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Melioration and Drainage Systems as a Factor of Building Durability: Water Management on the Adjacent Territory

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ABSTRACT

This article examines melioration and drainage systems as an engineering factor that determines the service life of buildings. It argues that durability is decided not only by the quality of structural materials but by the way water is managed on the plot of land that surrounds a structure, and that a foundation and the soil around it should be treated as a single hydro-mechanical system. The paper analyses the mechanisms through which groundwater and surface runoff degrade foundations and basements — hydrostatic pressure, capillary transfer of salts, frost heaving and suffusion — and relates them to published data on the deterioration of building structures in aggressive environments. It then considers the management of surface runoff on the adjacent territory, including vertical planning, storm sewerage and the controlled infiltration of runoff, and examines subsurface drainage together with the normative framework of engineering protection against flooding and inundation. The complementary roles of drainage and waterproofing are discussed, as is the monitoring of drainage systems during operation. The article concludes by substantiating a hierarchy of protective measures in which surface solutions precede subsurface drainage and waterproofing serves as the final barrier rather than the first.

Keywords: drainage, melioration, building durability, groundwater, surface runoff, foundation, engineering protection, waterproofing, storm sewerage, vertical planning

Introduction

Water is the most patient adversary of any building. It works slowly, without dramatic events, and for that reason its influence usually remains invisible until cracks appear on a wall or the basement floor turns damp in spring. Durability, in engineering terms, is decided not only by the grade of concrete or the quality of masonry. It is decided by what happens to water on the piece of land that surrounds the structure. Two identical buildings placed on two different plots will age at different speeds, and the difference between them is measured in decades rather than in years.

Design practice has traditionally concentrated on the object itself: the bearing capacity of the foundation, the thickness of the waterproofing membrane, the frost resistance of the materials. The adjacent territory was treated as a landscaping task to be resolved once the main work was finished. Such a division of labour is artificial. A foundation and the soil around it form a single mechanical and hydrological system, and the regime of that soil determines the loads, the aggressiveness of the environment and the rate at which the structure degrades. Moving the boundary of the design problem outward, from the wall of the building to the boundary of the plot, changes the whole logic of protection.

The engineering discipline with the longest experience of managing water in soil is melioration. Developed for agriculture, it produced the methods that construction later borrowed almost without modification: horizontal drainage, graded filters, regulation of the water table, deliberate control of the water, air and thermal regime of the ground. The drainage ring around a modern basement is a direct descendant of the agricultural drain. What changed was the criterion of success. An agronomist lowers the water table in order to grow a crop; an engineer lowers it in order to keep a structure dry and stable for the whole of its service life.

The relevance of the subject grows together with urbanisation. Sealed surfaces — roofs, pavements, parking areas — increase both the volume and the speed of runoff, while the green areas capable of absorbing rainfall steadily shrink. Rainfall itself has become more intense in many regions. The result is a paradox familiar to every operating engineer: cities with developed water supply systems suffer from an excess of water that they are unable to remove. The present article considers melioration and drainage as a single system of water management on the adjacent territory, examines the mechanisms by which water destroys the foundation–soil system, and formulates practical requirements for the design and operation of such systems.

Water as a factor of degradation of the foundation–soil system

The list of causes that lead to the loss of bearing capacity of a foundation is surprisingly short, and almost every item on it is connected with water. Researchers who study the strengthening and reconstruction of foundations name fluctuations of the groundwater level, excessive wetting of the

foundation body, the action of freeze–thaw cycles, suffusion of fine soil particles and poorly executed waterproofing among the principal reasons for defects (Zhugin, 2021). None of these processes is instantaneous. Each of them accumulates over seasons, and the visible damage appears years after the cause has started to act, which is exactly what makes diagnosis difficult and prevention unpopular.

The scale of the problem becomes easier to appreciate in figures. According to published estimates, from 15 to 75 % of the structures of buildings of various purposes are exposed to aggressive environments, and between 5 and 10 % of structural elements fail every year (Agafonkina, Vechkasov, & Valyakin, 2015). Water here plays a double role. It is the aggressive agent itself, and it is also the transport medium for other agents — sulphates, chlorides, the products of biological activity. A dry concrete element standing in an aggressive atmosphere degrades slowly. The same element, saturated with moisture, degrades quickly.

Three mechanisms deserve separate mention. The first is hydrostatic pressure: a raised water table turns a basement wall into a retaining structure loaded from the outside, and that load grows with the depth of immersion. The second is capillary rise — moisture climbing through the pores of the material and carrying dissolved salts into the zone of evaporation, where crystallisation gradually destroys the surface layer of masonry or render. The third is frost heaving, which appears when water-saturated soil freezes beneath the footing and lifts it unevenly. Uneven movement is what produces cracks. Uniform settlement, as a rule, does not.

The hydrological regime of a site is not a constant. Observations carried out on hydro-reclamation systems show how deeply it can change under human influence: on the surveyed territory more than 40 % of the area had a groundwater table shallower than three metres and more than 75 % shallower than five metres, with a level of mineralisation sufficient to make the water chemically aggressive towards concrete (Mirsalakhov & Begmatov, 2016). Urban development produces a comparable effect by different means — leakage from utility networks, the barrier effect of deep foundations and underground structures, the disappearance of natural evaporation from sealed surfaces. The water table under a built-up area tends to rise, and it rises quietly.

The economic consequence follows directly from all of the above. Strengthening an existing foundation — by piles, by cementation, by shotcrete or by reinforced concrete jackets — is an expensive operation that requires engineering surveys, excavation next to a working structure and the temporary transfer of loads (Zhugin, 2021). Preventive water management on the adjacent territory costs a small fraction of that sum. Stated plainly: drainage is cheap, underpinning is not. The difficulty is that the first expense is visible in the estimate today, while the second appears only in the future, and budgets are rarely written with that horizon in mind.

Management of surface runoff on the adjacent territory

The first line of defence is the shape of the ground. Vertical planning, the deliberate design of surface slopes, removes the greater part of rainfall and snowmelt before it has any chance of reaching the foundation. A slope directed away from the building, a blind area of sufficient width, correctly placed roof downspouts, a break in the paving that prevents water from running back along the wall — these measures are elementary, and they are elementary precisely because they were learned through a long history of failures. Where the terrain is flat, the slope has to be created artificially. Where the building stands on a hillside, an interception ditch above the structure is usually indispensable.

The second line is the storm sewerage network, and its condition in many cities is far from satisfactory. An assessment of the network of Krasnoyarsk recorded a total length of 124.6 km at a density of only 0.33 km per square kilometre, together with 47 outfalls discharging runoff into the Yenisei and its tributaries without treatment (Mikhaylov, 2017). A network of such density cannot serve the whole of a built-up area. The consequence for an individual building is direct and unpleasant: water that the municipal system does not take away remains on the plot, infiltrates the ground next to the foundation and feeds the very process that the designer tried to exclude.

The details of the collecting system matter far more than they appear to. Research on the spacing of storm water inlets along urban roads and streets demonstrates that an excessive distance between them increases the depth of the water film on the surface, reduces the friction coefficient between tyre and pavement and, what is more important for durability, allows water to penetrate into the base of the pavement, where it moistens the soil and intensifies plastic deformation of the whole construction (Semenova, Gerasimova, & Koronchevskaya, 2016). The same logic applies to the parking areas and driveways of a building site. A poorly drained car park is not merely uncomfortable; it is a permanent reservoir of moisture feeding the ground beneath the adjacent structure.

Modern practice adds a third element — the controlled infiltration of runoff. Rain gardens, retention and detention basins, permeable pavements and dry wells reduce the peak discharge into the municipal network and restore part of the natural water balance of the site. The approach is sound, yet it contains a trap. An infiltration device placed too close to a building turns into a source of recharge for exactly the soil that ought to remain dry. The rule that resolves the contradiction is simple enough to be remembered on site: infiltrate far from the foundation, drain near it. Distance, rather than technology, is what makes the difference here.

Finally, none of these systems works without maintenance. Inlets silt up, gratings are blocked by leaves, trays crack, and the slope of a blind area is lost after the first settlement of the backfill. The analysis of municipal networks quoted above links the deterioration of the system directly to the absence of a responsible operating structure and of a stable source of financing (Mikhaylov, 2017). At the scale of a single plot the same problem takes a domestic form: someone has to walk around the building twice a year, before and after the wet season, and simply look at what the water is doing. Remarkably often, nobody does.

Subsurface drainage and the normative framework of engineering protection

Where surface measures prove insufficient, subsurface drainage takes over. The Russian code of practice SP 104.13330.2016, "Engineering protection of a territory against flooding and inundation", approved by order of the Ministry of Construction and Housing of the Russian Federation of 16 December 2016 No. 964/pr and put into force on 17 June 2017, systematises the available solutions: drainage systems of several types — head, bank, cut-off and systematic; anti-filtration screens and curtains; vertical planning with the organisation of surface runoff; regulation of the level regime of water bodies; and the clearing of watercourses, which restores natural drainage of the territory (Minstroy of Russia, 2016). The classification is valuable because it separates tasks that are often confused. A head drain intercepts a flow arriving from outside; a systematic drain lowers the table beneath an entire territory; a ring drain protects one particular object.

For an individual building the working instruments are the wall drain and the ring drain. Both are laid below the level of the protected floor, both rely on a graded granular filter and a geotextile envelope to resist silting, both require a continuous slope towards the discharge point and inspection wells at every change of direction. The discharge point is the weakest element of the entire arrangement. A drain that ends in a reservoir which itself floods during heavy rain merely transfers the problem in time instead of solving it. Gravity discharge into a lower point of the relief is always preferable; pumping is a solution that works only for as long as the pump works.

The code also draws attention to a class of measures that designers frequently forget. Anti-filtration screens and curtains do not remove water at all — they block the path along which it arrives (Minstroy of Russia, 2016). On a site where recharge comes from a single identifiable direction, a curtain is considerably cheaper than a drainage system designed to pump the same flow continuously for several decades. The choice between removal and interception should therefore be made after a hydrogeological survey, not after the excavation has already been dug. This is the point at which the melioration tradition, with its habit of studying the water balance of a territory before touching it, proves most useful to construction.

Drainage and waterproofing are complementary, not alternative. Drainage reduces the hydrostatic head and shortens the duration of contact; waterproofing resists whatever remains. Penetrating compositions illustrate the principle particularly well: they fill the pores of concrete up to roughly 400 micrometres in width with needle-shaped crystals and act to a depth of 100 to 300 millimetres, so that the material does not cover the surface but changes the structure of the concrete itself (Agafonkina et al., 2015). A basement protected by waterproofing alone, without drainage, remains permanently under pressure. A basement drained but not waterproofed remains vulnerable to every failure of the drain. Only the pair of measures provides a genuine reserve of reliability.

The last component is monitoring during operation. Observation wells that allow the water table to be measured, periodic flushing of perforated pipes, inspection of wells for accumulated silt, a check of the discharge point before the wet season — all of these are inexpensive procedures with a disproportionately large effect on service life. Experience gained on hydro-reclamation systems suggests a workable scheme of three stages: recording the initial state of the soil and of the water regime, periodic control of the changes, and forecasting of further evolution (Mirsalakhov & Begmatov, 2016). Transferred to a building site, this means that a drainage system should have a passport and a schedule of servicing, in the same way as a lift or a heating system has one.

Conclusion

The durability of a building is formed outside its walls. The mechanisms that shorten the service life of a foundation — hydrostatic pressure, capillary transfer of salts, frost heaving, suffusion of fine particles — are all activated by a single factor, and that factor is controllable. Melioration and drainage systems are, in this sense, not auxiliary engineering services but a part of the load-bearing concept of the object. They deserve to be designed with the same attention as the structural frame, and to be described in the project documentation with the same degree of detail.

Practice suggests a clear hierarchy of measures. Surface solutions come first, because they are the cheapest and because they remove the largest volume of water: grading, blind areas, organised roof drainage, a working system of inlets and trays. Subsurface drainage comes second, chosen according to the direction and the source of recharge and combined with cut-off constructions wherever the flow can be intercepted rather than pumped. Waterproofing comes third, as the last barrier and not as the first. Reversing this order — which happens whenever a membrane is expected to compensate for a flooded plot — produces expensive and short-lived results.

A third conclusion concerns time. Drainage is the only part of a building that degrades silently and is discovered only when the damage has already reached the structure. Regular observation, a simple schedule of flushing and inspection, and a recorded history of the water table convert an invisible risk into a manageable one. The cost of such discipline is measured in hours per year. The cost of its absence is measured in the reconstruction of foundations, and that account is settled in full.

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