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ADVANCED BUILDING ENGINEERING SOLUTIONS OF THE FACILITIES OF PROTECTION/DEFENSE ORGANIZATIONS IN THE LIGHT OF SUSTAINABILITY

1. WATER AND SEWER NETWORK

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Abstract

Sustainability has now become a priority in the protection/defense sector as well. Compliance with protection/defense tasks, while consciously protecting the environment and managing its resources, is an often contradictory endeavor that challenges facility designers, builders and users alike. This is especially true for problems with the compliance with energy standards of facilities. The authors examine the failure trends of the engineering elements and the issues concerning their wear and tear within a series of articles on environmentally conscious building design and construction in order to make a recommendation for the use of up-to-date procedures, tools, materials and methods. Focusing on energy efficiency in this paper, the failure possibilities of water and sewer network were studied in a building sample of 20.

Keywords: sustainable building design, building engineering, building diagnostics, water and sewer network, plumbing/pipeline system

Absztrakt

A fenntarthatóság napjainkban a védelmi szférában is kiemelt területté vált. A védelmi feladatoknak való megfelelés, ugyanakkor a környezet tudatos védelme, az erőforrásaival való gazdálkodás olyan - sokszor egymásnak ellentmondó - törekvés, amely kihívás elé állítja az objektumokat tervezőket, építőket és használókat egyaránt. Különösen igaz ez az objektumok energetikai szabványoknak való megfelelése problémáira. A szerzők egy cikksorozatban vizsgálják a környezettudatos

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épülettervezés és létesítés témakörén belül a gépészeti elemek meghibásodási tendenciáit, az elhasználódásuk kérdéseit annak érdekében, hogy javaslatot tegyenek korszerű eljárások, eszközök, anyagok, módszerek alkalmazására. Ebben a cikkben az energiahatékonyságra koncentrálva egy 20-as épületmintán vizsgálták a víz- és csatornahálózat hibalehetőségeit.

Kulcsszavak: fenntartható épülettervezés, épületgépészet, épületdiagnosztika, víz- és csatornahálózat, vezetékhálózat

1. Introduction

Today, environmental damage and exploitation has reached such proportions that there is a growing demand worldwide for clean, environmentally friendly, less energy-intensive and less waste-generating processes and technologies. This is one of the objectives of more and more sectors, including architecture, including the construction and modernization of facilities.

To ensure sustainable development, environmentally friendly materials, new technologies and new methods must now be used on construction sites. In the field of protection/defense as well, there is an old need for the construction and maintenance of facilities, but also for the modernization to be carried out in such a way that the interests of environment protection are not harmed. One of the key factors in achieving the goals is environmentally conscious building design, including engineering, electrical, electronic, communications, architectural and structural design. Previous research, mainly in building diagnostics, has shown that the most defective element in a facility is its engineering system. A sustainable building design is a good starting point for achieving the environmental objectives of the area, in which modern building services solutions should play a key role, as these systems play a significant role in energy-saving operation. Designs using appropriate and state-of-the-art materials and technologies, can contribute to long-term survival, trouble-free, or low-fault operation, thus helping sustainability.

The question arises as to what new procedures and methods can be used in the design of building services systems, so that they are damaged as little as possible during use, as long as they can be used, and their operational safety increases. An important goal is to have a

regular building diagnostic inspection while using engineering components to detect failures and eliminate rapid wear and tear, thus helping sustainable development. In order to answer the above questions, as well as to be able to make suggestions on the topic, we examined the engineering elements and their failures in relation to 20 buildings. In this paper, we have summarized the lessons learnt with water and sewer networks. However, in order to analyze this issue, we must first turn to the energy policy of our region and its connections with architecture.

The emergence of EU energy policy in building design

By announcing the program of sustainable development,³ by the beginning of the 20th century, the rationalization of energy use and increasing the share of renewable energy sources have become the most important task in our region, but unarguably in the entire world. The European Union's 2011 Energy Efficiency Plan set out its 20-20-20 targets to reduce greenhouse gas emissions by 20% by 2020 compared to 1990 levels, increase the share of renewable energy sources by 20% and increase energy efficiency by 20%. In 2018, as part of the "Clean Energy for All Europeans" package, a new target of reducing energy consumption by at least 32.5% until 2030⁴ has been set. The pursuit of commitments entails constant monitoring of Member States' energy policies in all areas of life. As building stock accounts for 40% of EU energy consumption, all economically viable, energy-efficient installation and operation solutions in the building sector and the use of renewable energies also have an impact on energy consumption.⁵

The question arises as to what kind of energy policy the EU pursues in one of the dominant economic communities in our region, and how this regulates the design of buildings. The European Union's energy

³ Sustainable development is a complex concept that is seemingly contradictory and can be interpreted in several ways. On the one hand, what is sustainable and not temporary does not deplete its own foundations, does not narrow its own possibilities, as well as the possibilities of the future. On the other hand, sustainable development also means increasing the use of the environment's available reserves without depleting them. Kékedy-Nagy, László: Fenntartható fejlődés a 21. században. <https://muvelodes.net/tudomany/fenntarthato-fejlodes-a-21-szazadban> (30 October 2020).

⁴ Energiahatékonyság. <https://www.europarl.europa.eu/factsheets/hu/sheet/69/energiahatekonysag> (19 March 2020).

⁵ D. D'Agostino, B. Cuniberti – P. Bertoldi, (2017): Energy consumption and efficiency technology measures in European non-residential buildings. *Energy Building*, vol. 153. 72–86.

policy forces Member States to optimize both their existing building stock and their new buildings in terms of energy. This is the aim of the Energy Performance of Buildings Directive (EPBD 2002/91/EC)⁶ and its recast (EPBD recast, 2010/31/EC), which describes that after 31 December 2020, all new buildings must comply with the nearly zero energy buildings (NZEB) energy requirements.



Photo 1. Producing energy using solar panels⁷

A recent study highlights that such energy-using buildings have been of paramount importance in recent decades, but even further steps need to be taken to achieve full compliance with the instruments set out in the directive.⁸ With regard to the energy performance of the European building stock, the Energy Efficiency Directive (EED) and the Renewable Energy Directive (RED) have stated that technical solutions to reduce the energy use of the building stock should be given priority in all Member States. Interestingly, energy consumption in the industrial sector accounts for a significant 25.3% of total energy consumption in the European Union.⁹

In addition to manufacturing technologies and industrial processes, much of this comes from the energy use of the industrial building stock.

⁶ European Council and Parliament (2002): Energy Performance of Buildings Directive 2002/91/EC.

⁷ Average Solar Panel Dimensions and Sizes. <https://modernize.com/homeowner-resources/29543/average-solar-panel-dimensions-and-sizes> (04 November 2020)

⁸ D. D'Agostino (2015): "Assessment of the progress towards the establishment of definitions of Nearly Zero Energy Buildings in European Member States. *J. Build. Eng.*, vol. 1, pp. 20–32.

⁹ European Commission: *Consumption of energy*. (2015) http://ec.europa.eu/euro-stat/statistics-explained/index.php/Consumption_of_energy (12 March 2020).

Reducing this can make a significant contribution to achieving the objectives set out in the directives.

In Hungary, the National Energy Strategy 2030 program summarizes the steps taken by Hungary to rationalize energy use and increase efficiency. An important part of this is the reduction of energy consumption, the increase of energy efficiency, and the optimal use of the energy sources available in Hungary.¹⁰

Architecture and energy saving

In parallel with the technological revolution of today, architectural systems, including building engineering systems, have developed, which ensure the comfort of our everyday lives. Our lives seem almost unimaginable without the elements that meet our needs, such as from the tap, from the water running in our homes to heating to the energy that supplies our electrical appliances, or air conditioning. In contrast, several expectations have been formulated in recent decades, including in the case of protection/defense-related facilities. They must be durable, made of environmentally friendly material and designed and arranged in such a way that they do not wear out quickly. In addition, they must meet the special requirements of the users, and during construction and renovations, great emphasis must be placed on the use of up-to-date tools and materials, but even more so on good quality, the use of appropriate technologies and the elimination of failures. Without it, neither the principles of energy saving nor sustainability can be upheld. It is especially important to take into account the special aspects of the construction of the facilities, which result from the professional order of the users (protection/defense sector), such as high workload, continuous use, structure providing special activities, etc.

The currently used protection/defense facilities, such as barracks, fire stations, shooting ranges, training grounds, warehouses, etc. a significant part of which was made in the fifties and sixties of the last century, but there are several among them that are even older. They have already been partially renovated and modernized, but there are also a good number of those that are still waiting to be renovated. Failure of obsolete engineering systems in buildings cannot be avoided, and due to the use of inappropriate technology, various damages can be expected. They also raise environmental issues. Therefore, one of the

¹⁰ Without Author (2020): *Nemzeti Energiastratégia 2030. Kitekintéssel 2040-ig*, ITM, Budapest.

most important tasks is to map the situation and to identify failures and sources of failures with the help of building diagnostics.

In order to obtain an overview of the condition of the buildings that are still operating, we conducted research in 20 buildings, which are not exclusively used for protection/defense purposes, because by analogy the condition of the buildings of protection/defense organizations can be inferred. In order to obtain a wider scale, buildings of different ages, types and purposes were included in the studied samples. We studied the structure, insulation, roof, foundation, doors, windows, and engineering elements. The following is a study of water and sewer networks and its general characteristics, as well as the sources of failures encountered during site visits. The basis of the study and the definition of its variables were provided by the review of the structure, operation and requirements of water and sewerage systems, which is summarized below.

2. Water and sewer network¹¹

The water and sewage drainage system is one of the most important elements of a facility. There are strict building regulations for its design, which we will not cover because this is not the subject of our study, as we have investigated the existing, completed system.

Water supply system

Water is usually obtained from a public network, but water supply from one's own water source is also common. The water supply system is intended to provide water to the building and basically consists of water supply equipment, the basic (feed) pipeline, the backbone ascending and branch pipelines and connecting branch pipelines to which taps, i.e. water intakes, are connected. In addition to cold water, hot water supply is also an important part of the system. The critical points of the systems are the pipelines. While the construction of water utilities has a long history, the development of modern piping systems for individual buildings in the modern sense dates only back to the 20th century, starting from the beginning of the century. The first plumbing pipes were still made of lead and then replaced by steel pipes after the

¹¹ In this article we do not cover the basic concepts of water supply, such as the characteristics of water, the mechanics of liquids, water treatment or water supply, water storage, water management, only one general characterization is possible.

harmful effects of lead became known.¹² Corrosion-resistant materials have not yet been used for plumbing systems built around the 1950s and '60s, and as a result, some plumbing systems may require the replacement of the entire system. When a pipe is ruptured, it is often not possible to replace it completely, but the old pipeline has to be repaired, which is a big challenge to discover, weld and replace the faulty section.



Photo 2. Exploration of worn corroded pipes in concrete-stone foundation

*Photo source:*¹³

The systems used to work on the principle of moving vessels, today we usually come across mixed or pumped solutions.¹⁴ They are also significant sources of failure.

While in the past, sectioning of the pipelines was not common, nowadays, for better operation, state-of-the-art autonomous piping systems are built, allowing the various branches to be shut off independently, making it easier to operate, maintain or repair the plumbing system. Over time, the systems, like everything else, are exposed to

¹² Cséki, István (2008): Épületgépészeti tervezési segédlet rézcsöves szerelésekhez. Hungarian Copper Promotion Centre, Budapest, p. 131.

¹³ Source: Pipe rupture repair. <https://www.viz-gaz-futes.hu/csotores-javitas/> (17 September 2020).

¹⁴ Gárdos, Ferenc (edit.) (1982): Épületgépészeti munkák. Építésügyi Tájékoztatói Központ, Budapest. p. 12.

environmental influences (temperature, humidity, wetness) and the most exposed pipes are in the worst condition (pipelines in basements, shafts, etc.). In the case of water pipes placed at an inadequate depth or at risk of frost or poorly insulated, typically in unheated rooms, the water pipelines may freeze. The plumbing system must therefore be constantly maintained and inspected to prevent damage. Although it is almost impossible to inspect the entire network perfectly due to the location of the pipelines, there are signs of wear and tear that can be easily detected, for which building diagnostic inspections provide a good basis.¹⁵ For example, if the water pressure in the piping system drops and air flows in addition to the water when taps are opened, it indicates that air is being sucked in somewhere in the system. Often, dripping is caused by an aged seal or minimal damage, possibly a hidden pipe defect.

Sewage drainage systems

Sewage treatment is an old endeavor of humanity. The history of sewerage dates back a long time, with traces of ancient Greek and Roman settlements. The construction of a modern canalization network in Hungary, together with the European tendencies, in the 19th century. In order to reduce public health ailments, the development of the drainage system of buildings started in Budapest in the 19th century.¹⁶

This system basically consists of connecting pipelines, descending pipelines, and basic (feed) pipelines. They are connected to the utility network through tipping and cleaning shafts. Here, due to the design of the required slopes, leveling and geodetic layout, pipe-laying and the associated earthworks, as well as the design of the network's structures are of particular importance. In larger garages and car washes, sediment pools, grease and sand traps are also connected to the system. In the case of an inappropriate slope, it is a common mistake that the flow of water in the pipeline is either slow or fast, but in both cases serious deposits are expected in the pipeline, which can cause clogging. With the right slope and connections, the right cross-section must

¹⁵ The shape, location, form, direction, color, etc. of the various cracks and soaks give the answer to the causes and the source of the failure.

¹⁶ Cséki, István (2001): A csatornázás története. *Víz, Gáz, Fűtéstechnika és Hűtő, Klíma, Légtechnika Szaklap*. II. évfolyam, 9. szám, 2001. szeptember. https://www.vgfszaklap.hu/lapszamok/Pál_2001/szeptember/250-a-csatornazas-tortenete (Downloaded: 12. December 2019).

be provided to drain the expected amount of wastewater. If the available cross-section is too small, the amount of wastewater will not be able to pass through the pipeline according to the load rate, so, it will be congested and it is to be expected that backflow will occur in low-lying areas.

The sewage network inside and outside a building used to be made of eternite pipes, nowadays PVC pipes, but in the case of public sewers (street network) prefabricated concrete circular rings and other elements are often used as well. Water absorbers, water bags and odor traps, as well as grease traps and drain valves are installed in the system using auxiliary and sealing materials, with specific bonding methods. Mention should also be made of pipe reinforcement, suspension structures, supports, and fittings (gate valves, taps, valves, dampers, faucets, etc.), as their absence or wear can cause the pipes to crack or rupture.¹⁷

With regard to wastewater, we need to address the collection and treatment of wastewater, which is subject to strict regulations and standards. Nevertheless, even large amounts of raw or partially treated wastewater are discharged directly into our environment, the public sewer network is responsible for delivering untreated wastewater to the wastewater treatment plant, treated by chemical and mechanical processes, and separating solid contaminants and sludge from the liquid, using methods¹⁸ that can destroy the water flora and fauna, and may mean a significant danger to human health. Other options to wastewater treatment are also known. A traditional solution is on-site dewatering, in which case the drained wastewater enters the digestion pit on site. The disadvantages of this design are that the pit must be regularly maintained, its contents sniffed and prevented from overflowing (e.g., in the event of heavy rain), and thorough waterproofing must also prevent soil contamination. This desiccator is still part of the sewer system on several properties today and requires constant maintenance.

¹⁷ Balla, János – Marton, Pál (1977): Épületek vízellátása, csatornázása, gázellátása. Műszaki Kiadó, Budapest.

¹⁸ Jennifer Grey: Eco-Friendly Construction Methods and Materials. <http://www.sustainablebuild.co.uk/sustainabledesignsewage.html> (10 May 2020).

3. The description of the study of building engineering characteristics, in particular the failure possibilities of the elements of water and sewage systems

The theoretical aim of the study was to identify the elements (variables) of the water and sewerage systems of buildings built between 1948 and 2000 (study sample) and their failure characteristics, so that a similar study of the facilities of protection/defense organizations could be performed. Furthermore, the results obtained should provide a basis for comparison with the test results of non-protection/defense facilities.

The practical aim of our study was to identify the failures of the engineering systems of buildings of different ages, types, and purposes, and within this, first of all, the failures of the water and sewage systems.

In the following, we only summarize the process and results of the study of the water and sewage network.

The course of the study was as follows:

1. overview of engineering systems and materials, definition of the elements (variables) to be studied;
2. designation of study aspects and methods;
3. selection of the study sample;
4. conducting the study through onsite visits and visual inspection;
5. collecting and recording of the study data;
6. drawing conclusions, making proposals.

Presentation of the samples studied:

During the study, 20 buildings were randomly selected as samples and the problems were visually diagnosed in them. Their parameters are summarized in the following:

PRESENTATION OF THE SAMPLE STUDIED

Table 1.

Sample layering aspect	Sample layering
As per the purpose of use of the building	offices: 2, private dwellings: 7, educational institutions: 2, industrial, commercial establishments: 4, sports-leisure facilities: 2, defense/protection organization buildings: 3.
As per construction date	between 1948-1968: 10, between 1969-1989: 9, between 1990-2010: 1 building.
As per masonry	Brick: 9, concrete: 5, wood: 0, adobe or pise: 3, lightweight walls in 3 buildings.

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3.1. Elements of the studied water networks and their possible forms of failure

Failures and technological faults were analyzed in five areas, for the connection pipeline - water meter shaft, the basic (feed) line (Table 2), the ascending pipelines, faucets (taps) - sanitary ware (Table 3), and the hot water supply system (Table 4). Within them, we identified problem and failure categories and analyzed that occur and in how many buildings. There are 13+4 categories of the problems of the connection pipelines, the water meter shafts and the basic (feed) lines, 11 failure categories for the ascending and branch lines, 9 failure categories for taps (faucets) and sanitary ware, and 5 failure categories for the household hot water network. The study showed the following results:

Failure categories for the connecting pipeline and the water meter shaft

THE PROBLEMS OF THE CONNECTING PIPELINE, THE WATER METER SHAFT AND BASIC (FEED) PIPELINE AND THE OCCURRENCE (INCIDENCE) NUMBERS IN THE STUDIED SAMPLES

Table 2.

CONNECTING PIPELINE - WATER METER SHAFT		
PROBLEM/FAILURE CATEGORY	INCIDENCE	INCIDENCE PERCENTAGE
1. the size and design of the shaft is inappropriate	5	25
2. the connecting pipeline does not enter in a protected pipeline	6	30
3. the connecting pipeline is corroded	3	15
4. there is no shut-off valve in the shaft before or after the water meter	12	60
5. the shut-off valve is dripping	4	50 (where available)
6. the shut-off valve is corroded	6	75 (where available)
7. there is no drain tap	8	40
8. the drain tap is corroded	6	50 (where available)
9. the walls of the shaft are faultless	5	25
10. the walls of the shaft are wet	9	45
11. the walls are cracked or incomplete	6	30
12. the shut-off valve is dripping	7	35
13. the shut-off valve is inoperational	4	20
BASIC (FEED) PIPELINE		
PROBLEM/FAILURE CATEGORY	INCIDENCE	INCIDENCE PERCENTAGE
1. the conduit track is sunk	6	30
2. the conduit track is wet	2	10
3. there are no shut-off shafts at the branches of the basic (feed) pipelines	14	70
4. other failures: reduced output of the pipelines due to corrosion	5	25

Made by the authors.

The failure categories, possible failures of and damages to the main and branch pipelines, taps and sanitary ware

THE FAILURE CATEGORIES, POSSIBLE FAILURES OF AND DAMAGES TO THE MAIN AND BRANCH PIPELINES, TAPS AND SANITARY WARE IN THE STUDIED SAMPLES

Table 3.

MAIN AND BRANCH PIPELINES		
PROBLEM/FAILURE CATEGORY	INCIDENCE	INCIDENCE PERCENTAGE
1. when it enters the building, the pipeline is not in a sheath	14	70
2. the main shut-off valve is corroded	7	35
3. ascending branches do not have a shut-off mechanism	2	10
4. the shut-off valve does not work	8	44 (where available)
5. there are no numbering/markings on the ascending branches to facilitate identification	11	55
6. there is no assembly shaft	6	30
7. there is an assembly shaft but its dimensions or status is inadequate	9	64 (where available)
8. there is a non permissible amount of water in the assembly shaft	4	28 (where available)
9. all fastenings of the pipelines are in order but corroded	6	30
10. the household hot water pipeline is not thermally insulated	16	80
11. other failures: reduced output of the ascending pipelines due to internal corrosion and calcification	4	20

TAPS AND SANITARY WARE		
PROBLEM/FAILURE CATEGORY	INCIDENCE	INCIDENCE PERCENTAGE
1. a wash basin tap is dripping	19	95
2. a bathtub or shower tap is dripping	15	75
3. a tap's output is lower due to calcification	13	65
4. a fastening of a sanitary ware is corroded	9	45
5. the shut-off fittings of the toilets are corroded	17	85
6. the control valve in one of the toilet cisterns does not work	16	80
7. an element of the sanitary ware is not well fastened	17	85
8. an element of the sanitary ware is incorrectly set	18	90
9. an element of the sanitary ware is broken or cracked	7	35

Made by the authors.

THE FAILURES, THE POSSIBLE FAILURES OF AND THE DAMAGES TO THE HOUSEHOLD HOT WATER SYSTEM AND THEIR OCCURRENCE IN THE STUDIED SAMPLES

Table 4.

THE HOUSEHOLD HOT WATER SYSTEM		
PROBLEM/FAILURE CATEGORY	INCIDENCE	INCIDENCE PERCENTAGE
1. incorrect connection of the hot water branch	2	10
2. a tap of the hot water branch has failed	4	20
3. the hot water producing device is calcified	7	35
4. power supply and connection fault	2	10
5. device thermal switch failure	3	15

Made by the authors.

3.2. Failure categories of the studied sewage system, possible forms of failure of its elements

Each of the components of the drainage system presented in the previous section is prone to failure. In addition to checking their functionality, the following problems and malfunctions could be identified by visual inspection:

THE POSSIBLE FAILURES AND DAMAGES TO THE SEWAGE DRAINAGE SYSTEM AND THEIR OCCURRENCE IN THE STUDIED SAMPLES

Table 5

SEWAGE DRAINAGE SYSTEM		
PROBLEM/FAILURE CATEGORY	INCIDENCE	INCIDENCE PERCENTAGE
1. the conduit track of the basic pipeline is sunk	2	10
2. the connecting pipeline is in an inadequate distance from other pipelines	1	5
3. the downpipe connection to the basic pipeline is in an inadequate angle	3	15
4. the slope of the basic pipeline is incorrect	3	15
5. the connection of the basic pipeline is not through a protective pipeline	4	20
6. the floor drain is not installed properly	3	15
7. the odor trap is not installed properly	6	30
8. cleaning shafts are not installed	4	20
9. the technical condition of the tipping shafts (where available) is inadequate	(14 available) 8	40
10. the lifting shaft is not installed properly (no burrs)	(3 available) 1	5
11. pipe reinforcements, suspension structures, supports are missing or defective	9	45
12. due to the lack of filters, clogging developed in the drain lines	7	35
13. the necessary sand, grease and oil traps were not always installed	17	85

Made by the authors.

Overall, it can be stated that failures of water and sewage systems are mainly due to wear and tear, but there are also failures due to the use of faulty construction technology, as well as corrosion. As a result, pipe ruptures, leaks and drips occur, which can damage the masonry, slab and flooring. Clogging and blockages are also common in the drainage system. The analysis of the samples demonstrates that the construction time showed major problems mainly in terms of technology, while an interesting thing about the load from use originated in that the use in single-home houses showed a higher failure rate than in institutions.

In most cases, it could be seen that the components were no longer repairable, or difficult to repair and needed to be replaced. Rebuilding sections built with poor technology is costly and time consuming, so they are not easy to be implemented. A common failure is the incorrect connection of the pipeline branches and blockages due to deposits in the pipelines originating in slope problems in the main drainage pipes. Damage to the drainage system in buildings can cause similar problems as plumbing systems - outdated, damaged sewers often cause pipe ruptures, allowing sewage to escape from the system and flood the building or parts of it, causing serious material damages. However, in the case of sewers, clogging is much more common, which can also result in flooding of the building or parts of it with sewage. Another serious problem is the grease that flows into the drain. It also often results in malfunctions in older single-family homes and condominiums, but greasing is a major concern in workplace restaurants and canteens that cater many people.

Many times, early detection and maintenance could have been a good solution, but without them, only replacements and thus prevention of greater environmental damage were possible. It would be advisable to increase the inspection of buildings with the possibilities provided by building diagnostics. Problems arising from use could be prevented by raising the awareness of appropriate methods as well as paying more attention. Damage caused by faulty construction or the use of poor quality materials is the most difficult to solve, so special attention should be paid to them when constructing new facilities. Plastic pipes are becoming more common, as well as alternative forms of pipe placement, such as driving them in the upper part of a room instead of breaking the concrete, if the type of building allows it.



Photos 3-4. Plastic pipelines and an optional placement. Source:¹⁹

However, it is not easy to replace the existing metal pipes during a renovation, the replacement by PP-R (polypropylene) or five-layer pipelines is justified by the data in the table below.

¹⁹ Photo sources: *Vízvezetéktervezés. Szerelés műanyag vízcsövekkel*: https://ezermester.hu/cikk-997/Gyors_szereles_muanyag_vizcsovekkal (05 November 2020), <https://www.vgfszaklap.hu/lapszamok/2014/marcius/3272-vizveze-tek-tervezesi-szerelési-kerdesei-csovalasztas> (05 November 2020)

PIPE DIMENSIONS

Table 7.

DN	Steel pipelines			PPR pipelines				Five-layer pipelines				
	external	wall	internal	PP external	PP10 internal	DN	PP20 internal	DN	external	internal	DN	
15	½"	21.3	2.3	16.7	20	16.2	15	13.2	15	16	12	
20	¾"	26.9	2.3	22.3	25	20.4	20	16.6	20	20	15.5	15
25	1"	33.7	2.9	27.9	32	26.2	25	21.2	25	25	20	20
32	5/4"	42.4	3.2	36	40	32.6	32	26.6	32	32	26	25
40	6/4"	48.3	3.2	41.9	50	40.8	40	33.4	40	40	32	32
50	2"	60.3	3.2	53.9	63	51.4	50	42	50	50	41	40
65	2 ½"	76.1	3.2	69.7	75	61.4	65	50	65	63	51	50
80	3"	88.9	3.6	81.7	90	73.6	80	60	80	75	60	65
100	4"	114.3	4	106.3	110	90		73.4				
					125	102.2	100					
						130.8	125					

Made by the authors. Data source:²⁰

²⁰ Data source: idem <https://www.vgfszaklap.hu/lapszamok/2014/marcius/3272-vizvezetek-tervezesi-szerelési-kerdesei-csovalasztas>

In the case of sewage drains, the method of their laying is a key aspect: adequate depth and slope as well as support.

Damaged pipes may require the replacement of a section or the entire length of the pipe. When replacing a section, it is recommended to use a solution with rubber sleeve joints, and an appropriate soil compaction and support.



Photo 5: Sewage pipe repair. Source:²¹

It would be particularly important to look for cost-effective solutions, such as the construction of dual plumbing systems. There are also plumbing alternatives that focus primarily on water conservation. Such are dual plumbing systems (also known as double pipes) that serve to separate two types of water (potable and recovered). Drinking water can be used for drinking and washing, while recovered water can be used for irrigation and toilet flushing. Water, which has so far been treated completely as wastewater, may be suitable for agricultural use, for example, after the removal of waste and hazardous bacteria.

A similar, yet cheaper alternative to dual plumbing systems is the one that uses gray water. Recovering and reintroducing rinsed water when showering, washing dishes or laundry can significantly reduce household water use.

²¹ Water pipe replacement <https://vizvezetekszerelo.dugulaselharitas.net/szennyvizcsatorna-javitas-es-csere/> (12 October 2020)

4. Conclusion

Nowadays, the protection of the environment and the management of its values are becoming more and more important. There is a tendency in all areas for professionals to look for energy-saving solutions, and this is not different in architecture. Facilities of defense/protection organizations must also comply with environmental regulations and expectations. One of the critical points of the buildings is the engineering elements, including the water and sewage systems. In addition to environmentally conscious design, the development of environmental awareness of engineering systems, but also their maintenance, is therefore of paramount importance.

This paper studied the main failures of the connecting pipelines and water shafts, ascending and branch pipelines, taps and sanitary ware, and hot water producing devices in 20 buildings in order to observe the failure and design defects, respectively. In a similar way, we analyzed the failures of the sewage systems, including the main failures of the basic pipelines and drainage pipes, as well as the auxiliary structures.

The analysis showed that the most worn and vulnerable parts of a water and sewer system are pipelines, faucets (taps), drains, and sanitary ware within the building. Faulty construction technology can also lead to failures and corrosion due to the use of outdated materials, as well as ruptures and cracks caused by wear and tear can also cause serious damage. A common mistake in sewage drainage is that the system does not have a proper slope, so the water flows slowly, which is a cause of gradual deposits in the piping system. The opposite is also the case when, due to the high slope, the water cannot carry with it the solids that are deposited.

The problem categories set up in the study can be used to analyze the defects of the engineering elements of buildings.

We consider it expedient to develop control programs that can identify the main problems and prevent major damages before failures occur. It would therefore be important to employ personnel in protection/defense organizations who are also skilled in building diagnostics. Renovations need to be planned with modern building technologies and state-of-the-art materials and priorities set accordingly.

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