define elements of active exposure from which one can see the castle. An initial visibility map for selecting elements of active exposure was prepared for the castle towers. In order to improve legibility of the castle in the landscape in terms of its full

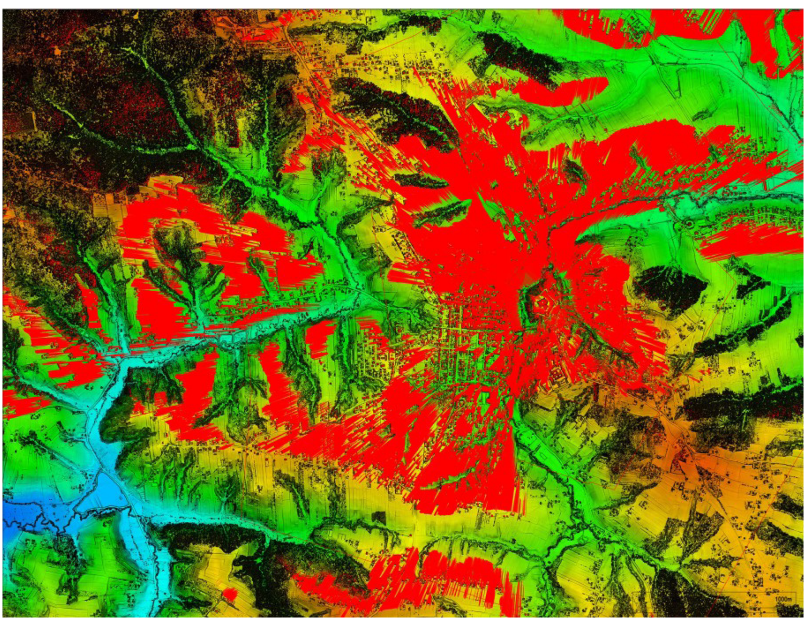

Fig. 4. Total map of visibility of five castle towers developed on the basis of the numerical terrain model [21]

form, i.e. the spectacular expansion of fortifications in the seventeenth century, the visibility study included the bastions. Exposure possibilities related to the topography, the shape of the hill and the shape of the bastions with curtains gives the highest exposure potential to the western curtain with the bastions around it. It is facing the town. Legibility of this part of the fortifications can be ensured provided there is visibility of the curtain peak and a piece of light wall up to a layer of stone fortifications slightly beneath the cornice. This is the line where the visibility checkpoints were placed for studying their exposure possibilities.

A visibility chart developed on the basis of the terrain model also formed the basis for further studies related to the acceptable level of greenery and the exposure results of greenery correction in the castle surroundings.

### 3.2. Active exposure

In terms of the viewshed of the bastion fortification line, we located elements of active exposure in the form of points, sequences, and visual planes. These elements were analysed in the context of historical visual approaches, the current state, and landscape transformations. Their gradation was completed on the basis of a comparative analysis. Key, specific and complementary elements were identified. Special attention was paid to visual points because of further stages of works. Cross section beams were introduced as key points. On this basis, a visualisation of the current state, the *do nothing scenario* state and the design stage were prepared in two options O1 and O2 (Fig. 5).

### 3.3. Panoramas

An integral part of visual studies is the study of panoramas [1]. In the case of passive exposure of the castle hill, panoramas constitute a key element of the analysis while visualisations are a major method for presenting the results. The following were presented as panoramas: the current state, the *do nothing scenario* state, the options of exposing the castle hill in a minimal form (O1) and an optimal form (O2).

Panoramas were prepared in the form of a catalogue of key points with a larger summary of the above four options narrowing it down to the castle hill. Moreover, the document entitled *Study of the exposure…* [21] presents views from these points at full panorama widths [12]. A summary of the panoramas in different options clearly shows the need for undertaking some form of activity. Additionally, a map of acceptable heights was used as a source of data for preparing and supplementing the options. The map supplements the panoramas and the plan indicates what height ranges of cover in particular parts of the slope would guarantee visual effects visible on the panoramas (Figs. 6, 7).

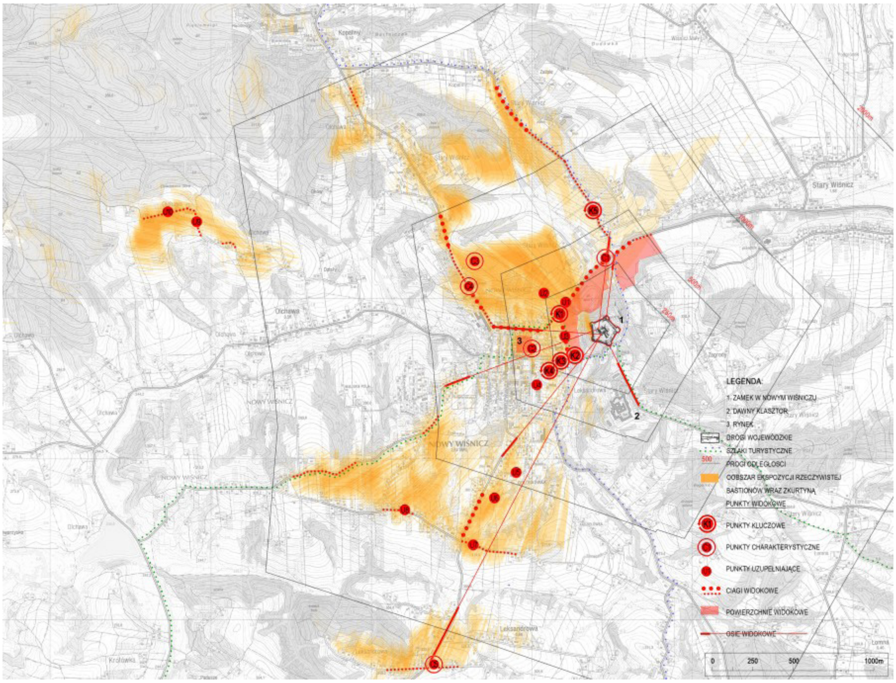


Fig. 5. Elements of active exposure on the map of visibility of the western bastions [21]


Fig. 6. The full panorama width in three options: the current state, the options of exposing the castle hill in the minimal form (O1) and the optimal form (O2) [21]


Fig. 7. Catalogue of panoramas - key point 3 visualisations of scenarios of options of guidelines: the current state, the *do nothing scenario* state, the options of exposing the castle hill in the minimal form (O1) and the optimal form (O2) [21]

### 3.4. Cross sections

The prioritisation of visual points became the basis for preparing a map of the acceptable height of land cover which constitutes the condition for making the castle fortification more visually readable. This map was developed on the basis of detailed cross section beams. The first study of the map was prepared on the basis of key points. Line beams were drawn from the key points and directed towards the exposure object (Fig. 8A). The lines marked the location of cross sections that were generated from the terrain model. These formed the background for the first study of the acceptable height of elements of land cover. For a clearer view from the key visual sequence of Podzamcze street, the first study was supplemented with another layer of data (Fig. 8B). Placing both layers of data resulted in a map. The parameters ensured exposure both from the key points and the key visual sequence at Podzamcze street. The map shows the acceptable sizes of cover elements as levels.

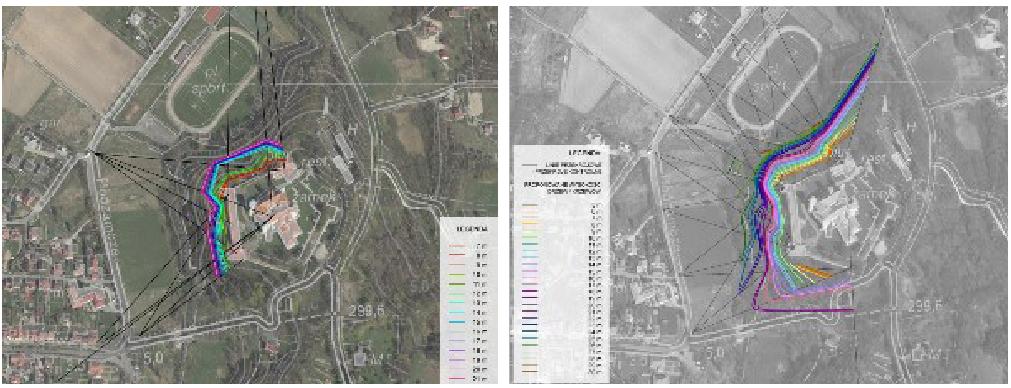


Fig. 8. A – The first study of acceptable terrain cover height based on views from key points,
B – The second study taking into account the view from nearby visual sequences [21]

### 3.5. The degree of visibility

The degree of exposure is a factor that allows us to measure the effects of actions for correcting the visibility of certain elements. It is a tool for gaining more detailed information in relation to the viewshed. This is because the viewshed indicates the area from which a given object or a part of the object is visible. The visibility degree gives us information regarding whether or not the object is visible as a whole or just partially[3].

This is key information in relation to line and surface objects. In this case, the studied degree of exposure was of the western curtain with bastions around it. In order to obtain the data related to the exposure of the most attractive part of the fortifications, facing the

3 A method of studying the degree of visibility was applied numerous times when working on exposure of line elements. A summary of this research can be found in *Visible space. A visual analysis in the landscape planning and designing* [5].

centre of Nowy Wiśnicz, a sequence of checkpoints was placed on the wall. The beginning determines the coefficient for potential visibility and hence its threshold. Next, the degree of exposure of the current state and the designed state in optionsO1 and O2 was calculated. The degree of visibility shows what wall length would be visible from a given area. The degree of visibility '0 VD' indicates full shade. From the area marked '0', no part of the studied object would be visible. On the map, this area is marked in black. The degree of visibility '5 VD' means that from this area, the wall would be visible in full over its entire length. Intermediate values successively show which part of a studied element would be visible. Areas marked '4 VD' means that it will be over three-quarters of the length of the studied element; degree of visibility '3 VD'means that from a given area, over half but no more than three-quarters of the wall would be visible . Areas marked '2 VD' means that less than a half of the wall would be visible but no more than one quarter. As a result of the above, 1 VD means that the wall would be visible from this area but less than one quarter of it. An analysis of potential exposure, i.e. visual possibilities that are characteristic of this part of the fortification, would yield data regarding the maximum degree of visibility of this object. The largest possible area with the possibility of viewing the wall is the area of its potential exposure. For a greater clarity of data, the calculations assume that it constitutes 100%. Because of this, any further measurements of visibility indicate the percentage of visible space against the one that can be seen.

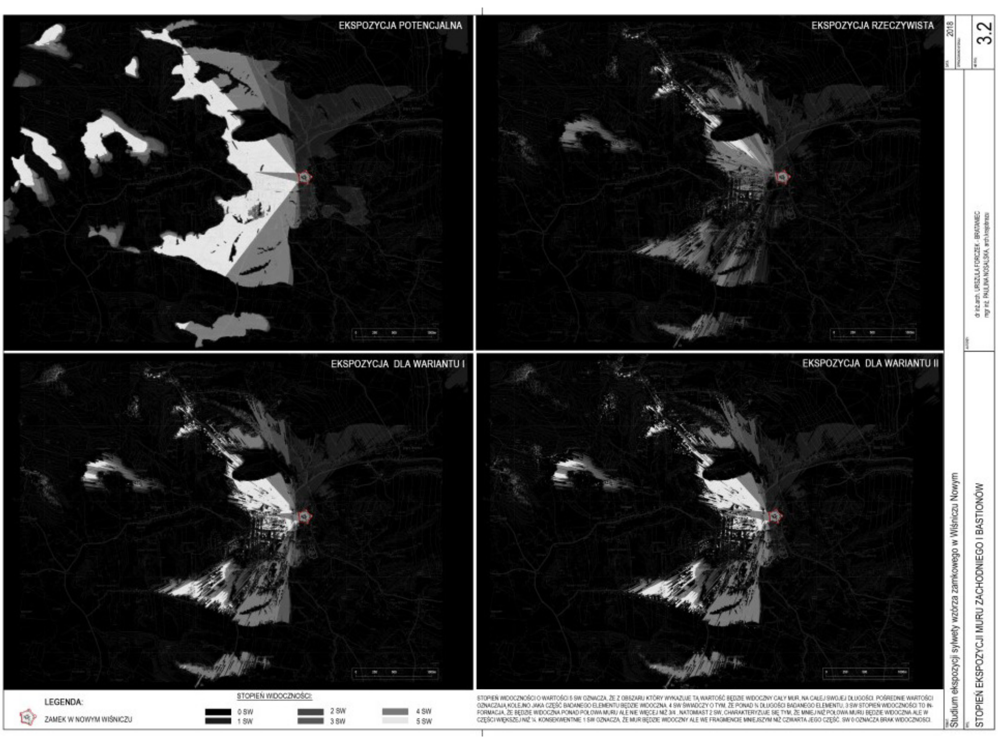


Fig. 9. Boards presenting the degree of exposure A-for potential exposure, B - for the current state, C - for option O1, D- for option O2; colour markings ■ 0VD, ■1VD, ■ 2VD, ■3VD, ■ 4VD, □ 5VD

On the basis of the determined degree of visibility, every place on the map located within the study range is identified with regard to the visual impact of a studied element. In this way, one can precisely indicate the changes that will take place in the visibility of the bastions and curtains, on the market surface, at key points, or in sections of visual sequences. When comparing the analysed options, we can observe much greater visibility of the curtain and the bastions for the second option. The fourth and fifth degree of visibility covers a larger area, which means that the entire studied line as well as more than three-quarters of its length will be visible from 20% of the analysed area, while option 1 indicates only 14%. A larger area from where the fortifications will be visible translates directly into their better legibility in the landscape (Fig. 9, Table 1).

Table 1. Analysis of exposure degree for options O1 andO2

| Visibility degree | 0 VD 0 | 1 VD 0-1/4 | 2 VD ¼-1/2 | 3 VD ½-3/4 | 4 VD ¾-1 | 5 VD 1 |
|---|---|---|---|---|---|---|
| A) Potential exposure | 0% | 28% | 5% | 7% | 25% | 35% |
| B) Real exposure | 55% | 28% | 4.5% | 5.5% | 6.5% | 0.5% |
| O1) Option1 | 53.5% | 26% | 2.5% | 4% | 8% | 6 % |
| O2) Option 2 | 53% | 17.5% | 5% | 4.5% | 12% | 8% |

## 4. Conclusions

### 4.1. General conclusions

The case of Nowy Wiśnicz draws attention to the need for the continuous protection of both historic value sites and their surroundings. The significance and value of the site as well as the preserved landscape requires adequate exposure in order to highlight its greatest values in the urban space. Many years of negligence and wrong decisions by the management of the terrain surrounding the castle have resulted in the transformation of the cultural landscape and, consequently, the gradual reduction of the exposure of the castle in the landscape of Nowy Wiśnicz. An analysis of archive materials in the form of iconography has fully justified undertaking activity for making the castle and its surrounding fortifications that constitute an integral whole in the form of a Baroque fortress more readable. An analysis of the planning data forms the legal basis for intervention since the object is located within an area of strict protection. It is also surrounded by an indirect protection zone. This data matches the zones of exposure protection where the view of the castle hill is the subject of the utmost attention. Available data in source materials regarding the natural environment and the greatest concentration of bat flight routes prove that the area that requires redevelopment of afforestation is located within a certain distance from the main cluster of flight corridors. The proximity makes terrain development possible which in turn makes exposure more readable and safeguards suitable conditions for the protected species. Other natural qualities in the form of compliance with the habitat and the issue of stability of the slope provide support for the local redevelopment of afforestation and hence its improvement (Fig. 10).

### 4.2. Conclusions from the visual analysis

As a result of the conducted research, exposure elements were located in the form of points, sequences, and visual areas. These are sites from which exposure is still the most attractive. Due to the gradual expansion of development and the disappearance of many former visual connections, these elements require specific attention and protection. This is also justified in the *do nothing scenario* covered in the analysis. It demonstrates visual effects of further failures to provide care, which indicates the necessity to take immediate steps.

As a result of the analyses, two options of intervention were developed in order to restore the castle hill crowned with a world class monument. The presented options could be treated as the first and second phase of actions. The first option (O1) determines the minimal range of greenery correction that enables partial exposure of the castle and minimal exposure of the fortifications. These works should be completed as soon as possible. They are vital due to their visual values and also because of the risk of the deepening erosion of the hill caused by expansion of the spruce trees. The second option (O2) is the target state that is to be achieved when conducting care works of the castle hill. It constitutes the second phase of protection activities. It determines the permitted height of the base layer of the cover in the surroundings of the castle. Moreover, it defines zone of exceeding the height dimensions, the zone of absolute prohibition of exceeding the land cover height as well as a special zone adjacent to the site for the bat flight routes.

**Option 1** includes the removal of the spruces and other trees that are closest to the fortification walls from the north. This is a minimal strategy, and is aimed at stopping the process of covering the hill from the city with a dense number of evergreen trees. Both in summer and in winter, they are like a tight veil which has been increasingly limiting the visibility of the castle over recent years. The northern side has been selected as the key view. Due to the configuration and thick growth of trees closest to the bastions and curtains by the walls, the castle is almost completely covered. The trees present there are mainly deciduous; therefore, in winter the castle is visible through them and it is clear that its further uncovering requires only small corrections. Removal of the spruce trees as proposed in option 1 is necessary not only for visual reasons but also for the stability and durability of the slope. Spruces are types of trees that facilitate erosion. They have a shallow root system, while the proportion of the overground component to the underground parts poses a great threat to the stability of the slope. Therefore, it is recommended that a method of tree removal be planned for taking into account a permanent method of its implementation. It is essential that the total removal of greenery from the terrain is prohibited as there is a risk of deeper erosion.

**Option 2** proposes the major reconstruction of greenery on the hill while indicating acceptable height of different land cover types. This is the target option for the basis of development of the design of the castle hill with regard to continuous reconstruction of afforestation. This option includes the following: the concentration of activity in the western part of the hill due to the main direction of its exposure; preservation of greenery in the eastern part would provide the background and unmodified natural conditions for the population of bats living in the castle; moving plantings five metres away from the wall; shaping the main green mass on the basis of the limits of height levels arising from the visual analysis; preserving marshy meadows at the foot of the hill; preserving the most precious greenery, natural monuments and introducing groups of vegetation necessary for maintaining and strengthening wildlife corridors, i.e. corridors for bat movements. The visualisations present visual effects for the implementation of both options in the form of key panoramas. The coefficient of the visibility degree prepared for them demonstrates the surface level of changes in the exposure. It shows which part of the western fortification would be visible from particular points in the surrounding terrain.

A detailed visual analysis allowed us to define the conditions for making the castle hill more readable. The findings are presented in numerical form, in the form of maps and clear visualisations of the design state. The *do nothing scenario* state is also considered. Additionally, the study contains detailed guidelines regarding land use as well as composition and technical guidelines for the design of the greenery development. Further stages of proceedings were

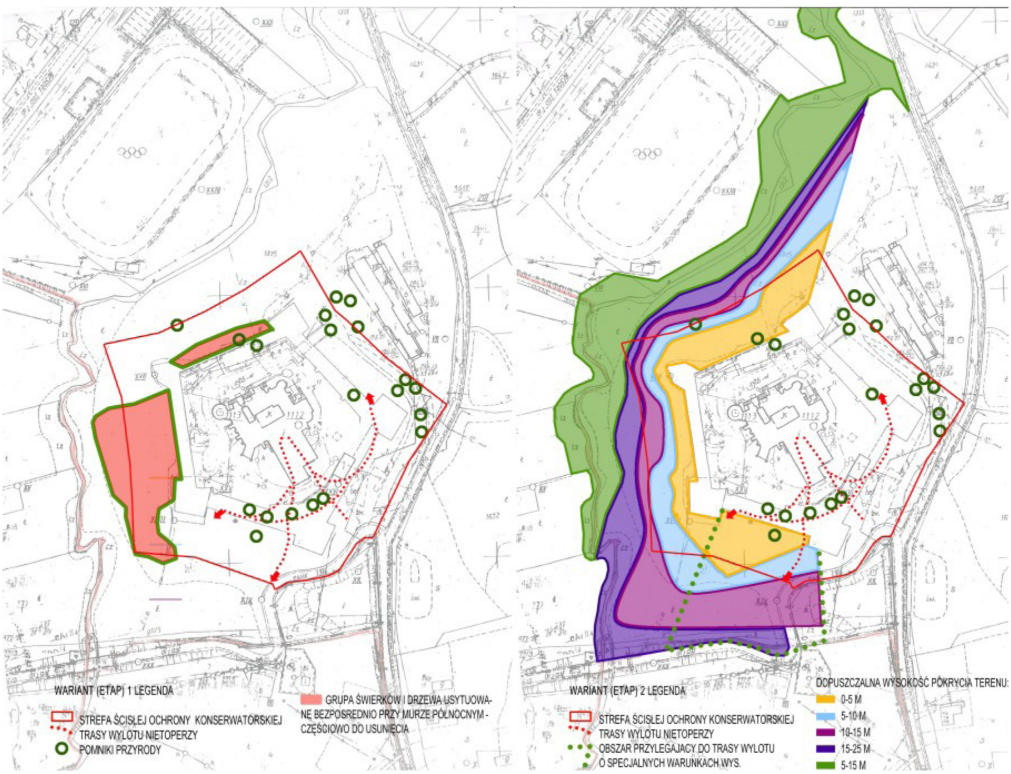


Fig. 10. The first and second option of the intervention to make the castle hill more readable [21]


Fig. 11. Guidelines for designing greenery development[21]

prepared in the form of: 1. a detailed greenery design preceded by several necessary source materials, such as a greenery inventory, and an analysis of the degree and type of erosion on the hill; 2.a specification of major bat habitats and flight zones. Collecting this data indicates the most valuable trees, the sites requiring utmost precaution in terms of erosion, and areas that are sensitive due to the presence of bats.

The guidelines define the threshold for terrain cover but the above-mentioned arguments make it possible to exceed this threshold in some areas. As a result, necessary conditions for the integration of protecting the natural and cultural values are ensured while the safety and stability of the slopes is preserved (Fig. 10).

## 5. Summary

The landscape of Nowy Wiśnicz represents a considerable number of cases in which the protection of a historic value site fails to go hand in hand with the protection of its surroundings. This is proof that even in the existing legal framework the passive approach to protection can be harmful or even pose a threat to the place of historic value itself as a result of uncontrolled processes, such as the erosion of natural succession. As a result of the gradual overlapping of these phenomena, the protection of a landscape complex of historic value takes on the form of multiple multifaceted issues which include contradictory grounds for situations of conflict. Lack of a clear strategy prolongs the whole process which in turn poses a threat for the whole site of historic value.

Taking the decision to prepare *Study of exposure…* [21] in this case opened a discussion and helped set out an action plan for the future. An analysis of the visual exposure covering both close and distant views set out the necessary spatial frames for the desired landscape effect. As a result of this, the implementation of further steps in the form of development and management that takes into account both natural and cultural values will enable obtaining the appropriate landscape framework.

## References


[1] Dąbrowska-Budziło K., *Wśród panoram Krakowa. O przemianach widoków i o tym jak je ocalić*, WL, Warszawa 1990.

[2] Flagorowska L., *Metoda wyznaczania zakresu widoczności dla potrzeb architektury krajobrazu*, Cracow University of Technology, Kraków 1981.

[3] Forczek-Brataniec U., *View from the Road. Landscape in Dynamic Perception*, Katowice 2008.

[4] Forczek-Brataniec U., *The degree of visibility as a tool to assess and design of a visual corridor*, [in:] Greenways and Landscapes in Change: proceedings of 5th Fábos Conference on Landscape and Greenway Planning (Budapest, 30 June, 2016), Szent István University, Department of Landscape Planning and Regional Development, Budapest 2016, 295–302.

[5] Forczek-Brataniec U., *Visible space. A Visual Analysis in the Landscape Planning and Designing*, Cracow University of Technology, Kraków 2018.

[6] Litton R.B., *Descriptive Approaches to Landscape Analysis*, [in:] *Proceedings of Our National Landscape, A Conference onApplied Techniques for Analysis and Management of the Visual Resource*, Gen. Tech. Rep. PSW-GTR-35. Berkeley, CA.Pacific Southwest Forest and Range Exp. Stn., Forest Service, U.S. Department of Agriculture, Incline Village 1979, 77–87.

[7] Majewski A., *Zamek w Wiśniczu*, „Teka Konserwatorska" 1956, Vol. 3, 3–102

[8] Majewski A., *Zamek w Wiśniczu*, Nowy Wiśnicz 1992.

[9] Marcinek R., *Nowy Wiśnicz niezwykły świat polskiego baroku*, Zamek Wiśnicz, Nowy Wiśnicz 2018.

[10] Myczkowski Z., Forczek-Brataniec U., *Visual aspects of a place's identity – conflicts*, "Technical Transactions", Vol. 5A/2007, 150-152.

[11] Ozimek P., Ozimek A.,*Visibility Method for Landscape Analyses in Historical City Center Environment*, [in:] *8th International Conference on Information Technologies in Landscape Architecture*, Dessau 2007, 380–391.

[12] *Visual Representation of Windfarms Good Practice Guidance,* Prepared for Scottish Natural Heritage, The Scottish Renewables Forum and the Scottish Society of directors of Planning, H+M, Envision, Inverness, Edinburgh 2006.
[13] Siewniak M., R*ola i funkcja drzew pomnikowych w krajobrazie kulturowym i zasady ich ochrony*, [in:] *Miasto-ogród: sto lat rozwoju idei,* eds. M. Siewniak, J. Hrynkiewicz-Sudnik, DWN, Wrocław 1998, 97–105.
[14] Siewniak M., *Rola i możliwości wykorzystania roślinności do trwałego zabezpieczenia skarp w nawiązaniu do katastrof Kopców Piłsudskiego i Kościuszki,* Spraw. Pos. Komis. Nauk. PAN Kraków 1999, Vol. 42/1998, 153–154.
[15] XVII century map of Dahlberg/Pufendorf.
[16] *Koncepcja zagospodarowania zieleni na Wzgórzu Zamkowym oraz studium stref ochronnych dla miasta i Zamku w Wiśniczu Nowym*, by: J. Bogdanowski, W. Genga, Z. Myczkowski, K. Fabijanowska, Kraków 1979.
[17] *Study of Conditions and Directions of Spatial Development of the City and Commune of Nowy Wiśnicz* authors: A. Skoczek., E. Kaczmarska, A. Boratyński, W. Gleń, M. Halagarda, M. Niemirowski, J. Niemirowska, W. Zaleski, S. Sroga; the concept and development of conservation zones: K. Kuśnierz; main designer: E. Kaczmarska, 1996–1997.
[18] *Local Spatial Development Plan of Downtown of Nowy Wiśnicz*; authors: A. Skoczek., E. Kaczmarska, A. Boratyński, W. Zaleski, S. Sroga; the concept and development of conservation zones: K. Kuśnierz; plan forecast - M. Niemirowski, J. Niemirowska main designer: E. Kaczmarska, 1997–1998.
[19] *Local Spatial Development Plan* „Śródmieście" Nowego Wiśnicza. Law No. IX/53/2007 of the City Council in Nowy Wiśnicz from 31 August 2007. Małopolska Region Official Journal No. 178 from 12 March 2008.
[20] *Nowy Wiśnicz, krajobraz kulturowy doby baroku. Wniosek o uznanie za pomnik historii*, by: R.Marcinek, A. Siwek, maps: M. Myczkowska-Szałankiewicz, Nowy Wiśnicz 2017.
[21] *Studium ekspozycji sylwety wzgórza zamkowego w Nowym Wiśniczu w zakresie jego uczytelnienia w krajobrazie/ A study of the visual exposure of the castle hill in Nowy Wiśnicz in terms of its greater legibility in the landscape,* by: U. Forczek-Brataniec, P. Nosalska, dendrological consultation: M. Siewniak, historic preservation consultation: R. Marcinek, 2018.

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# Jordanów – the town's genesis, urban layout and heritage protection. Initial remarks

# Jordanów – geneza powstania, układ urbanistyczny oraz problematyka ochrony dziedzictwa kulturowego. Uwagi wstępne

**Abstract**

This article discusses the history of the spatial development of the town of Jordanów, as well as the cultural heritage sites located inside the territory of this urban centre. Jordanów, currently located within the administrative area of the Lesser Poland Voivodship, in the district of Sucha, was founded as a private town in 1564 and issued a charter by the Krakow Voivod Spytek Jordan of Zakliczyn. The urban centre is an example of a town which was founded in cruda radice–i.e. on previously undepeveloped land–during the early modern period but whose model bears a similarity to traditional urban forms used in previous centuries.
**Keywords:** Jordanów, Jordanów's urban layout, Jordanów's cultural heritage

**Streszczenie**

Niniejszy artykuł dotyczy problematyki historii rozwoju przestrzennego miasta Jordanów oraz zabytków dziedzictwa kulturowego zlokalizowanych na terenie tego ośrodka. Jordanów, położony obecnie w granicach województwa małopolskiego, w powiecie suskim, został założony jako miasto prywatne w 1564 roku z fundacji wojewody krakowskiego Spytka Jordana z Zakliczyna. Ośrodek jest przykładem miasta, które lokowano na surowym korzeniu w okresie nowożytnym, ale jego rozplanowanie nawiązuje do tradycyjnych form urbanistycznych stosowanych w wiekach wcześniejszych.
**Słowa kluczowe:** Jordanów, układ urbanistyczny Jordanowa, dziedzictwo kulturowe Jordanowa

## 1. Introduction

The goal of this study is to present an analysis of the genesis of the town of Jordanów, its charter-period urban layout–developed in accordance with its original town charter – and its heritage sites in the context of highlighting their value and the need to renovate and protect them.

The town of Jordanów is located in the Lesser Poland Voivodship, in the district of Sucha. In administrative terms, it is the seat of a rural municipality. The urban centre was founded in 1564 near the Skawa river, in the Rabka basin, in the southern foothills of the Beskid Makowski mountain chain. Jordanów is an example of a modern-period urban layout – an economic centre featuring references to Medieval traditions in its plan, with a well-preserved spatial structure that should be protected because of its high cultural value.

Economic centres in the Land of Krakow were essentially founded between the sixteenth and the eighteenth century. These were economic centres of territorial units (village complexes, called *klucze* in Polish sources), fulfilling trade-related functions associated with the exchange of goods, including the selling of craft products. These economic centres differed in size and their functional and spatial programme, as well as their role and significance within their respective regions, which led to their division into simple and complex layouts. Complex layouts were characterised by relatively small areas and were primarily associated with local trade. The complex layouts, in turn, were larger towns or cities, which, apart from a trade-related form of use, also featured other functions which were not necessarily linked with

Fig. 1. Jordanów on a contemporary aerial photograph, view from the south-west (Photo by W. Gorgolewski, 2017)

the primary role of a given *latifundium*. The urban layout of Jordanów should therefore be regarded as a simple layout, while it should be noted that – when performing an analysis of the use of Renaissance compositional models in its plan – the traditional model of urban space organisation was employed [1].

At present, Jordanów's urban layout per se is not a heritage site listed in the Voivodship heritage sites registry. It has been placed under protection by means of the provisions of the local spatial development plan, which encompasses the territory of the historical town centre. Apart from the town's historical urban layout, the town's territory also includes four listed heritage sites. These are: the church of the Holy Trinity and its surroundings; the town hall located at Rynek 1 (1 Market Square), the building of the former town hall and town court, also located near the market square, at Rynek 2 (2 Market Square); the former inn at 10 Kolejowa Street [2]. The group of listed sites is supplemented by buildings featured in the municipal heritage sites registry, which features a total of 102 items. Among other structures, this list includes: masonry residential buildings located near the market square, largely dated to the years around 1900, nineteenth-century timber residential buildings; public buildings such as the former post office building or the high school building; statues and roadside chapels [3]. The previously mentioned elements of Jordanów's cultural landscape make it one of the more interesting urban complexes in this part of Lesser Poland.

## 2. State of the art

There is a rather limited amount of publications on the history of the founding of Jordanow and its cultural heritage. The most notable publications include: *Geograficzny Królestwa Polskiego i innych krajów słowiańskich* [4, p. 604], published in the years 1880–1914; a monograph devoted to the town from 2013 [5]; the works of Feliks Kiryk, entitled *Rozwój urbanizacji Małopolski XIII–XVI w.* [6]; a monograph by M. Książek entitled *Zagadnienia genezy rozplanowania i typologii miast prywatnych XVI i XVII wieku w południowej Małopolsce* [7]; the works of the author of this article concerning the economic urban centres of the large *latifundia* of southern Poland in the sixteenth and the seventeenth centuries [8].

## 3. History of the founding of the town

The town of Jordanów was founded by Krakow Voivod Spytek Jordan of Zakliczyn in 1564 as a private town. It was founded *in cruda radice*, on the basis of the Magdeburg rights.

The town was linked with the region by a route that ran to the south-west of the town, in the direction of the village of Bystra, a route that ran eastwards, to Naprawa, and another, which led to the northeast, to Łętownia. These latter two were linked to the Myślenice–Nowy Targ route [9, 6, p. 233].

It can be assumed that Jordanów's urban layout was erected on what was formerly the territory of the village of Malejowa, which belonged to the parish of Łętownia. It had already been the site of a chapel of St. Laurence, with its own vicar. Prior to the town's founding, it belonged to the parish in Łętownia, later taking on the function of Jordanów's parish church.

In the town's charter, King Sigismund II Augustus permitted Jordanów's residents to hold markets and fairs on the days of their choosing. Monday was set as market day, while fairs were to be organised during parish festivals. In 1576, by request of Anna Zebrzydowska, King Stephen Báthory issued a charter in which he permitted the town's residents to host two additional fairs: on the day of the Conversion of Paul the Apostle and on the day of St. Giles [6, p. 232].

Spytek Jordan delegated noblemen Stanisław Gostyński, who was the Krakow Vogt, and Jan Biedrzycki, the Myślenice Starost, to carry out the process of the town's founding. Stanisław Gostyński was tasked with founding the town using the model of Krakow, while Jan Biedrzycki's obligations revolved around safeguarding the entire process's finance and settlement side. The *lokators* were primarily aided by the residents of nearby villages, which belonged to the Jordan family [6, p. 232].

Sources indicate that towards the end of the 1560s, the town was already filled with buildings. The mayor and councillors were chosen from among the settlers, who were partially comprised of residents of the villages surrounding Jordanów. The town assembly also included a scribe and town servant. Among the provisions that regulated the centre's functioning, there were also regulations concerning the obligations of the town's authorities, the organisation of fairs, the repairing of roads, the building of houses, forest use, fields, mills and defence. What is interesting is that Jordanów was not bestowed with a hereditary vogt office, which was typically awarded to the *lokators* of a centre. It can therefore be presumed that, in this case, the *lokators* received payment in land or money from Spytek.

Of note is the fact that the owner of Jordanów gave the settlers twelve years of *wolnizna*, which was a period during which they were exempt from all payments (including taxes) [10, p. 56] owed to Spytek Jordan and his descendants. After the adoption of the town charter, every new settler received a plot of land for building a house and a farmland allocation, one half of which was to be assigned for growing crops, while the other was to be a pasture. The settlers built timber houses, which were located near the market square, along the main paths, with barns behind them in the fields. Of note is the fact that Jordanów's residents mostly earned their livelihoods by farming and animal husbandry, in addition to trading and crafts [4, p. 604; 6, pp. 236-237].

It is known that the centre had a hospital for the poor, an inn, a parish house, a bathhouse and a town hall, located on the market square, around ten years after its founding. The buildings were made of timber, but differed depending upon the wealth of their owner [4, p. 604].

## 4. The urban layout of the town

The state of Jordanów as surveyed in the middle of the sixteenth century presents a traditional manner of urban space organisation. It belongs to a group of cities and towns from the southern part of the former Land of Krakow (along with Limanowa and Zakliczyn) which are characterised by 'transitory' layouts. These layouts were a kind of link between Medieval and Renaissance urban planning, preceding the appearance of typically modern-period plans. The urban centres in questions were the economic centres of the vast estates of the Jordan family of Melsztyn.

In its programmatic assumptions, Jordanów was established as a centre of the exchange of goods for a complex of villages and the surrounding region. Spatial solutions that referred to traditional urban settlements were used here. A small, rectangular market square was delineated in the centre of Jordanów, measuring around 81 x 143 metres. Individual urban blocks were delineated around it and were further divided into deep plots, which transitioned into farmland meant for the town's settlers. The concentration of functions and buildings, which significantly differs from the extensive functional programme of the cities of the modern period, can be considered proof of Jordanów's plan referencing traditional urban models from the Middle Ages. The circulation system of Jordanów is likewise noteworthy. Five streets lead out of the town's centre. Two lead eastwards, each extending from a different corner of the market square (the north-eastern and the south-eastern). Another street leads westward, starting at the north-eastern corner of the market square, with the last two leading northwards and southwards from the market square. It should be noted that this circulation layout also features characteristics of Medieval tradition [8, pp. 88–90].

Jordanów's urban plan has been depicted on archival plans: on Mieg's map from the years 1779–1783, on a cadastral plan from the middle of the nineteenth century, and on the second military survey from the years 1861–1864. It should be noted that this modern-period urban layout has survived almost unchanged to the present day. This was proven with the use of a research procedure developed by D. Kuśnierz-Krupa [11], which is based on, among other things, comparing archival cartography with a contemporary orthophotomap.


Fig. 2. Jordanów on Mieg's map from 1779-1783, copy [from:] archive of the Chair of the History of Architecture, Urban Planning and Art, CUT FoA, s.v.

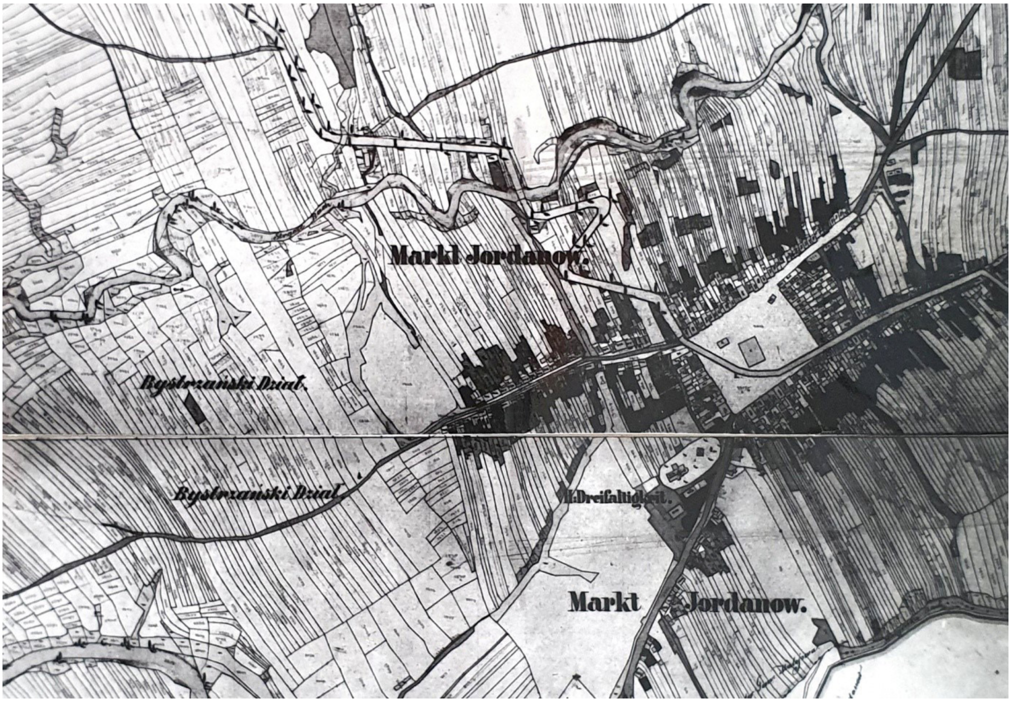


Fig. 3. Jordanów on a cadastral plan from 1844, photo [from:] archive of the Chair of the History of Architecture, Urban Planning and Art, CUT FoA, s.v.


Fig. 4. Jordanów on the second military survey from 1861-1864, copy [from:] archive of the Chair of the History of Architecture, Urban Planning and Art, CUT FoA, s.v.

Fig. 5. Jordanów on a contemporary orthophotomap (Photo by W. Gorgolewski, 2017)

## 5. Conclusion

The historical value of Jordanów's cultural heritage is indisputable. The modern-period urban layout, which represents a group of simple layouts developed on the basis of traditional urban planning models of the Middle Ages, is of particular historical value. In addition to Jordanów, this group also includes towns like Limanowa, Zakliczyn or Lutowiska.

Because of the aforementioned reason, the urban layout in question should be placed in the heritage sites registry. At present, its conservation, as well as that of other elements of Jordanów's cultural heritage, is enforced by the provisions of the town's local spatial development plan. The plan stipulates, among other things, that the town's cultural landscape and urban layout within the area covered by the plan is to be placed under protection, along with immovable historical monuments (buildings, structures and complexes) listed in the heritage sites registry (along with their surroundings). Also to be placed under protection according to the plan are historical monuments listed in the municipal heritage sites registry, in addition to archaeological research sites. Of note is also the obligation to protect buildings, other structures and complexes thereof that are listed in the heritage sites registry as being within territories outlined in decisions concerning placement in the heritage sites registry, as marked on the plan's graphical appendix. This provision applies to structures and complexes such as the parish church with its furnishings and tree stands, the town hall and the Market

Square within the area outlined by the lines of its frontages, the statue of St. Nepomucen and the former 'Poczekaj' inn. The local spatial development plan also stipulates an obligation to protect the historical urban layout of the town centre within the area outlined in the plan as a 'conservation zone'. The object of protection is understood here as the spatial urban layout, including the market square with its primary street layout, its buildings in the form of the market square's frontages and the streets that extend out of it, heritage sites listed in the heritage sites registry and placed in the municipal heritage sites registry, as well as old trees. The provisions of the local spatial development plan impose constraints on measures that could significantly alter the historically developed character of the layout and introduce, among other things, adapting the size and architectural form of newly designed buildings to those that predominate in the individual frontages and groups of buildings. One important aspect of the protection of Jordanów's cultural landscape is also the obligation to protect the 'skyline' of the central complex.

In conclusion, it should be stated that guidelines associated with the protection of Jordanów's heritage sites and spaces, as written in the local spatial development plan, do protect the town's cultural landscape. However, it should be noted that for this protection to be complete, then in light of applicable regulations, the charter-period urban layout, which possesses indisputable historical value as determined earlier in the article, should be placed in the voivodship heritage sites registry. This would provide it with better protection and ensure properly conducted revalorisation.

## References


[1] Kuśnierz K., *Rynki wybranych miast nowożytnych w Małopolsce – cz. 1 (ośrodki gospodarcze) / Market squares in the selected modern towns in Lesser Poland – p. 1 (economic centres),* "Wiadomości konserwatorskie – Journal of Heritage Conservation" no. 55/2018, 135–140.

[2] Rejestr Zabytków Województwa Małopolskiego, www.wuoz.malopolska.pl (online: 15.10.2019).

[3] Miejscowy plan zagospodarowania przestrzennego miasta Jordanów, Uchwała Nr XXXVI/245/2006 Rady Miasta Jordanowa z dnia 26 czerwca 2006 r. w sprawie miejscowego planu zagospodarowania przestrzennego Miasta Jordanów. app. no 5.

[4] *Słownik geograficzny Królestwa Polskiego i innych krajów słowiańskich*, Publ. Filip Sulimierski and Władysław Walewski, Warszawa 1880–1914, vol. 3.

[5] *Jordanów. Monografia miasta*, S. Bednarz, P. Sadowski (ed.), Publ. Prasa Beskidzka, Bielsko-Biała 2013.

[6] Kiryk F., *Rozwój urbanizacji Małopolski XIII-XVI*, Wydawnictwo Naukowe WSP, Kraków 1985.

[7] Książek M., *Zagadnienia genezy rozplanowania i typologii miast prywatnych XVI i XVII wieku w Południowej Małopolsce*, Wydawnictwo PK, Kraków 1988.

[8] Kuśnierz K., *Miejskie ośrodki gospodarcze wielkich latyfundiów południowej Polski w XVI oraz XVII wieku*, Wydawnictwo PK, Kraków 1989.

[9] Książek M., Kuśnierz K., Wójcikiewicz M., Malik R., Motak M., *Ziemia Krakowska. Studium struktury osadniczej i sieci dróg*, Gdańsk-Kraków 1990, typescript [in:] Chair of the History of Architecture, Urban Planning and Art, CUT FoA.
[10] Kuśnierz-Krupa D., *Jaśliska w średniowieczu na tle miast dawnego powiatu bieckiego*, Wydawnictwo PK, Kraków 2013.
[11] Kuśnierz-Krupa D., *Original historical spatial development research methodology on the example of the town of Skawina in Lesser Poland*, "Landscape Architecture and Art" no. 14/2019, 18–23.

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# The architecture of the town wall gates and towers in Bystrzyca Kłodzka between the fourteenth and twentieth centuries

## Architektura bram i wież murów miejskich Bystrzycy Kłodzkiej od XIV do XX wieku

**Abstract**

The results of research into two city gates, Kłodzka and Wodna (Water), and into the Rycerska (Knight's) Tower in Bystrzyca Kłodzka are discussed in this paper. The research into the architecture of the three structures helped review the chronology of transformations they were subjected to between the beginning of the fourteenth century and the second half of the twentieth century. The city walls, together with the two gates and the tower, were probably erected by Alderman Jakub Rücker in the first half of the fourteenth century. All the towers were probably raised and converted in the fifteenth century and in around 1568, they were topped with masonry pyramid cupolas. The work performed in the nineteenth century was aimed at restoring the damaged elements and at introducing bells to the Rycerska (Knight's) Tower. The conservation work conducted in the years 2013–2017 resulted in the restoration of the damaged details and in the enhancement of all of the structures' features of historical value.

**Keywords:** Silesia, architecture, city gates, Gothic, the Renaissance

**Streszczenie**

Artykuł omawia wyniki badań dwóch bram miejskich: Kłodzkiej i Wodnej oraz wieży Rycerskiej w Bystrzycy Kłodzkiej. Bazując na badaniach architektonicznych trzech obiektów możliwe było przeanalizowanie chronologii ich przemian w okresie od początku XIV do II połowy XX wieku. Przypuszczalnie w pierwszej połowie XIV wieku wójt Jakub Rücker wzniósł mury miejskie z dwoma bramami i wieżą. W XV wieku prawdopodobnie wszystkie wieże podwyższono i przebudowano a w około 1568 roku zwieńczono murowanymi ostrosłupowymi hełmami. Prace zrealizowane w XIX wieku miały na celu odtworzenie zniszczonych elementów oraz wprowadzenie w wieży Rycerskiej - dzwonów. Podczas prac konserwatorskich zrealizowanych w latach 2013–2017 przywrócono zniszczony detal oraz wyeksponowano zatarte formy historyczne wszystkich obiektów.

**Słowa kluczowe:** Śląsk, architektura, bramy miejskie, gotyk, renesans

## 1. Introduction

Bystrzyca Kłodzka (*Habelschwerdt* in German, *Kladská Bystřice* in Czech) is situated in Kotlina Kłodzka, a basin north of Bohemia, near the Silesian boarder. It was situated on the trade route that linked Wrocław with Olomouc and Brno via Kłodzko. The date of the establishment of the town remains unknown because the establishment charter is lost. Therefore, the thesis advanced by Rafał Eysymontt that it was established in the second half of the thirteenth century [4, p. 265] seems to be probable. A record dated 4 July 1319 states that an aldermanship was established and that the city was surrounded by a wall by Alderman Jakub Rücker [1, No. 3929]. The original city had an oval plan that was elongated northwards. It was situated on a small upland and surrounded from the south and east by two rivers, the Nysa Kłodzka and the Bystrzyca. The medieval enclosure originally had two gates – Kłodzka in the north and Wodna (Water) in the south – in its north-east corner, it was strengthened with a fortified tower. In 1580, the Nowa (Wyszewicka) Gate [2, p. 113][1] was built near the parish church. The first two gates referred to above and the Rycerska (Knight's) Tower have survived until the present time.

## 2. Description of Kłodzka and Wodna (Water) Gates and the Rycerska (Knight's) Tower

The Kłodzka Gate tower is situated in the north part of the town , on the west side of the present Stefan Okrzeja Street. It was erected on a 6.1/6.3 metre, square-like plan. The structure consists of a high cuboidal core and is topped with a low attic wall with an openwork balustrade, which surrounds a high plastered pyramid-shaped cupola. Up to a height of almost 19.7 metres, the elevations are unplastered and expose rough-stone and partly finished with ashlar bonding. The entrance is located in the basement of the east elevation. The naked wall of the former gateway can be seen above it; together with a roofing mark; the tower reaches a height of almost 12 m. above the present ground level. There are two narrow windows, of which the upper window is in place of the former doorway that led to a walkway. Other, stone-framed windows, were about 17.7 m above ground level, just beneath the walkway balustrade. There were two such windows on each of the elevations. The entire structure was topped with an octagonal pyramid cupola; an entrance to the walkway was located on the cupola's west elevation. From the north, there is the remnants of a chimney. In the pyramid finial, there is a forged iron spire, although this is lacking an ensign and a ball. The rainwater from the walkway is drained via four gargoyles, which are situated along the wall axes; three of these are made of stone and the northern most is made of metal. The tower is embedded into the buildings of the west frontage of St. Okrzeja Street (Fig. 1a, b).

The second of the city gates, Wodna (Water) Gate, is situated on the slope that falls down to the river in the south-east part of the establishment of the town. It was erected in a niche

[1] The gate can be seen on a plan view of Bystrzyca dated 1739 and that was published in 1862 [14, Table 19]. Item 3 shows a building covered with a gable roof (this may be the gate building) and a semicircular gateway. The gate was demolished in 1842 [2, p. 116].


Fig. 1. a) Bystrzyca Kłodzka, Kłodzka Gate's tower, view from the east (before conservation works) (photo by A. Legendziewicz), b) Bystrzyca Kłodzka, Kłodzka Gate's tower, view from the east (after conservation works)(photo by A. Marcinów)

between the city enclosure and the former alderman's tower enclosure. It was the setting of the entrance from the Czech side. The gate has a trapezium-like plan of 8.7/6.5 m.. The stone core is topped with an attic in the form of crenellations and with a high, plastered pyramid cupola. The almost 12-metre-high elevations with exposed, machined rough stone bonding have retained their plasterwork. There is a lancet recess along the south elevation's bay axis; it has a cut stone frame and originally housed a portcullis. Beneath, at ground level, there is a gateway; it is surrounded by two stone frames, of which one has shaped heads and arcades with bevelled edges. On the elevation, there are also two other window openings – the first is almost at the base of the portcullis recess arch, square in shape, framed in a stone with bevelled edges and has a sill and the second is narrow, rectangular and positioned above the lancet. The entrance from the direction of the city is located in the north elevation, around 6.5 m above the ground level. It's setting consists of an almost semi-circular archivolt that is based on two secondary posts. The entrance is preceded by stone steps; the steps are built on an arcade that is added to the tower wall. Above the stairs, almost along the bay axis, there are two stone-framed slot windows; the lower, square window is made of the second time used elements, the upper window is slot, stone-framed. On the west elevation, there is a reconstructed latrine bay that is is based on two stone consoles. All the walls except for the west wall are topped with an brick attic in the form of crenellations. The tower is covered with a high pyramid-shaped cupola that has an irregular octagonal plan (Fig. 2a, b; 3 a, b).

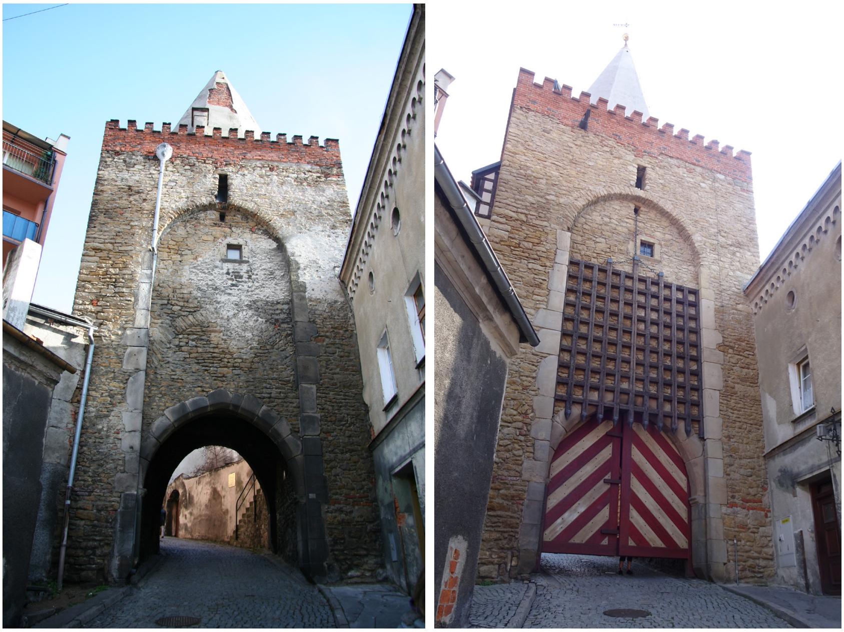

Fig. 2. a) Bystrzyca Kłodzka, Wodna (Water) Gate, view from the south (before conservation works) (photo by A. Legendziewicz), b) Bystrzyca Kłodzka, Wodna (Water) Gate, view from the south (after conservation works) (photo by A. Marcinów)

Fig. 3. a) Bystrzyca Kłodzka, Wodna (Water) Gate, view from the north (before conservation works) (photo by A. Legendziewicz), b) Bystrzyca Kłodzka, Wodna (Water) Gate, view from the north (after conservation works) (photo by A. Marcinów)


Fig. 4. a) Bystrzyca Kłodzka, Rycerska (Knight's) Tower, view from the south (before conservation works) (photo by A. Legendziewicz), b) Bystrzyca Kłodzka, Rycerska (Knight's) Tower, view from the north (after conservation works) (photo by A. Marcinów)

The Rycerska (Knight's) Tower is the last of the surviving towers. It is located in the north-eastern part of the enclosure, on the edge of the area that slopes down to the Nysa Kłodzka river. It was built in the place where the city hill sloped down steeply to the river. This is probably the endpoint of a dry moat that strengthened the enclosure's north and east segments. Adaptation work performed in 1843 resulted in the construction of inner stairs to the belfry and in the installation of two bells on the top floor. West of the tower, there is an arcade that links the tower with the building of a former evangelical church (at present, the Phillumeny Museum) [2, p. 113]. The tower has a 5.2/5.3 m square-like plan. It is topped with a low attic wall, of which a high polygonal pyramid cupola arises from behind.

Up to a height of almost 18.5 m, the elevations are not plastered and expose rough-stone and are partly finished with ashlar bonding. The entrance is situated in the south elevation's at the ground level. Above the entrance, at a height of around 6.2 m above the present ground level, there are two partly demolished consoles of a porch. Above the brackets, at a height of around 8.7 m above ground level, there is a stone-framed lancet entrance opening. Below the opening, at the sill level, there are two stone brackets. On the west elevation, there is the second opening, which is bricked in now and which led to the curtain wall; below it, there is a mark of a demolished wall. Small, rectangular slot openings were built in the elevations: one each on the south and east elevations and three on the north elevation. The tower's last storey is decorated with brick-framed, lancet biforium openings (Fig. 4 a, b).

The tower is topped with a low attic wall that terminates a stone slab walkway. From that level, the rainwater is drained via four stone gargoyles, which are situated along each elevation's bay axes. The structure is covered with a high pyramid brick cupola that is octagonal in plan and has a spear with a ball and a cross.

## 3. Discussion of sources, literature and iconography

The oldest record of the construction of the wall enclosure and of the gates appeared in a document issued by John of Bohemia on 4 July 1319. It confirmed that the town of *Habelswerde* had been surrounded with walls by Alderman Jakub Rückner [1, No. 3929]. The walls were first discussed by H. Lutsch, who pointed to the time of construction indicated in the above-mentioned record [10, p. 56]. The position was supported by F. Volkmer [17, p. 4] and E. Keyser [5, p. 769]. Similar results of the dating of the city fortifications, including that of the Kłodzka and Wodna (Water) Gates were also based on the 1319 record and quoted by T. Dziewulski [3], M. Przyłęcki [15, p. 99], K. Bartnik [2, p. 110], J.Pilch [12, p. 28; 13 p. 41], M. Ruchniewicz, S. Rosik, P. Wiszniewski [16, pp. 24, 28], R. Eysymontt, [4, p. 265] and A. Małachowicz [11, p. 37].

General information about modernisation work on the walls in the fifteenth century was given by M. Przyłęcki [15, p. 99] and also by A. Małachowicz [11, p. 37]. The authors were not precise about whether the work also applied to the city gates and the Rycerska (Knight's) Tower or not. Of vital importance to considerations of modern transformations to the city fortifications is the information of 1568 concerning city brickworks, which is quoted by Z.

Dziewulski [3, p. 14]. The author links the existence of the brickworks with alterations to the gate towers and the Rycerska (Knight's) Tower. Similarly, K. Bartnik dated the cupolas of the two gate towers to the same year, and considered the Rycerska (Knight's) Tower finial as younger and dated it to 1608, although she did not refer to any source [2, p. 124]. The author mentioned unidentified work on the Kłodzka Gate in the nineteenth century [2, pp. 111–112]. The demolition of Bystrzyca Kłodzka fortifications commenced in 1840 in the opinion of some researchers [12 p. 28; 13, p. 41; 15, p. 99; 11, p. 37]. K. Bartnik dated the demolition of the Kłodzka Gate to 1843 [2, p. 116].

At the same time as the demolition of the Kłodzka Gate, the Rycerska (Knight's) Gate was converted to an evangelical church bell tower [2, p. 126; 2 p. 28; 13, p. 41; 15, p. 99; 11, p. 38]. The Water Gate was converted to a historical room in 1922 according to K. Bartnik [2, p. 124]. General information about fortification repair and maintenance work in the years 1960-62 was given by J. Pilch [12 p. 28; 13, p. 41]. A more detailed description of the work was given by M. Przyłęcki, who mentioned, *inter alia*, that the ceramic covering of the existing gate towers' cupolas had been supplemented at that time and that the Water Gate was adapted for tourist visits [15, pp. 99-101]. The information quoted by M. Przyłęcki was echoed by A. Małachowicz [11, p. 38]. The repair to the Kłodzka Gate in the years 1975-1977 and the Wodna (Water) Gate tower in 1985 was mentioned by K. Bartnik [2, p. 126]. Architectural research into fragments of the city walls, *inter alia*, the Kłodzka and Wodna (Water) Gates and the Rycerska (Knight's) Tower, was performed in 2010 [6; 7] and in 2014 [8].

Archive prints contribute to considerations of tower architecture to some extent. The oldest view plan of the city dates back to 1739 and was issued by F.A. Pompejus and O. Pompejus in 1862 [14, Table 19]. It shows the north-east view of the city that is surrounded by walls, where there are the Wodna (Water) and Kłodzka Gates and the Rycerska (Knight's) Tower. A simplified drawing of the enclosure is shown in the south panorama of Bystrzyca; it dates back to 1760 and it is an element ot the frame of coloured copperplate engraving of a *Comitatus Glacensis* map [18, No. 36]. General views of the walls and three towers as of the end of 19th century and the beginning of the 20th century are documented by a few prints and postcards from that period [19; 20].

## 4. Research results – the Kłodzka Gate Tower

The oldest parts of the tower can be seen on the east and west elevations in the lower part of the stone core up to a height of almost 9.5 m above the present ground level and on the naked wall of a hoarding up to a height of almost 12 m above ground level. The parts include the gate tower, which has survived to a significant degree, and the gate building attached to it to the east, which was connected to the gate tower via internal passages. The original gate complex, which consisted of the tower and the gateway that adhered to it from the east, was probably constructed in the first half of the fourteenth century. This fact is confirmed by chronicles, which date the inception of the construction of fortifications in the city of Bystrzyca to 1319 [1, No. 3929]. The gate was probably around 12.5 m high and probably slightly higher than the walkway that laid over the gateway. The form of the tower finial remains unknown due to the demolition of its upper part during a conversion that probably took place in the fifteenth century. The elevation was plastered by covering the irregular stone bonding with plaster mortar, it was then trowelled and probably white-washed. In the lower part of the tower, there was probably an unlit dungeon with inner dimensions of around 2.9/3.0 m. It was accessible via a hole in the floor of a shed-like structure at entry level, *i.e.* around 8.15 m above ground level. The stone framing of the lancet entrance to the tower has not survived to the present day, although its imprint can be seen from the inside of the tower. A door hinged in the doorway was blocked with a pocket lock; one such pocket has survived in the south reveal. The doorway recess was covered from the inside with a segmental vault that was built through the application of boarding; the imprints of boards can be seen in excessive mortar that must have flowed from between the stones. It is worth noting that the tower enclosure wall was around 160 cm thick in the basement (Fig. 5).

An almost two-metre-thick curtain wall adhered to the tower from the east; it probably had a ogive gateway that was preceded by a draw bridge over a dry moat. Above the bridge, there was a shed-like structure with embrasures, which was secured with almost three-metre-high stone breastwork. The gallery was covered with a gable roof, the shape of which can be seen on the tower elevation. The tower and the gateway were built of machined rough stone that was laid in about 70 to 90-cm-high layers. More carefully machined ashlar was applied to the corners (Fig. 1a, b).

The tower was raised and finished with crenellations, probably in the first half of the fifteenth century. The original enclosure was lowered to a height of 9.5 metres above ground level, and was then raised by almost 10 m. The upper (defensive) storey was built in the form of crenellations, the crenels of which were about 85cm wide and about 1m high on every elevation. The lack of traces of washing out and damage to the joint inside suggests that the storey must have been covered with a roof with a shape that is now unknown. The storey floor was built at a height of 17 m above the present ground level (Fig. 5).

Marks on the beam-framed floor at the level of 12.6 m above ground level confirm the division of the interiors into two levels. The lower storey included the entrance to the shed-like structure and the floor at the level of 8.15 m above ground level; it was lit through a north-facing slot window, the reveals and sill of which were carved in the wall in around 1319. The segmental vault above the window recess was made of wedge-shaped rough stone. Another north-facing window was built on the above storey. Both of the windows had their outer edges framed with stone. The walls were built of rough stone; the stone was sand-yellow and rusty in colour and was laid in 70 to 80-cm-high layers (Fig. 5).

A record of the city brickworks dates back to 1568 [3, p. 14]. The gate tower finial was probably altered in or close to that year; the alteration consisted in the introduction of an octagonal pyramid brick cupola with an attic, which is indicated by the identified building material and the shape of the cupola. The fifteenth-century roof was then demolished up to the crenel level. Rough stone pillars were erected on the highest floor in the corners and behind the merlons. Half-brick thick segmental arches were built between the pillars. The side walls of the pillar were shaped as embrasures and a set-off was made at the height

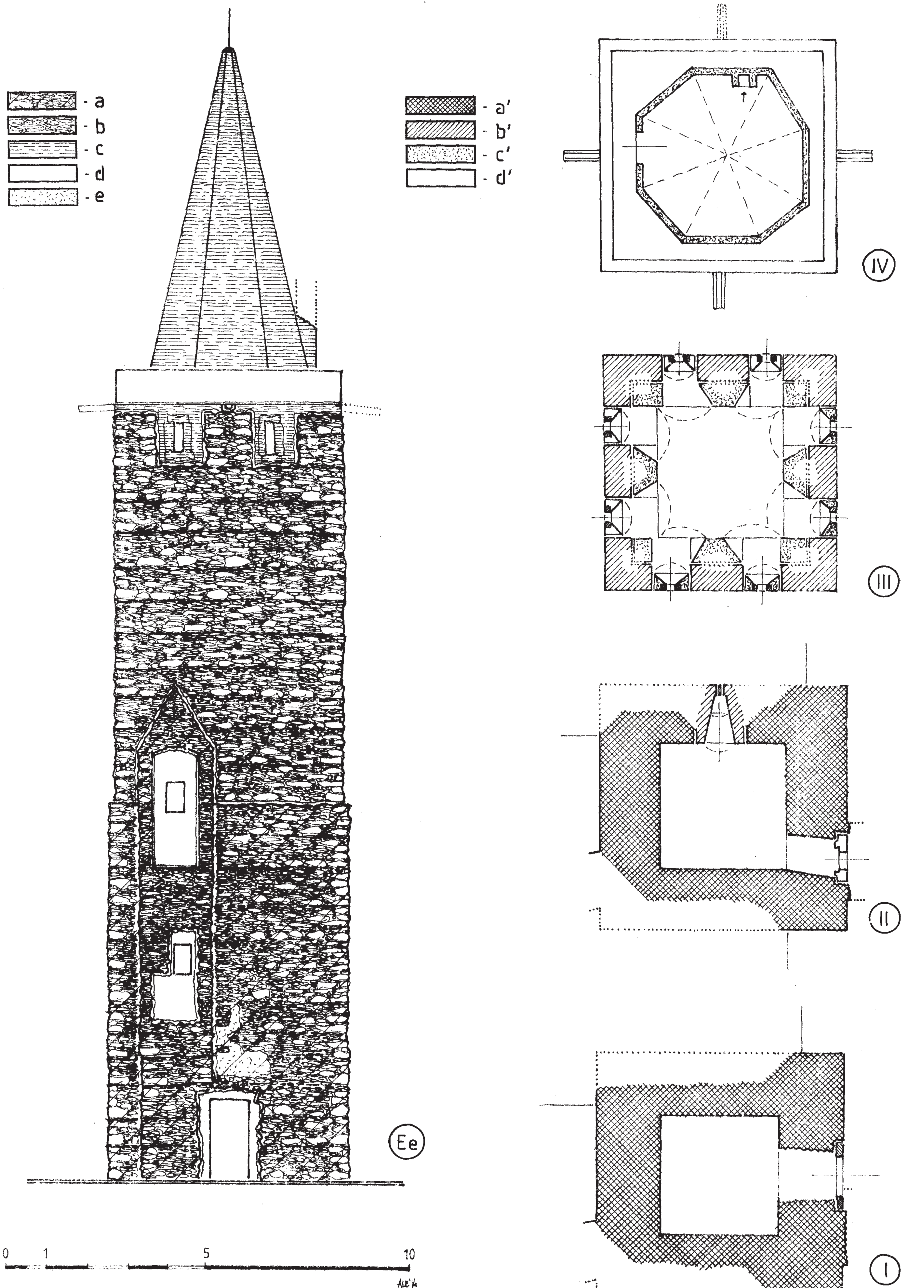


Fig. 5. Bystrzyca Kłodzka, Kłodzka Gate's tower, eastern elevation (Ee) and projection of dungeon levels, defensive, entrance and bypass of the helmet (I–IV) with chronological wall stratification (signs: a, a' – Gothic walls from the 14th century; b, b' – Gothic walls from the 15th century; c, c' – Renaissance walls from around 1568; d, d' – walls from the 20th century and unrecognized walls; e– elevation plasters (drawn by A. Legendziewicz)

of the window sills. Simple stone framing was applied to the embrasures. Arches were used to increase the height of the tower's enclosure by two brick layers and to place the ceiling beams on. An 8.7-m-high, half-brick-thick octagonal brick cupola was built above. A rectangular entrance to the gallery that surrounds the cupola was built to the west and a fireplace with a furnace for heating the guard room was built to the north. The cupola finial included a spire with a ball and an ensign that have not survived. An attic was built around the cupola; it took the form of stylised crenellations. The rainwater from the walkway was drained via four simple stone gargoyles that were installed along the bay axes; three gargoyles have survived (Fig. 5).

The gate building, together with the draw bridge, was demolished and the dry moat was backfilled probably in the nineteenth century [15, p. 99]. The enclosure wall was partly removed and flushed with the tower elevation. The doorway was bricked and its stone reveal was removed. The attic wall was repaired and its crenellations were demolished. The brick cupola was plastered.

The wooden beam floors and stairs were probably added in the years 1974-1975 when the tower was adapted to an observation deck. An entrance was built in the basement and a window opening was made above it to supply light to the storey that was added inside the former dungeon. The attic wall was converted through the application of block bonding, building material recovered from demolition and new machine bricks. The wall height was increased because an openwork forged balustrade was added [15, p. 101].

## 5. Water Gate

A quadrilateral with a height of around 12 m above the present ground level is the oldest part of the tower that has survived. It was built of machined rough stone and of carefully arranged cut stone in the corners. Among the identified parts, there is a fortified masonry tower that has survived to almost its full height. It has a recess where a portcullis was installed, and it has four windows and an entrance, as well as relicts of walkway imprints and of a wooden finial structure. The construction of the enclosure walls, together with the city gates, commenced around 1319 [1, No. 3929]. The masonry part of the tower was about 12 m high and was probably almost two storeys higher than the curtain. There was a gateway in the basement of the tower. The gateway was covered with an ogive vault. The barrel was built of stone similar to that used for building the walls. The stone was laid on a timber centring the boarding of which left its imprints in excessive mortar. The gateway was surrounded by two slightly sharp lancet stone frames. The south gateway was designed as an archivolt with bevelled edges. It was based on moulded heads and was preceded by a lancet recess where a portcullis was installed. The opening was closed with a double door. The door was probably of a rocker and board construction; its upper mandrel was put in a wooden beam and the lower mandrel was put in a stone bearing at the level of the cobbled floor. The door was blocked from the inside by placing at least two beams in pairs of pockets that were made in the walls on either side of the gateway. The basement walls are around 2 m thick (Fig. 6, 7).

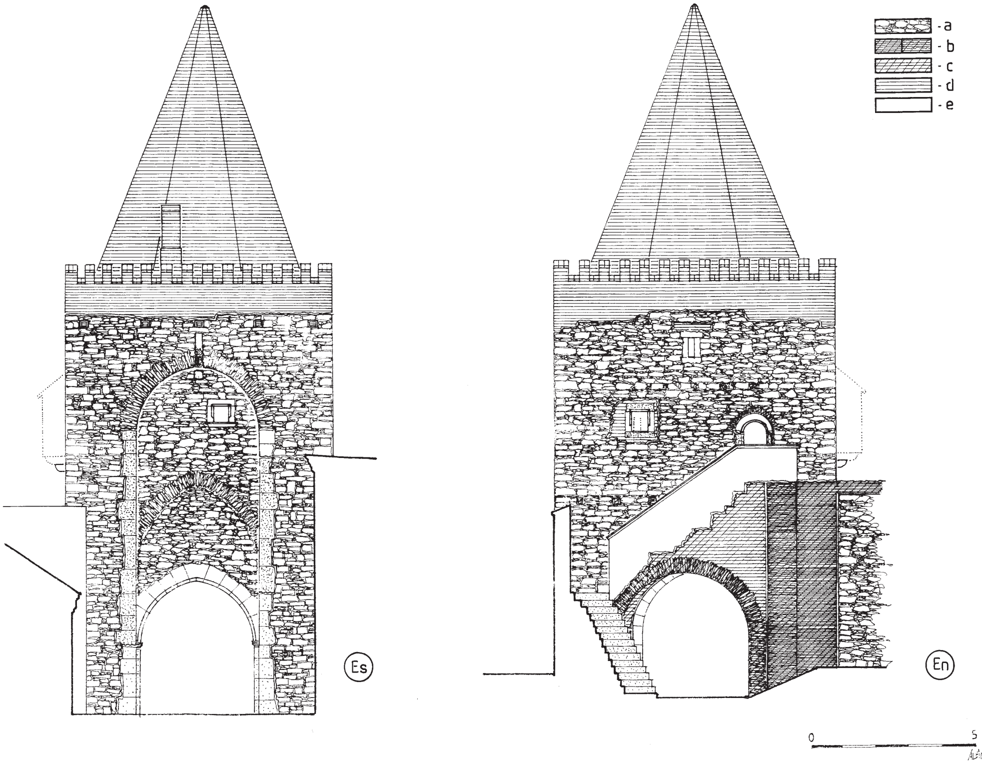


Fig. 6. Bystrzyca Kłodzka, Wodna (Water) Gate, south elevation (Es) and north (En) with chronological wall stratification (signs: a – Gothic walls from the 14th century; b – Renaissance walls (tenement house adjacent); c– Baroque walls from the 18th century; d– walls from the 19th century; e– walls from the 20th century (drawn by A. Legendziewicz)

In the south elevation, there was a lancet recess where a portcullis was installed. A square window with a bevelled framing was built in the upper part of the recess to light the guard room. Above the window, almost at the top of the lancet, there was a small hole to pull the portcullis chain, and above the hole, there was a slot window. The vertical edges of the portcullis recess were shaped with neatly machined cut stone. On the city side, the elevation contained two entrances, one to the tower and the other to the walls. Segments of the curtain were probably linked via a wooden shed-like structure that was supported by brackets, the seats of which have survived. The tower was accessible from the walkway level via an opening, the stone elements of a bevelled-edge archivolt of which have survived. Both of the pillars might have looked similar. The guard room was lit through a slot window that was built almost along the same bay axis as the present window, a stone sill of which has survived; above this, there is another slot window. While the east elevation is devoid of decorative elements, the west elevation contains a latrine bay, two stone consoles of which and an outline of a bricked entrance opening have survived. The building material technology applied may indicate that the tower elevations were plastered or trowelled in Gothic times. The Wodna (Water) Gate finial probably consisted of a wooden shed-like construction (a hoarding), which was built at a height of around 12 m above the present ground level. The structure was based on wooden consoles that were fastened to the wall. The hoarding contained embrasures and it probably surrounded the wall coping from three directions – the east, the south and the west – which is indicated by the imprints of the consoles' wooden beams in the upper part of the stone wall face. The whole structure was probably covered with a short ridge hip roof [9, p. 71-103] (Fig. 8).

Inside the tower, there were probably three rooms. These would have been separated from each other with wooden floors, accessible via ladders. The room accessible through a portal from the direction of the city was used as a guard room; from that room, there was access to the latrine bay. It was lit through two stone-framed window openings: the square, south-facing opening in the portcullis recess, and the slot, city-facing opening. The above storey

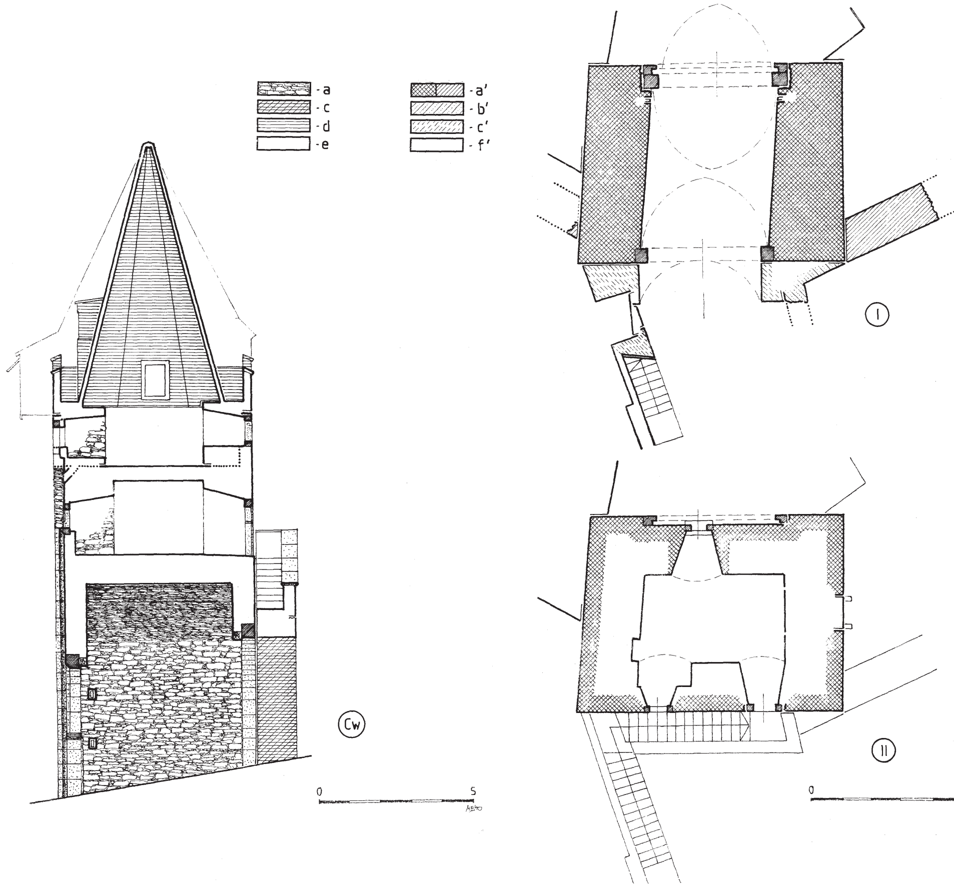


Fig. 7. Bystrzyca Kłodzka, Wodna (Water) Gate, crosssection with a view to the west (Cw) and projections of passage and guardhouse (guardroom ?) levels (I, II) with chronological wall stratification (signs: a, a' – Gothic walls from the 14th century; b, b' – Renaissance walls (tenement house adjacent); c– Baroque walls from the 18th century ; d, d' – walls from the 19th century; e, e'– walls from the 20th century; f– unrecognized walls (drawn by A. Legendziewicz))

probably contained a mechanism for drawing a portcullis. Light entered through two slot openings situated along the south and north bay axes. The last storey was surrounded by the hoarding and performed a defensive function. Every window was situated in a recess and covered with a segmental arch. The inner walls where whitewashed. The tower was built of machined rough stone and the corners were made of more carefully machined cut stone.

The information about the city brickworks [3. p. 14], the analysis of building material and of the shape of the cupola dated back to 1568 and lead to the conclusion that the tower finial must have been converted at that time. The existing Gothic hip roof and the hoarding were replaced with a masonry pyramid cupola surrounded by an attic in the form of crenellations with 4 crenels (Fig. 6, 7).

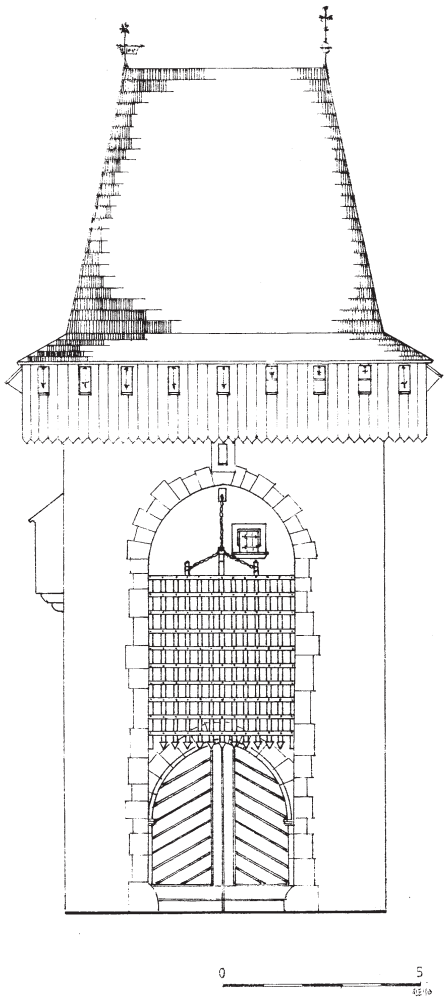


Fig. 8. Bystrzyca Kłodzka, Wodna (Water) Gate, reconstruction of the form of the Gate tower with the wooden hoarding from the 14th century (shape of the roof, its covering, – hypothetical) (drawn by A. Legendziewicz).

In the eighteenth century, the wooden shed-like construction that linked the east and west segments of the curtain must have been demolished. Two-flight stone stairs were built in place of the structure; the stairs led to the tower entrance directly from street level. The construction was based on a semi-circular arcade and was added to the tower elevation, partly obscuring the frame of the gateway from the direction of the city. The upper flight was secured with a masonry balustrade. The arcade was built of rough stone, which was laid on timber centring.

The tower, or rather its finial, was subjected to repair, probably in about the middle of the nineteenth century. The Renaissance attic, the cupola, and the stair balustrade were demolished, probably due to them being in a poor state of repair. A new attic took the form of stylised crenellations with thirteen low crenels to the north, east and south; a simple wall was built to the west. The stone balustrade was probably replaced with a new brick balustrade covered with stone plates that might have come from a Baroque balustrade. The two elements described above were built of brick recovered from demolition – which was in the Renaissance format – and of new brick or roofing tiles in places. The Renaissance cupola was replaced with a new version, the shape of which was probably similar to the previous cupola. Material similar to that of the attic and balustrade was applied. Unfortunately, the elevation plastering was removed completely, probably while the work was performed. Almost all of the cut stones in the portcullis recess framing were removed, leaving just two in the east, and the portcullis itself was probably removed, together with the pulling mechanism. The openings from the direction of the city were also transformed by replacing both of the entrance pillars and by enlarging the guard room window. A stone slab floor was laid at the cupola base and the rainwater was drained via a riser which was installed on the south elevation (Fig. 6, 7).

The repair was conducted owing to the arrangement of a historical room in the tower in 1922. The elevation was covered with rough, coarse-grained, rough-cast plaster; the portal pillars and lower fragments of the portcullis recess frame were replaced on the south elevation. In 1985, Bystrzycka Spółdzielnia Rzemieślnicza [*Bystrzyca Craftsmen's Cooperative*] subjected the tower to further repair, and after completion, it arranged an exhibition of guild members' work in the tower rooms. The cupola and inner walls were covered with cement plaster at that time. A new cement joint was made in the basement belt and the brick balustrade at the entrance was replaced with a rough stone joint.

## 6. The Rycerska (Knight's) Tower

The oldest parts of the tower can be seen on the north elevation, in the lower part of the stone core to a height of almost 8.5 m above the present ground level. Among the identified parts, there is a fortified masonry tower, which has survived almost completely. The tower is open towards the city, it is topped with merlons and has passages to the curtain wall on its east and west sides. The original fortified tower was probably erected in the first half of the fourteenth century, which is indicated by a source reference that states that city fortifications were built in around 1319 [1, No. 3929]. This look-out tower has a rectangular plan of around

5.2/3 metres; it protrudes the wall thickness from the curtain wall face and is built of ashlar. It is as high as the curtain wall and its height is almost 8.5 m above the present ground level. One rectangular crenel was built in its high breastwork finial, along the bay axis (Fig. 9).

In the first half of the fifteenth century, the open fortified tower was transformed into a regular tower by increasing its height. The enclosure wall was closed up from the city and its outline had a square-like plan of around 5.3/5.2 m. The existing structure was raised by over 10 m and topped in an unknown way. The newly erected and added parts of the elevations were moderately decorated. There were at least three stone-framed slot openings on the north elevation; the lowest opening was integrated with the existing crenel between the merlons. On the city-facing south elevation, there is a lancet doorway; it is 8.7 m above the present ground level and it is framed with a simple stone portal. The doorway was accessible via external stairs or ladders and a porch situated about 6.2 m above the ground level and based on stone consoles. It is worth noting that similar consoles were installed beneath the platform before the doorway. The entrances to the curtain's shed-like structure were left on two side elevations. The stone-framed slot window was build ion the east. The layout of openings on the last storeys that has partly survived remains unknown (Fig.9).

There must have been at least five storeys in the tower; the storeys were separated with wooden floors with beams which rested on set-offs. The lowest storey probably contained a dungeon; prisoners were likely to have been' lowered into it via a hole in the floor [9, pp. 71–103]. The dungeon was unlit. Above it, there was a walkway that provided access to curtain wall segments. Light entered the tower from the north through a slot opening, or through a crenel between the merlons. The opening head was made of overlapping stone slabs. The higher storeys were probably accessible via ladders. The second floor was also accessible via an opening from the direction of the city. The door was probably blocked with a pocket lock beam that was situated in the east reveal. Natural light came into the room through two openings from the east and from the north; the opening heads were also made of stone slabs. On the last floor that has survived as a whole, there were slot openings from the north and from the south. The building material and technology applied suggest that the tower elevations might have been plastered in Gothic times.

The Rycerska (Knight's) Tower finial was probably altered in around 1568, as was the case with the two gates described above [3, p. 14]. A high pyramid masonry cupola was erected in place of an unknown Gothic finial and attic in the form of crenellations with three crenels was built at the base of the cupola. The cupola was linked with the tower via a semi-circular arcade that was based on moulded consoles when an evangelical church was built in the years 1821–1822. The arcade was located in the place of the demolished city wall curtain [15, p. 99-101] (Fig. 4a, b, 9).

The decision to convert the tower into a belfry was taken in connection with the construction of an evangelical church west of the tower in the years 1821–1822 [15, p. 99]. Therefore, the Renaissance masonry copula together with the attic and parts of the enclosure walls up to around 15 m above the present ground level were demolished. Lancet biforium openings were along the bay axis of each of the elevations to mark the space for a pair of bells. Before installation, the construction of the tower was strengthened through the introduction

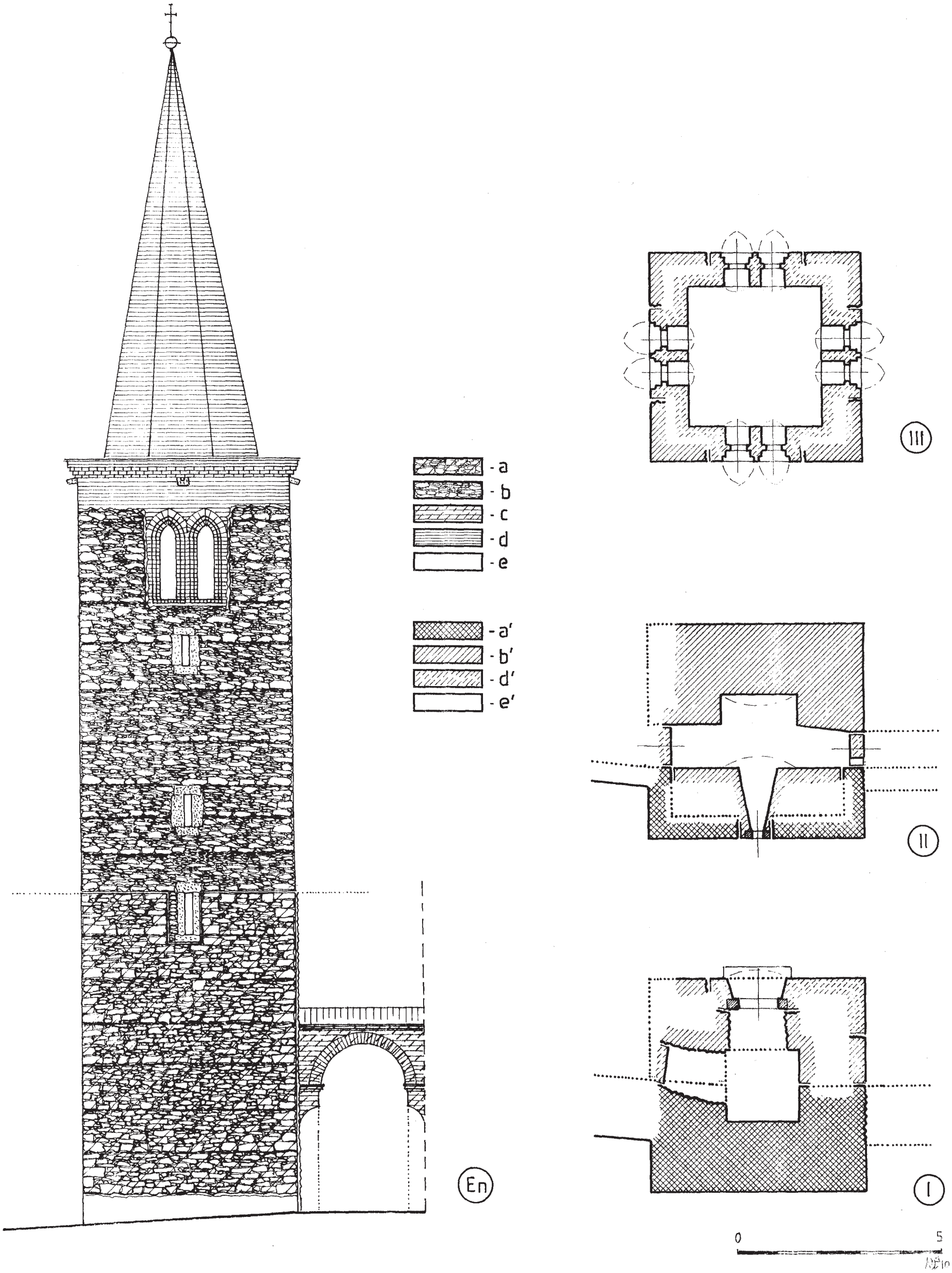


Fig. 9. Bystrzyca Kłodzka, Rycerska (Knight's) Tower, north elevation (En) and projection of dungeon levels, sentry porch and bells (I–III) with chronological wall stratification (signs: a, a' – Gothic walls from the 14th century; b, b' – Gothic walls from the 15th century; c– Baroque walls; ; d, d' – walls from the 19th century; e, e' unrecognized walls (drawn by A. Legendziewicz)

of two masonry vaults: at the former walkway level (at a level of 5.5 m) and above the entrance level (at a level of 8.7 m). Moreover, the window openings on the highest Gothic storey that had survived were blocked, as were the entrances to the curtain's shed-like structure. Owing to the construction of a belfry and stairs, two entrances were made in the tower's basement: one of them was rectangular, recessed, covered with a segmental arch and accessible at street level; the other was from the building that was attached to the tower from the east (Fig. 9).

The most significant alterations were applied to the finial and attic, which – as we mentioned above – were demolished. After the biforium openings were built, the walls were made higher to around 18.5 m and topped with a simple brick cornice. The tower was topped with a masonry pyramid cupola that had an octagonal plan; a stone slab walkway was built around it and restricted with a low attic wall. The cupola was topped with a cross and a gold-plated ball. The rainwater from the walkway floor was drained with four stone gargoyles that were installed along each axis of the elevation. The fifth gargoyle was installed near the roof of the building that was attached to the tower from the east. Relicts of the elevation plastering, which can be seen on the 1739 city view plan issued by F.A. Pompejus and O. Pompejus in 1862 [14 Table 19; 19], must have been removed at the same time.

The only work taken up on the Rycerska (Knight's) Tower in the postwar period consisted of the covering of the cupola with cement plaster and covering of the attic wall with a ceramic material. Moreover, the east entrance to the residential building was altered and a grate was introduced at that time.

## 7. Summary

The research into the architecture of the Bystrzyca Kłodzka enclosure wall towers that have survived allowed the authors to partly identify the towers' original forms that dated back to the beginning of the fourteenth century. It also enabled the authors to follow through the transformation that were made in the fifteenth century and in the second half of the sixteenth centuries as well as in the eighteenth and nineteenth centuries. Based on research, we know that the entrance at the Water Gate was secured with doors and portcullises, with the latter being installed in specifically shaped recesses and equipped with runners and crowned with a porch and wooden hoardings. The Kłodzka Gate and the Knight's Tower were made higher. Brick build cupolas were introduced on each of the towers during the Renaissance. The findings were used as source material for designing the restoration of all three towers. The conservation work performed in the years 2013-2017 restored the towers to their historical form and the partly damaged architectural details to their former glory

## References

[1] Regesten zur schlesischen Geschichte, 1316–1326, [in:] *Codex Diplomaticus Silesiae*, Bd. 18, red. C. Grünhagen, C. Wutke, Breslau 1898;
[2] Bartnik K., *Śląsk w Zabytkach Sztuki. Bystrzyca Kłodzka*, Wrocław 1992.
[3] Dziewulski T., *Studium historyczno-urbanistyczne do planu zagospodarowania przestrzennego*, PKZ Wrocław 1957.
[4] Eysymontt R. *Kod genetyczny miasta. Średniowieczne miasta lokacyjne Dolnego Śląska na tle urbanistyki europejskiej*, Wrocław 2009.
[5] Keyser E., *Deutsches Stadtbuch. Handbuch Staedtichscher Geschichte*, Stuttgart-Berlin 1939, Vol. I.
[6] Legendziewicz A., *Wieża Rycerska w Bystrzycy Kłodzkiej. Wyniki badań architektonicznych oraz wnioski konserwatorskie*, maszynopis w archiwum WKZ we Wrocławiu Delegatura w Wałbrzychu, Wrocław 2010.
[7] Legendziewicz A., *Brama Wodna w Bystrzycy Kłodzkiej. Wyniki badań architektonicznych oraz wnioski konserwatorskie*, maszynopis w archiwum WKZ we Wrocławiu Delegatura w Wałbrzychu, Wrocław 2010.
[8] Legendziewicz A., *Wieża Bramy Kłodzkiej i odcinek murów miejskich wzdłuż ulicy Wojska Polskiego w Bystrzycy Kłodzkiej. Wyniki badań architektonicznych oraz wnioski konserwatorskie*, maszynopis w archiwum WKZ we Wrocławiu Delegatura w Wałbrzychu, Wrocław 2014.
[9] Legendziewicz A., *Selected City Gates in Silesia – research issues*, Technical Transactions 3/2019, 71–103.
[10] Lutsch H., *Verzeichnis der Kunstdenmäler der Provinz Schlesien*, Bd. II, *Die Landkreise des Reg. – Bezirks Breslau*, Breslau 1889.
[11] Małachowicz A., *Mury obronne na Śląsku do połowy XV wieku*, mps. pracy doktorskiej, Archiwum Politechniki Wrocławskiej, Wrocław 2014.
[12] Pilch J., *Zabytki architektury Dolnego Śląska*, Wrocław 1978.
[13] Pilch J., *Leksykon zabytków architektury Dolnego Śląska*, Warszawa 2004.
[14] Pompejus F.A., *Album der Grafschaft Glatz oder Abbildungen der Städte, Kirchen,Kloster, Schlösser und Burgen derselben, von mehr als 150 Jahren,* Druck von O. Pompejus, Glatz 1862.
[15] Przyłęcki M., *Miejskie fortyfikacje średniowieczne na Dolnym Śląsku. Ochrona, konserwacja i ekspozycja 1850–1960*, Studia i materiały, Przedsiębiorstwo Konserwacji Zabytków, Warszawa 1987.
[16] Ruchniewicz M., Rosik S., Wiszniewski P., *Bystrzyca Kłodzka*, Wrocław–Bystrzyca Kłodzka 2007.
[17] Volkmer F., *Geschichte der Stadt Habelschwerdt,* Habelschwerdt 1897.
[18] Werner F.B., Schleuen J.D., *Comitatus Glacensis novissimum compendium moderne ordine in hac formam,* Berlin 1760, (miedzioryt w zbiorach Biblioteki Uniwersytetu Wrocławskiego, sygn.2433-IV.B.)
[19] Wziątek A., *Bystrzyca Kłodzka i okolice na dawnej pocztówce*, Bystrzyca Kłodzka 2006.
[20] www.polska-org.pl (online: 30.10.2018).

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# The second life of a shooting range – the conservation and adaptation of the historic shooting range at Wola Justowska in Krakow for its new function

# Drugie życie strzelnicy – konserwacja i adaptacja do nowych funkcji zabytkowej Strzelnicy na Woli Justowskiej w Krakowie

**Abstract**

This article presents the problem of the maintenance and adaptation of a historic shooting pavilion for new premises of the Museum of Photography in Krakow. The wooden pavilion used to be a part of the military shooting range development in Wola Justowska, established for the Austrian army in the 1880s. The adaptation of the pavilion for new functions has primarily enabled the protection of this historic and derelict building, which was entered into the Register of Historical Monuments in 1993. Conservation works have restored the shooting pavilion to it former splendour; there is also an effective display of preserved architectual elements, although these vary in their technical condition.

**Keywords:** adaptation, conservation, protection, monument, shooting pavilion

**Streszczenie**

W artykule przedstawiono problematykę konserwacji i adaptacji zabytkowego pawilonu strzelniczego na nową siedzibę Muzeum Fotografii w Krakowie. Drewniany pawilon wchodził w skład Założenia Strzelnicy Wojskowej na Woli Justowskiej, powstałego w latach 80. XIX w. dla wojska austriackiego. Przystosowanie pawilonu do nowych funkcji umożliwiło przede wszystkim ochronę popadającego w ruinę zabytku, wpisanego do rejestru w 1993 roku. Obecnie pawilon strzelniczy odzyskał swoją dawną świetność dzięki konserwacji i umiejętnemu wyeksponowaniu zachowanych w różnym stanie technicznym elementów architektonicznych.

**Słowa kluczowe:** adaptacja, konserwacja, ochrona, zabytek, pawilon strzelniczy

## 1. Introduction

Cultural assets gradually become an important component in the field of urban regeneration strategies or other types of urban space transformation or restructuring, not only for the cities themselves, but also for the communities. Urban policies embrace this heritage as an instrument for the activation of economic space that defines the context for social life. Such heritage is also an important factor that integrates the existence of any community, especially in the process of its further development [9]. According to UNESCO research, the development of civilisation predominantly occurs in an uncontrolled manner and has a negative impact on urban areas and their surroundings. This results both in the degradation of the environment and the destruction of urban cultural heritage. UNESCO states that urban heritage is a type of capital for humankind, created in the process of the historical accumulation of values which stem from both old and modern cultures as well as from acquired raditions and experiences [6]. For this reason, it is important to focus on the preparation of strategies that may protect and allow the management of historical city structures as well as better coordinated development planning in both local initiatives and large-scale urban projects; this all ensures that future generations can benefit from historical objects and appreciate their values.

Krakow is a city that has several monuments entered into the UNESCO World Heritage List, but there are also a number of other objects in the city, often in poor condition, that await such a special protection and require conservation. Because Krakow is a city with a unique atmosphere and a rare collection of historic objects, every such intervention strengthens its position, and emphasises the identity and specific character of this royal city. Various geographical conditions, the diversity of the local community, historical events, economic activity, and contacts with other cities all prove the uniqueness of this city, its exclusive atmosphere and specific identity. The cultural heritage of Krakow is somewhat dominated by Wawel Royal Castle with its silhouette clearly standing against the background of the meandering Vistula river. The main square, which is the centre of the city and a vibrant public space, is located to the north of Wawel Castle. Other recently revitalised districts include Kazimierz, Podgórze and Zabłocie; these are located on opposite bank of the Vistula and connected by the Father L. Bernatka footbridge. Relatively small objects that are located outside the Old Town, often neglected or forgotten, are being successively restored to the city and its residents.

The value of architecture is most effectively verified by history, but technical durability, artistic and aesthetic values as well as importance for the local community are also important. Objects that have survived to this day constitute authentic substance and every effort should be put to protect and preserve them. However, this requires intervention, not only with regard to applicable conservation doctrines, but also to changing needs and conditions of civilization, as well as the need to introduce new values. Architectural stratifications, which accumulate over the centuries, have created a material record of the history, culture, identity of the cities. The fascination with history, the inspiration that it provides its contemporary reinterpretation and the dialogue with historical context all lead to several creative experiments for architects [7].

The use of historical objects, their protection and care and their re-adaptation to urban space are issues both for scientists and practitioners. An extensive body of literature exists on the subject of the conservation of architectural monuments. This work, however, focuses on a very specific and interesting case, which is the shooting range at Wola Justowska in Krakow. The first stage of revitalisation works included an inquiry on the historical materials concerning this architectural complex. During subsequent stages of the works, a new functional program for providing new technical conditions for the building and its historical structure was introduced. This was based on architects' expertise and experience, and with respect to the historical value of the object, unfortunately, the building was in a very poor condition. The shooting range in Wola Justowska was established in the 1880s. In the interwar period, and after World War II, it was used according to its original purpose. Adaptation of the derelict monument for the new functions primarily enabled its protection; the building was entered into the Register of Historical Monuments in 1993 (No. A-965, decision of 2/12/1993). It was necessary to replace the structure and construction of the building, which were in a critical technical condition. The salvation of the building was possible through the installation of an additional support structure to prevent its collapse. The former shooting pavilion has now regained its splendour through an effective display of various preserved architectural elements which remain in different technical conditions. The architectural and construction project was prepared by the Ateliers for Conservation of Cultural Property PKZ ARKONA LLC. The main designer was Paweł Górkiewicz.

## 2. History of the military shooting range in Wola Justowska.

The General J. Pelletier KuK Elementar-Schiessplatz shooting range was established in the area of the former medieval settlements Zwierzyniec and Wola Justowska, called Łysa Góra [4]. The area is located in the western part of Krakow, north of the Vistula, in District VII – Zwierzyniec, in Wola Justowska, at 220 Królowej Jadwigi Street, in its southern s section, between Koło Strzelnicy Street and Pod Sikornikiem Street. The complex includes the shooting pavilion and earth embankments with the wooden constructions of the bullet barrier, as well as auxiliary buildings that were constructed at a later stage during the operation of facility, such as stables, a gazebo, toilets and warehouses. The garrison shooting range was one of two shooting ranges constructed as part of the "III Fort Group Krakow Fortress" project, having been built in the vicinity of Krakow for the Austrian army since 1864 [1]. The facility, which was the support base of the "Krakow Fortress"[1], had the shape of an elongated trapezium with dimensions of 725 x 125–225 m, with an area of over 10 ha and orientated in a north-south direction. The open shooting field was about 800 m long and was protected by transverse and longitudinal earth embankments that diverted the area into sections for shooting with the use of various types of weapons [4]. The building structures were located only in the northern part of the area, where the wooden pavilion in the form of a three-part shooting hall and

[1] Kraków Fortress is one of the largest and best-preserved defence facilities built in Europe in the 19$^{th}$ century.

frontal landscape development was located. The basic purpose of the pavilion was to protect the shooting posts and the mezzanine audience sector from rain and wind; thus, the original building had no closing external wall on the southern side. The pavilion was also a venue for shooting association meetings and for ceremonies held during shooting competitions[2].

The main shooting pavilion was located next to Królowej Jadwigi Street at an angle of approximately 30 degrees, which formed space for the triangular garden in front of the

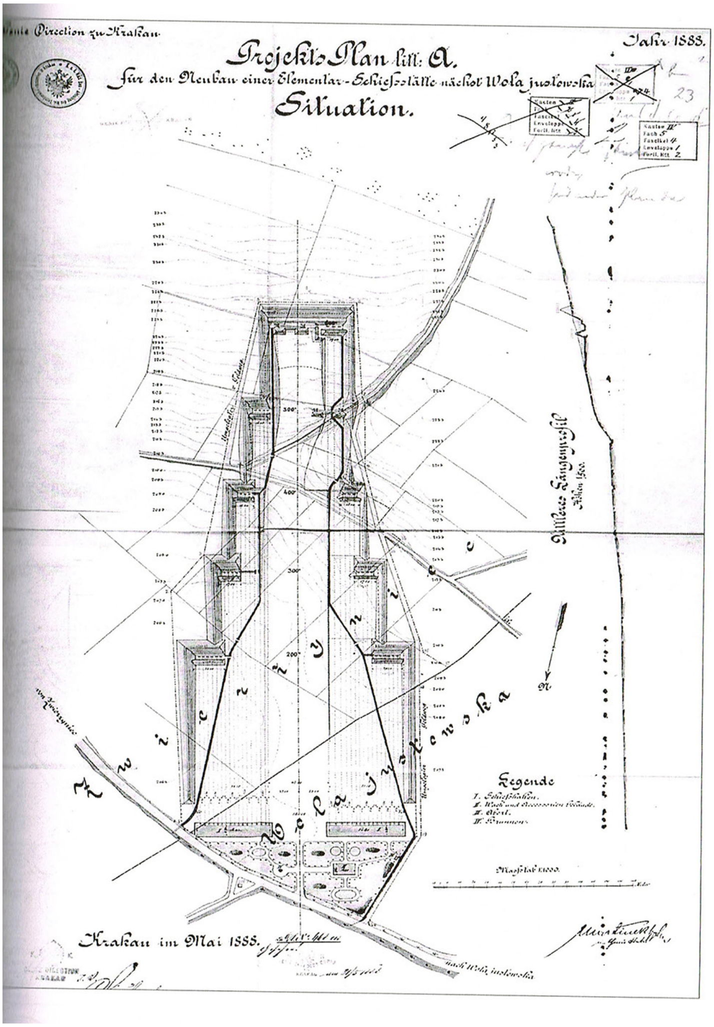


Fig. 1. Construction project of the shooting range, dated 1888 with the then yet unimplemented concept of two shooting pavilions (copy of CAW, DOK V, Ref. No.: I/371/5/95), (Source: PKZ ARKONA Sp. z o. o.)

2 The shooting competition was usually concluded with a group photograph of all participants with their wives in front of the avant-corps of the pavilion seen from the north and inside the building (in its central part). Based on the photographs included in [5].

building. The shooting fields were located for further down the plot. Due to the lack of records, the exact construction date of the shooting range and its main pavilion remains unclear. One of the notes from the interwar period states that the shooting range was built in 1886 [5, p. 2]. The first record of the project can be found in the situational plan dated 1888 (Fig. 1). Presumably, the author of the shooting range project was the chief sapper inspector in the Austro-Hungarian army, Eng. Emil Gołogórski [4]. This plan shows a drawing of two separate shooting pavilion buildings of approximately 6.5 by 40 m each. Both the pavilion buildings and the orientation of the embankments have a common axis of symmetry in the north-south direction. The embankments decrease stepwise to a length of about 320 m; the outlines of fields and roads can also be seen (Fig. 1).

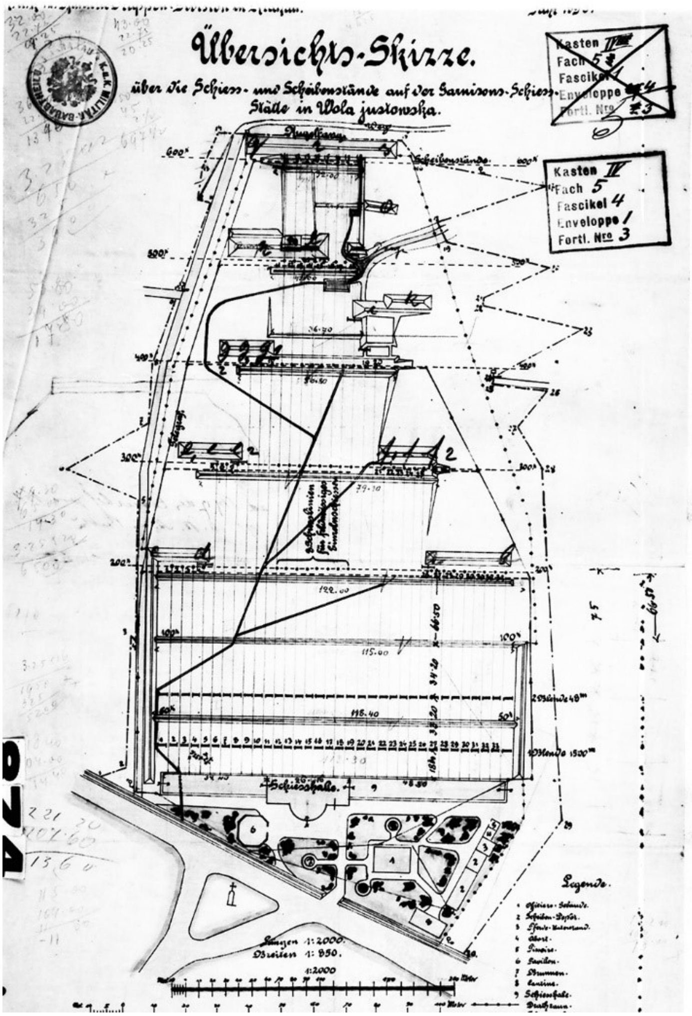


Fig. 2. Situational plan of the shooting range, dated 1896, presenting one long shooting pavilion with a wider middle section including an avant-corps (copy of CAW, DOK V, Ref. No.: I/371/5/95), (Source: PKZ ARKONA Sp. z o. o.)

The situational plan from 1896 presents one long pavilion building, which consists of three clearly distinguishable parts with individual segment lengths of 33 m (eastern section), 26 m (central section) and 49 m (western section) with a total length of 108 m (Fig. 2). Apart from the main shooting pavilion building divided into three halls that were open towards the south in the direction of shooting, the plan also includes several smaller buildings, such as a guardhouse, stables, a gazebo and latrines. The wooden fencing raised along the street consisted of several decorative entrance gates[3]. The axis of symmetry of the entire development is marked in the plan from 1888 in the layout of the front garden. Additionally, upon examination of the plan from 1888, one may observe that the layout of the earth embankments changed, and that the length of the whole development was around 255 m. An interesting fact is that for some time, the eastern segment of the pavilion was extended with an oblique vestibule, that was parallel to Królowej Jadwigi Street. It was probably erected between 1896 and 1900 as it is visible on the plan rom 1905 and is still exists on the plan from 1912; in the later period, it was demolished [7] (Fig. 3).

Initially, the shooting range was used by the Austrian Army, then by members of the Riflemen's Association, commonly called the 'Rifleman'which was a paramilitary organisation established in 1910. The Józef Piłsudski' legionnaires, many of whom had previously been members of the Rifleman, mastered their skills in the facility. Starting from 1918, when Poland regained its independence, the shooting range went under the supervision of the Shooting and Combat Garrisons Command. It served both the army and the civilians associated in the Falcon Society and the Cock Brotherhoods. After the cancellation of the shooting range command in 1922, the shooting range was moved under the authority of the War Camp Command [5]. In 1925, the earth embankments, known as "kulochwyty", were modernised [7]. In this same year, the shooting range was given the name 'General Zygmunt Zieliński' [5, p. 10]. Between 1912 and 1922, the southern façade and sections of the lower segments on the southern side were boarded with timbers. Between 1912 and 1929, a shooting officer's bureau was built of

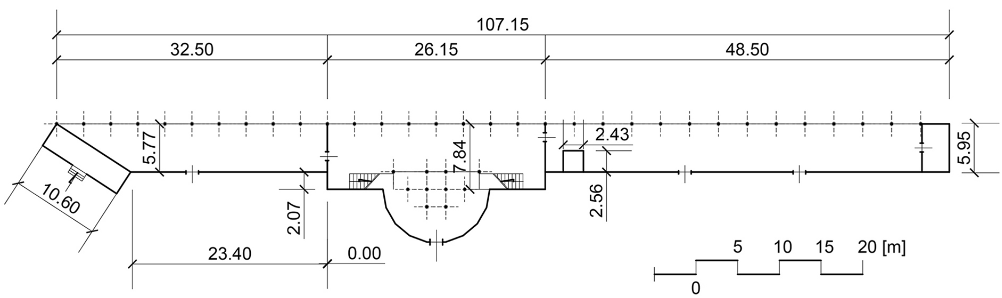


Fig. 3. Schematic layout of the shooting pavilion prepared on the basis of a drawing from 1912. The layout consists of the oblique vestibule added to the eastern segment. The eastern segment still has 10 spans, the middle segment has 8 spans, and the western segment has 14 spans. In the subsequent years, the eastern segment was shortened and it currently has 7 spans
(Source: [3]. Diagram by the Author)

[3] There were several wooden decorative gates there, but only the image of the north-western gate has survived on a photograph. See [3].

Fig. 4. Photograph from the shooting competition of the „Falcon" Krakow, which took place in May 1924. The southern side of the shooting range is visible in the background. During this period, it was still open, without the timber boarding. There is also a fragment of the western wall of the upper central hall interior with its richly elaborate wood carving detail and the edge of the lower wing of the hall roof with an openwork ornament cut into the timber. In the foreground, a row of tall ash trees is visible (Source: [5])

Fig. 5. Photograph of the central hall apse from the north-western side taken in 1927. The colour diversity between the framing and wall surface elements is visible; these are probably the original painting layers. Roof patches are covered with roofing felt. The front garden consists of well-maintained plants and paths (Source: [5])

brick in the western part of the facility (Figs. 4, 5). In the post-war period, the facility was managed by the WKS 'Wawel', the sports club which had a shooting section established in April 1928 [5, p. 22]. The area for small arms shooting was created in the shooting range after 1945 [4]. After World War II, the building was exposed to successive destruction; not only wooden stables and sheds but also decorative wooden entrance gates were demolished.

In as late as the 1990s, two earth embankments forming the base for the wooden bullet barrier walls that were parallel to the pavilion still existed. Two earth embankments sitting along the long edges of the site also survived (one on the eastern side and two on the western side). The site still bears the marks of the original development, which are the sections of longitudinal earth embankments covered by wild growth and the remains of the old road from Zwierzyniec to Wola Justowska, one of the side roads to today's Koło Strzelnicy Street [4]. Nevertheless, the transverse earth embankments have been mostly destroyed. In the meantime, new building objects, such as the Ortopedicum Hospital and the tennis centre were constructed. Interestingly, the original tree planting laid out during the shooting pavilion construction has survived in good condition. Nowadays, the longitudinal foundation of the shooting pavilion is marked by a row of impressive ash trees planted along its southern façade. Additionally, the front garden includes impressive specimens of lime trees, ash trees, oaks, elms, acers, black locusts, horse chestnuts, as well as other plants which are the remains of the diverse park once founded between the building and the street. One can assume that some of the trees may have been planted at the time of the shooting range construction or be even earlier [2].

## 3. Architecture and structure of the shooting range

The shooting pavilion, which has survived until the present day, was erected on the plan of a narrow rectangle, on the east-west axis, as a single-storey building with a higher and wider section and asymmetrically arranged axis of the whole building. The building has a main supporting structure formed of a wooden frame supported by a brick-and-stone foundation. The posts and wall plate beams are wooden with decoratively hewn angle braces. Some posts are positioned on concrete bases. The area of the shooting range building is 800 $m^2$ and the floor space is 1180 $m^2$. The height of the central section is 9.30 m and the height of the side wings is 5.40 m [2].

Fig. 6. View of the eastern segment interior eastwards; on the left and in the background there are the walls with a half-timbered structure, on the right there are posts of the open wall of the hall immersed in a concrete shooting bench (post-war) – the other side presents the original level of the hall (concrete pavement slabs, possibly from the inter-war period). This is the condition before the adaptation of the pavilion (Source: Author's archive)

Fig. 7. The interior of the eastern hall; the pyramids/cones are visible. This is the condition before the adaptation of the pavilion (Source: Author's archive)

The building is covered with a gable roof excluding the avant-corps, which is covered with a multi-hipped roof with a single-frame structure, reinforced with angle braces and struts in each full truss. The whole frame of the building bears a specific carpentry detail finishing: smooth undercuts and chamfers on the ends of the vertical elements with four-sided pyramids, so-called cones, cantilevered ends of beams, decorative cut-outs of rafters; angle braces and struts are also decoratively finished. The framing of exterior walls is filled with shuttering, glazed woodwork or remains open. The northern external walls, side walls and parts of the southern walls in the western segment are supported by a concrete pedestal (Fig. 6, 7).

The central segment of the pavilion is distinguished from its side wings by its increased height and width. It is also separated from the neighbouring wings by stud walls covered with timbers. The central part is also characterised by decorative carvings in the form of geometric and floral patterns. On the north-western side, it is extended by the nine-sided avant-corps on the plan of a semi-circle. The avant-corps includes a mezzanine observation area facing the shooting field, with access through a single-flight staircase (originally there were two symmetrical flights of stairs). The staircase and the mezzanine were equipped with closed wooden balustrades. The mezzanine is topped with a hoist supported on four posts with struts, and is connected from the north to radially spreading ceiling beams and three middle beams on an additional hoist supported on two posts. Both the eastern and the western wing are single-storey, single-spaced and lower than the central section. The brick room was built in the west wing. The wings are boarded with vertical planks (originally on the northern side and, in the later period, in the western wing on the southern side).

Fig. 8. Interior of the middle segment - view of the western wall - the open roof truss, single-frame with struts and king posts supporting the ridge. A view of the interior of the avant-corps – the closed balcony balustrade, the avant-corps roof truss and secondary reinforcement of the original structure are visible. This is the condition before the adaptation of the pavilion (Source: Author's archive)

The southern elevation of the central section, including the avant-corps, is glazed with two rows of windows placed between the ground floor posts and the mezzanine floor. The single loom windows have several quarters. The colour of the wooden frame is clearly distinguishable on the northern façade and is darker than the wall surface elements (Fig. 5). The carpentry of struts and crosses was also designed in a decorative way. The avant-corps has an exposed frame, and the post heads are profiled. Its roof is multi-hipped and flattened and the surfaces of gable roofs are topped with decorative wooden pinnacles. The central section is entirely open to the south. High construction posts sitting on pedestals have decoratively finished capitals. At the turn of the 20$^{th}$ and 21$^{st}$ century, the upper part of the building was supported, which preserved the stability of the original wooden frame [2] (Fig. 8).

## 4. Problems of adaptation and maintenance of the shooting pavilion

The shooting pavilion required urgent renovation works. Despite the ongoing disintegration, the building still had an attractive form and the richness of its carpentry ornamentation was impressive. The front garden and plants on the southern side of the building had also been neglected. The central section of the pavilion was in the worst condition and thus it was reinforced with the framing support. The need for maintenance and renovation was urgent, and its goal was to halt the disintegration processes, to obtain stable technical parameters and to preserve as many of the original elements of the building as possible.

The main cause of the poor condition of the wooden framing was leaky roof coverings and damage to the metal-sheet work. In many places, the wood had darkened and was covered with stains; white patches of salt were apparent on the borders. (Fig. 9). The mould had spead on the structural frame elements, the decorative details and the covering boards. Significant changes to the geometry of the wooden frame system were visible (22 cm deviation from the perpendicular position of the posts). Deformations, breaks, numerous cracks and the delamination of oil paint coatings were also spotted. The window and door wings were warped, and the glazing was destroyed. The ironwork elements were corroded and incomplete [2].

Fig. 9. The critical condition of the shooting range pavilion showing a view of the central section from the southern side. This shows the condition before the adaptation of the pavilion (Source: Author's archive)

The planned adaptation of the facility, initially for leisure and sports purposes, was covered by a multi-branch project and number of expert opinions; this was followed by a wide range of construction and conservation works. The overriding objective of the project covering the reconstruction, extension and change of the building purpose was to extract its architectural values and the advantages of its external surroundings. The projection and shape of the building and the roof shape were subject to legal protection as elements of the original development. Elements such as the secondary concrete shooting benches/shelves could be removed, which allowed for the display of original post bases in the southern façade.

Due to the limited space on the ground floor and the character of the building, a partial basement of the building was designed for auxiliary functions. Hygienic facilities for the staff and visitors, a catering area and an exhibition room have been planned for the ground floor. The viewing function of the mezzanine has been maintained. It was necessary to insulate the building and enclose the pavilion with a glazed curtain wall. In addition, the usable space has been extended through the construction of the basement section in the central and eastern segment of the building. The stratigraphic studies defined the original colour scheme of both the interior and the exterior of the pavilion. Construction elements had been covered with brick-coloured paint, while the covering boards were probably unpainted. Chronologically the oldest coating inside the building was iron red paint and this was later confirmed in micro-chemical tests [2] (Fig. 10).

As a result of professional inquiries conducted in the field of construction, stratigraphy and micro-chemistry at the design stage of the project (including the schedule of conservation works) and with consideration to the planned construction of the basement, the decision to dismantle and reassemble the entire wooden frame and foundations was made. This enabled performing conservation procedures on the original structural elements and making necessary replacements. The dismantling started with the removal of the old roofing and was followed by the deglazing of windows. The original glazing was secured and re-used as "witnesses". Initially, the structural elements of the upper part of the avant-corps were dismantled. Each element of the dismantled truss was recorded and was examined by an authorised mycologist

Fig. 10. View of the interior of the central segment. The open roof truss was restored by decorating it in the original colour scheme. The southern wall has been glazed to the entire height of the pavilion which was feasible after installation of a steel support structure (Source: Author's archive)

in order to determine which should be kept and which should be replaced. The disassembled elements of the trusses were laid out in sets to form complete trusses. Surface pre-cleaning was also performed, and all of the elements were then secured for the duration of further works. The wooden elements went through a preservation procedure: they were disinfected, cleaned, stripped of their secondary oil coatings, reinforced or repaired according to their condition, and protected against weather conditions, microbiological decomposition and damage caused by insects. Rejected elements of the structure were replaced with components made from seasoned wood in accordance with the original parameters relating to wood type, grain direction and dimensions. The original pavilion structure had been made of native conifer species, primarily fir but also pine and spruce[4].

With regard to the need for adapting the building to applicable legal regulations, it was also necessary to increase the cross sections of the wooden structural elements of the trusses. The whole wooden structure of the central segment that included preserved and new wooden or steel components was placed on a 15-cm steel-reinforced concrete slab laid above the new basement. The curtain wall supporting structure consists of I 300 steel columns at intervals adjusted to the dimensions of the wooden trusses (approximately every 325 cm). The excavation was secured with a Larsen-type sheet wall. Due to the vicinity of the legally protected old trees on the southern side of the building, the wall was left in the ground, constituting a part of the foundation. In other places, the wall was extracted out of the ground. The dismantling of the structure was also followed by the construction of the planned basement under the central and eastern parts of the complex. The basement was made in the form of a tight reinforced-concrete basin with a bottom plate and external 25-cm-thick walls. Due to the relative proximity of old trees with an estimated age of over 100 years, some of them required correcting cuts of their crowns in addition to regular care procedures [2].

Interior and exterior decorating works included the reconstruction of the earliest colour scheme of the object (Fig. 10). For this purpose, the framing elements were painted with red-

Fig. 11. View of the central segment of the pavilion with the apse from the southern side. This shows the condition after adaptation (Source: Author's archive)

4 See [2] detailed inventory report of plants, with the assessment of tree condition and recommendations for further tree care works.

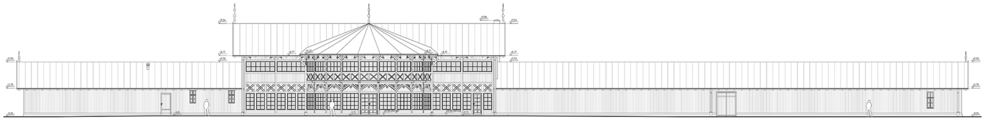

Fig. 12. Northern elevation of the shooting pavilion (Source: PKZ ARKONA Sp. z o. o.)

brick paint and the wall surface sections were left the colour of natural wood. The preserved elements of the original ironwork were subjected to metal conservation. The roof surface was insulated from the outside in order to keep the elements of the roof truss visible from the inside. The wooden decorative detail was reconstructed in the original form and vertically planked. Decorative constructions of the avant-corps and the apse were also made [2] (Figs. 11–14).

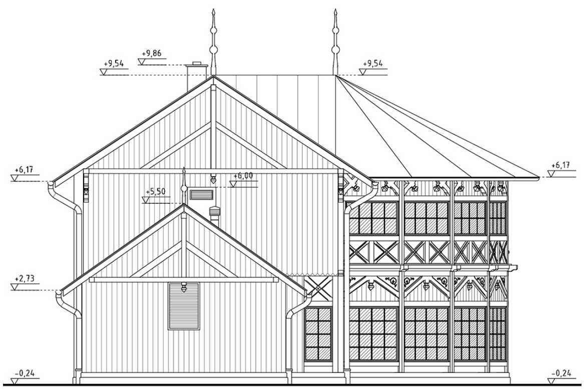


Fig. 13. Eastern elevation of the shooting pavilion (Source: PKZ ARKONA Sp. z o. o.)

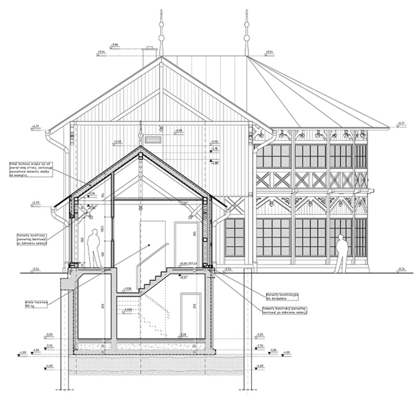

Fig. 14. Cross section through the eastern wing (Source: PKZ ARKONA Sp. z o. o.)

## 5. Conclusion

The unique character of buildings and urban complexes, as well as their architectural forms, become the engine of tourism development and also contribute to urban identity. This is the reason why we are so eager to visit European cities, to experience their atmosphere and mood, perhaps in search of new impressions and lasting emotions. The city of Krakow has acquired one more interesting place which is an attractive public space that has military history heritage. The reconstructed shooting pavilion is the only noteworthy relic of the original foundation of the shooting ranges that were built as part of the fortification of Krakow by the Austrian Army in the 19$^{th}$ century. In line with the conservation recommendations and despite the all/roof insulation and partial basement construction, the complex has kept its historical form. The design emphasized the frame structure by making the truss elements visible. The original ornamental details such as capitals, decorative cones, piles and chamfers of the rafters have been reconstructed. The reconstructed original decoration of the interior and exterior also has high aesthetic value. The glazing of the southern façade (in the central and eastern sections) created an impression of synergy resulting from the accumulation of historical values and modern standards. Designers who work on projects of this kind should be inspired by humility, the aesthetics of elegance, the careful use of means of expression, and be able to integrate new technologies with existing structures and be aware of the value of each monument. The criteria of authenticity and awareness of sensitivity are also crucial as is the awareness of the volatility of matter, which is a witness of history and events, especially when the monument is in ruins [8]. It is a case of perfect interference in the historic tissue of the building, combined with the careful preservation of historical details. In this respect, the object and public space have been revitalised, together with the recovery of their historical features.

## References


[1] Bogdanowski J., *Warownie i zieleń Twierdzy Kraków*, Wydawnictwo Literackie, Kraków 1979.

[2] *Dokumentacja wielobranżowa remontu, przebudowy i rozbudowy budynku dawnej strzelnicy i służbówki,* PKZ ARKONA Sp. z o o., Kraków 2013.

[3] Hiżycka J., Sławiński S., *Strzelnica na Woli Justowskiej. Materiały archiwalne i dane historyczne*, Pracownie Konserwacji Zabytków w Krakowie SA, Kraków 1993.

[4] Komorowski W., Kęder I., *Zespół strzelnicy sportowej na Woli Justowskiej – karta ewidencyjna zabytków architektury i budownictwa*, Kraków 1994.

[5] *Księga pamiątkowa strzelnicy na Woli Justowskiej w Krakowie,* Jagiellonian Library Collection, 9998 IV.

[6] Kuśnierz-Krupa D., *Protection Issues in Selected European Historic Towns and Their Contemporary Development,* E3S Web of Conferences, vol. 45, 2018, Source: https://doi.org/10.1051/e3sconf/20184500043 (access: 29.01.2019).

[7] Sławiński S., Szostak D., *Kraków - Wola Justowska, ul. Królowej Jadwigi 220, pawilon strzelnicy. Opracowanie historyczno-konserwatorskie,* PKZ ARKONA Sp. z o.o., Kraków 2013.

[8] Węcławowicz-Gyurkovich E., *Architektura najnowsza w historycznym środowisku miast Europejskich*, Politechnika Krakowska, Kraków 2013.

[9] Zuziak K. Z., *Strategie rewitalizacji przestrzeni śródmiejskich,* Wydawnictwo Politechniki Krakowskiej, Kraków 1998.




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# The assessment of spatial changes in the size of the spa park in the Inowrocław spa town since the 19th century

# Ocena zmian przestrzennych w wielkości parku zdrojowego w miejscowości uzdrowiskowej Inowrocław od XIX wieku

**Abstract**

The aim of this study was to document spatial changes in the size of the Spa Park in Inowrocław from the 19th century onwards based on archival maps as well as field research and observations of the current status. Towns providing a highly specialised health resort and spa services, such as Inowrocław, need large expanses of green areas as public spaces for outdoor therapy for spa town visitors and patients. In Inowrocław, this may not be limited only to the surroundings of the greatest asset of this spa town - its graduation towers. The fascinating history of the area and planning decisions concerning green areas over the years have brought many benefits to the town, which also extend outside the scope of health resort services. This article presents the multi-faceted changes and transformations of this area along with the plans and intended uses.

**Keywords:** spa park, spa town, spatial planning in spa towns

**Streszczenie**

Celem pracy jest udokumentowana na podstawie archiwalnych map oraz badań terenowych i stanu obecnego ocena zmian przestrzennych wielkości Parku Zdrojowego w Inowrocławiu na przestrzeni lat od XIX wieku. Miasta pełniące wysoko wyspecjalizowane usługi uzdrowiskowe, takie jak Inowrocław, potrzebują dużo obszarów dla terenów zieleni dzięki temu gwarantują kuracjuszom oraz turystom teren ogólnie dostępny potrzebny do terenoterapii i przebywania na wolnym powietrz,u a nie tylko w pobliżu tężni, z których słynie Inowrocław. Bardzo ciekawa historia tego obszaru oraz decyzje planistyczne na przestrzeni lat przyniosły dziś miastu szereg korzyści – nie tylko zdrowotnych z punktu widzenia terenów zieleni. Przekształcenia i dążenia obszaru zaprezentowano w niniejszym artykule.

**Słowa kluczowe:** park zdrojowy, miejscowość uzdrowiskowa, planowanie przestrzenne w uzdrowiskach

## 1. Material and methods

This study comprised analyses of cartographic and graphical materials. The following maps were analysed: Messtischblatt 1:25,000, Berlin 1890, map sheet 1722 (Inowrozlaw) reference number UP 2290, Messtischblatt 1:25 000, Berlin 1911, map sheet 3275 (1722) (Hohensalza), Messtischblatt 1:25,000, Berlin 1944, map sheet 3275 (Hohensalza), the City Map of Inowrocław of 1910 scale 1:10,000, Berlin, PHARUS-PAN VON HOHENSALZA, the City Map of Inowrocław of 1933 scale 1:5,000, the City Map of Inowrocław. A review of literature on the subject of urban green was conducted and publicly available planning Study and other documents were analysed.

## 2. Results and conclusions

Results of spatial planning analyses were elaborated using the QGIS programme, which facilitated the presentation of the spatial changes in the Spa Park over the years. The spatial scope of this study covers zones A, B and C of the spa town protection. This research topic was investigated in more detail in 2017 within the framework of a B.Sc. thesis, of which this author was the scientific supervisor.

## 3. Introduction

Inowrocław is located in the Kujawsko–Pomorskie province (also referred to as the Kuyavian-Pomeranian voivodship) and thus it is a lowland spa town. In 2019 Poland has a total of 45 spa towns, of which only 17 are lowland spa towns. In addition to Inowrocław, the list also includes such towns located at an altitude of maximum 200 m a.s.l. as Augustów, Busko–Zdrój, Ciechocinek, Goczałkowice–Zdrój, Gołdap, Horyniec–Zdrój, Konstancin–Jeziorna, Kraków–Swoszowice, Krasnobród, Nałęczów, Połczyn–Zdrój, Przerzeczyn–Zdrój,Solec–Zdrój, Supraśl, Uniejów and Wieniec–Zdrój. The map below shows the locations of the Polish spa towns in 2019.

Other spa towns of Ciechocinek and Wieniec Zdrój are situated in the immediate vicinity of Inowrocław to the west. Its convenient position in central Poland is advantageous and enables greater accessibility. The beginnings of the Inowrocław spa town date back to 1875, when the company named Solanki Inowrocławskie [the Inowrocław Salt Springs] was established [3].

**Inowrocław is one of the very few spa towns in Poland, which thanks to their spatial planning decisions managed to increase the area of the Spa Park from 5 ha in 1876 to 85 ha in 2017. As specified in the research hypothesis, this article describes the stages of the spatial changes and spatial planning decisions.**

Such a spatial layout of the Spa Park is unique on the national scale, as in terms of its area it is at present one of the largest Spa Parks in Poland. In 1875, a salt mine began operating in Inowrocław, but it was closed and flooded in 1907. In 1929, salt mining operations were

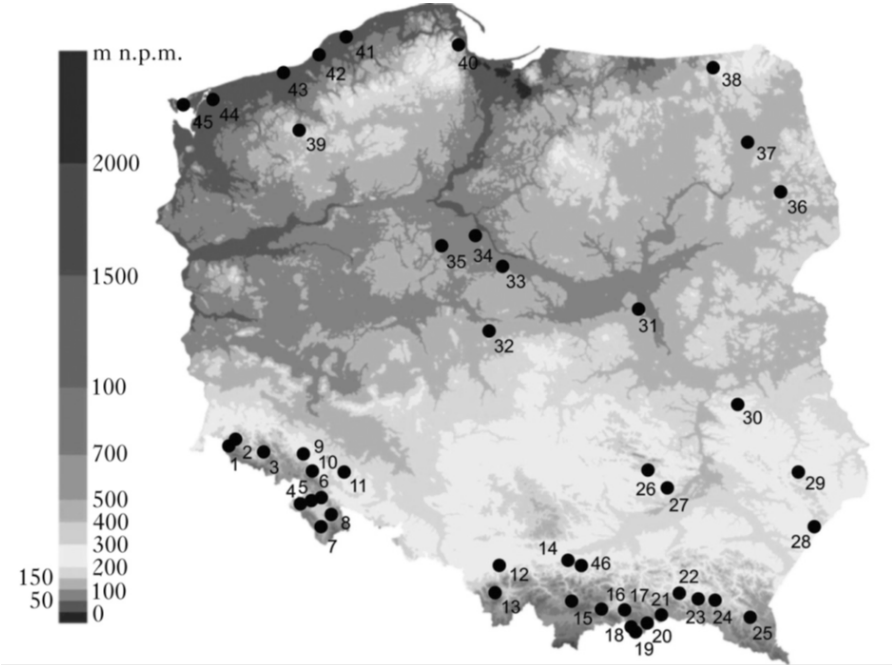


Fig. 1. Locations of spa towns in Poland [5]. Inowrocław is denoted by no. 35.
Locations of Polish spa towns: 1 – Czerniawa–Zdrój, 2 – Świeradów–Zdrój, 3 – Cieplice, 4 – Kudowa–Zdrój, 5 – Duszniki–Zdrój, 6 – Polanica–Zdrój, 7 – Długopole–Zdrój, 8 – Lądek–Zdrój, 9 – Szczawno–Zdrój, 10 – Jedlina–Zdrój, 11 – Przerzeczyn–Zdrój, 12 – Goczałkowice–Zdrój, 13 – Ustroń, 14 – Swoszowice, 15 – Rabka–Zdrój, 16 – Szczawnica, 17 – Piwniczna–Zdrój, 18 – Żegiestów–Zdrój, 19 – Muszyna–Złockie, 20 – Krynica–Zdrój, 21 – Wysowa–Zdrój, 22 – Wapienne, 23 – Iwonicz–Zdrój, 24 – Rymanów–Zdrój, 25 – Polańczyk, 26 – Busko–Zdrój, 27 – Solec–Zdrój, 28 – Horyniec–Zdrój, 29 – Krasnobród, 30 – Nałęczów, 31 – Konstancin–Jeziorna, 32 – Uniejów, 33 – Wieniec–Zdrój, 34 – Ciechocinek, 35 – Inowrocław, 36 – Supraśl, 37 – Augustów (Meller, Bernat 2019).

restarted and they continued until 1991 when they were ceased again and the remaining salt wells were flooded. The excavation operations led to mine-related subsidence being observed throughout the town (SUiKZP, Inowrocław, 2008) [12].

Inowrocław has been a spa town since 25 July 1967. In 2014, the registered population was 74,564 permanent residents (GUS, 2014). Most areas around Inowrocław are arable lands, with the other land use types including permanent grassland, permanent pastures, developed agricultural areas, and forests and other land use types (SUiKZP, Inowrocław 2008) [12].

The Act of 28 July 2005 on Health Resort Treatment, spa towns and spa town protection areas and on health resort communes stipulates that in order to be granted a spa town status, a given area has to meet the following conditions: to have deposits of natural therapeutic raw materials with confirmed therapeutic properties as specified in the Act; to have a climate with therapeutic properties confirmed as specified in the Act; to contain within spa treatment institutions and spa treatment facilities dedicated to spa treatment its area; to meet environmental requirements specified in the regulations concerning environmental protection; to have technical infrastructure such as water supply and sewage management, power supply and public transport; to have implemented waste management procedures [11].

## 4. Material and methods k 18 - town

Studies on archival resources were conducted using cartographic and graphic materials pertaining to green areas in the city of Inowrocław, focusing on the Spa Park in Inowrocław. Analyses were carried out on secondary sources, literature on the subject, spatial planning documents, legal resolutions of the city authorities and internet sources. The final analysis was also performed on both maps and archive city plans.

## 5. Results

The beginnings of the spa park date back to 1876, when the Spa Park based on the initiative of Lucjan Grabski and design by Michał Budziński was established in an area of 5 ha. This original small park was rectangular in shape. The avenue, which in the past ran towards the city centre, has been preserved up to the present day. In the past, it was planted with roses and trees. Today, it is Solankowa street, linking the city with the spa town. The Bath house was the most prestigious building. In front of the Bath house, gravel roads were laid and lined with flower baskets. The park was surrounded by a circular parkway which linked transverse paths.

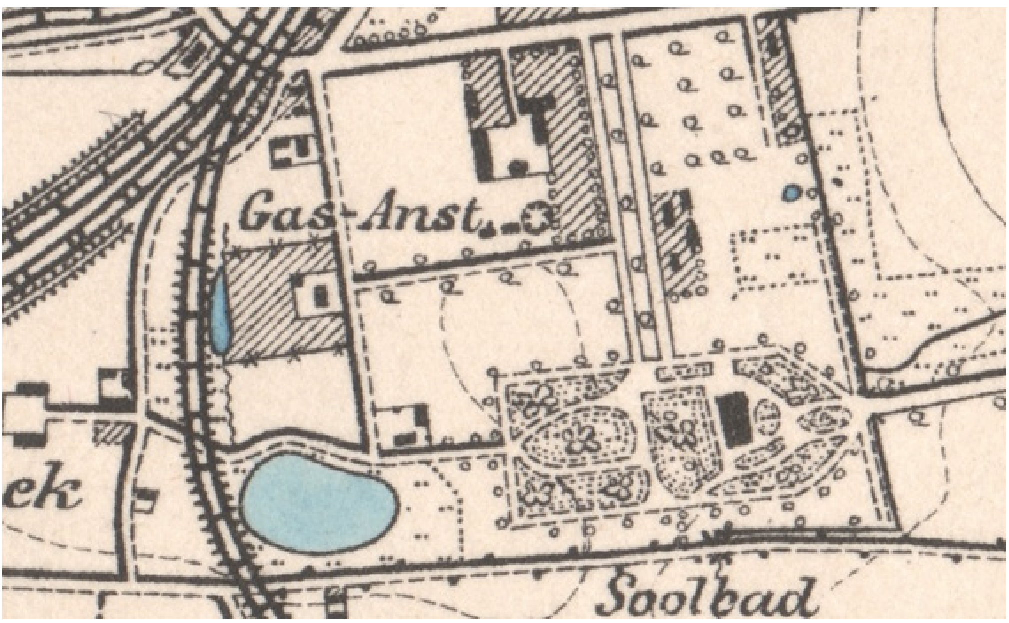


Fig. 2. A fragment of a map from 1890, presenting the area of Park Solankowy [the Salt Spring Park] in its original outline and with an area of almost 5 ha (the Poznań University Library), (Source: [1])


Fig. 3. A fragment of a map from 1911, presenting the area of Park Solankowy [the Salt Spring Park] (Poznań University of Life Sciences, the Division of Spatial Management and Geodesy), (Source: [1])

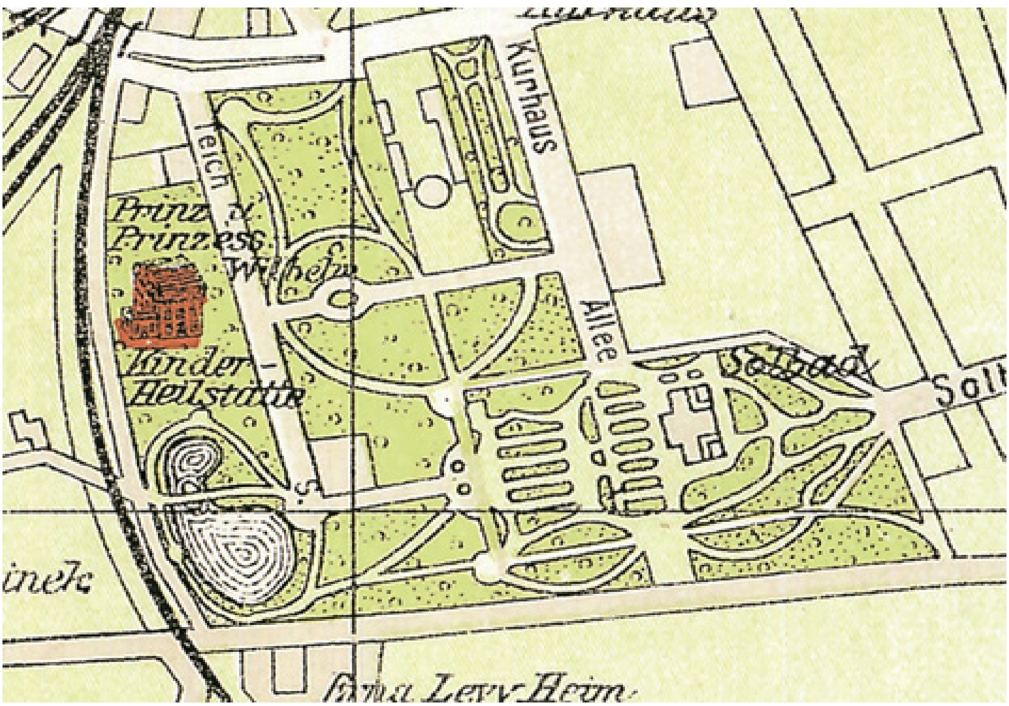


Fig. 4. A fragment of a city map from 1910, presenting Park Solankowy [the Salt Spring Park], (Source: [1, 14])

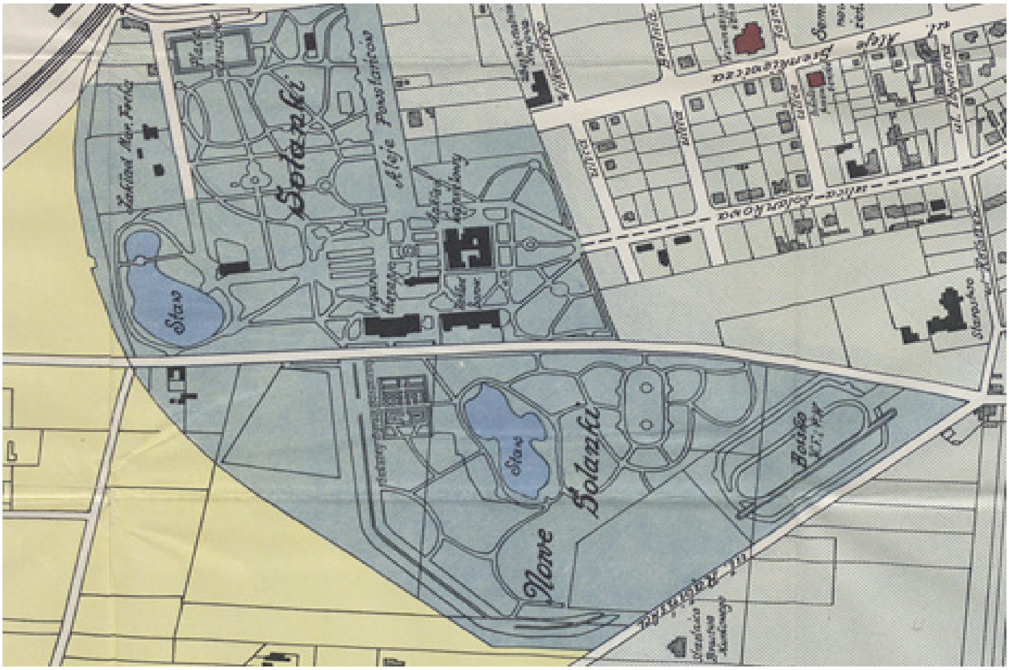


Fig. 5. A fragment of a city map from 1933 presenting the area of Park Solankowy [the Salt Spring Park] (Source: [1, 14])

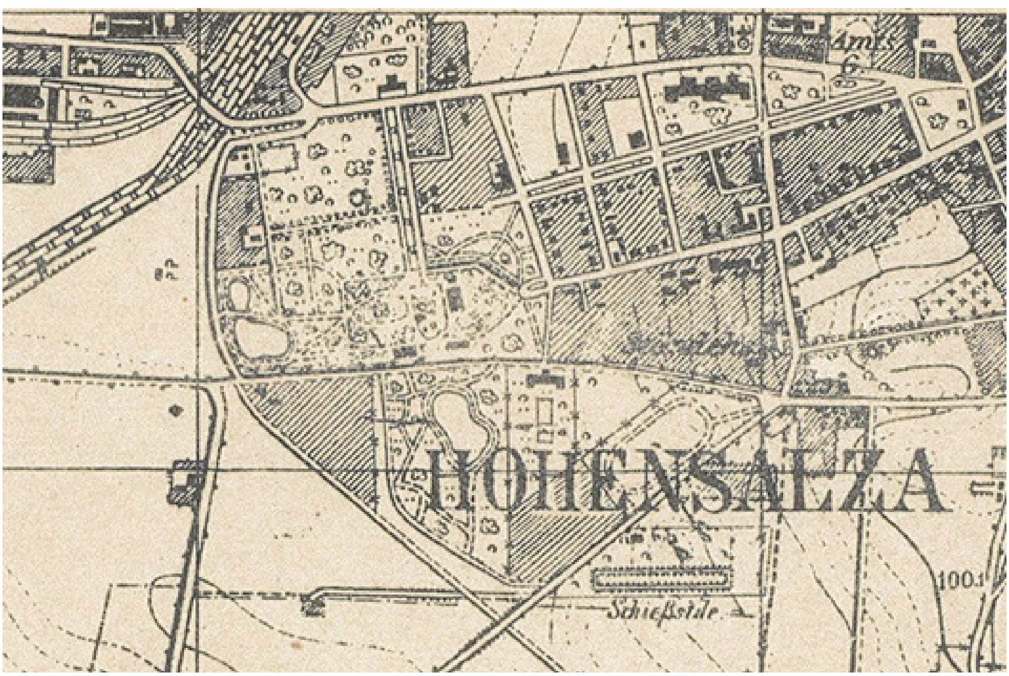


Fig. 6. A fragment of a map from 1944 presenting the area of Park Solankowy [the Salt Spring Park] (Poznań University of Life Sciences, the Division of Spatial Management and Geodesy), (Source: [1])

A pond was situated in the south-west corner. A two-lane avenue, accessible for horse riding, ran from the north [4, 6, 13].

On a map from 1890, we can clearly see the facility and the layout along the east-west axis with ponds at the end of the vistas. On the north-western side, the railway tracks are preserved to the present day as originally outlined in the past.

In the early twentieth century, changes were introduced as it was necessary to link the new buildings in the Spa Park with parkways. At that time, the landscape designs were stylistically linked with the geometric layouts of the park (e.g. marked by showy flower parterres, also called flower carpets). Former parkways intersect at the present-day bandshell and a fountain. Flower carpets of seasonal plants continued to be designed and planted [4 6, 13].

The city map from that period shows the parkways and the designed layout of the park plantings in detail.

In the mid nineteen-twenties, an area of 42.5 ha adjacent to the southern boundary of the Spa Park was purchased due to the initiative of Władysław Fabiszewski. This new area was named Nowe Solanki [the New Salt Springs] and the park green areas were also established there. An increasing numbers of spa town patients came to Inowrocław [6, 13].

The area of Park Zdrojowy [the Spa Park] has also been analysed in terms of noise nuisance [9]. These authors also stressed the importance of westerly winds, thanks to which, urban pollution does not reach the park [9]. Our spatial analyses and the area size were also independently confirmed in another study [9] stating that in the 19$^{th}$ century, one bath house dominated the park, with roads surrounding the park in the north-western section leading to the saltworks located on the other side of the railway tracks. Only the oldest part of the Spa Park (within the original boundaries) is covered by conservation protection.

## 6. Graphic analysis of the spa park

Old postcards show these places, the parks and spa town patients. Examples of such postcards are shown further.

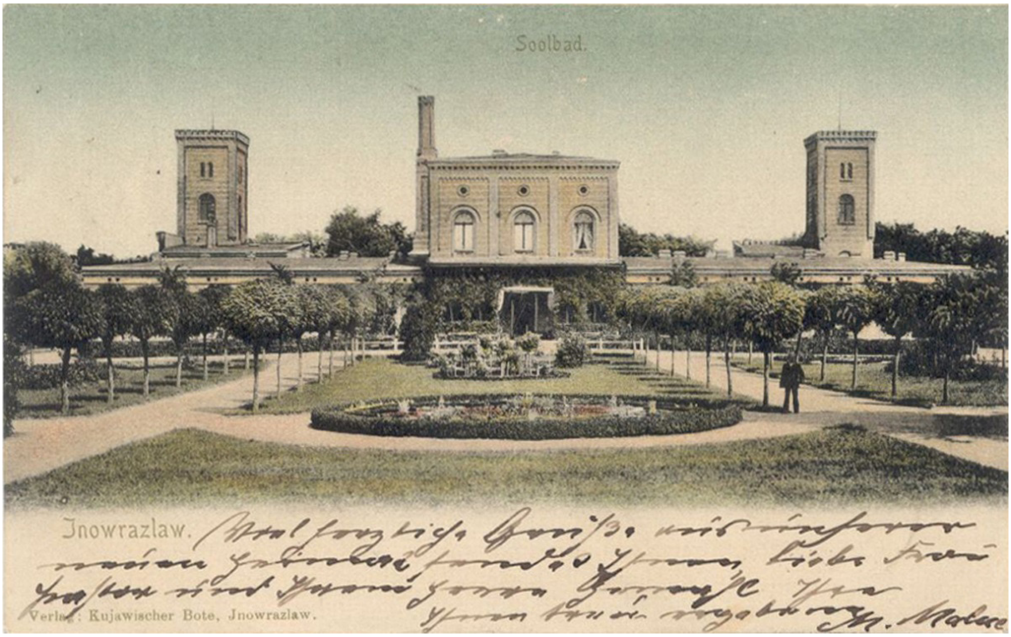


Fig. 7. The Spa Park in Inowrocław in 1903. The main axis of the park layout. At that time the future cafe had not yet been constructed, this was to be erected soon afterwards (Source: [15])


Fig. 8. The Salt Spring Park in 1911. Inowrocław. The lawn parterre is completed with a cafe and outdoor coffee tables. The axial layout is reinforced by the tree plantings (Source: [15])

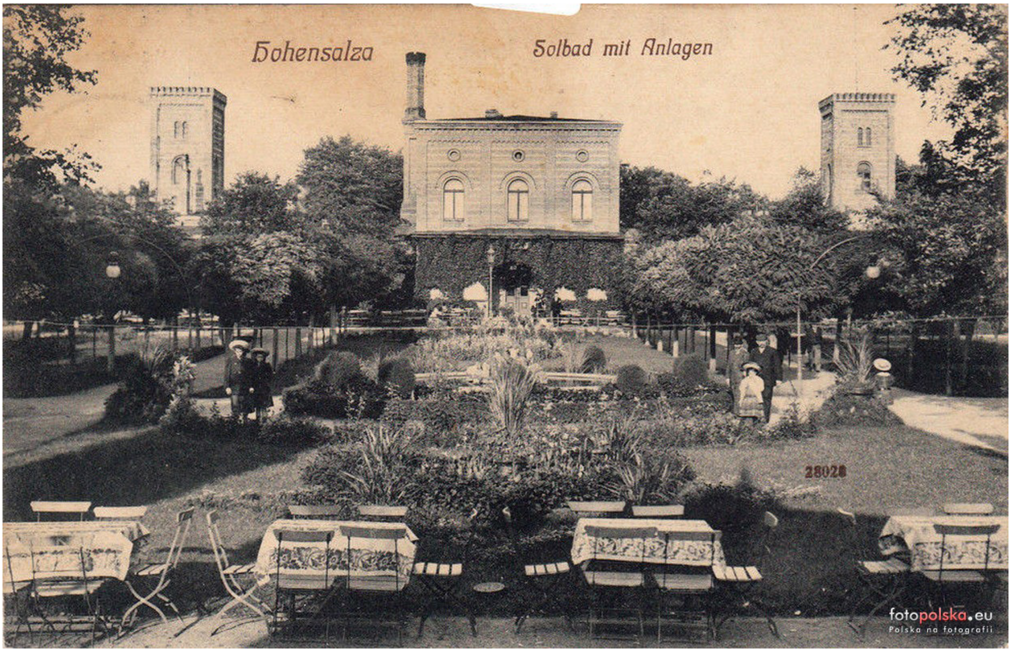


Fig. 9. The Spa Park in Inowrocław. The above image is a close-up from the previous postcard presenting specific details of the cafe. There are tables for the seating of sixpersons covered with table cloths and classical heavy chairs of a visually light design. The photograph was taken in the centre of the main axis of the park layout (Source: [15])

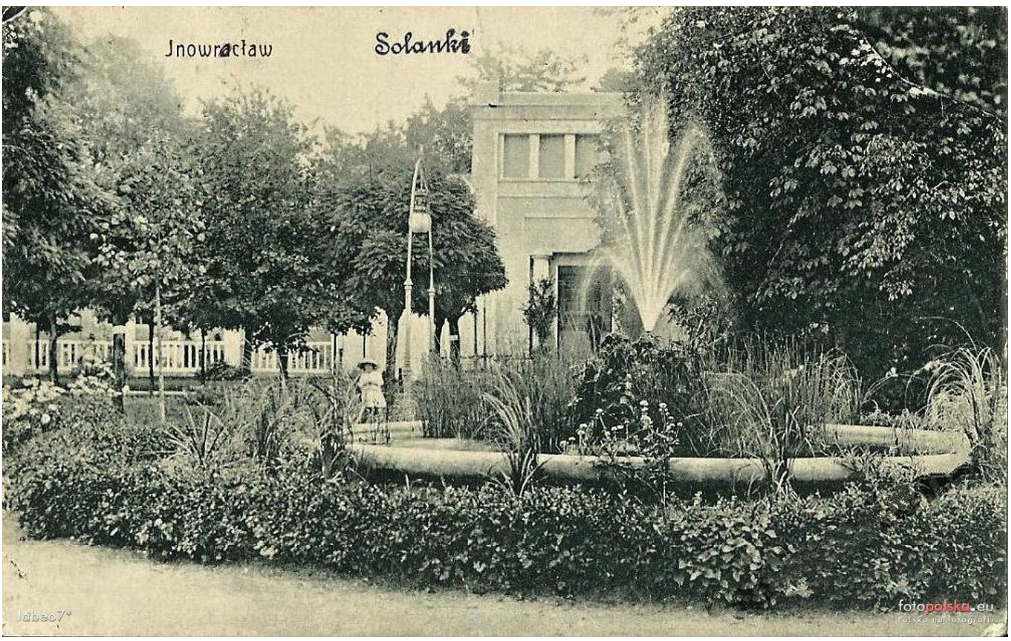


Fig. 10. The Spa Park in Inowrocław in 1913. The above image shows a fountain in the foreground with the Pump Room building in the background (Source: [15])


Fig. 11. The Spa Park in Inowrocław in 1915. The main axis of the park layout runs through the parterre planted with low box shrubs and trimmed trees. This is an iconic photograph of Inowrocław on an old postcard (Source: [15])


Fig. 12. Inowrocław – Zakład Kąpieli Borowinowych [the Peat Pulp Bath House] in 1926 (Source: [15])

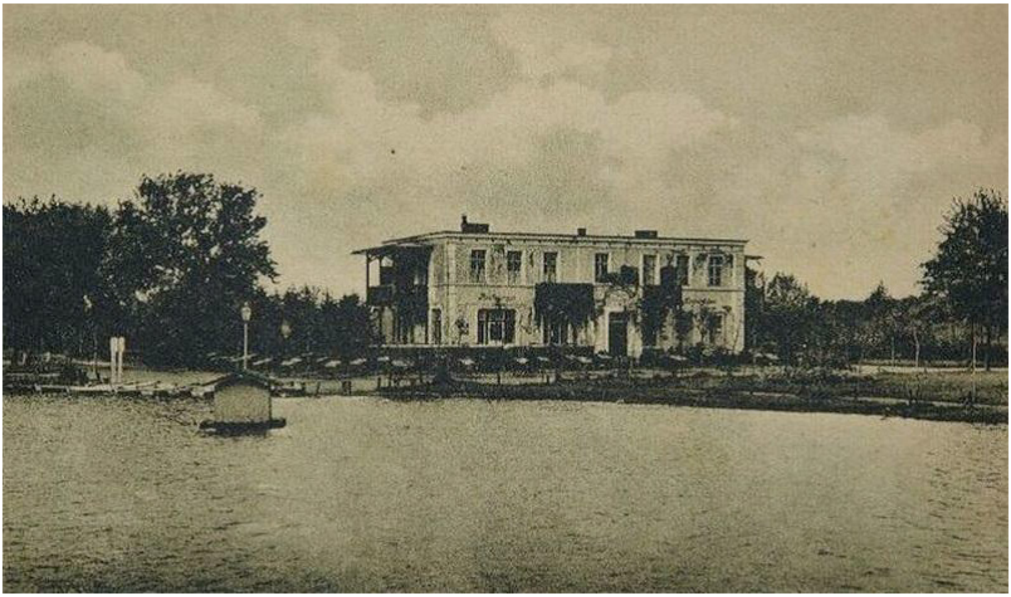

Fig. 13. The cafe building in Solanki [the Salt Springs] around 1920 (Source: [1, 16])

Fig. 14. Restauracja nad Stawkiem [Restaurant on the Pond] in Solanki, 2016. The view in the foreground – the water surface surrounded by old trees (Source: [1])


Fig. 15. A graphic from 2015 promoting the initiative "Solanki masz gratis" [you get the Salt Springs for free] (Source: [1, 17])

## 7. Discussion

As we can see from all the archive maps, the railway tracks located in the north-western section of the Spa Park constituted the spatial barrier. Thus, it may be concluded that the park was initially developing in stages in a northerly direction, then in an easterly direction and only recently in a south-westerly direction. Each of these maps is sufficiently detailed to indicate in separate analyses the status of the preservation of the historical layout, the impact and influences of the specific epochs and the system of parkways. This constituted the starting point for further studies and research hypotheses.

Initially, the Salt Spring Park was rectangular in shape, with an isosceles triangle on its eastern side. As was the case in the past, Solankowa street runs from its vertex, linking the spa town with the city. In the beginning, this area was approx. 5 ha [1]. Between 1890 and 1911, the Salt Spring Park was enlarged to incorporate areas located to the north of the original park, thus increasing the park area almost two-fold. Postcards from this period are presented in this article. In the period from 1911 to 1944, the area of the Salt Spring Park increased by 42.5 ha as a result of new land being purchased. This time, the newly acquired area was located to the south of the previous park boundary; it was triangular in shape and provided ground for Nowe Solanki [the New Salt Springs] comprising a pond, an indoor swimming pool and numerous park paths. During this period, the park also included a small plot of land in the northern part of the park [1].

In the diagram, the light-green colour marks an area which was incorporated into the park in the period from 1944 to the present. The area is situated to the west of the original park boundaries. It can be stated that during the period of approx. seventy years, the park area increased two-fold. This was the result of investments made in the years 2008-2013, when 30 ha of land were purchased and Nowe Solanki [the New Salt Springs] were designed to resemble those of the past. At present, the park is approx. 85 ha in area [1]. In the future, the park may be further expanded to the south-west of the Salt Spring Park because undeveloped land is located there [1].

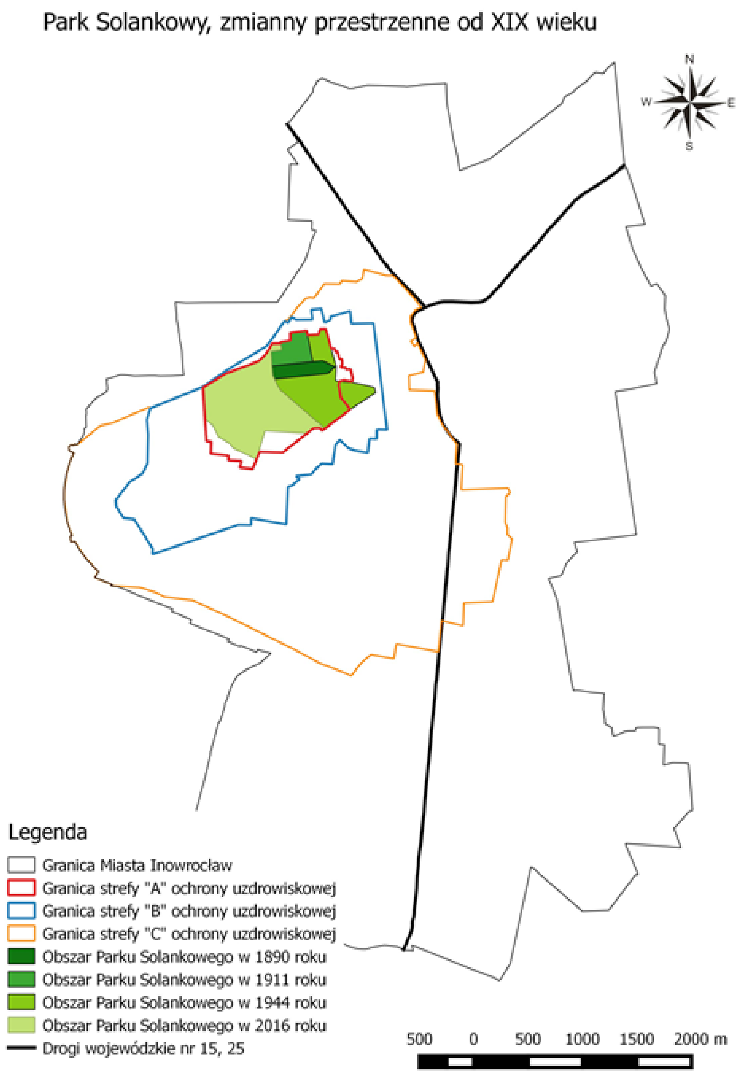


Fig. 16. Spatial changes in Park Solankowy [the Salt Spring Park] since the 19th century (Source: [1])

## 8. Concluding remarks

Unfortunately, the city of Inowrocław has no forests. The fact that the city authorities have managed to enlarge the Spa Park to such an extensive area is clear evidence of their willingness to preserve the natural value of the spa town and prevent so-called urban congestion which is so typical of other Polish spa towns. The establishment of zone A in a specific area indicates a reasonable potential for the establishment of new green areas there.

Research results show that in spa protection zone A, the percentage share of green areas as indicated by the diagnosis of the current status is as high as 90.72%. In zone B, the percentage share of biologically active green areas identified in the analysis of the actual status is as high as 80.49%, while in zone C, the percentage share of biologically active green areas according to the diagnosis of the actual conditions is 75.55% [10]. This means that the data considerably exceeds the requirements of the Act of 2005 because for zone A, this Act imposes the requirement of a minimum of 65% green areas, for zone B, a minimum of 50% green areas and for zone C, the percentage share of green areas is 45%.

In 2008, the total area of green spaces in Inowrocław was 343.30 ha, which gives approx. 43 $m^2$ per capita. By contrast, the national index of green areas per capita is only 16.3 $m^2$ [2] thus, in Inowrocław, this figure is over 2.5-fold higher. It needs to be stressed here that from 2008 to 2016, the Salt Spring Park increased in area by another 30 ha [1, 12].

The Salt Spring Park (Park Solankowy) in Inowrocław has expanded from the initial small area of 5 ha in 1876 to be one of largest areas in Poland in 2017 covering as much as 85 ha. It is a tremendous asset for the spa town of Inowrocław. Firstly, the increase in green spaces, being biologically active areas, provides an opportunity to enhance the health-promoting impact on the inhabitants, spa town patients and visitors. Trees producing oxygen (in the dark stage of photosynthesis) have a beneficial effect participating in the modification of the town's microclimate. Secondly, the considerable quantity and sizesof areas of green spaces in the spa town of Inowrocław create the therapeutic landscape. The green areas reduce the burden of pollutants, specifically suspended matter, dust and noise. Over a longer time perspective, green spaces also provide several tangible economic benefits to the city because prices of the local real estate and plots may soon increase as a result of their proximity to the highly attractive, prestigious park. All these and other benefits for Inowrocław will be brought about by the expansion of the Spa Park to an area of 85 ha.

## References


[1] Gedowski P., *Analiza przestrzenna terenów zieleni na terenie miejscowości uzdrowiskowej Inowrocław od XIX w. [Spatial analysis of green areas in the spa town of Inowrocław since the 19th century]*, B.Sc. thesis prepared under the scientific supervision of dr inż. arch. kraj. Magdalena Meller, Poznań University of Life Sciences, Faculty of Environmental Engineering and Spatial Management, Institute of Land Improvement, Environmental Engineering and Geodesy, Poznań 2017.

[2] Main Statistical Office GUS, Główny Urząd Statystyczny, *Powierzchnia i Ludność w Przekroju Terytorialnym*, 2014.

[3] Kasińska B., Mikołajczak E., Strachanowski P., *Po prostu Inowrocław*, Drukarnia POZKAL, Inowrocław 2008.

[4] Majewski B., *Uroki starego Inowrocławia*, Biuro turystyczne PIAST, Inowrocław 2002.

[5] Meller M., Bernat S., *Drzewa pomnikowe na terenie uzdrowisk w Polsce*, Sylwan 163 (3): 258–264, 2019. DOI:https://doi.org/10.26202/sylwan.2018104.

[6] Sikorski Cz., Sikorska J., *Świadkowie 800-lecia: encyklopedia wiedzy o zabytkach Inowrocławia*, Oficyna Wydawnicza Muzeum im. Jana Kasprowicza, Inowrocław 2002.

[7] Study of Spatial Management Conditions and Directions in the Commune and Town of Inowrocław, 2008.

[8] Szczechowicz H., *Kujawy wschodnie i ziemia dobrzyńska w II Rzeczpospolitej*, Agencja reklamowa TOP, Włocławek 2013.

[9] Sztubecka M., Skiba M., *Warunki akustyczne na obszarach jednolitego zagospodarowania Parku Zdrojowego w Inowrocławiu* Uniwersytet Zielonogórski, Zeszyty Naukowe no. 16, Inżynieria Środowiska no. 41, 2016.

[10] Resolution no. XLVIII/639/2014 of the Inowrocław City Council of 20 October 2014 on the evaluation of the current status of spatial management conditions and directions and local spatial management plans of the city of Inowrocław.

[11] The Act of 28 July 2005 on Health Resort Treatment, spa towns and spa town protection areas and on health resort communes.

[12] Studium Uwarunkowań i Kierunków Zagospodarowania Przestrzennego Gminy Miasto Inowrocław, 2008.

[13] www.parki.org.pl (online: 18.12.2016).

[14] http://stareplanymiast.pl/wg-miast/inowroclaw (online: 5.11.2016).

[15] www.fotopolska.eu (online: 26.05.2017).

[16] http://www.inowroclawfakty.pl/galeria-fotograficzna/solanki-zdj%C4%99ciaarchiwalne (online: 23.11.2016).

[17] http://www.idk.inowroclaw.info.pl/aktua/2015/pazdziernik/sola1.jpg (online: 13.12.2016).



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# Churches from former factories – conversions and controversies

# Kościół w fabryce – konwersje i kontrowersje

**Abstract**

This paper focuses on architectural transformations of some post-industrial objects into sacral functions. The discussed works mainly relate to churches, chapels and parish houses of various Christian denominations, mainly Protestant. Such transformations provoke questions about the limits of acceptance for adaptation works in the context of objects associated with a religious cult. The doubts that arise are connected primarily with the theological-liturgical dimension, that means the interpretation of the sacrum space. As far as conservation work is concerned, the analysed examples confirm the thesis of high architectural potential inherent in post-industrial objects. They also show a wide spectrum of possible interferences in a given structure during the conversion process.

**Keywords:** sacrum, profanum, conversion, post-industrial architecture

**Streszczenie**

W artykule skupiono się na problematyce architektonicznych przekształceń wybranych przypadków obiektów poprzemysłowych na funkcje sakralne. Przykłady dotyczą adaptacji dawnych fabryk na funkcje religijne lub z nimi związane (kościoły, kaplice, domy parafialne, itp.) dla różnych wyznań chrześcijańskich, głównie protestanckich. Takie konwersje rodzą pytania o granice akceptacji działań adaptacyjnych w kontekście obiektów związanych z kultem religijnym. Pojawiające się wątpliwości dotyczą przede wszystkim wymiaru teologiczno-liturgicznego, a mianowicie interpretacji przestrzeni sacrum. W ujęciu konserwatorskim analizowane przypadki potwierdzają tezę o dużym potencjale architektonicznym tkwiącym w obiektach poprzemysłowych i możliwościach ingerencji w ich strukturę w procesie konwersji.

**Słowa kluczowe:** sacrum, profanum, konwersja, architektura poprzemysłowa

## 1. Introduction

In 1999, the Korean Presbyterian church in New York was located within an area between Northern Boulevard and Sunnyside Gardens, Queens. It is considered to be one of the most authentic religious buildings of the newest generation. Four designers, including Doug Garafolo, Greg Lynn and Michael McIntruf, collaborated on this project using Alias – an online graphics software tool used in industrial design and film animation. This project, to which we will return later in this article, has received many awards, including the Engineering Awards of Excellence (2002). Nowadays, it is a well-known established facility. Not everyone realises that in the imposing building of a former laundry factory, which represents good-quality American art-deco architecture, one can find a unique church. The harmonious combination of the new form with the existing building was made possible due to the use of an integrated design. Thus, a specific hybrid was created. Also, according to the designers, its funerary tricolour of grey, black and violet-pink (*mauvre*) symbolically refers to the previous function of the existing building with one difference – washing dirty army uniforms was replaced with 'cleaning' the souls of the dead (Fig. 1).


Fig. 1. The Presbyterian Church (Queens, New York), established in 1999 as a result of the adaptation of the Knickboker industrial laundry (source: [24])

This surprising conversion of a post-industrial building into a sacred building is not the only example of a building which began to perform liturgical functions after adaptation and expansion. Such transformations can be found in both Europe and America. They relate to adaptations performed for various Christian denominations, especially the Protestant faith. The adapted buildings may take on religious functions (churches, chapels) or other related functions, such as parish houses. This phenomenon is puzzling, especially when comparing the number of buildings that previously performed religious function and are now being abandoned or, at best, adapted for other purposes. It is also paradoxical, because in both cases (factories and churches) we are dealing with a process of disappearance – factories, in connection with entering the post-industrial phase of economic transformation, and churches, due to the ongoing secularisation of society.

Depending on the type of object, these transformations are implemented using various strategies related to different types of changes. Sometimes it is a significant transformation of the building's architecture which includes the total integration of the new construction with the existing structure (like the aforementioned laundry); in other cases, it is an addition which is completely independent of the existing facility, with its own autonomous spatial structures and no connection with the existing building (e.g., a former barn in Schwindkirchen, Germany – today a Protestant parish house of the Parish of the Assumption[1]). We also observe that conversions can involve minimal intervention in the structure of the building and implement a conservation program aimed at preserving the characteristic form of the historic building as much as possible (e.g. the former gas plant in Birmingham, England, rebuilt as an Anglican church[2]). Additionally, we can observe activities aimed at adapting specific elements, such as chimneys, cooling towers, pressure towers or mine towers of post-industrial complexes. This case is demonstrated by the church tower accompanying the Santo Volto church, built in the Parco Doro area of Turin. It is also worth mentioning conversion activities in which the building structure is left intact and the elements of the building from the demolition are used in the process of transformation. Such transformations bear all the features of material recycling in architecture (e.g., the Orthodox Church of St. Nicholas in Sprungdale, USA).

Let us explain here that the objective of architectural conversion is to reuse elements that have been abandoned or unable to fulfil their current tasks – in our case, post-industrial tasks– and give them a new function. The change of the object's purpose results in a large range of transformations to both the exterior and interior of the structure. The scope of adaptation depends on both the degree of suitability of the construction and its structure to its new function, as well as on how the strategy adopted may influence the integration between the existing and the new architecture. Apart from the cultural, economic and environmental dimensions, the modification of post-industrial buildings is often treated as an architectural and urban experiment. It is an important element in the process of merging the revitalised post-industrial areas within the city.

It is noteworthy that, although infrequent, the adaptation of objects that previously performed other functions for religious purposes is not a new phenomenon. One example is Michelangelo's adaptation of a large part of the former Diocletian bathing complex to the needs of the Basilica of Maria degli Angeli e dei Martiri[3]. Whilst this was clearly not

1 Or the former Municipal Tram Power Station in Warsaw, now the ecumenical chapel of the Warsaw Uprising Museum, designed by Archetus.

2 Also the Denver-area Stapleton Fellowship Church, designed by Visioneering Studios of Irvine (2010), which was founded after an adaptation (mainly through the formation of a new interior) of the former airport hangar.

3 More on this subject: [2, pp. 141–152].

a factory, it was definitely a multifunctional object. Other parts of this magnificent object were transformed into the church of *San Bernardo alle Terme*[4].

Other examples we are aware of were factory buildings which were deliberately given the form of a temple, as in the case of a textile factory called Temple Works (or Temple Mill), erected in 1838-1840 in Leeds and designed by Joseph Bonomi (Younger)[5]. The stylisation of its facade into an Egyptian temple (Horus in Edfu) resulted from the Egyptological fascination of its owner, John Marshall, as well as from the fact that the place belonged to the great Empire.

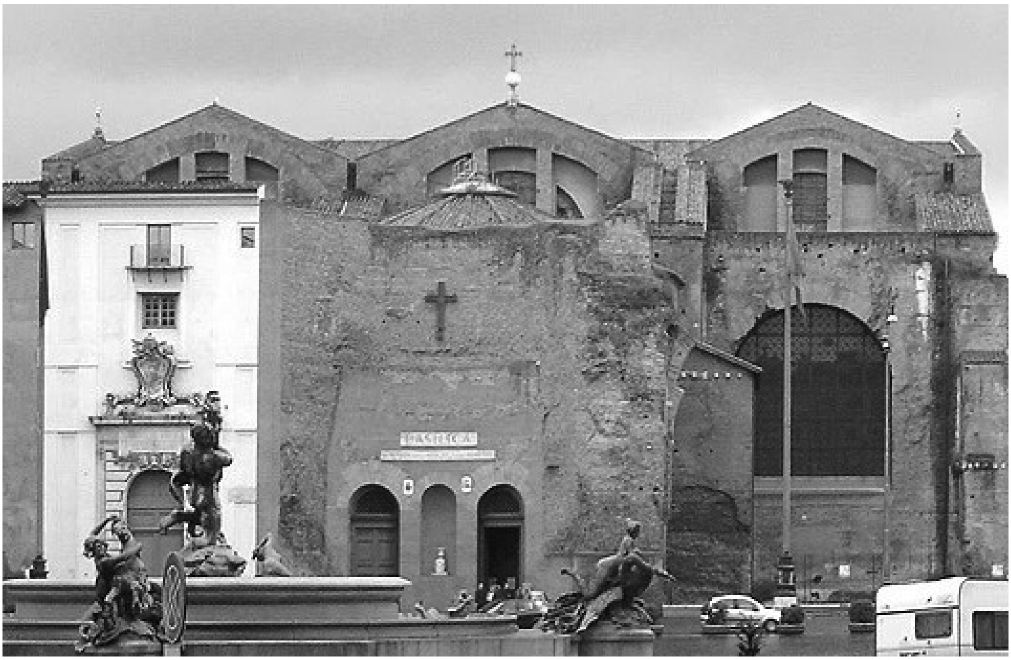


Fig. 2. Entrance to the Basilica of Maria degli Angeli e dei Martiri, created on the site of the former Diocletian bathing complex and adapted for the sacred function following the design of Michelangelo, around 1598 (photo by R.A. Frantz, 2005; source: [25])

These two types of conversions (a former temple into a secular object and vice versa) raise the question of limits of acceptance for adaptations of objects related to religious worship. The doubts that arise concern both theological and liturgical aspects (the interpretation of a sacred space). Additionally, there is an architectural problem which should be taken into consideration; it is related to the context of conservation, especially in relation to post-industrial monuments.

4 In 1598, one of the circular towers of the former Diocletian Term was converted into a church and handed over to the French Cistercian Order. [2, p. 142].

5 The design of the roof over the factory was very interesting. It was equipped with skylights in the shape of cones, while the flat surface was covered with grass to maintain the moisture. The height of the grass was regulated by sheep grazing on the roof [3].

Regarding liturgical issues, it is clear that such transformations are easier to carry out in the case of Protestant denominations, in which the church is defined as a community of believers and does not have a sacred character, as is the case with Catholic and Orthodox churches. It is also important that in Protestantism, the form and its physical existence appears as a so-called adiaphoron and is indifferent from a theological point of view. Thus, the space of the church can be easily adopted and modified.

Architectural ground for converting various secular objects into religious places began to be prepared from the beginning of the twentieth century. Due to modernists, a significant change in the concept of the role of art and beauty in architecture appeared. This also applied to sacral architecture, although "the attempt to adapt art originating from sources contrary to Christian ideas [...] was burdened with great difficulties" [3, p.42]. In the first half of the twentieth century, these 'difficulties' led to the development of two contrasting currents in sacral design of modernist architecture that are still visible today[6]. Therefore, churches are maintained either in the traditional style (late historicism) or belong to avant-garde modernism [3, p.9]. In the latter case, new building materials and constructions, as well as innovative functional solutions, gained importance. This was in accordance with the principle of constant search, transformation and modernisation, which has been in force since the end of the nineteenth century. "In this way, a group of churches began to be built as almost only engineering buildings... Beauty... was not as crucial as material or construction factors. Most often it resulted from the beauty of perfectly manufactured steel and glass elements, as well as from the ideal form of various stones" [3, p.8]. Some church buildings have even become "similar to factory buildings, railway stations or pavilions of world exhibitions of current technological achievements" [3, p.9]. Lastly, the most prominent example will be the technologically advanced Pavilion (not a church or chapel) of Christ, erected at the Expo 2000 exhibition in Hanover. Within this structure, the existing traditional semantics and church symbolism have been replaced with "sublimity" [4, p.27; 5, p. 264].

What was equally important was the change of attitude towards the architectural post-industrial heritage – this paradigm shift occurred towards the end of the seventies [6, pp. 92–101]). Post-industrial objects "from the utilitarian perspective entered the world of architecture and art" [6]. Their functional interiors with characteristic forms and proportions met strict technological requirements. At the same time, these post-industrial objects were aesthetically raw and erected utilising original constructions and materials. They have become excellent reference points, inspiration and, moreover, places affected by 'genius loci' for various types of adaptation activities, [7, p. 6][7].

It is not only aesthetic considerations that have played a role in the protection of post-industrial objects – which has become the cultural norm in many countries. Preservation of the general image of cities and their panoramas filled with buildings of this type has also

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6 The traditional trend has gained special importance, for example, in Poland, as evidenced by the shape of many churches erected after the Second World War, as well as a discussion on the competition for the Church of Divine Providence in Warsaw, which was won by Marek Budzyński.

7 This interesting article is unfortunately not free from categorical statements of a character that is difficult to consider acceptable in the scientific discourse, e.g. that "Man is composed of spirit and body".

been taken into account. Additionally, an important role has been played by economic and ecological factors. All these aspects have led to the conversion of nearly 40% of various buildings of this type in Europe [8, p. 9][8]. Today, project activities based on existing materials impose necessary limitations on the designer. Activities of this type are considered to be some of the most creative and fascinating tasks in architecture. Moreover, the revitalisation and conversion of industrial heritage is seen as a key element of building in the urban strategies of many cities.

## 2. Examples of conversions

The Korean Presbyterian church mentioned at the beginning of this article, as we have already written, was based on an earlier building erected in 1930 in Queens, New York, designed by Irving Fenichel for the Knickerbocker industrial laundry factory[9]. The designers of the conversion were faced with the difficult task of preserving and transforming the existing complex of buildings into a new function and giving it a reutilised architectural expression reflecting its new purpose. The transformed object was to serve as a religious, social and educational centre for the Korean community living in New York and sharing the same religious identity. It was decided that the building should be built on the basis of the former laundry factory and should be able to accommodate a congregation of 2.5 thousand people in the main hall, a school (with eighty classrooms), a library, a café, a banquet hall (for 1000 people), a wedding chapel, a day-care centre and a medical clinic (Fig. 1). The main challenge was to design a new meeting room without columns. The problem was solved through the addition of an independent steel structure over the ceiling of the former laundrette. Its columns were reused, placed throughout the interior and exterior of the existing building and were erected on independent foundations. The new construction consists of trusses that are more than thirty-six metres long, providing a single-room layout for the main meeting room.

For the main part of the temple, the designers came up with a form that they called the 'Nestor'. It was constructed from trapezoidal elements nested inside each other like a stack of baskets arranged on their sides. This is similar to Jurassic fossils with a serrated surface. This element is only partially visible from the outside as a row of zinc-coated, overlapping elements. This cascade falls on the northern facade of the building, protecting the external, reinforced-concrete staircase[10]. The space of the sanctuary is asymmetrical, which makes it seem more 'flowing', and the size of the room is less overwhelming. The fragmented glass wall makes it possible for natural light to penetrate the interior of the sanctuary, reducing the feeling of being enclosed.

[8] Starting from the revitalization of the docks in London, to the Poblenou district in Barcelona, Parco Dora in Turin and Hafen City in Hamburg – we are dealing with transformations of old industrial areas carrying out three basic revitalisation goals: revive degraded areas economically, eliminate environmental threats and protect post-industrial heritage.

[9] Later transformed into a perfume plant.

[10] Similar to St. Patrick's Cathedral in New York.


Fig. 3. View of the main entrance to the Knickerboker industrial laundry building (source: [26])

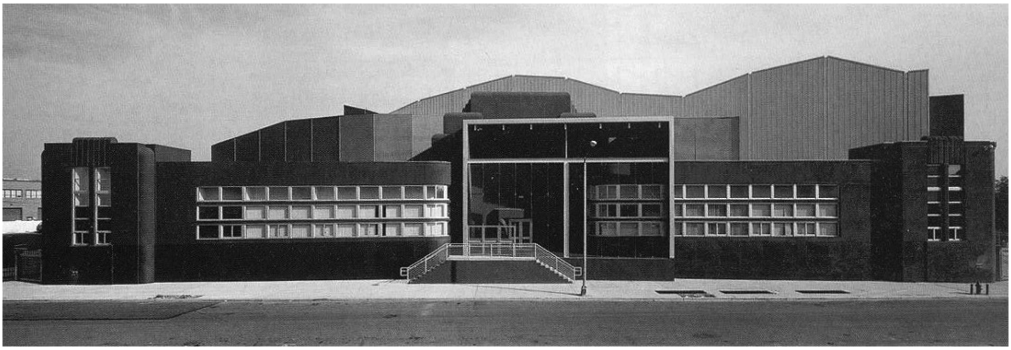

Fig. 4. Front elevation of the laundry building after its conversion into church (source: [27])

While implementing the project, the architects kept the facade of the original laundry. Only the entrance area was moved to a new position. The whole object was given a black colour and was called the 'Shroud'.

The interior of the church represents the most interesting solutions that have recently been created in New York. The parametric interior shell has an acoustic function. 'Architecture of folding' was implemented; this is an experimental trend in modern architecture by which one bends planes and shapes various forms. It is inspired by, among others, the works of Peter Eisenman[11].

11 Leading representative of deconstructivism in architecture, author of, among others, the monument to the victims of the Holocaust in Berlin.

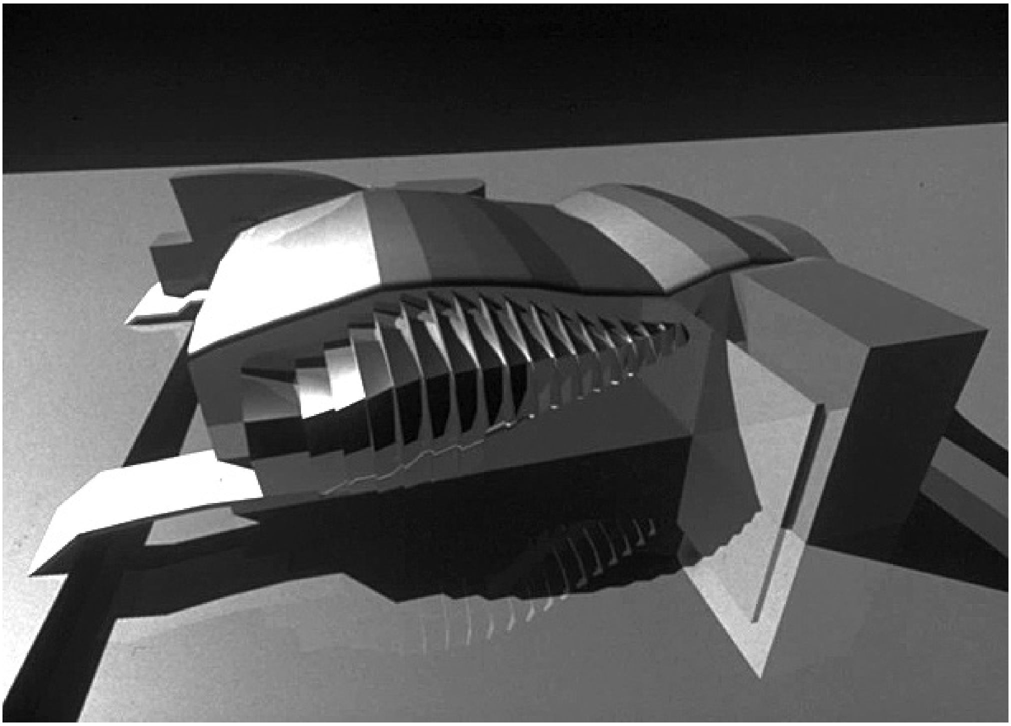

Fig. 5. Picture 3D model of the new church casing with a characteristic ‘pleated’ side entry cover for the main hall of the church (source: [27])

From the point of view of conservation methods used to adapt historical objects to new functions, the method of folding is an exceptional experiment. Folding is derived from topology – a science that deals with qualitative features of geometrical objects in n-dimensional space. The creators of topology were L. Euler and H. Poincaré[12]. As a result of the introduction of advanced CAD programs in the nineteen-nineties, it became possible to apply the theory of topology in architecture in both theoretical and practical contexts. The contemporary interpretation of folding is liquid ‘organic’ forms as well as angular forms originating from the art of origami. Behind the geometric interpretation of the folding of architecture is the philosophical interpretation of Gilles Deleuze concerning undulating entities, each of which is a complex multitude of further undulated parts (Fig. 9).

Folding in architecture has become a vocal point of inspiration for various spatial experiments in project design. In most cases, these experiments are based on the application of advanced computer programs for parametric and generative design[13].

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12 *Analysis Situs*, an article published in 1895 in the Journal de l’École Polytechnique (2, pp. 1-123) by Henri Poincaré, defined topology as a science.

13 Another name was used previously – BLOB. It was created by G. Lynn as an acronym of the module name in the software created by the Wavefront Technologies (specialising in software for the purposes of film animation): binary large objects. This is where the term ‘blobarchitecture’ appeared. Patrik Schumacher created a new term for software creating topological architecture - parametric architecture.

Deleuze compared the fold to a two-story building. On the ground floor, there is a well-lit room opened to the outside and ready to receive guests. The first floor is a dark area without any windows. These two spaces symbolise the two levels of our world – the material level and the spiritual level, connected to each other only by narrow crevices of the five senses. The two levels are separated by the fold.

In the Presbyterian church project in Queens, the allegory of the Deleuzian fold (a baroque house symbolising the model of the world at two levels[14]) can be found. The division of the building into two parts is clear. The lower level is occupied by the profane, while the upper level is reserved for the sacred function. These two levels are connected by a corrugated shell, constituting a Deleuzial fold. It defines the flowing boundary between the material and the spiritual, and between the visible and the invisible.

The existing structure was like a kind of 'pupa' for the designers. It was surrounded by a new body, which completely changed the sense of the existing space. The process of creating the new form itself also had to be changed due to the investor's interference in the project, and dynamic modifications of the project were possible as a result of the advanced Meta-BLOB computer programs[15].

This sophisticated design process has not prevented technical and technological problems (including those of a financial nature) related to its implementation. The differences are significant and it seems that in some areas, both the design and the implementation stages should be analysed and evaluated separately. After the erection, the building gives the impression of consisting of many, not entirely matching, elements. Attention is drawn to the lack of flow in the communication system of the interior, which devaluates the object in terms of the topological continuity of the space - important in the architecture of folding.

It seems that the most important remark should concern the doctrinal contradiction between the form of the neo-baroque curving of the space, 'folding', blobbing, or the currently very fashionable, parameterisation of the architectural form, and the idea of the Protestant congregation as a place of assembly, for which one of the basic principles is to preach the scripture (*sola scriptura*), and churches should be primarily designed for such activities.

A change in concept, specifically the introduction of an independent structure to an existing building, was performed in the town of Schwindkirchen (Bavaria). It was the conversion of a former barn into the Protestant Parish House of the Assumption. The architects responsible for this project had the task of protecting the cohesion of a compact historical complex, consisting of a church, an old parish house and a farm with a large unused barn, an administrator's house and smaller outbuildings. The new parish house, suitable for the needs of the parish, was not to be too large but functional and corresponding to modern standards. After long discussions, it

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14 "A world with only two floors, separated from each other by a fold, in different ways reflected on two sides - this is the unparalleled contribution of the Baroque" [9, p. 69].

15 In 1995, the American architect Greg Lynn began his adventure with digital design and introduced the term "blob architecture".

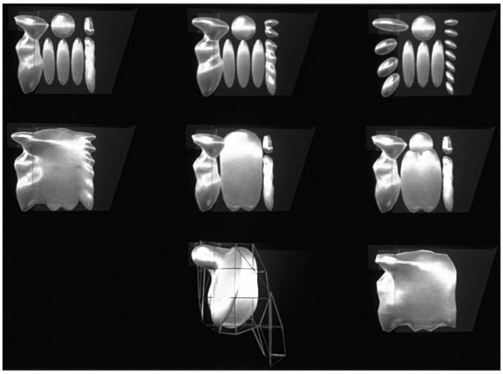

Fig. 6. The process of the computerised generation of a new form using the Meta-BLOB program for the Presbyterian church in New York (source: [27])

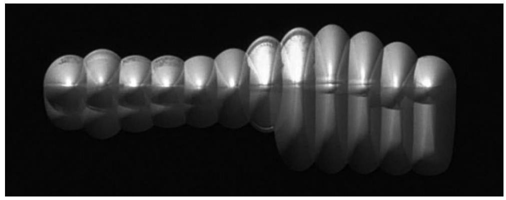

Fig. 7. The next phase of transforming the interior of the Presbyterian church in New York using the Meta-BLOB program (source: [27])

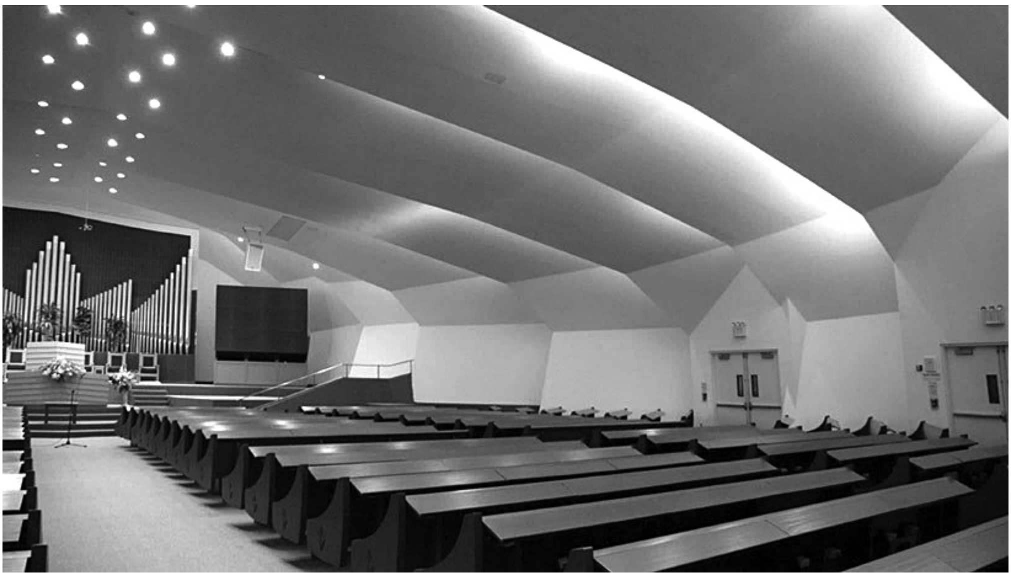

Fig. 8. The interior of the Presbyterian church in New York with the characteristic 'folding' of the ceiling (source: [28])

was decided that the best solution would be to construct the parish house inside the old barn; this was also a preferable option from an economic point of view.

The discussions mentioned above concerned not only functional problems (e.g. proper lighting) but, more importantly, doctrinal problems. It was debated whether the old barn was a proper, worthy 'packaging' for the building that was to serve as a parish house[16]. These

16 These doubts troubled the parish people for some time after the construction of the building, which manifested itself in their refusal to clean it [10].

Fig. 9. View of the parish church complex in Schwindkirchen, the barn converted into a parish house on the left (source: [29])

doubts dissolved over time, mainly because of the intense work of the pastor. Additionally, all the advantages of the revitalised object were appreciated as the building, in addition to its basic function, began to be made available to parishioners for the organisation of various events, such as weddings[17].

The concept of the design, 'building within a building', was devised by the Munich studio of Arc Architecten. The project included the renovation of the existing, stone-built barn by drying and repairing the walls, securing and reinforcing the existing, wooden lattice supporting the roof with steel elements, replacing the roof cover and installing a skylight running along the roof ridge. A completely independent pavilion of the new parish house with the area of 347 m$^2$ was introduced into the prepared barn with an area of 1,085 m$^2$ . The new pavilion has a rectangular form, is constructed from light prefabricated elements and is very ascetic and devoid of decoration. The new object is captivating due to its simplicity and indirect lighting (except for artificial light) resulting from the system of holes placed in the ceiling. Apart from the parish hall, there is also a kitchen, a common room, rooms for young people, a gallery and technical rooms (Fig. 10).

In addition to illumination, the skylight plays another important role in buildings such as the new pavilion. Specifically, skylights are important elements in air exchange systems. Natural ventilation supports mechanical ventilation while simultaneously helping to dry the damp external walls during the summer. The roof of the barn serves as a solar energy absorber; the energy is then transformed into heat and stored in heat pumps used to heat water and support the gas heating of the building in the winter.

[17] Particularly useful in such circumstances is the unbuilt space of the old barn.

Fig. 10. The parish house in the former barn (building within a building) of the parish complex in Schwindkirchen (source: [29])

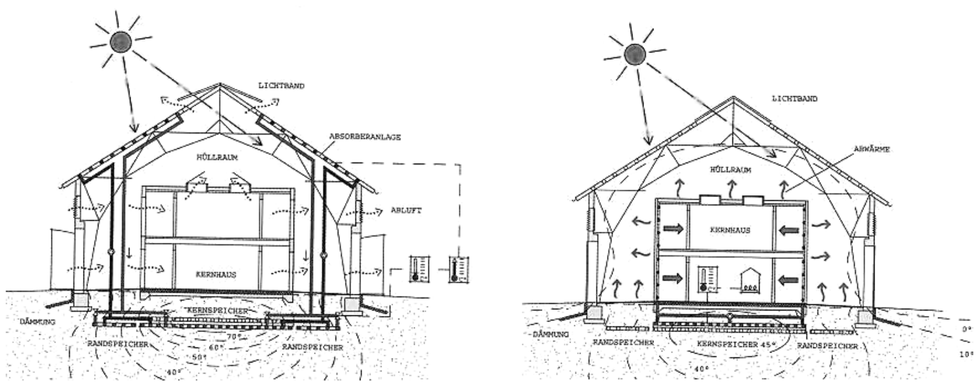


Fig. 11. Diagram of the heating and ventilation of the Protestant Parish House of the Assumption in Schwindkirchen (Bavaria): a) storage of heat in the summer, b) heating the building in winter (source: [30])

Another example of a limited interference in the structure of the historic building, but on a different basis (without incorporating a separate box structure) is the conversion of the former gas plant in the centre of Birmingham, England. It was transformed into the Anglican church, now known as St Luke's, Gas Street. For the purpose of this alteration, a former gas retort house was used – this is the last remaining building of Birmingham's first gasworks. In

Fig. 12. View of gas buildings with their characteristic chimney, after maintenance, with the main entrance to the present church (source: [31])

the past, it was the place where the town gas was produced by heating coal in the absence of air. The gas was used for street lighting and as fuel for factories. The building was designed by Alexander Smith and erected in 1822. It then underwent a period of expansion until the middle of the nineteenth century. A coal warehouse and an administrative unit were also used in the conversion. All these buildings were located on a plot of land between the modern-day Berkely Street and Gas Street. The gasworks buildings were subjected to modernisation works up until 1925 and were used for various industry-related purposes until the middle of the twentieth century; they were subsequently abandoned. They were 'discovered' again in 1993 when the city council of Birmingham decided to carry out a complex revalorisation of this area, while at the same time, putting the old gas plant on the list of monuments[18]. The then innovative construction solutions – specifically, the unusual roof design of cast iron arch trusses, which were reinforced with wrought iron rods resulting in a reduced load on the walls of the building – were considered to be the most important reasons for protecting the building, aside from its obvious historical value.

The legal protection of the old gas plant was included in the protection of the city's industrial heritage and its most valuable elements. The complex was refurbished by Crosby Homes. The plan was to turn the old industrial buildings into a non-residential office, leisure facility or workshop space. A total renovation of the building of the former retort house was only performed as recently as 2000, at the request of the City Hall of Birmingham. In 2014, the building was handed over to the new owner – the Diocese of the Anglican Church. The diocese decided to transform it into a place of worship and a cultural centre mainly aimed at

[18] Giving it category II [11].

Fig. 13. The interior of a former coal warehouse built in the 1950s (source: [31])

Fig. 14. The interior of the workshop part of the former gas plant, with its characteristic construction of steel girders added at the end of the nineteenth century (source: [31])

students and young adults[19]. At the same time, it was decided to refer to the *genius loci* of this place and, using the gas-related aspect of lighting, make the new church emanate 'light' in the metaphorical sense of the word.

In order to prepare the adaptation of the building, the Birmingham-based company Apec Architect (Fig. 13) was employed. This company claims to adopt a 'progressive' approach to revalorisation issues, which means that they deal not only with the reconstruction and renovation of the building but also with the business plan of its operation and the management of its protection. This approach ensures the durability and functionality of a new object. In the case of the conversion of the former gasworks, intensive social consultations were also conducted. This led to the creation of a proper utility program and significantly increased the sense of identification of the parishioners with the adapted object as an important element of the city's development history and its industrial heritage.

The project was divided into stages; it dealt with the maintenance and, where necessary, with the reconstruction of the original building structure. This was to be achieved by reinforcing defective areas of the walls and by replacing the old roof with a new roof over the meeting room[20]. The roof construction was preserved and exposed from the inside. The only significant change was the removal of the plasters covering the facade of the building and the return to the original facade of red brick, which further highlighted the different stages of the construction of the building. A hexagonal brick chimney with an onion-shaped end was also preserved. This became a dominant point over the entire complex.

A meeting room, with a capacity of 800 seats, was obtained from two connected retort rooms and the former coal warehouse (Fig. 13). It was lit up by the arcade openings, which were originally used for the ventilation system. The interference to the interior of the building

[19] Birmingham is one of the "youngest" cities of Great Britain.

[20] An old wooden lattice structure in a former coal warehouse, as well as cast-iron, triangle-arch in a former retort and a steel truss of a technological building.

Fig. 15. A visualisation of the design of the interior of St. Luke's, Gas Street (source: [31])

has been limited to the necessary minimum, preserving the single-space design of the assembly hall. The remaining rooms (cafeteria, kitchen, toilets, etc.) were separated from the existing structure (Fig. 14).

The interior of the nineteenth-century gasworks building is raw and limited in its detail. This aids the objective of meeting the liturgical and cultural-social needs of the congregation of the modern Anglican church. The Protestant religious community is based on the unity of faith and life organised within the church space. This unity is emphasised by the building's interior, which is flexible and easily adapted for a variety of events. It is also interesting that the religious symbolism here is reduced to a minimum – specifically, to a white cross painted on a brick wall.

Less common than the conversions discussed above are those performed for the Catholic Church; one such example can be found in Italy. The chimney of the former industrial building of the Fiat steelworks in Turin was transformed into the campanile of the church del Santo Volto in the Parco Doro area. This post-industrial area, comprising former Michelin, Valdocco, Mortana, Ingest and Vitali factories, has been transformed, into a new recreation, sports and culture centre based on the creative adaptation of the surviving elements of the former industrial area. The project was prepared by the German company Latz & Partner and assumed the use of post-industrial areas to create unique recreational spaces. The revitalisation program was implemented in 2004–2012[21]. Thus, one of the largest green spaces, with an area of over 45 ha, was created there.

The Santo Volto church (erected in 2004–2006), had the reputation of being "the most 'non-sacred'- in the traditional sense of the word - architecture [of the previous - author] decade" (Fig. 15], also refers to the industrial forms. The decision about its construction was taken, in a way, with reference to the post-industrial area revitalisation program and at the same time, in response to the demand for a religious building in connection with the nearby construction of new housing estates. It is a central part of a compact complex. Other elements include parish buildings, the city curia office and a conference centre with a car park.

21 The project was awarded in 2012, receiving The International Architecture Award and Premio Architetture Rivelate.

Fig. 16. The Church of Santo Volto is visible from the side of post-industrial areas revitalised for recreational purposes. On the right, there is a footbridge connecting the areas of former factories (photo by: M. Jagiełło, 2013)

Fig. 17. The church and the chimney of the former Fiat factory transformed into a campanile (source: [32])

The church was built on the plan of a heptagon, similar to a cogwheel surrounded by seven[22] chapels symbolising fullness and perfection. They look like massive factory chimneys and serve as skylights that bring light to the chapels and to the main part of the church. The central part of the church was covered with a tent-shaped form[23], and inside it, just behind the sacrificial table, there is a relief prepared in the 'pixel' convention, depicting the face of Christ modelled on the famous Turin Shroud. At the base of each of the 35-meter towers there is a chapel, which is additionally illuminated by lower skylights[24], and under the central part of the church, there is a large, underground conference room (Fig. 17). The designer of the complex of objects is the Swiss architect Mario Botta[25], known for many other projects of sacred places that are also controversial (Evry cathedral, the chapel in Monte Tamaro).

Accompanying the church, a 60-meter tall stainless-steel chimney spirals upwards – it is a remnant of the former steelworks. It symbolises the crown of thorns and climbs towards the cross at the top. The concept adopted here by the designer of this element is clear – the remains of a former industrial plant highlight the hard work of factory workers. Both elements (the church and the chimney), create a compositional feature of this part of the city. They are links between the post-industrial area and nearby residential districts, and at the same time create a new centre of social and religious life.

Let us add here, that the construction of the Turin temple was initially accompanied by great controversies connected with both the proposed form and with the huge costs of the

[22] The number seven is considered mystical and symbolic in many mythologies and religions of the world, including Christianity.

[23] It can also be associated with an inverted silo funnel or an hourglass.

[24] According to Botta, these are "nails whose spindles are skylights". Two skylights were designed for each tower (there are 14 of them) [16].

[25] M. Botta is a representative of the trend called neo-modernist regionalism. His works also show influences of modernists, in particular Louis Kahn.

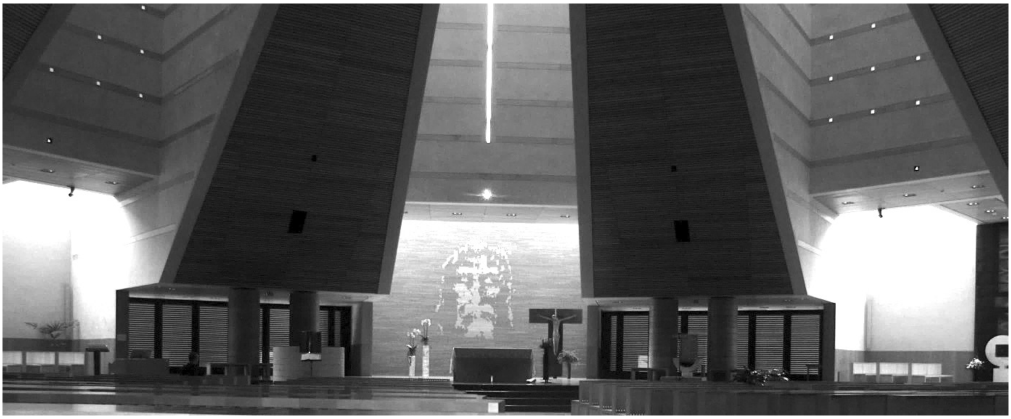

Fig. 18. The interior of the church with the characteristic 'pixel' image of Christ, modelled on the Shroud of Turin (photo by: M. Jagiełło, 2013)

investment (30 million euros). Today, the cost of the use of the air conditioning equipment installed in it, which exceeds the budget of the parish, raises more emotions[26].

Another conversion of a post-industrial facility into a church which is also a rare case as it is not connected with the Protestant faith is the Orthodox church of St. Nicholas (Saint Nicholas Eastern Orthodox Church). It was established in 2010 in the town of Springdale, Arkansas. The method employed here could be described as architectural recycling. The church was created as a result of the adaptation of a relatively small building (335 square meters), which used to serve as a metal goods warehouse and a welding facility. A sanctuary based on this object was constructed following a design by the American architect, Marlon Blackwell. In the adaptation of this building, the principle of preserving the building's construction was followed. A small tower with a cross marked on it was added to help identify the object as a place of worship. Furthermore, the front was slightly extended to create a vestibule. The whole object was then covered with a corrugated metal cladding – material from the original building was used to achieve this. This was performed at the special request of the parishioners and was also helpful due to the considerable financial constraints; this recycling of material, as the designer stated, proved to be particularly inspiring. For the same reason, other elements from the old building were also used, including an old satellite antenna that was used to construct a small, symbolic dome located above the main hall [20].

The functions of the building were designed in a manner that allows the correct orientation (east-west) of the main part of the church. In the new narrow vestibule (narthex), an oak table was set up for candles to be lit by worshippers. An important role is performed in this zone; because of the glazing that covers the tower, it illuminates the vestibule and at night, additional artificial red lighting is used to illuminate the building (Fig. 21).

The main part of the sanctuary, designed for around eighty people, was equipped with the basic elements defining this small space, specifically, the iconostasis – the screen wall separating the sanctuary from the nave. Two skylights were installed over this area in order

26 The Turin clergy took part in the vote. As many as 48% percent of the respondents were against [18, p. 37].

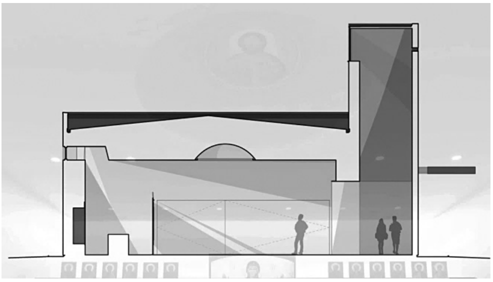

Fig. 19. A crosssection after the adaptation of the former metal warehouse into the church(source: [33])

Fig. 20. Interior of the Orthodox church after adaptation(source: [34])

to provide some natural light. In the dome, located above the central part of the sanctuary, an image of Christ Pantocrator was placed. In the adjacent rooms (community meeting room, kitchen, toilets, offices), the construction elements of the old building have been exposed as evidence of its original function (Fig. 22).

The adopted stylisation is typical American regionalism, which sees architecture as a kind of billboard. It is derived from the postmodern architecture of R. Venturi, whose fire service building from Columbus (1968) seems to be a clear inspiration for the Blackwell church.

The project and its realisation is an example of the perfect unity between the three criteria of modern architecture: the implementation of utility and formal needs; sustainable design by using existing resources[27]; minimisation of implementation costs. In this case, all three paradigms contributed to one sacred entity (Fig. 20). It is apparent that all this was appreciated, as this humble implementation was given a lot of awards in the field of architecture and interior design[28].

## 3. Summary

[27] As far as conversions of existing objects into churches is concerned, it seems that only architects adapting old railway carriages into sanctuaries went further. We encounter examples of such unusual activities in many places in Russia [23].

[28] Among others: 2013: The American Institute of Architect (AIA Awards) – AIA National Awards – Honor Award; 2013: Faith and Form Awards – Honor Award; 2012: The American Institute of Architect (AIA Awards) – AIA National Awards –Small Projects Award; 2011: World Architecture Festival Award – Category: CIVIC AND COMMUNITY – Winner; 2011: Chicago Athenaeum Museum of Architecture and Design Awards – American Architecture Awards; 2011: AIA Gulf States Region Awards – Merit Award; 2010: Architect Magazine Awards – Citation; 2010: The American Institute of Architect (AIA Awards) – AIA Arkansas State Awards – Honor Award.


Fig. 21. American message (billboard) architecture: a) fire brigade building in Columbus, designed by R. Venturi, 1968 (photo by: MAS Studio CHICAGO), b) building of the church of Saint Nicholas in Springdale, designed by M. Blackwell, [n.a.] 2010 (source: [35; 36])

At the beginning of this article, it was written that the phenomenon of the conversion of post-industrial objects into places of worship is quite rare and arouses various controversies and diverse emotions. However, when one takes into account contemporary architectural and aesthetic trends and principles of sustainable (recirculation) design, post-industrial objects seem to respond well to the needs of religious buildings today. At the same time, they fulfil the requirements of flexibility and functionality of the space, energy efficiency and the use of ecological material solutions, as well as having high standards with regard to technical equipment. Particularly significant points are raised within this article in the context of conversions of post-industrial objects in the case of Protestant churches. Protestant places of worship play important religious and social roles in society. This approach requires an architectural response to complex and time-varying functional and spatial demands. It seems that the Catholic church, especially during post-conciliar liturgical changes, does not significantly differ from Protestant church in demand. Maybe instead of a building being a bizarre, 'immature', or monstrous example of sacred construction (such examples are much too frequent, particularly in Poland) it is worth considering converting existing post-industrial objects into sanctuaries. Especially when we consider that some of them, for instance power plants or gas plants, at least from the distance, resemble towering gothic cathedrals.

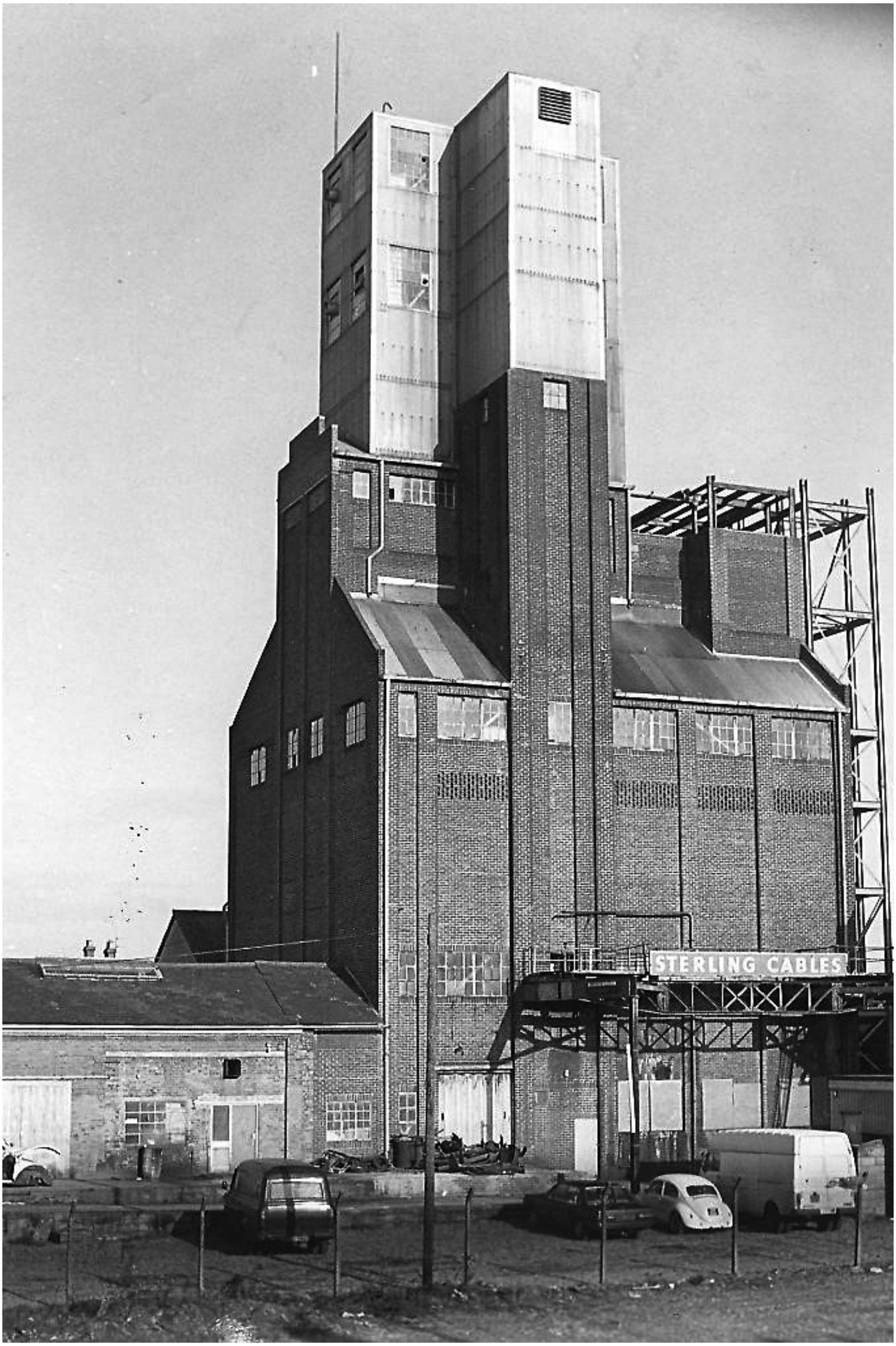


Fig. 22. Industrial architecture can be in its form close to sacred architecture: a gasworks repository in Newbury (Great Britain) from 1925 (source: [37])

## References


[1] Muschamp H., *Art/architecture; A Queens Factory Is Born Again, as a Church*, The New York Times, 5.09.1999, http://www.nytimes.com/1999/09/05/arts/art-architecture-a-queens-factory-is-born-again-as-a-church.html (online: 15.06.2017).

[2] Karmon D., *Michelangelo's "Minimalism" in the Design of Santa Maria degli Angeli*, Annali di Architettura no. 20, Vicenza 2008, 141–152, https://www.researchgate.net/publication/287843721_Michelangelo's_Minimalism_in_the_design_of_Santa_Maria_degli_Angeli (online: 14.06.2017).

[3] http://templeworks.weebly.com (online: 28.06.2017).

[4] Pastuschka B., Schwebel H., Wittstock J, *Meinhard von Gerkan, Geometrie der Stille*, Darmstadt 2002.

[5] Wąs C., *Antynomie współczesnej architektury sakralnej*, Wrocław 2008.

[6] Dąbrowska-Milewska G., *Nowe życie dawnej architektury przemysłowej – przykłady z „Manchesteru Północy"*, Czasopismo Techniczne, 4-A/1/2011, 92–101.

[7] Wojtuszek M., *Przemysł i sacrum– transformacja architektury*, http://repolis.bg.polsl.pl/Content/23566/mw_przem_sacrum.pdf (online: 14/06/2017).

[8] Schittich Ch., *Creative conversion*, In detail. Buildings in existing fabric. Refurbischment-Extension-New design, Basel-Boston-Berlin 2003.

[9] Deleuze GT., *Fold. Leibniz and Baroque*, Warszawa 2014.

[10] http://www.arcarchitekten.de/home/pfarrstadel (online: 28.06.2017).

[11] http://www.imagesofengland.org.uk/Details/Default.aspx?id=410202&PrintPage=true (online: 20.06.2017)

[12] http://www.apec.ac/ (online: 20.06.2017).

[13] http://www.apec.ac/st-lukes-gas-street-phase-1-launch (online: 22.06.2017).

[14] www.gasstreet.org (online: 22.06.2017).

[15] http://www.polityka.pl/tygodnikpolityka/architektura/galerie/1508566,11,koscioly-ostatnich-dekad.read (online: 27.06.2017).

[16] http://www.sacredarchitecture.org/articles/a_faceless_santo_volto (online: 28.06.2017).

[17] https://architizer.com/projects/church-santo-volto/ (online: 27.06.2017).

[18] "La Stampa", 28.07.2005.

[19] https://architizer.com/projects/church-santo-volto/ (online: 27.06.2017).

[20] http://gbdmagazine.com/2013/marlon-blackwell-architect/ (online: 29.06.2017).

[21] http://designalmic.com/saint-nicholas-antiochian-orthodox-christian-church-marlon-blackwell-architect/ (online: 29.06.2017).

[22] https://www10.aeccafe.com/blogs/arch-showcase/2011/11/16/saint-nicholas-antiochian-orthodox-christian-church-in-springdale-utah-by-marlon-blackwell-architect/ (online: 29.06.2017).

[23] Staff D., *Religious Conversions: Old Train Cars Turned into Churches*, http://dornob.com/religious-conversions-old-train-cars-turned-into-churches/ (online: 30.06.2017).

[24] http://www.mcinturf.info/kpc-ny (online: 29.06.2017).

[25] https://upload.wikimedia.org/wikipedia/commons/c/cf/Mariadosanjos2.jpg (online: 29.06.2017).
[26] https://www.architecture.com/imagelibrary/imagecache/galleryitems/5105.1.434.434.FFFFFF.jpeg (online: 27.06.2017).
[27] http://www.mcinturf.info/image-archive-gallery/?category=KPC.ny (online: 29.06.2017).
[28] http://dididadidi.com/structure/201403/139480470616695.html (online: 27.06.2017).
[29] http://www.arcarchitekten.de/buero/projekte-and-referenzen/neue-seite/ (online: 20.06.2017).
[30] http://pfarrei-schwindkirchen.de/p_heim/energie.htm (online: 27.06.2017).
[31] http://www.birminghammail.co.uk/news/midlands-news/gallery/pictures-church-plans-gas-retort-8819461 (online: 27.06.2017).
[32] http://edificisacri.compagniadisanpaolo.it/en/church/santo-volto/ (online: 27.06.2017).
[33] https://i.ytimg.com/vi/qIW4Yprp-ak/maxresdefault.jpg (online: 27.06.2017).
[34] http://images.adsttc.com/media/images/5005/a5af/28ba/0d07/7900/0ff4/slideshow/stringio.jpg?1414431549 (online: 27.06.2017).
[35] https://pl.pinterest.com/pin/405535141417423302/ (online: 29.06.2017).
[36] http://www.marlonblackwell.com/assets/images/work/institutional/saint-nicholas-eastern-orthodox-church/sneoc-two.jpg (online: 29.06.2017).
[37] http://www.newburytoday.co.uk/news/home/19976/the-changing-face-of-newbury-part-seven.html (online: 28.07.2017).

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# The equivalent mortar volume method in the manufacturing of recycled aggregate concrete

# Metoda równoważnej objętości zaprawy w wytwarzaniu betonu z kruszywem z recyklingu

**Abstract**

Many studies have observed that the mechanical properties of concrete made of recycled aggregate are worse than for concrete made of natural aggregate; this is mainly due to the mortar that is attached to the recycled aggregate. In literature, an equivalent mortar volume method in the manufacturing of recycled aggregate concrete has been proposed. This method treats the attached mortar as new mortar. The application of this method can reduce the use of natural materials while maintaining mechanical properties and eliminate the additional processes required for the production of recycled aggregates. The aim of this paper is to briefly describe the recent application of this method, present gaps in current research and anticipated directions for further research.

**Keywords:** concrete, recycled aggregate, equivalent mortar volume method, sustainable development

**Streszczenie**

Wiele badań wykazało, że właściwości mechaniczne betonu wykonanego z kruszywem pochodzącym z recyklingu są gorsze niż właściwości betonu wykonanego z kruszywa naturalnego, głównie ze względu na zaprawę zespoloną z kruszywem z recyklingu. W związku z tym w literaturze zaproponowano metodę równoważnej objętości zaprawy w wytwarzaniu betonu z kruszywem z recyklingu. Ta metoda traktuje dołączoną zaprawę jako nową zaprawę. Zastosowanie tej metody może zmniejszyć zużycie materiałów naturalnych przy jednoczesnym zachowaniu właściwości mechanicznych betonu i wyeliminować dodatkowe procesy wymagane do produkcji kruszyw z recyklingu. Celem tego artykułu jest krótki opis najnowszych zastosowań tej metody, przedstawienie luk w obecnych badaniach i przewidywanych kierunków dalszych badań.

**Słowa kluczowe:** beton, kruszywo z recyklingu, metoda równoważnej objętości zaprawy, zrównoważony rozwój

## 1. Introduction

As the amount of natural aggregates (NA) used for building and road construction increases, so does the amount of recycled aggregates (RA). With the depletion of natural resources, researchers investigated the possibility of reusing used aggregates [1-6]. However, many studies have observed that the mechanical properties of recycled aggregate concrete (RAC) are lower than those of natural aggregate concrete (NAC), mainly as a result of the mortar attached to the RA [3, 6–13].

Figure 1 presents the cross section of a cylinder specimen made with RA and white cement to show the actual composition of RA. Through simple visual inspection, a form of non-destructive testing, the residual mortar can be distinguished from RA. In the figure, RA is composed of residual mortar (RM) and original virgin aggregate (OVA). Many studies have been conducted to improve the properties of RA and RAC through mechanical, chemical and biological processes [12–21], the addition of fibres [10, 22, 23], and the addition of mineral additives such as fly ash and blast furnace slag [24–26].

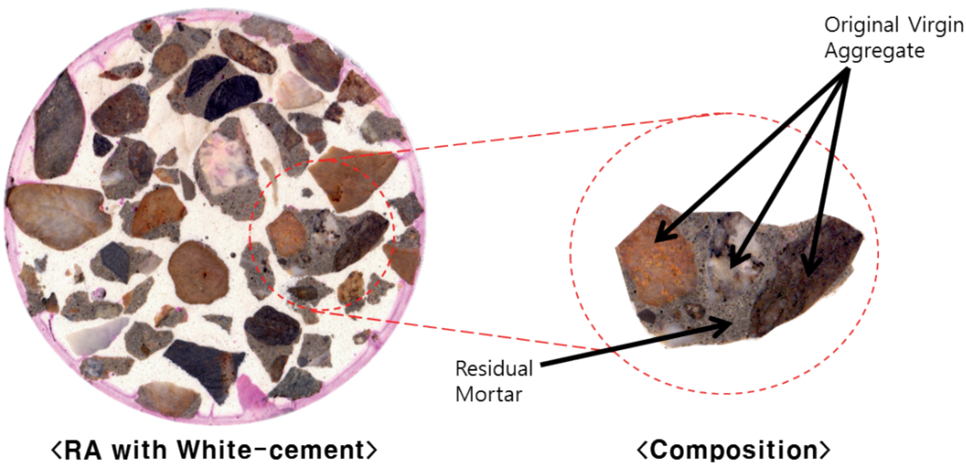


Fig. 1. Example of the composition of recycled aggregate

Although the addition of specific materials and additional processes to improve the properties of RA may be effective, it seems to be somewhat less than ideal in terms of time, economy and eco-friendliness. From this point of view, it is hard to consider it a fundamental solution. With this in mind, a new mix design for RAC was proposed by Fathifazl et al. [27]. While the conventional concrete mix design (CMD) did not take into account the mortar attached to the RA, the proposed method treats the attached mortar as mortar (Fig. 2). Therefore, the application of the equivalent mortar volume (EMV) method not only reduces the amount of new input material but also eliminates the time and economic factors for processing RA.

The purpose of this paper is to review the recent applications of the EMV method in the manufacturing of RAC by comparing RAC mixed by the EMV method with CMD concrete.

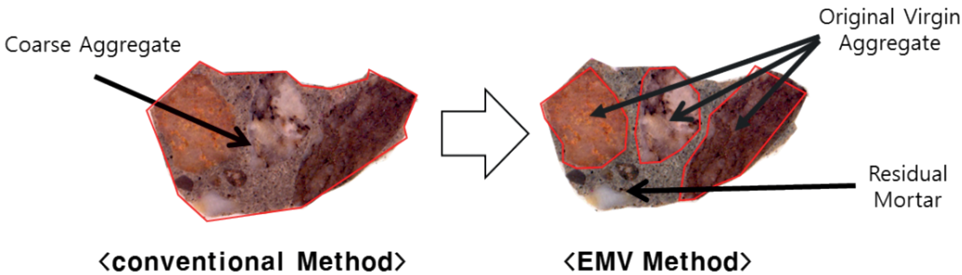


Fig. 2. Concept of RA according to CMD (L) and EMV method (R)

## 2. Recycled aggregate

Although it makes a little difference, waste concrete is produced as RA after several crushing, screening, and cleaning processes (Fig. 3) [28]. The produced RA contains a certain percentage of already hardened mortar (also named attached mortar, residual mortar, or adhered mortar). Figure 4 shows the absorption rate and specific gravity of the RA used in many different research projects. Specially processed RA such as HCI were excluded. As shown in Fig. 4, the water absorption rate of NA ranges from 0.26% to 1.2%, while RA have a range of 1.4-9.68%. In addition, as the absorption rate increases, the specific gravity tends to decrease.

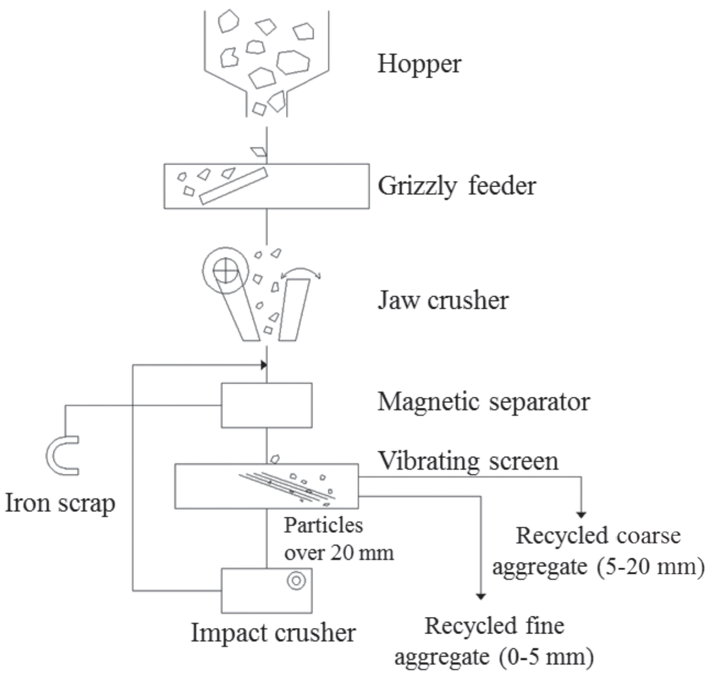


Fig. 3. General flowchart for RA production

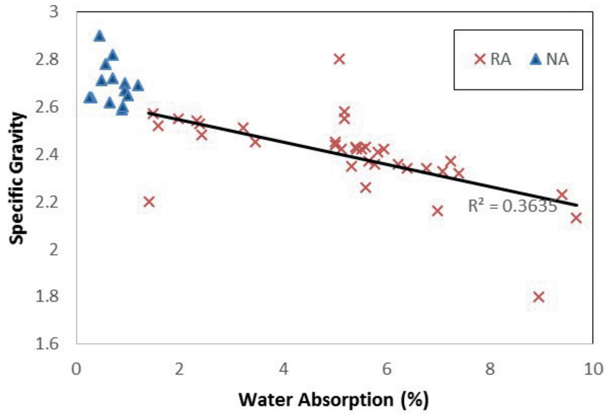


Fig. 4. Correlation between specific gravity and absorption rate of RA and NA (data from [6, 13, 16, 17, 22–24, 26, 29–36])

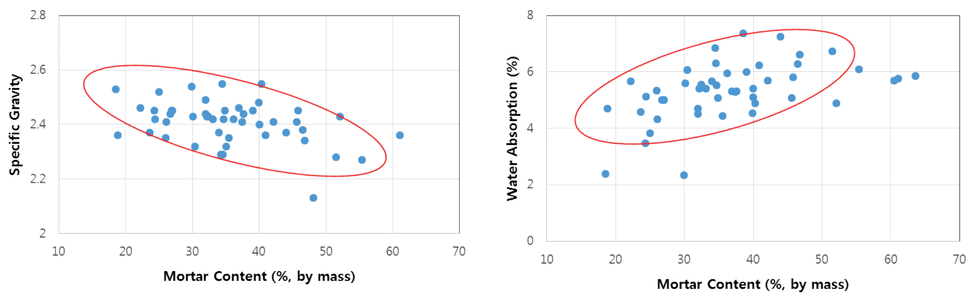


Fig. 5. Correlation between the RMC and specific gravity (L), Water absorption (R) (data from [3, 13, 33, 35, 36, 38–44])

The presence of RM adversely affects the basic properties of RA by, for example, lowering the specific gravity and increasing the water absorption rate compared to NA, which leads to a degradation of the properties of the RAC [3, 6, 10, 13, 37]. Figure 5 shows the relationship between the residual mortar content (RMC) on RA and the density and water absorption of RA investigated in other studies. There may be differences depending on production processes and the impurities contained in aggregates, in general, as the RMC increases, the specific gravity decreases and the water absorption rate tends to increase [3, 13, 33, 35, 36, 38–44].

## 3. Mixing methods

### 3.1. Conventional mix design (CMD) method

Many studies related to RAC have used the national standard mix design [45, 46] or standard ASTM/ACI mix design [47, 48]. However, these mix designs have a fixed amount of newly added materials irrespective of the type and characteristics of the corresponding aggregate [49–58]. When using the monotonous concrete mix method which has the same amount of water, cement, and sand with RA, the actual mortar content of RAC increases due to RM on RA (Fig. 8 (a) & (b)).

Figures 6 and 7 show the compressive strength and elastic modulus as a function of the RA replacement ratio. Due to variables such as water/cement ratios and admixture use, the range of the mechanical properties of compressive strength and elastic modulus of RAC varies somewhat; the same concrete mixing design, i.e. the same amount of cement and sand, was employed for each group of RA. The results showed that the mechanical properties decrease as replacement ratios of RA increase.

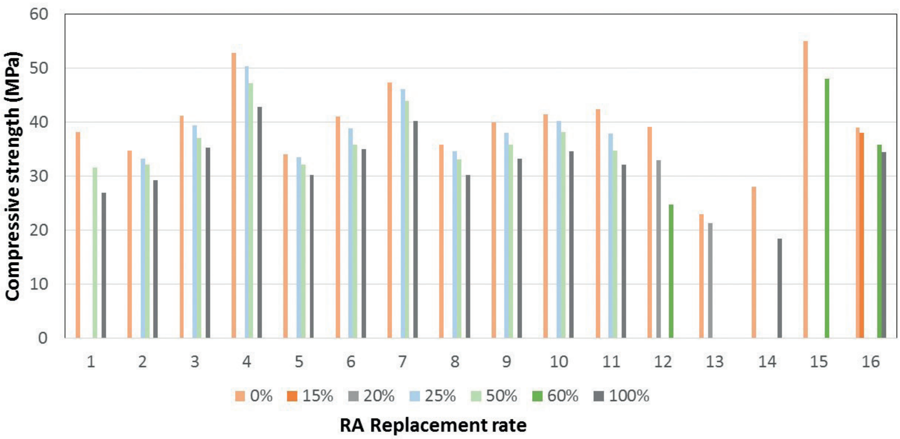


Fig. 6. Relationship between compressive strength and RA replacement rate (data from [6, 10, 15, 22, 24, 29, 32, 36, 37])

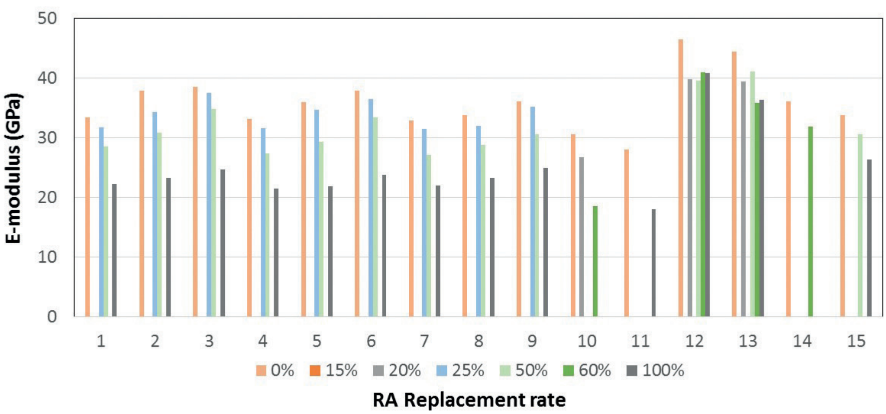


Fig. 7. Relationship between elastic modulus and RA replacement rate (data from [6, 15, 29, 36, 37, 59])

### 3.2. EMV methods

3.2.1. Original equivalent mortar volume (EMV) method

Fathifazl et al. [60] claimed that the observed inferior physical properties of RAC may be responsible for the mix design, and this can be overcome by the proper mix design method. Therefore, the proposed EMV method equates RM with newly added mortar, and reduces the amount of new cement, sand, and water by as much as the volume amount of RM. Based on this, the total mortar volume of the RAC is kept the same as the mortar volume of NAC (Fig. 8 (a) & (c)).

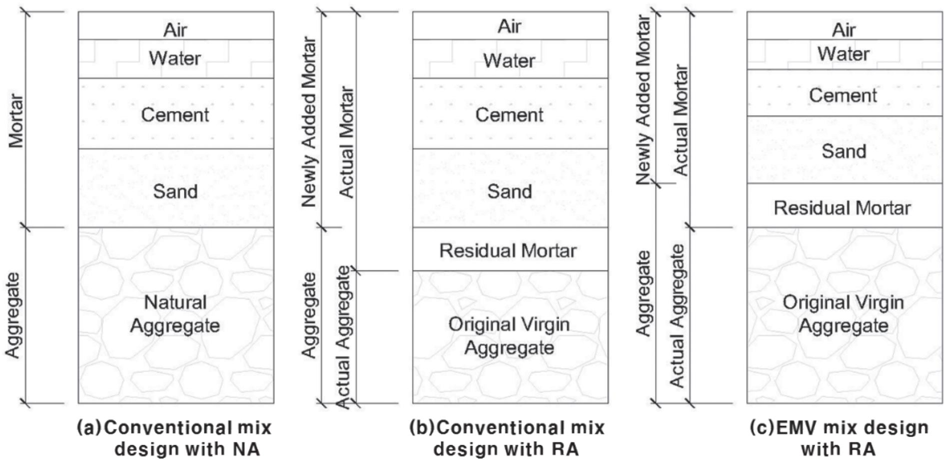


Fig. 8. Comparison of concrete mix design

The process of this mixing method is as follows.

RAC consists of a mixture of RA and NA, where the NA is replaced with the same volume of RM as the volume of RA. Thus, the NA input ratio, R, can be defined as the follows (Eq. (1)):

$$R = \frac{V_{NA}^{RAC}}{V_{NA}^{NAC}} = \frac{V_{RM}^{RAC}}{V_{RA}^{RAC}} \tag{1}$$

Where R = proportion of NA; $V_{NA}^{RAC}$= volume of NA in RAC; $V_{NA}^{NAC}$= volume of NA in NAC; $V_{RM}^{RAC}$= volume of RM in RAC; $V_{RA}^{RAC}$= volume of RA in RAC.

In addition to the above, Eq. (2) and (3) should be satisfied to equalise the volume of mortar and aggregate in RAC and NAC.

$$V_{TM}^{RAC} = V_{M}^{NAC} = V_{RM}^{RAC} + V_{NM}^{RAC} \tag{2}$$

$$V_{TNA}^{RAC} = V_{NA}^{NAC} = V_{OVA}^{RAC} + V_{NA}^{RAC} \tag{3}$$

Where $V_{TM}^{RAC}$= total mortar volume in RAC; $V_{M}^{NAC}$= mortar volume in NAC; $V_{RM}^{RAC}$= RM volume in RAC; $V_{NM}^{RAC}$= new mortar volume in RAC; $V_{TNA}^{RAC}$=Total NA volume in RAC; $V_{NA}^{NAC}$= NA volume in NAC; $V_{OVA}^{RAC}$= OVA volume in RAC.

Because the NA volume of the RAC and the NA volume of the NAC should be equal, the volume of the OVA of NAC should be calculated; this can be obtained from the RMC and the apparent density of the OVA (4). RMC in RA can be obtained by subtracting the OVA weight from RA (5).

$$V_{OVA}^{RAC} = V_{RA}^{RAC} \times (1 - RMC) \times \frac{SG_b^{RA}}{SG_b^{ova}} \tag{4}$$

$$RMC\% = \left[ \frac{W_{RCA} - W_{OVA}}{W_{RCA}} \right] \times 100 \tag{5}$$

Where $SG_b^{RA}$ and $SG_b^{ova}$= bulk specific gravity of RA and OVA, respectively.

Many studies have been conducted on the estimation of RMC in RA to obtain OVA (thermal treatment [11], soaking in acids [61-63], microwave heating [64]), but there are no standard regulations yet. Fathifazl et al. [60] used the following method, as presented in [65, 66]. The approximate process of the test is as follows: sampling the aggregate, drying the sample for 24 hours in 105°C oven, immersing it in a 26% sodium sulphate solution for 24 hours. The freeze-thaw test is repeated for five cycles with sodium sulphate (-17°C for 16 hours, 80°C for 8 hours).

Figure 9 shows the before and after RMC calculation test of RA used in [67]. The right side of Fig. 9 (b) shows the RM after passing through a 4.75 mm sieve following the test.

Using the Eqs. (1), (3) and (4), presented above, the volumes of RA and NA for RAC can be obtained (6), (7).

$$V_{RA}^{RAC} = \frac{V_{NA}^{NAC} \times (1 - R)}{(1 - RMC) \times \dfrac{SG_b^{RA}}{SG_b^{OVA}}} \tag{6}$$


Fig. 9. RCA sample before (a) and after (b) RMC determination [67]

$$V_{RA}^{RAC} = V_{NA}^{NAC} \times R \tag{7}$$

$V_{RM}^{RAC}$ to be calculated to satisfy Eq. (2) can be obtained by subtracting $V_{OVA}^{RAC}$ from $V_{RA}^{RAC}$ (8), and the amount of mortar to be newly added is as shown in Eq. (9).

$$V_{RM}^{RAC} = V_{RA}^{RAC} \times \left[1 - (1 - RMC) \times \frac{SG_b^{RA}}{SG_b^{OVA}}\right] \tag{8}$$

$$V_{NM}^{RAC} = V_{M}^{NAC} - V_{RM}^{RAC} \tag{9}$$

By substituting Eq. (1) and Eq. (3) into Eq. (6), Eq. (10) can be derived, i.e. Eq. (11)

$$V_{RA}^{RAC} = V_{NA}^{NAC} \tag{10}$$

$$V_{RA}^{RAC} = V_{NA}^{NAC} = \frac{W_{OD-NA}^{NAC}}{SG_b^{NA} \times 1000} \tag{11}$$

Where, $W_{OD-NA}^{NAC}$ = oven-dried weight of NA in NAC; $SG_b^{NA}$ = bulk specific gravity of NA.

Once $V_{RA}^{RAC}$ is determined, the mass of the material to be used is given by Eqs. (12)-(17).

$$W_{OD-RA}^{RAC} = V_{RA}^{RAC} \times SG_b^{RA} \times 100 \tag{12}$$

$$W_{OD-NA}^{RAC} = V_{NA}^{RAC} \times SG_b^{NA} \times 1000 \tag{13}$$

$$W_{W}^{RAC} = W_{W}^{RAC} \times \frac{V_{NM}^{RAC}}{V_{M}^{NAC}} \tag{14}$$

$$W_{C}^{RAC} = W_{C}^{NAC} \times \frac{V_{NM}^{RAC}}{V_{M}^{NAC}} \tag{15}$$

$$W_{OD-FA}^{RAC} = W_{OD-FA}^{NAC} \times \frac{V_{NM}^{RAC}}{V_{M}^{NAC}} \tag{16}$$

$$W_{TM}^{RAC} = W_{W}^{RAC} + W_{C}^{RAC} + W_{OD-FA}^{RAC} + \tag{17}$$

$$+\left(W_{OD-RA}^{RAC} \times RMC \times Acceptance\ ratio\right)$$

Where, $W_{OD-RA}^{RAC}$, $W_{OD-NA}^{RAC}$, $W_{OD-FA}^{RAC}$ = oven-dry weights of RA, NA, and FA in RAC, respectively; $W_{W}^{RAC}$, $W_{C}^{RAC}$, $W_{TM}^{RAC}$ = weights of water, cement, and total mortar, respectively.

### 3.2.2. Modified Equivalent Mortar Volume (M-EMV) methods

If RA has a high amount of RMC, it may not be possible to replace 100% NA with RA. Thus, concrete mixed by the EMV method has a minimum proportion of NA (18). According to [60], it is assumed that the OVA of RCA is similar to NA, and when bulk specific gravity of RA = 2.31, RMC = 41%, and bulk specific gravity of NA is 2.7, the minimum required NA proportion is 21%. In other words, 21% of the volume of RAC must be NA, and new mortar equivalent to the corresponding proportion is required.

$$R_{\min} = 1 - \frac{(1 - RMC)}{V_{DR-NA}^{NAC}} \times \frac{SG_b^{RGA}}{SG_b^{NA}} \geq 0 \qquad (18)$$

Where, = dry-rodded unit volume of NA in NAC.

Some studies have shown poor performance in slump and workability due to the lack of cement when the replacement ratio of RA increases [38, 68-72]. Therefore, the modified EMV methods (M-EMV) were introduced.

Yang et al. [69] introduced the parameter S-factor, which regulates the effective residual mortar content, assuming that some of the RM contained in RA acts as aggregate and rest acts as mortar (Fig. 10 (d)). Thus, the NA input R is as shown in Eq. (19), and the other equations are the same as in study [60].

$$R = 1 - \frac{V_{RCA}^{RAC}}{V_{NA}^{NAC}} \times \left(1 - \frac{1}{S} \times RMC\right) \times \frac{SG_b^{RGA}}{SG_b^{NA}} \qquad (19)$$

In [69], S-factor 2 was applied for a 100% replacement rate of RA containing 11.6% of RMC, and in the case of RMC, 35.5%, 2 and 3 were applied to the 50% and 75% replacement rate, respectively. In other words, as the content of the RA was increased, the mix design was adjusted in such a way as to reduce the effective ratio of the RMC. Studies [41-43, 67, 68] were performed using the M-EMV method, the test results obtained from the studies showed properties that were either similar to or higher than those of CMD concrete.

Ahimoghadam et al. [38] notes that in the original EMV method, RM in RA is considered to behave as fresh mortar, but in practice, the RM is already hardened, and this difference causes poor performance in the fresh state of the RAC mixed by the EMV method. Therefore, the equivalent volume (EV) method based on having the same volume of aggregate and cement was proposed (Fig. 10 (a), (b)), while the EMV method had the same volume of aggregate and mortar as the CMD (Fig. 10 (b), (c)). In [38], the ratio of sand and cement of RM was determined on the basis of the concrete composition volume ratio (with regard to sand, cement, aggregate) by the ACI mix design, and afterwards, the new mortar content was determined.

In some mixtures prepared in [72], the phenomenon of mortar not completely covering the coarse aggregates was observed due to a lack of new mortar, thus modifying the EMV method by reducing the sand and increasing the cement content was tried in an attempt to improve the properties of fresh concrete.

Rajhans et al. [33] analysed the property difference by applying the two stage mixing approach (TSMA) [73], which divides the input materials and the order of input during the concrete mixing process. In this way, compressive strength at twenty-eight days was improved by 9.5% in comparison to the conventional aggregate-cement-water mixture.

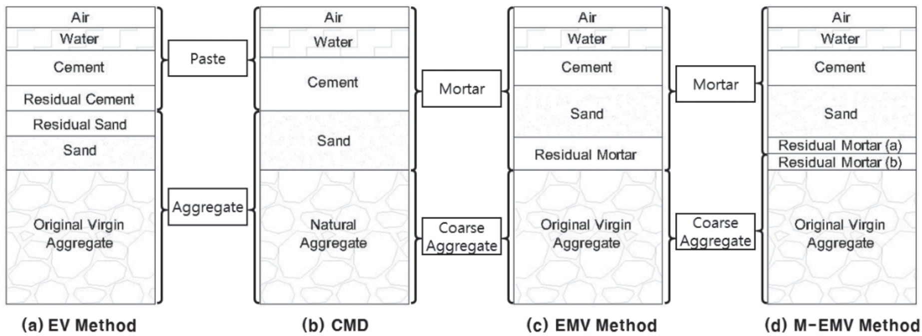


Fig. 10. Comparison of concrete mix design

## 4. Results and Discussion

Table 1 summarises the research on EMV based methods. As shown in the table, the mechanical properties of RAC using the EMV and M-EMV methods showed similar or higher values in comparison to conventional natural aggregate concrete. Yang et al. [42] and Abbas et al. [74] investigated EMV-based RAC and found it comparable to or superior than NAC in terms of durability as well as mechanical properties such as compressive strength and elastic modulus.

In study [68], two types of RA with different RMC were produced by regulating the process of waste concrete crushing from the same source; the compressive strength and elastic modulus of RAC made from these RAs were analysed. In the study, the results of experiments with the same mortar volume of two RAs with different RMC showed less variation than the results obtained from the CMD concrete. If the source of RA was the same, regardless of the amount of RM, the compressive strength range of the M-EMV concrete was 29.3-31.5 MPa and the elastic modulus was 22.2-23.4 GPa, whereas the CMD concrete represented a scattered distribution of 23.6-30.9 MPa and 17.4-23.6 GPa, respectively. In addition, for CMD concrete, the mechanical properties decreased significantly as a function of increasing volume of total mortar. However, M-EMV concrete did not cause a decrease in the mechanical properties because it had the same volume of the total mortar. In this regard, the author claimed that the volume of the entire mortar in the concrete had a direct effect on the mechanical properties.

The proper use of supplementary cementitious material (SCM) such as blast furnace slag (BFS) and fly ash (FA) can further reduce the amount of cement injected [60] and have a higher resistance to chloride penetration [74]. Rajhans et al. [75] stated that the addition of the FA and the adjustment of the mixing order improved the compressive strength by 21.7% compared to CMD, and Abbas et al. [74] stated that using the FA can make the carbonation coefficient of EMV concrete lower than or similar to that of the CMD concrete.

In [76-78], shear tests on a beam with and without a stirrup showed no significant difference in failure mode, cracking, or shear performance from CMD concrete beams. In

[79], a life-cycle assessment analysis of the EMV method was analysed, and it was evaluated to be better than CMD concrete in terms of CO2 emissions, ozone layer depletion, and eutrophication, etc.

Table 1. Selected studies and highlights on the EMV-based method

| Ref | Method | Highlight |
|---|---|---|
| [33] | EMV<br>TSMA | • Compressive strength increased up to 9.5% than normal mix design |
| [38] | EV | • Equivalent volume (EV) method was proposed |
| [49] | EMV | • Slump decreased by 33-65%<br>• Air content decreased by 15-26.5% than ACI mix design<br>• Compressive strength was similar<br>• Elastic modulus increased by 18-24%<br>• Cement 21-24%, water approximate 40 litres less than ACI mix design |
| [40] | EMV | • Rheology test was investigated<br>• Slump decreased and yield stress increased<br>• EMV influence on plastic viscosity<br>• Cement reduced by 14% |
| [41] | M-EMV | • Slump decreased by 33-47%<br>• Compressive strength was similar -3-+4.8%<br>• Elastic modulus increased by 8.7-13%<br>• Drying shrinkage decreased<br>• Cement reduced by 8.5-14% |
| [42] | M-EMV | • Drying shrinkage decreased by 3-27% by day 585<br>• Freeze and thaw was similar<br>• Cement reduced by 10-16.7% |
| [43] | M-EMV | • Compressive strength decreased by 11-20%<br>• Elastic modulus decreased by 6-10%<br>• Flexural strength decreased by 8-16% at RA replacement ratio 100%, increased by 4-10% at RA 50%<br>• Tensile strength decreased by 9-17% |
| [44] | EMV | • Compressive strength and secant modulus of elasticity investigated |
| [60] | EMV | • Compressive strength range -6.67-+0.83%<br>• Elastic modulus increased by 4.5-11.4%<br>• Proper use of SCMs can further reduce amount of cement |
| [68] | M-EMV | • Verification of the correlation of the total mortar volume in concrete with mechanical properties; two types of RA from the same source but different RMC were used<br>• For the RA replacement ratio 25, 50, 100%, the compressive strength range of the E-EMV concrete was 29.3-31.5 MPa and the elastic modulus was 22.2-23.4 GPa; the CMD concrete represented 23.6-30.9 MPa and 17.4-23.6 GPa, respectively<br>• Cement reduced by 2.7-10% |

| | | |
|---|---|---|
| [69] | M-EMV | • Compressive strength increased by 6.7-8.8% by day 7<br>• Elastic modulus increased by 2-8.7% by day 7<br>• Introduced the parameter S-factor, which regulates the RMC |
| [72] | M-EMV | • By reducing sand and adding cement, the performance of fresh concrete was improved<br>• RA containing impurities such as clay and asphalt reduce the mechanical strength of concrete |
| [74] | EMV | • Strong resistance to freeze-and-thaw<br>• Lower apparent chloride diffusion coefficients than CMD concrete<br>• High resistance to chloride penetration achieved through the use of EMV with SCM.<br>• Use of FA making the carbonation coefficient of EMV concrete lower than or similar to CMD concrete |
| [75] | EMV<br>TSMA | • By adding FA and changing the material input order, compressive strength increased by 21.7% |
| [76] | EMV | • Higher shear strength |
| [77] | EMV | • No significant difference in failure mode, cracking patterns, shear performance of concrete beam with stirrup compared to CMD concrete<br>• Higher ultimate shear stress resistance than CMD concrete |
| [78] | EMV | • No significant difference in failure mode, cracking patterns, shear performance of concrete beam without stirrup compared to CMD concrete<br>• More ductile behaviour than CMD concrete |
| [79] | EMV | • Based on ISO14040 [82], life-cycle assessment of ACI, Bolomey, and EMV compared<br>• EMV method praised for being more ecologically friendly in the fields of Co2 emissions, ozone depletion, Eutrophication, etc.<br>• Reuse of concrete waste improved through the application of EMV |
| [80] | M-EMV | • Compressive strength increased by 1.2-11.9%<br>• Elastic modulus increased by 4.8-8.9%<br>• Drying shrinkage lower |
| [81] | EMV | • Compressive strength decreased by 15-17%<br>• Flexural strength increased by 8.5-16%<br>• Tensile strength decreased by 9.7-38%<br>• Elastic modulus range -18.9-+28.7%<br>• UPV decreased by 5.7-6% |

## 5. Conclusions and Perspectives

In this paper, the effectiveness of RAC mixed by the EMV-based method treated residual mortar attached on recycled aggregate as new mortar has been reviewed by comparing it with concrete produced using a conventional mix design. From the results of this review, the following conclusions and perspectives can be drawn.

RAC using CMD has shown a tendency to degrade mechanical properties as the ratio of RA is increased, and through the application of the EMV and M-EMV methods, the mechanical properties and durability of RAC can be comparable to those of NAC.

It is worth mentioning that the application of the EMV method is environmentally friendly because it can reduce the use of cement, sand and water while maintaining mechanical properties, and it can eliminate the additional processes required for the production of recycled aggregates.

Since the EMV method was introduced around ten years ago, various studies have been conducted, but the accumulation of data remains insufficient. Moreover, the fact that many studies are focused on its mechanical properties such as compressive strength, tensile strength, and elastic modulus can be an indicator of the direction of future research. In addition, considering EMV-based RAC is a mixture of hardened residual mortar and new mortar, the study of early-aged properties is also considered important.

## References


[1] Kim J.H., Sung J.H., Jeon C.S., Lee S.H., Kim H.S., *A study on the properties of recycled aggregate concrete and its production facilities*, Applied Sciences 9-9/2019, 1935.

[2] Akhtar A., Sarmah A. K., *Construction and demolition waste generation and properties of recycled aggregate concrete: a global perspective*, Journal of Cleaner Production 186/2018, 262–281.

[3] Zhu P., Hao Y., Liu H., Wei D., Liu S., Gu L., *Durability evaluation of three generations of 100% repeatedly recycled coarse aggregate concrete*, Construction and Building Materials 210/2019, 442–450.

[4] Zhang L., Sojobi A., Kodur V., Liew K., *Effective utilization and recycling of mixed recycled aggregates for a greener environment*, Journal of Cleaner Production 236/2019, 117600.

[5] Tam V. W., Gao X., Tam C., *Microstructural analysis of recycled aggregate concrete produced from two-stage mixing approach*, Cement and Concrete Research 35-6/2005, 1195–1203.

[6] Thomas J., Thaickavil N. N., Wilson P., *Strength and durability of concrete containing recycled concrete aggregates*, Journal of Building Engineering 19/2018, 349–365.

[7] Pellegrino C., Faleschini F., *Sustainability improvements in the concrete industry: use of recycled materials for structural concrete production*, Springer, 2018.

[8] Cleary D. B., *Recycled concrete aggregate in portland cement concrete (No. FHWA-NJ-2013-001)*, New Jersey. Dept. of Transportation, 2013.

[9] Mcneil K., Kang T. H.K., *Recycled concrete aggregates: a review*, International Journal of Concrete Structures and Materials 7-1/2013, 61–69.

[10] Wang Y., Hughes P., Niu H., Fan Y., *A new method to improve the properties of recycled aggregate concrete: composite addition of basalt fiber and nano-silica*, Journal of Cleaner Production 236/2019, 117602.

[11] Juan M. S. D., Gutiérrez P. A., *Study on the influence of attached mortar content on the properties of recycled concrete aggregate*, Construction and Building Materials 23-2/2009, 872–877.

[12] Omary S., Ghorbel E., Wardeh G., *Relationships between recycled concrete aggregates characteristics and recycled aggregates concretes properties,* Construction and Building Materials 108/2016, 163–174.
[13] Duan Z. H., Poon C. S., *Properties of recycled aggregate concrete made with recycled aggregates with different amounts of old adhered mortars,* Materials & Design 58/2014, 19–29.
[14] Zeng W., Zhao Y., Poon C. S., Feng Z., Lu Z., Shah S. P., *Using microbial carbonate precipitation to improve the properties of recycled aggregate,* Construction and Building Materials 228/2019, 116743.
[15] Ismail S., Ramli M., *Mechanical strength and drying shrinkage properties of concrete containing treated coarse recycled concrete aggregates,* Construction and Building Materials 68/2014, 726–739.
[16] Kim Y., Hanif A., Kazmi S. M., Munir M. J., Park C., *Properties enhancement of recycled aggregate concrete through pretreatment of coarse aggregates – comparative assessment of assorted techniques,* Journal of Cleaner Production 191/2018, 339–349.
[17] Singh L., Bisht V., Aswathy M., Chaurasia L., Gupta S., *Studies on performance enhancement of recycled aggregate by incorporating bio and nano materials,* Construction and Building Materials 181/2018, 217–226.
[18] Wang L., Wang J., Qian X., Chen P., Xu Y., Guo J., *An environmentally friendly method to improve the quality of recycled concrete aggregates,* Construction and Building Materials 144/2017, 432–441.
[19] Wu C. R., Zhu Y. G., Zhang X. T., Kou S. C., *Improving the properties of recycled concrete aggregate with bio-deposition approach,* Cement and Concrete Composites 94/2018, 248–254.
[20] Kencanawati N. N., Akmaluddin, Merdana I. N., Nuraida N., Hadi I. R., Shigeishi M., *Improving of recycled aggregate quality by thermal-mechanical-chemical process,* Procedia Engineering 171/2017, 640–644.
[21] Saravanakumar P., Abhiram K., Manoj B., *Properties of treated recycled aggregates and its influence on concrete strength characteristics,* Construction and Building Materials 111/2016, 611–617.
[22] Katkhuda H., Shatarat N., *Improving the mechanical properties of recycled concrete aggregate using chopped basalt fibers and acid treatment*, Construction and Building Materials 140/2017, 328–335.
[23] Hossain F. Z., Shahjalal M., Islam K., Tiznobaik M., Alam M. S., *Mechanical properties of recycled aggregate concrete containing crumb rubber and polypropylene fiber,* Construction and Building Materials 225/2019, 983–996.
[24] Çakır Ö., *Experimental analysis of properties of recycled coarse aggregate (rca) concrete with mineral additives,* Construction and Building Materials 68/2014, 17–25.
[25] Mardani-Aghabaglou A., Yüksel C., Beglarigale A., Ramyar K., *Improving the mechanical and durability performance of recycled concrete aggregate-bearing mortar mixtures by using binary and ternary cementitious systems,* Construction and Building Materials 196/2019, 295–306.
[26] Hu Y., Tang Z., Li W., Li Y., Tam V. W., *Physical-mechanical properties of fly ash/ggbfs geopolymer composites with recycled aggregates,* Construction and Building Materials 226/2019, 139–151.

[27] Fathifazl, G. *Structural performance of steel reinforced recycled concrete members,* Doctoral dissertation, Carleton University, Ottawa, Canada, 2008.

[28] Eguchi K., Teranishi K., Nakagome A., Kishimoto H., Shinozaki K., Narikawa M., *Application of recycled coarse aggregate by mixture to concrete construction,* Construction and Building Materials 21-7/2007, 1542–1551.

[29] Dilbas H., Çakır Ö., Atiş C., *Experimental investigation on properties of recycled aggregate concrete with optimized ball milling method,* Construction and Building Materials 212/2019, 716–726.

[30] Kim Y., Hanif A., Usman M., Park W., *Influence of bonded mortar of recycled concrete aggregates on interfacial characteristics – porosity assessment based on pore segmentation from backscattered electron image analysis,* Construction and Building Materials 212/2019, 149–163.

[31] Huda S. B., Alam M. S., *Mechanical behavior of three generations of 100% repeated recycled coarse aggregate concrete,* Construction and Building Materials 65/2014, 574–582.

[32] Gómez-Soberón J. M., *Porosity of recycled concrete with substitution of recycled concrete aggregate,* Cement and Concrete Research 32-8/2002, 1301–1311.

[33] Rajhans P., Chand G., Kisku N., Panda S. K., Nayak S., *Proposed mix design method for producing sustainable self compacting heat cured recycled aggregate concrete and its microstructural investigation,* Construction and Building Materials 218/2019, 568–581.

[34] Juez J. M., Cazacliu B., Cothenet A., Artoni R., Roquet N., *Recycled concrete aggregate attrition during mixing new concrete,* Construction and Building Materials 116/2016, 299–309.

[35] Michael J. McGinnis, Mark Davis, Andres de la Rosa, Brad D. Weldon, Yahya C. Kurama, *Strength and stiffness of concrete with recycled concrete aggregates,* Construction and Building Materials 154/2017, 258–269.

[36] Zhang H., Wang Y., Lehman D. E., Geng Y., Kuder K., *Time-dependent drying shrinkage model for concrete with coarse and fine recycled aggregate,* Cement and Concrete Composites 105/2020, 103426.

[37] Kazmi S. M. S., Munir M. J., Wu Y. F., Patnaikuni I., Zhou Y., Xing F., *Influence of different treatment methods on the mechanical behavior of recycled aggregate concrete: a comparative study,* Cement and Concrete Composites 104/2019, 103398.

[38] Ahimoghadam F., *Effect of recycled concrete aggregate properties on the behaviour of new concrete,* Doctoral dissertation, University of Ottawa, Ottawa, Canada, 2018.

[39] Jiménez C., Barra M., Valls S., Aponte D., Vázquez E., *Durability of recycled aggregate concrete designed with the equivalent mortar volume (EMV) method: validation under the spanish context and its adaptation to bolomey methodology,* Materiales de Construcción 64-313/2014, e006-1.

[40] Faleschini F., Jiménez C., Barra M., Aponte D., Vázquez E., Pellegrino C., *Rheology of fresh concretes with recycled aggregates,* Construction and Building Materials 73/2014, 407–416.

[41] Yang S., Lee H., *Structural performance of reinforced rca concrete beams made by a modified EMV method,* Sustainability 9-1/2017, 131.

[42] Yang S., Lee H., *Freeze–thaw resistance and drying shrinkage of recycled aggregate concrete proportioned by the modified equivalent mortar volume method,* International Journal of Concrete Structures and Materials 11-4/2017, 617–626.
[43] Yang S., *Effect of different types of recycled concrete aggregates on equivalent concrete strength and drying shrinkage properties,* Applied Sciences 8-11/2018, 2190.
[44] Knaack A. M., Kurama Y. C., *Design of concrete mixtures with recycled concrete aggregates,* ACI Materials Journal 110-5/2013, 483.
[45] standard JGJ55, C. *Specification for mix proportion design of ordinary concrete*. Beijing, China, 2000.
[46] IS 10262:2009 *Indian standard concrete mix proportioning - Guidelines (First revision),* Bureau of India Standard, New Delhi, India, 2009
[47] ASTM, A. *C192/C192M-13a-Standard practice for making and curing concrete test specimens in the laboratory*. Technical report, ASTM International, 2013
[48] ACI Committee 211, *Standard practice for selecting proportions for normal, heavyweight, and mass concrete* (ACI 211.1-91), 2002.
[49] Abreu V., Evangelista L., Brito J. D., *The effect of multi-recycling on the mechanical performance of coarse recycled aggregates concrete,* Construction and Building Materials 188/2018, 480–489.
[50] Xiao J., Li J., Zhang C., *Mechanical properties of recycled aggregate concrete under uniaxial loading,* Cement and Concrete Research 35-6/2005, 1187–1194.
[51] Olorunsogo F., Padayachee N., *Performance of recycled aggregate concrete monitored by durability indexes,* Cement and Concrete Research 32-2/2002, 179–185.
[52] Thomas C., Setién J., Polanco J., Alaejos P., De Juan M. S., *Durability of recycled aggregate concrete,* Construction and Building Materials 40/2013, 1054-1065.
[53] Domingo-Cabo A., Lázaro C., López-Gayarre F., Serrano-López M., Serna P., Castaño-Tabares J., *Creep and shrinkage of recycled aggregate concrete,* Construction and Building Materials 23-7/2009, 2545–2553.
[54] Corinaldesi V., Moriconi G., *Influence of mineral additions on the performance of 100% recycled aggregate concrete,* Construction and Building Materials 23-8/2009, 2869–2876.
[55] Rao M. C., Bhattacharyya S. K., Barai S. V., *Influence of field recycled coarse aggregate on properties of concrete,* Materials and Structures 44-1/2010, 205–220.
[56] Kwan W. H., Ramli M., Kam K. J., Sulieman M. Z., *Influence of the amount of recycled coarse aggregate in concrete design and durability properties,* Construction and Building Materials 26-1/2011, 565-573.
[57] Andreu G., Miren E., *Experimental analysis of properties of high performance recycled aggregate concrete,* Construction and Building Materials 52/2014, 227-235.
[58] Kou S. C., Poon C. S., *Mechanical properties of 5-year-old concrete prepared with recycled aggregates obtained from three different sources,* Magazine of Concrete Research 60-1/2008, 57–64.
[59] Zhou C., Chen Z., *Mechanical properties of recycled concrete made with different types of coarse aggregate,* Construction and Building Materials 134/2017, 497–506.

[60] Fathifazl G., Abbas A., Razaqpur A. G., Isgor O. B., Fournier B., Foo S., *New mixture proportioning method for concrete made with coarse recycled concrete aggregate,* Journal of Materials in Civil Engineering 21-10/2009, 601–611.
[61] Tam V. W., Tam C., Le K., *Removal of cement mortar remains from recycled aggregate using pre-soaking approaches,* Resources, Conservation and Recycling 50-1/2007, 82–101.
[62] Akbarnezhad A., Ong K. C. G., Zhang M. H., Tam C. T., *Acid treatment technique for determining the mortar content of recycled concrete aggregates,* Journal of Testing and Evaluation 41-3/2013, 441-450.
[63] Movassaghi R., *Durability of reinforced concrete incorporating recycled concrete as aggregate (RCA),* Master's thesis, University of Waterloo, Waterloo, Canada, 2006
[64] Akbarnezhad A., Ong K., Zhang M., Tam C., Foo T., *Microwave-assisted beneficiation of recycled concrete aggregates,* Construction and Building Materials 25-8/2011, 3469–3479.
[65] Dean S. W., Abbas A., Fathifazl G., Isgor O. B., Razaqpur A. G., Fournier B., Foo S., *Proposed method for determining the residual mortar content of recycled concrete aggregates,* Journal of ASTM International 5-1/2008, 101087.
[66] Abbas A., Fathifazl G., Fournier B., Isgor O., Zavadil R., Razaqpur A., Foo S., *Quantification of the residual mortar content in recycled concrete aggregates by image analysis,* Materials Characterization 60-7/2009, 716–728.
[67] Kim J., *The effect of residual mortar in recycled aggregate on behavior of recycled aggregate concrete,* Master's Thesis, Korea University of Technology and Education, Cheonan, Korea, 2016 (In Korean)
[68] Kim N., Kim J., Yang S., *Mechanical strength properties of rca concrete made by a modified EMV method,* Sustainability 8-9/2016, 924.
[69] Yang S., Lee H., *Mechanical properties of recycled aggregate concrete proportioned with modified equivalent mortar volume method for paving applications,* Construction and Building Materials 136/2017, 9–17.
[70] Surya M., Rao V. L. K., Lakshmy P., *Mechanical, durability, and time-dependent properties of recycled aggregate concrete with fly ash,* ACI Materials Journal 112-5/2015, 653.
[71] Knaack A. M., Kurama Y. C., *Design of concrete mixtures with recycled concrete aggregates,* ACI Materials Journal 110-5/2013, 483.
[72] Hayles M., Sanchez L. F., Noël M., *Eco-efficient low cement recycled concrete aggregate mixtures for structural applications,* Construction and Building Materials 169/2018, 724–732.
[73] Rajhans P., Panda S. K., Nayak S., *Sustainable self compacting concrete from C&D waste by improving the microstructures of concrete ITZ,* Construction and Building Materials 163/2018, 557–570.
[74] Abbas A., Fathifazl G., Isgor O. B., Razaqpur A. G., Fournier B., Foo S., *Durability of recycled aggregate concrete designed with equivalent mortar volume method,* Cement and Concrete Composites 31-8/2009, 555–563.

[75] Rajhans P., Gupta P. K., Kumar R. R., Panda S. K., Nayak S., *EMV mix design method for preparing sustainable self compacting recycled aggregate concrete subjected to chloride environment*, Construction and Building Materials 199/2019, 705–716.
[76] Fathifazl G., Razaqpur A., Isgor O. B., Abbas A., Fournier B., Foo S., *Shear capacity evaluation of steel reinforced recycled concrete (RRC) Beams*, Engineering Structures 33-3/2011, 1025–1033.
[77] Fathifazl G., Razaqpur A., Isgor O. B., Abbas A., Fournier B., Foo S., *Shear strength of reinforced recycled concrete beams with stirrups*, Magazine of Concrete Research 62-10/2010, 685-699.
[78] Fathifazl G., Abbas A., Foo S., Isgor O., Fournier B., Razaqpur A., *Shear strength of reinforced recycled concrete beams without stirrups*, Magazine of Concrete Research 61-7/2009, 387–400.
[79] Jiménez C., Barra M., Josa A., Valls S., *LCA of recycled and conventional concretes designed using the equivalent mortar volume and classic methods*, Construction and Building Materials 84/2015, 245–252.
[80] Yang S., Lim Y., *Mechanical strength and drying shrinkage properties of rca concretes produced from old railway concrete sleepers using by a modified EMV method*, Construction and Building Materials 185/2018, 499–507.
[81] Mathew P., Baby V., Sahoo D. K., Joseph G., *Manually recycled coarse aggregate from concrete waste—a sustainable substitute for customary coarse aggregate*, Am. J. Eng. Res 3/2013, 34-38.
[82] ISO14040. *Environmental management: life cycle assessment; principles and framework (No. 2006)*, ISO, 2006


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