FACTA UNIVERSITATIS
Series: **Architecture and Civil Engineering** Vol. 4, N° 1, 2006, pp. 1 - 17

CHARACTERISTIC STRUCTURES OF THE INDUSTRIAL BUILDINGS FROM THE XIX-XX CENTURIES AND TECHNICAL INTERVENTIONS FOR THE RE-UTILIZATION

UDC 725.4(045)=20

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Abstract. *This paper analyses the technical interventions needed for the re-utilization of late industrial buildings. It reviews the characteristic structures of the industrial buildings from the XIX.-XX. centuries and the methods to be used for the refurbishment. The main goal of the research is to create a collection in the form of tables summarising the characteristic structures of the industrial buildings and the methods of their examination and refurbishment that may be used not only theoretically, but also practically, for the planning of such re-utilizations.*

Key words: *Industrial architecture, re-utilization, building diagnostics, refurbishment, reinforcement*

1. INTRODUCTION

Apart from unfolding technological development, the changes in the structure of industry resulted in the closing of several plants and factories and the loss of function of the industrial buildings. This process became observable in Western Europe since the 1970's, while in Eastern Europe since the early 1990's. The re-utilization of the industrial buildings is an alternative solution to their demolition, particularly in the case of buildings of historic or architectural value. There are several examples for the re-utilisation of the industrial buildings both in Europe and the United States implementing several local projects in addition to the international ones.

In order to plan the refurbishment and re-building of the characteristic structures, the buildings failures and examination methods as well as the applicable construction technologies must be known. The literature [5], [7], [8] entertain the subject of the industrial architecture [3], [5], [9] and the examination of the structural units [1], [2], [4], [5], [10] along with the characteristic failures in detail. However, there are few data in the special literature concerning the cast iron and steel structures used for the construction of industrial buildings.

Received November 25, 2006

The goal of my study is to summarise the knowledge needed for the preparations of the technical interventions concerning the re-utilisation of industrial buildings. I would like to integrate the materials and architectural solutions of the individual parts of the buildings and the related methods of their examination and refurbishment into a coherent system.

1. TECHNICAL RELATIONS OF THE RE-UTILISATION

My paper [6] treated the creation of the new functions of a late industrial building.

Generally, the temporary re-utilisation can be carried out by the comparatively simple interventions, but the long term ("final") one may require large-scale (partial demolition, structural reinforcements, re-buildings or refurbishment, integration of new structures) interventions.

The conditions required for preceding the re-utilisation are influenced first of all by the construction technology, the former use, the maintenances carried out during the use, the refurbishments and the re-buildings. The wear and tear of the structures can be unperceivable or physical. The reason of the physical wear is the wear out, aging or physical damages. The reasons of the damages may be material defects, design, use and/or operational faults. The most important effects among those which can result in serious damages are the material- and structure-specific corrosion as well as the physical, mechanical and environmental influences on the construction. (Fig. 1)

Fig. 1. Industrial building in poor condition: various building failures can be observed

2. BUILDING DIAGNOSTICS

The surveys to be carried out for the building and its parts are numerous, their details are determined by the phase and type of the re-utilization. A basic principle is that such surveys shall fit the structure's significance and the expected result.

For the analysis of the construction history, the most important documents and rebuilding designs must be available. But the building journal, the bills, diagrammatic layouts (photographs, paintings) and the recollection of the late users may also play an important role.

The inspection is the basis for any further tests. The knocking (material quality, cavities), touching (surface dampness, temperature differences) and in some cases smelling are a part of these tests. The visual inspections determine what further tests ought to be done. By revealing the characteristic defects occurring in the individual structural units and building materials our work becomes effective and to the point.

The non-destructive tests do not destroy the structure and can favourably be applied to buildings in use as well. The types of test belonging to this category are listed in detail in Table 1.

The details of the ground-plans and sections created during the survey depend on the purpose. The structural tests and the preparation of the refurbishment may require the detailed survey of the individual parts of the building concerned. A photographic documentation might complement the other examinations and fix the testing and sampling points, alterations and cracks.

More detailed and accurate tests can be carried out, if the structure can partially be demolished. The quality of the basic structures can be determined by removing the various coverings (plastering, paints, tapestry, floor coverings, wall coverings). The destructions suffered by the covering and the basic structure and the defects hiding behind the sound covering can be checked. The evidences of earlier rebuilding and alterations can be discovered.

Beside the non-destructive testing mentioned above, sampling can be made after the exploration of the supporting structures. By the exploration and sampling operations the supporting structures must not be impaired and the stability of the building and safety of the users and the inspectors must not be threatened. For the preparation of the re-utilisation disused buildings are to be preferred facilitating the accomplishment of the tests needed. The explorations can be completed with endoscope tests used to the discovery of cavities, utility lines and internal structures in confined spaces.

Several kinds of tests require samples taken from the structure itself or the building material. The calcium-carbide tests to determine the humidity, the testing of the carbonate saturation of the concrete (by indicator), but also the various material and mechanical properties belong to this group.

Important phases of the testing are the static inspection of the existing structure (load capacity and deformation in critical failure state) and the execution of building physical (thermal) and sanitary engineering calculations. The consideration of the results of the non-destructive and destructive tests are very important for these tests.

Table 1. Non-destructive construction diagnostic methods

Types of tests and object of the tests	Steel, cast iron	Wood	Concrete, reinforced concrete (stone, brick, mortar)	Building structures
Visual inspection (structural survey, discovering defects and determining the further tests required)	X	X	X	X
Checking the displacement and deformation				
Geodetic or traditional methods	X	X	X	X
Crack testing microscope	X	X	X	X
Photogrammetric survey				X
Surface, near-surface quality, strength				
Knocking	X	X	X	X
Brinell-, Rockwell-, Vickers-hardness tests	X			
Poldi-hammer	X			
Crack testing by magnetic field deterioration	X			
Schmidt-hammer, swinging hammer			X	X
Surface sticking and tensile tests			X	
Strength tests, homogeneity				
Ultrasound tests	X			
X-ray tests	X			
Ultrasound concrete tester			X	
Corrosion tests with inspectoscope	X			
Moisture tests				
Measuring the electric conductivity		X	X	X
Measuring the water absorption			X	X
Temperature measurements				
E.g. infrared thermometer	X	X	X	X
Infrared thermography				X
Searching for metals				
Metal indicating probe			X	X
Magnetic induction tool			X	X
Inspectoscope			X	X
Supporting structure test with test loads				X

2. Characteristic structures

Beside the presentation of the most important original structures, the refurbishment and rebuilding technologies to be used to the re-utilisation of the individual categories of structures will be dwelt on below.

4.1. Foundation

In the past, the foundation of the buildings was built as strip foundation made of stone or bricks, while during the 19th century concrete or reinforced concrete, if the quality of the soil made it possible. In simple cases no binding agents were added to the foundation or compacted soil was used as foundation. In case of harsh soil and ground-water conditions compacted sand or stones rammed in the soil was used. In low-grade soils, deep foundation was used; bearing piles (wood, iron, subsequently reinforced concrete piles), cylinder foundation or box frame foundations were applied. To resist the water pressure, concrete slabs or reversed brick vaults were erected.

Engineering interventions are needed, if significant structural changes take place or significant additional loads occur or the foundation is faulty or damaged the signs of which may be the damage and cracking of the superstructure. The direct checking of the foundation requires exploration in the course of which the building must be protected accordingly. The geo-technical examination of the soil shall always be carried out and the old foundation shall be checked and the new one designed in possession of the results of such examinations.

When extensions are built, the foundation of the new part of building shall be designed under consideration of the earlier foundation plane. The inspection of the connection between the foundations of the former extensions and the existing building is expedient. The usual techniques for the reinforcement of the foundation and the deepening of the foundation plane are the sectional underpinning, concrete backing, the application of pressed piles and the jet-grouting process (Table 2). Every intervention implies potential failures (deformations and cracks) caused by the disturbed soil; the number of such failures shall therefore be minimised.

Table 2. Building materials, structures, tests and refurbishment technologies – foundations

Structure	Materials	Test	Refurbishment
Plane foundation	Compacted soil Brick Stone Concrete (reinf. concrete) Wood (beam grid)	Visual inspection of the linked structures Foundation survey Corrosion tests	Reinforcement (base encasement) Underpinning, supporting concrete Jet Grouting Injected concrete reinforcement Changing for new foundation
Deep foundation	Wood Steel Concrete Reinf. concrete	Visual inspection of the linked structures Foundation survey	Jet Grouting or additional piling Changing for new foundation
Machine base	Brick Concrete Reinf. concrete	Base surveys Corrosion tests	Reinforcement (base encasement) Repair with repair mortar

4.2. Insulation against soil moisture and ground water

The protection against soil moisture and ground water was solved by pitchy or bituminous or metal plates furnished with paper carrier layer. The pitch, bitumen and asphalt are used as lubricants or in cast formation. The application of insulating mortars was a wide spread method as well; such mortars were applied to foundation bodies laid in aggressive environments. During the first decades of the 20th century, the concrete was deemed a water-proof material, i.e. it was used to water insulation purposes. The clay insulation, however, proved to be a cheaper solution with fat clay rammed between the foundation bodies in a thickness of 30–45 cm.

The aged or damaged insulation destroyed by the demolition and rebuilding works during the refurbishment shall be repaired, changed and replaced (Table 3). The defects of the insulation are indicated by the wet building structures. The in the meanwhile increased ground water level might necessitate the replacement of the entire insulation system of the building. Any repair or partial replacement is only practicable, if the original insulation satisfies the requirements of our age and is compatible with the new materials. The additional insulation of the walls against water can be solved by injection, installation of metal plates or electro-physical methods. The efficiency of such processes may be decreased by thick walls.

Table 3. Insulations against soil moisture and ground water

Structure	Materials	Test	Refurbishment
Wall insulation	(missing) Lubricated bitumen Kent bitumen, tar, asphalt (cast or with carrier layer) Tar or bitumen sheet Lead plate	Visual inspection of the linked structures Survey	Additional wall insulation technologies: breaking through the wall, injection, electro-physical process Auxiliary wall drying Draining the ground water by draining system
Base insulation	Clay Asphalt, asphalt felt Concrete		Production of new insulation (lubricated, sheet)

4.3. Vertical load carrying structures

The vertical load carrying structures of the earliest industrial buildings did not differ from those of the dwelling-houses, i.e. they were constructed of bricks, stone and wood. At first, wooden pillars were used, later, when the span was increased, the internal pillars were made of cast iron (as shown in Fig. 2) or rolled steel elements, while from the end of the 19th century, of reinforced concrete. The reinforced concrete structures have spread throughout the industrial architecture quickly. The load of the floors and roof structures was carried by internal columns, pillars or external load carrying walls. The load carrying walls were combined brick or stone walls or they were built as light structures. Pure reinforced concrete walls were built from the 1900's.

Fig. 2. Cast iron column supporting timber floor

The rebuilding or extension of the structure, the rising of the usage-related loads, the difference between the load capacities at the time of the construction and today and the age of the supporting structure may necessitate the reinforcement or demolition and rebuilding of the construction concerned. In case of protected buildings, the old structures shall be replaced by pieces manufactured after the fashion of the original ones. The method and scale of the required interventions will be specified by the static designer in co-operation with the architect (Table 4).

Table 4. Vertical load carrying structures

Structure	Materials	Test	Refurbishment
Load carrying walls	Brick wall Sand-lime brick Mixed wall Reinforced concrete wall	Damage tests, Crack tests Deformation tests Moisture damage test Strength test Corrosion tests Heat tests	Repairing the cracks (with cement mortar injection, elastic sealing kit, rebuilging the wall, wall stitching, and reinforced concrete bracing beams) Injected concrete, reinforcement with composite tape and textile) Building in drawing iron, reinforced concrete crown
Pillars, columns	Wood Cast iron Wrought steel, steel Brick, stone Reinf. concrete		Replacing the pieces Reinforcement of the cross section (reinforced concrete, profile steel, encasement, reinforced concrete filling, etc, welding, bolted profiles)

The damaged parts of the wooden columns must be replaced. The reinforcement can take place by both wooden and steel structures using metal clamps at the nodes, sticking or replacement by resin. The reinforcement of the cast iron pillars without changing their appearance can be made by reinforcing the hollow pillars internally or casting them with concrete. In case of need, the application of new elements manufactured of quality materials are recommended. The reinforcement of the welded steel girders can be made by welding steel profiles (T, I, U) or flat steels on them. The damaged rivets can be replaced by screw or in case of weldable materials, by welding. The steel structures will be protected against fire by fire-proof coating or, in case of hidden structures, plasterboard or plaster fibre covering or surrounding by concrete. This latter structure provides not only fire resistance but improves the load capacity as well.

The reinforcement of built walls may be carried out by the so called wall stitching technology (Fig. 3) or the erection of reinforced concrete pillars. Furthermore, the walls can be reinforced by carbon or glass fibre composite tapes, textiles, injected concrete, steel structures and steel bands. The usual way of the reinforcement of reinforced concrete walls is the injected concrete reinforcement technique increasing the degree of the concrete covering and being able to receive additional armouring. The carbon composites or steel band reinforcements can be used in such cases as well.

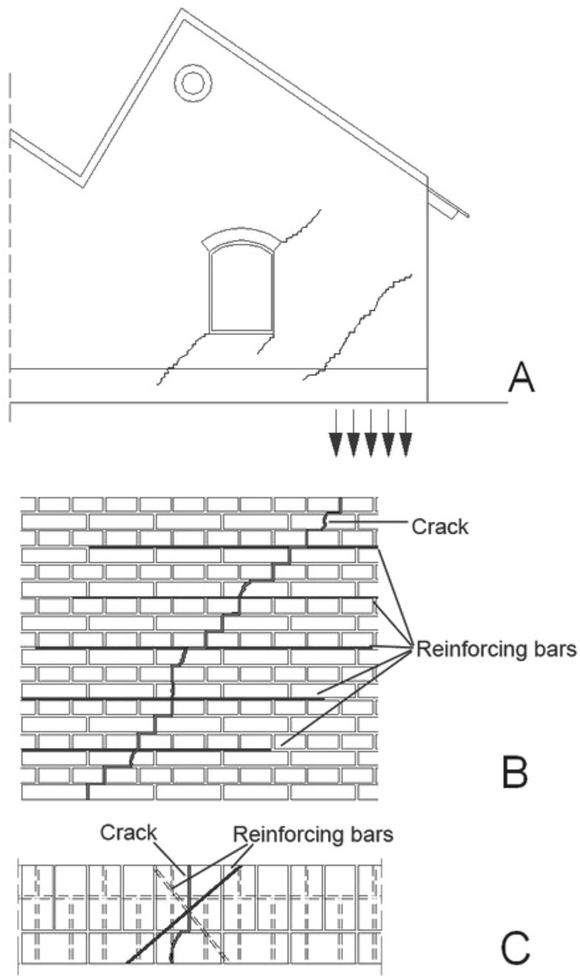

Fig. 3. Repairing masonry by reinforcing:
a) Cracks on walls caused by the movement of the soil;
b) Placing the reinforcing bars in bed joints;
c) Placing the reinforcing bars in diagonal bores.

4.4. Horizontal load carrying structures

Similarly to the vertical supporting structures, the wooden structures of the floors (as shown in Fig. 2) were gradually replaced by steel, concrete and reinforced concrete. The Prussian vault built between rolled steel I-girders was used between the mid 19th and the early 20th centuries. In its improved version the vaulted sections were made of compacted concrete or concrete reinforced by armouring. With the general application of the reinforced concrete, the floors were made more and more of this material and the related calculations were based on patents, later on standards.

The rebuilding and refurbishment needed to the re-utilisation involves always the floors as well. The possible additional loads (interior design, machinery, etc), the floor breakthroughs required for various reasons, the changing requirements and fire protection points require the reinforcement of the structures. The floors may be replaced by both assembled or monolithic floors. The designing shall be done by a structural engineer in this case as well. The reinforcement can be made of the material of the old floor or materials differing from it for all types of floor (Table 5).

Table 5. Horizontal load carrying structures and stairs

Structure	Materials	Test	Refurbishment
Timber floor	Wood	Damage tests Crack pattern test Stability test (supporting structure, links) Strength test (flexion, vibration) Moisture damage test Heat tests Corrosion tests	Partial or full replacement Replacement by wood, steel or reinforced concrete girders Adding mortar Surface reinforcement (injected concrete) Reinforcement with composite tape, textile and steel band Building in steel girder
Beam floor	Wood Steel beams -Brick vault -Concrete vault - Reinf. concrete vault -Planar reinf. concrete field Prefabricated reinf. concrete		
Monolithic floors	Reinforced concrete ribs or sheet		Injected concrete, reinforcement with repair mortar, resin or composite tape and textile
Stairs	Stone Reinforced concrete Steel, cast iron Wood Brick	Damage tests Crack pattern test Stability test Strength test (flexion, vibration) Corrosion tests	Surface repairs with concrete with resin binding agent added Building in auxiliary metal or reinforced concrete beams Reinforcement of the stone with steel or composite tape Wedging the floating steps

For the reinforcement of wooden floors, the most frequent methods of the several ones available are the insertion of steel, wood or reinforced concrete girders, the repair of the wooden girders by resins or their replacement and – retaining the floor – the addition or integration of monolithic reinforced concrete slabs.

The erased and cracked parts of the Prussian vaults can be repaired by scraping the gaps, removing the dust and applying plastering. In case of more serious defects, the vaults may be rebuilt, but the placement of reinforced concrete sections is a simpler solution. (Fig. 4) The arched shuttering can be used in the individual sections beside each other several times. The reinforcement of the rolled girders can be made by one of the above mentioned methods.

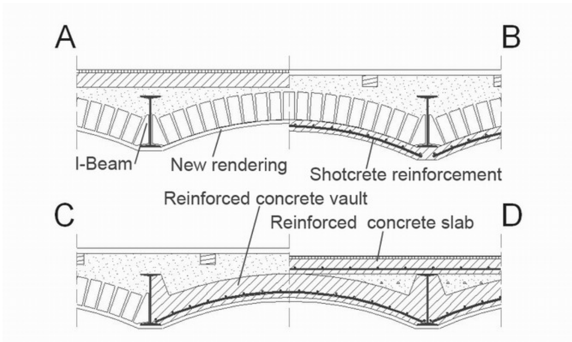

Fig. 4. Repairing methods of brick vaults between I-beams (jack arches):
a) Repairing of brick joints, new rendering; b) Shotcrete reinforcement;
c) Replacing the vault using reinforced concrete;
d) New reinforced concrete vault and slab.

In case of reinforced concrete floors the injected concrete reinforcement, the application of repairing mortar or steel, carbon fibre composite tapes and textiles are used most frequently. The replacement of the floor sections and girders can take place by steel or monolithic reinforced concrete girders.

When building new floors or parts of floor, the load transfer and the synergy between the new and old structures (floors, walls and columns) must be solved (Fig. 5.). For the replacement of the floor sections, the original structure or the modern technologies can be used. The attachment of the beam floors to the wall occurs point by point. The seats of the pre-fabricated reinforced concrete floor panels may cause problems when the intermediate levels are built; the application of such seats is better for locking floors.

Fig. 5. New reinforced concrete floor built in an existing reinforced concrete structure

4.5. Skeleton constructions

The application of the skeleton constructions is characteristic for halls and multi-storey buildings. The skeleton constructions can be made by hinged or rigid interconnection of wooden, cast iron, rolled steel beams or lattice girders. The reinforced concrete pillar structures gained ground in the 20th century. The backing were built of bricks, corkwood building blocks, artificial tuff (porous concrete), gypsum or reed panels or they were erected as thin reinforced concrete constructions. The wall-board solution mounted onto skeleton pillars was also typical.

If the pillars or beams are damaged, the faulty parts shall be repaired and reinforced as described in items 4.3 and 4.4. The fixed and rigid connections are typically damaged at the corners and the links. The nodes of steel structures shall be repaired by welding or bolting, the wooden constructions need sticking or steel links, while the reinforced concrete structures shall be repaired with repair mortar, carbon fibre textiles or additional steel structures (Table 6).

Table 6. Skeleton constructions

<table>
<tr><th>Structure</th><th>Materials</th><th>Test</th><th>Refurbishment</th></tr>
<tr><td>Column and beam structures</td><td>Wood
Cast iron
Steel
Reinforced concrete</td><td rowspan="2">Damage tests
Crack pattern test
Stability test (supporting structure, links)
Strength test (flexion, vibration)
Moisture damage test
Heat tests
Corrosion tests</td><td>Reinforcing the nodes (bolting, welding, repair mortar, composite textile, etc)</td></tr>
<tr><td>Frames</td><td>Wood
Steel
Reinforced concrete</td><td>Reinforcement (bolting, welding, repair mortar, composite tape and textile, steel band or building in additional armouring)</td></tr>
</table>

4.6. Roof structures and covers

The early industrial buildings were built with wooden roof structure clamped with raft dogs and cast iron or wrought steel links. Later on, the wooden structures were completed by steel holding elements (drawing iron, strainers). Rolled and riveted steel links were also used for the purposes of roof structures. The large-span roof structures are very spectacular. The flat roof structures were made either similarly to the floors or, as light structures, to the high-pitched roofs.

The material of the roof covering is determined by the angle of slope of the roof. In many cases, the angle of slope was fitted to the material. The largest angle of slope is required by the hard-burnt roof-tiles and roof slates (60 - 100%), while the zinc, lead, galvanised steel or copper shells can be used at reduced angle of slopes as well (30%). During the early years of the 20th century, the production of the small and large panels of the artificial slates (eternity) was started. The flat roofs were insulated mostly by tar, bitumen, asphalt and the so called „Holzzement" insulating materials composed of tar, pitch and sulphur. These materials were either applied on the spot between paper layers or used as insulating plates. The surfaces were protected by pearl pebble, sand or gravel layers.

The condition of the roof structure may require reinforcement or replacement. In case of characteristic structures of aesthetic value or technically interesting, visible ones, the manufacturing of the elements after the fashion of the original ones is recommended. The reinforcement of the wooden roof structures may take place by the installation of wooden or steel parts. If only one part of the wood is damaged, the destroyed parts shall be replaced by wood. The wood shall be treated with fire resistant agent. The reinforcement and fire protection of the steel structures is possible by the methods described above (Table 7).

Table 7. Roof structures and covers

Structure	Materials	Test	Refurbishment
High-pitched roofs	Wooden carpenter structure Wooden structure, steel links Steel, cast iron Monolithic reinforced concrete Prefabricated reinforced concrete	Visual inspection Damage test Deformation test Crack pattern test Link test Corrosion tests	Partial or full replacement Structural reinforcement by increasing the cross sectional area Adding wood by resin, reinforcement with composite tape Additional wood protection, fire protection
Flat roofs	Reinforced concrete (like the floors) Steel structure and corrugated sheet		Floor reinforcement and refurbishment methods
High-pitched roof covers	Metal plate (copper, zinc, galvanized steel) Roof tile Slate, asbestos Tarred felt	Structure link test Shell test Corrosion tests	Heat and moisture protection Replacement of individual elements or the entire covering
Flat roof insulations	Asphalt 'Holzzement' Tarred felt Bituminous thin plate	Soak-through test Checking the slope Cavity building test (knocking) Crack pattern test Corrosion tests Structure link test	Repairing the insulation or spot repair Replacement of the insulation Steam pressure balancing by perforating the old layers, building in new insulations Additional heat insulation

The refurbishment of the cover may be required by the condition of the covering materials (condition of the cover) and the different temperature and moisture conditions. Accordingly, the original order of layers will be replaced by an up to date, ventilated heat insulation structure furnished with air gaps, but the own weight of the original covering material and the slope of the roof shall always be considered. According to the basic principle: if a large area of the shell is intact, it can be used, if there is an adequate material for the replacement (fitting the quality, colour and dimensions) and it can be built in. The asbestos cement elements shall be replaced due to their carcinogenic properties.

The rainwater insulation of flat roofs produced before World War II is age-worn and requires refurbishment. If the old structures constitute a uniform plane, they can be used as basis for the new insulation. The inadequate slope, the poor heat insulation and the upwarping and destruction of the insulation due to inadequate moisture diversion are general deficiencies of the early flat roofs. In the latter case the perforation of the insulation may solve the problem by balancing the steam pressure. The best way of the repair is the installation of a new cover that can be produced by laying the layers in straight or reverse order. Reverse layer order can be used, if the locking floor is able to carry the load. In case of straight layer order the insulation shall be fixed mechanically or by sticking.

4.7. Facades

The external appearance of the building is determined by the architectural styles prevailing in the given age, the construction technologies and the requirements of the principal. For economic reasons, the façade frequently remains unplastered forming the typical architecture characterising the industrial buildings. In case of more demanding industrial buildings the bricks are used in combination with stone and plastered surfaces. After the turn of the XIX.-20th centuries the raw concrete and the metal corrugated sheets appeared on the facades; later, these materials gained more and more ground.

The manner of the refurbishment of a façade is determined by the outer design of the building and the heat and moisture insulation properties. The installation of additional heat insulation to a simple, plastered building is easy, while the heat insulation of an existing brick façade is much more problematic, because the ideal placement of the heat insulation on the external surface of the wall is impossible. If the façade is not damaged seriously, the surface can be cleaned by water, chemical or grit blasting (dry or wet) (Fig. 6).

Fig. 6. Renewal of facades: the external walls are cleaned and repaired if necessary, new window is placed behind the original one.

If the façade is damaged, the defects, depending on their dimensions shall be repaired or a new façade shall be formed (Table 8).

Table 8. Facades

Structure	Materials	Test	Refurbishment
Filling walls	Brick Artificial tuff (gas concrete), Cork derivatives Sand-lime brick Gypsum board	Cavity building test Heat tests Moisture damage test Crack pattern test Corrosion test Strength test Deformation test	Repairing the cracks (cement mortar injection, elastic sealing kit, rebuilding the walls) Partial or full replacement
Façade materials	Brick Plastering Stone, artificial stone Concrete, reinf. concrete Corrugated sheet (Wood)		Additional heat insulation Replacement of elements Cleaning the surfaces (water, chemical or grit blasting technology) Material conservation (with chemicals) Building new covering

4.8. Doors and windows

The doors and windows used in the industrial architecture were manufactured of wood and steel as delicate structures with segmental arch closing and installed in dense spacing. Generally, they were manufactured with cast iron or steel dividing ribs and small opening wings. The windows and transom lights were furnished with simple or double glazing, but cast glass or wire glass plates built in walls or used as roof covering along with glass bricks were applied. The doors and gates were built as opening or sliding type structures. The wings were solid or made of skeleton and concrete elements. The solid structure was manufactured of wood, while the material of the skeleton was steel and the insert pieces were manufactured of metal plate, concrete or other materials similar to the concrete.

The replacement of the doors and windows is required by heat insulation reasons. The new doors and windows can be manufactured of wood, steel, aluminium or plastic furnished with at least double-layer, heat insulating glazing. The retention of the original dense-spacing character and the insufficient thickness of the typical profiles may cause problems. This problem can be solved by using unique constructions or new ones placed behind the old doors and windows (shown in Fig. 6), if the wall thickness does not exclude such solutions. If the original structures are retained, the armouring shall be checked, because their failure may require the manufacturing of the structure concerned after the fashion of the original one. (Table 9).

Table 9. Doors and windows

Structure	Materials	Test	Refurbishment
Gates	Wooden casing and wing Steel structure -steel covering -wooden covering -reinf. concrete covering	Damage test Deformation test Case clamping test Heat tests Surface protection test Corrosion test Function test	Cleaning the surfaces Refurbishment of paintings, protection against corrosion Repairing the armouring Repairing the seals Repairing the cases and wings Replacing the doors and windows
Doors	Wooden or steel structure Simple or double plate covering Concrete or asbestos cement inserts		
Windows, transom lights	Rolled steel profiles Cast iron profiles Wood profiles Simple or double glazing		Cleaning the surface Refurbishment of paintings, protection against corrosion Replacing the glass (possibly by heat insulating glazing) Repairing the armouring Repairing the seals Repairing the casing and wing Replacement of the doors and windows, building in new doors and windows

4.9. Internal surfaces and partition walls

The interior of the industrial buildings was determined by the technology as early as the mid 19th century. To provide better lighting conditions, the walls were light-coloured or furnished with covering. The early buildings had compacted earth or sand or stone covered floors. Later, the smoothed concrete, brick, clinker and asphalt coverings took over along with the patented floor coverings (e. g. Xylolith, Antielaeolith). The partition walls were made of bricks, reinforced concrete, plasterboard or thatchboard, artificial tuff and cork elements or, in case of skeleton structures, gypsum or cement mesh structures.

The replacement of the wall and floor coverings is advisable, except, if the condition of the structure or the new function does not necessitates it or the protection of monument or the historic value excludes such replacement. If the strength of the original covering is adequate, it cans be used as base for new covering after smoothing. In many cases the replacement is accompanied by the formation of a new heat or acoustic insulating base which can be produced with dry or wet technology. The new base can receive any commercial floor or wall covering. However, the changed function requires the alteration of the inner spaces as well. The new partition walls can be erected by normal building or dry (assembled) technology (Table 10).

Table 10. Internal surfaces and partition walls

Structure	Materials	Test	Refurbishment
Partition walls	Brick Gypsum or cement mesh Reinforced concrete Gypsum board Thatchboard Artificial tuff Cork constr. elements	Cavity building test Moisture damage test Crack pattern test Corrosion test Strength test Deformation test	Repairing the cracks (cement mortar injection, elastic sealing kit, rebuilding the walls) Repairing and completing the mesh structures Partial or full replacement
Floor coverings	Stone covering Ceramic tiles Cement smoothing Asphalt Clinker, brick Wood (cube, board, parquet) Gypsum-lime	Cavity building test Wear test Damage test Crack pattern test Deformation test Moisture damage test Corrosion test Strength test	Replacement of single plates in case of plate coverings Replacing one part of the surface Replacing the entire surface and laying new covering Reinforcing the base Placing the heat and acoustic insulations
Wall and ceiling coverings	Plastering (lime, cement or gypsum mortar) Painting Tiles		Reinforcing the basic surface Adding plastering or replacing the plastering Surface smoothing and reinforcement Repairing or replacing the coating Removing the salt efflorescence

3. Summary

The structures used for the earliest industrial buildings did not differ from the structures of other buildings; however, the typical solutions of the industrial architecture gaining ground from the 19th century and the materials used coincide only partially with those used for the residential and public buildings. The building diagnostic methods and refurbishment technologies used to the traditional refurbishments and protection of monument are not always optimal, in some cases even unusable. In case of industrial buildings special approach is needed as summarised in the tables below.

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KARAKTERISTIČNE KONSTRUKCIJE INDUSTRIJSKIH ZGRADA 19. I 20. VEKA I TEHNIČKE INTERVENCIJE ZA NJIHOVO VRAĆANJE U FUNKCIJU

Adrienn Lepel

Ovaj rad analizira tehničke intervencije koje su potrebne kod vraćanja u funkciju industrijskih zgrada. Rad daje pregled karakterističnih konstrukcija industrijskih zgrada iz 19. i 20. veka i metode koje se koriste u njihovoj revitalizaciji. Glavni cilj istraživanja ja da formira skup tabela koje sistematizuju karakteristične konstrukcije industrijskih zgrada i metode ispitivanja i revitalizacije koje mogu biti korišćene, ne samo u teorijske svrhe, već i u praktične, u cilju projektovanja ovih revitalizacija.