Application of Forced Drainage in Road and Rail Infrastructure

Introduction

Careful drainage is a fundamental condition of maintaining durable surfaces. Ditches, sewerages and line drainage channels are considered the most effective equipment. Simple design, ease of technical inspection and preventative maintenance are among their key advantages. Extensive area, traffic difficulties and troublesome maintenance, especially associated with recurrent vegetation growth, are the drawbacks, on the other hand. Urban land developments may affect directions of stormwater by means of ditches or underground sewage systems. Adverse topographic situation can require forced drainage by means of sewage intermediate pumping stations.

Selected structures of road and rail infrastructure

Road and motorway surfaces

Surfaces of both roads and motorways are directly exposed to variable dynamic loads, vibrations, and weather conditions: rain, snow, wind, frost and heat. Subgrades are normally liable to continuous humidity variations; in addition, they are situated in the freezing zone. Intensity of traffic has a decisive impact on damage to road surfaces. Superficial underground waters saturate the native subgrade and cause heaves and then fissures. Frost damage is caused by heaving soil, incoming water, and frost. If the three factors coincide, ice lenticles are formed in the subgrade which, drawing water from lower strata, expand and give rise to...
heaves that are a risk to traffic [10].

Careful drainage is a fundamental condition of maintaining durable surfaces. Fast and efficient drainage of water from routes involves draining of stormwater via street sewerage into wells. The latter’s arrangement must be designed on the basis of crossroads contour maps (Fig. 1, 2). Rapid drainage of city squares or large crossroads where water can be retained on the surface is of particular importance. Effective drainage of stormwater, especially in areas of urban development, involves construction of stormwater sewage systems linked to impounding reservoirs. Multi-level designs of sewerage systems may require application of intermediate sewage pumping stations to deliver water to receiving bodies.

**Railways**

Polish railways must adjust their transportation capacities to requirements of European carriers. This involves modernisation of some lines, including greater speeds of express trains. The necessary modernisation of railways and their associated civil engineering facilities requires solutions to a range of technical issues, including effective land stabilisation by, inter alia, lowering subgrade water levels and efficient drainage systems to capture both underground and rain waters [1, 2, 3, 4, 6, 7, 9, 10].

High soil water levels and river and stream jams caused by blockage of existing spans of small bridges and culverts are particular risks to durability of subgrades. The latter can be affected by heavy or continuing rains. Free gravi-

![Fig. 2. Square drainage showing well arrangement [10]](image)

![Fig. 3. Cross-sections of oblong drainage in a station plain: a), b), c), d), e) – elements draining a station plain, 1 – ceramic drains, 2 – filtration layer [10]](image)
tional water drainage from improved areas adjacent to rail lines must be assured by means of appropriate water equipment. Subgrades are superficially drained with side ditches in cross-cuts, top protective ditches near embankments which drain the surrounding area and regulation ditches near cross-cuts.

Shallow pipe drainage is used in subgrades made of impervious soils. Oblong drainage paths of station plains must be situated between and parallel to tracks. Drains must not be placed under tracks, along their longitudinal axes. Drain pipes can be substituted with stone pipes in connection with ceramic drainage path systems (Fig. 3). Water is disposed of into a collector or impounding lake, connected to stormwater sewerage including pumping stations at some selected points.

Efficient drainage of railway stations is of the essence not only to durability and stability of subgrades but is also necessary for proper operation of turnouts, traffic control equipment and other equipment powered with electricity. In addition, such other buildings and facilities must be drained as platforms, ramps, loading yards, pedestrian paths and car passages beneath tracks. Ditches, superficial drains and gutters...
ters are direct methods of draining station plains [8]. Drainage of an asphalt platform is illustrated in Figure 4. Yards are drained using solutions like those applied to municipal sewerage and public roads [11]. Extensive station areas accumulate substantial quantities of stormwater which require application of impounding lakes and water pumping stations.

Actions to drain the remaining rail infrastructure facilities including paths and passages under tracks, platforms, viaducts or tunnels, are important as well. Rain or ground waters should be drained by gravitational means wherever possible. Different levels of these facilities may require construction of wells or artificial impounding lakes, from underground passages. This drainage consists of a series of drainage pipes placed along axes of buildings. They principally lower levels of ground, more rarely of underground waters, capture incoming waters and run them off out of protected facilities (Fig. 5). Lie of the land and high situation of stormwater receivers require application of stormwater pumping stations.

**Tunnels**

Road tunnels are mainly constructed to provide convenient transportation of people, materials or goods across

![Fig. 6. Drainage of tunnel structure by means of geofabric drains][10]
residential development, or streets of high traffic intensity. The need for collision-free course of a road, pedestrian traffic, water, municipal sewerage or telecommunication cables are some other reasons for constructing tunnels. Road tunnels and passenger paths are commonly run under railways [5, 9, 10].

A sewage system receiving superficial stormwater brought by vehicles or flowing directly into an underground passage normally disposes of such water into an impounding lake immediately close to an intermediate pumping station. Waters can as a rule be gravitationally channelled from shallow tunnels or underground passages to adjacent external sewage ducts. Discharge of waters captured by surface and frequently deep drainage systems should be adapted to location of a drained facility. In the case of out-of-town tunnels, water can be discharged to nearby natural reservoirs or, failing those, to parts of a road surface drainage system upstream of a tunnel.

Deep drainage systems have two kinds of goals: first, they lower groundwater levels in a shallow tunnel or underground passage; second, they capture incoming groundwaters and channel them out of deep tunnels without lowering underground water tables while relieving pressure of these waters against enclosures. Depending on the type of soil, ground or underground water level and quantities of water, deep drainage systems of shallow and deep tunnels and underground passages must be produced by:
- Incorporating drainage pipes that build a lateral drainage system into the body of a deep tunnel
- Incorporating systemic drainage across a shallow tunnel or underground passage to lower groundwater levels in the vicinity of a structure and control impact of the waters on the structure
- Installation of an underground water pooling gallery outside a deep tunnel, connected to water headers from a rock mass surrounding the tunnel and channelling water out of the facility by means of a gravitational or enforced drainage system [9].

Geofabric drains are some elements of superficial drainage systems. They are used in transport tunnels across mountains which require particularly careful drainage. Water from cracks and crevasses in a rock mass is captured and transported by three-layer geofabric drains between the enclosure and the rock mass into a drainage system, which provides for controlled flows of percolating and infiltrating waters (Fig. 6). Water is then channelled into a stormwater sewage system of the tunnel. Due to considerable elevation differences, it is rarely drained by force of gravitation and more commonly collected into a stormwater impounding lake and then forcedly pumped to a stormwater receiving body.

**Conclusion**

Drainage of road and rail infrastructure is becoming particularly important in the context of improvements to functional reliability and operational safety. Methods of gravitational drainage are applied extensively. Situation of a stormwater receiving body or other geodesic considerations require forced drainage of rain or ground waters by means of appropriate intermediate pumping stations. Adequate stabilisation of rail or road subgrades requires formation of an appropriate depression cone using deep-well pumps. Development of control systems focuses on reliable and energy-efficient pumping. Coordination of a number of pumping stations incorporated into joint stormwater sewage systems is becoming significant. The need to develop the above systems has been demonstrated in this paper by describing a broad range of applications for stormwater pumping stations.

**Abstract**

Drainage of storm or groundwaters from areas of rail and motor roads is an important factor in improving surface stability and traffic safety. The paper reviews applications of storm or groundwater pumping stations to selected rail and road facilities. Methods of water drainage are defined synthetically and conditions for use of forced drainage are indicated. Rail and motor roads, tunnels and station facilities are subjects of the analysis. Improvement of traffic safety and effective land stabilization are adopted as fundamental criteria for application of forced road drainage. Examples of stormwater pumping combined with water gravity drainage at varying land topologies and with underground sewage systems are presented. The discussion is important for ensuring development of proper operation of rail and road transportation.

**Key words:** drainage of road and rail infrastructure, stormwater pump stations, maintaining durable surfaces

**References**