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THE STUDY OF PLANNING AND DESIGNING OF SOME ELEMENTS OF AGRICULTURAL ROADS LOCATED WITHIN UPLAND PROTECTED AREAS

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The paper presents the principles for planning and designing of selected elements of agricultural roads to be built on uplands located within protected areas. Special attention was paid to road localisation and choice of geometric elements size. Various surface technologies, both presently applied and suggested to be used on local and internal roads have been also discussed.

Key words: agricultural road, protected landscape, upland, planning, designing

The economic development of rural terrains contributes to considerable growth of motorization, which extorts building of new agricultural roads as well as modernization of existing ones. It concerns particularly upland areas, where the lattices of agricultural roads should make up aesthetical component of surrounding landscape and simultaneously fully satisfy communication needs as well as create one of elements of anti-erosion meliorations. Agricultural roads on these areas pass often gullies and ravines. The transportation in such roads is difficult with regard to lack of hardened surface , ornate drives on adjoining fields limiting the size of transported cargo, small width of road and steep slopes, often embushed and afforested, restricting the visibility. They are also periodically closed as result of covering up by snow or strong erosion in period of superficial flows.

The principles of planning and geometrical projecting agricultural roads circumscribed by different authors [1–5, 7] are hardly sketched and they require further research, which will allow elaboration of exact guidelines.

The work presents the results of many years research on extension bases for spatial planning and geometrical projecting of agricultural roads on the country areas, including protected areas.

The investigations were conducted in years 1995–2002 on the chosen objects on Nałęczow Plateau on ten segments of roads of joint length 14,5 km in the communes Kazimierz Dolny and Wąwolnica. For chosen road segments the conceptions of road belt development were worked out, followed by systematic investigations concerning:

- the analysis of route of studied roads on topographical maps in scale 1:10 000, with special regard to the terrain relief – the planes, slopes, river valleys, gullies;
- the elaboration of conception of roads chosen geometrical elements – route composition, establishing road straight lines and curvilinear segments in situational plan,

formation line and vertical curves in longitudinal intersection of road route and width: the road together with its side – spaces, crown of road, road belt and road gauge as well as transverse slopes;

- the behaviour analysis of agricultural units and vehicles during movement on chosen elements of agricultural roads;
- the recognition of roads accessibility to adjacent fields and built-up terrains.

Investigations showed that on slopes with inclination to 6% existing and newly projected agricultural roads with longitudinal formation line slope to 4% , by correction of the ground texture covering the road may be strengthened to so-called optimum mixture or left in profiled shape. However roads with slope exceeding 4% require surface hardening and realization especially strengthened devices for piping away superficial run – off waters. Such roads, if they have only land surface, are transformed in to road gullies, deepening fairly 4,5 cm/year, and maximum to 9,0 cm/year.

The roads were located on slopes with inclination to 14% in dorsal slope parts, on local watershed borders with smallest concentration of superficial waters, to limit erosion(fig. 1, *a*, 1, *b*). On so situated roads there were no destructions caused by erosive processes. However, on slopes with inclination exceeding 14% the roads were projected obliquely to slope, along curvilinear route with the aim of decreasing their longitudinal slope, (to 6%) and achieving esthetical composition with landscape (fig. 1, *c*). Thus, situated roads have however large drainage areas, so that flowing periodical waters erode them considerably. In given investigations rills in road surfaces have reached even 1,8 m. Therefore it is better to locate roads in inter-slope valleys, under the condition, that road belt will lay apart from the range of concentrated flow of superficial waters (fig. 1, *d*). Besides this one should avoid crossing valleys, because it requires constructing road roll passes and draining devices which increase the cost of strengthening.

Investigations showed also that agricultural roads in river valleys should be located, if possible, on the edge of valley – at the foot of the slope. They have then smaller longitudinal formation line slopes (to 4%) and are slightly threatened with erosion. Such roads are put into a composition in surrounding landscape correctly and characterized in situational plan with large quantity of curvatures as well as many draining objects (ditches, roll passes and bridges).

Studied roads, located on planes were characterized with gentle curvatures in plan and small longitudinal formation line slopes (to 4%) as well as small road drainage areas. Water concentration in road belt did not threaten land surface. Natural sod protected surface of these roads are perfect, therefore one should conclude that durable sodding strengthens surface of such roads well.

Studied roads in gullies were characterized with high longitudinal formation line slopes (above 6%) and large road drainage areas. The water concentrating in road belt caused large erosive damages of ground surface. Therefore one should harden roads located in gullies, and strengthen their draining devices. Road gullies with special natural values should be intended for foot-bicycle *paths, preserving natural ground surface, whereas vehicular traffic should be reduced* to indispensable minimum. For piping away superficial waters from drainage area of such gully one should apply strengthened draining devices, projected severally for protected gully.

The basis for dimensioning of geometrical elements of agricultural roads is projected velocity – Vp (km/h) as well as a typical gauge for agricultural units and combined harvesters.

In conducted investigations projected velocity served first of all to projecting the size of curvatures in plan and in section as well as transverse intersection, and also longitudinal and

transverse slopes. Numerical values of projected velocities were assumed in dependence on form of terrain, foreseen traffic intensity and its meanings as well as economical conditioning (tab. 1).

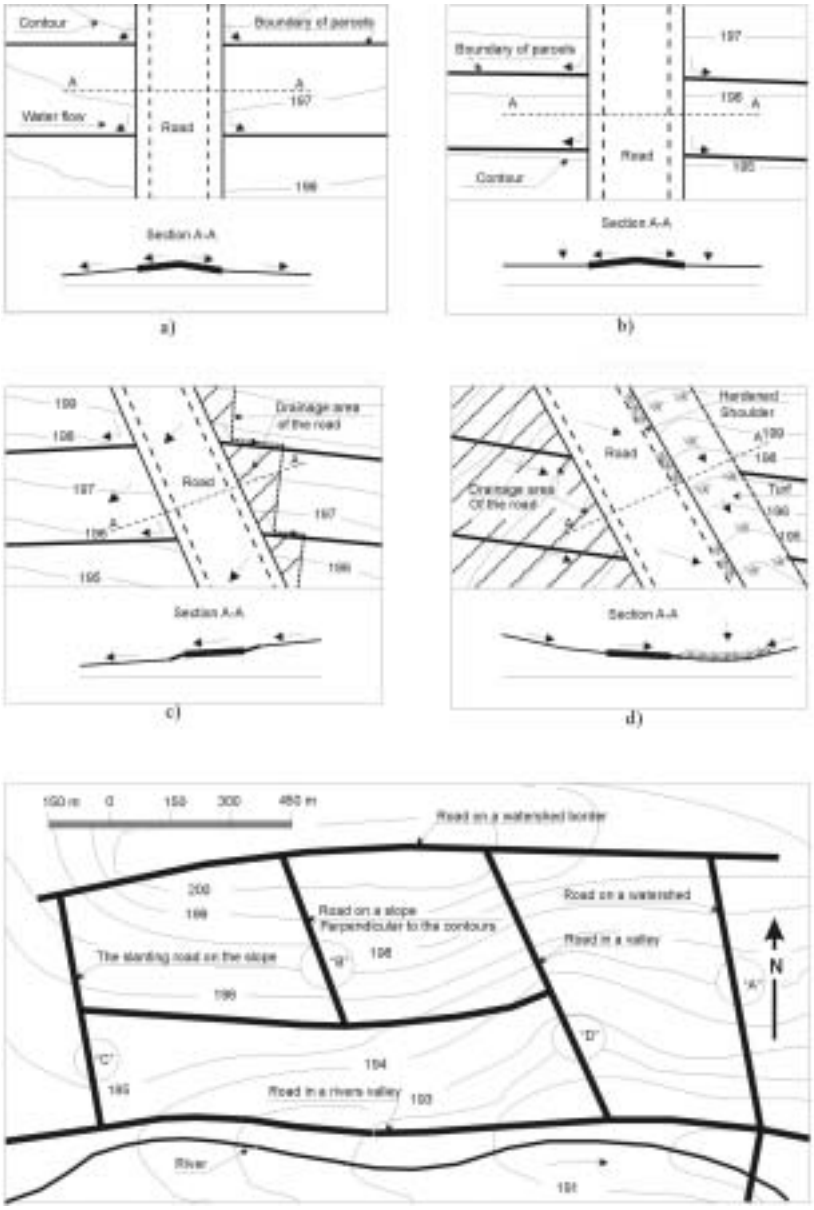

Fig. 1. Localization of roads in relief: *a* – road on watershed border; *b* – road on a slope perpendicular to the contours; *c* – slanting road on a slope; *d* – road in a valley.

The basic geometrical elements of studied agricultural roads in situational plan are straight lines, transitory straight lines, horizontal circular arcs as well as in several cases horizontal basket arcs. The length of straight lines segments on studied roads in terrain of protected landscape was dependent on a composition in surrounding landscape and terrains relief.

The transitory straight lines were designed between straight line segments and circular arcs in situations exacting use of extension or one-sided superelevation on circular arc. The applied lengths of transitory straight lines from 15 to 20 m put themselves correctly into a composition between straight line and circular arc. The radius of circular arcs for every curvature in situational plan was counted with formula:

$$Rmin = Vp2 \cdot [127 \cdot (mi + i)]\text{-}1 \quad [1].$$

To calculate values of minimum radii maximum superelevation of i = 7% on horizontal arc was assumed as well as coefficient of transverse adhesiveness R = mi in numerical range from 0,27 to 0,34, for Vp correspondingly 40–20 km/h. so enumerated radii values for horizontal arcs recommended for roads in conditions of upland areas are given in table 1.

Table 1

Factors for geometric designing of studied rural roads elements on terrains with diverse relief

Technical data	Unit of measure	Agricultural road category		
		main road	common road	field road
		A	B	C
Design speed (V_p)	km/h	40	30	30
Minimum radius of horizontal curve	m	60	30	30(15)
Width of roadway	m	5,0–6,0	3,5–4,0	3,0–3,5
Width of road crown (road and shoulder)	m	6,5–8,0	5,0–6,0	5,0–6,0
Width of road line	m	10,0–15,0	8,0–10,0	6,0–8,0
Minimum visibility distance on horizontal curves ($2S_H$)	m	50	40	40
Recommended length of transient lines	m	20	20	15
Maximum gradient of formation line	%	7	8	10
Minimum rays of vertical convex curves	m	300	200	180
Minimum rays of vertical concave curves	m	200	120	100
Maximum cross slope on horizontal curves	%	7	6	6

Basic units of the formation line of studied roads were straight linear segments with uniform inclination as well as perpendicular concave and convex arcs. It was observed that on terrain of investigations, used vehicles overcame considerable longitudinal slopes of the roads. To maintain fluency of movement on roads, one tested longitudinal slopes with interval 1%, which made possible to establish maximum inclinations of road formation line (tab. 1). In worked out conceptions formation line refractions were softened by convex and concave perpendicular arcs, and the values of curvatures radius were assigned on basis of geodesic measurements by method of longitudinal intersections. The recommended minimum values of radius obtained in investigations , that assure required softening of formation line refraction and putting road into a composition in terrain are given in tab. 1. The conducted investigations show, that correct management of the road belt of agricultural roads on the protected areas should contain hardened or improved surface of the road, the earth or hardened shoulders,

bicycle paths, the foot draws (the sidewalks), the path for horsemanship, the draining devices as well as safety side belts (fig. 2). Mentioned elements establish integral area called road belt. The widths of the road with shoulders have the close relationship to the function of the road, the exploational velocity, intensity of traffic as well as to the width of combine harvesters and agricultural units. On the basis of field and cartographical investigations one established the dimensions of road with shoulders, the crown of road and road belt (tab. 1).

The road gauge of transverse intersection, i.e. part of space occupied by moving vehicles, should not be covered by any buildings, signs, concurrent devices as well as afforestations and embushments. The analysis of passage possibility of agricultural machine engines 3,5 to 6,5 m wide in working state has resulted on studied roads that gauge has to assure safe width, about 1 m larger than the largest width of machine engine.

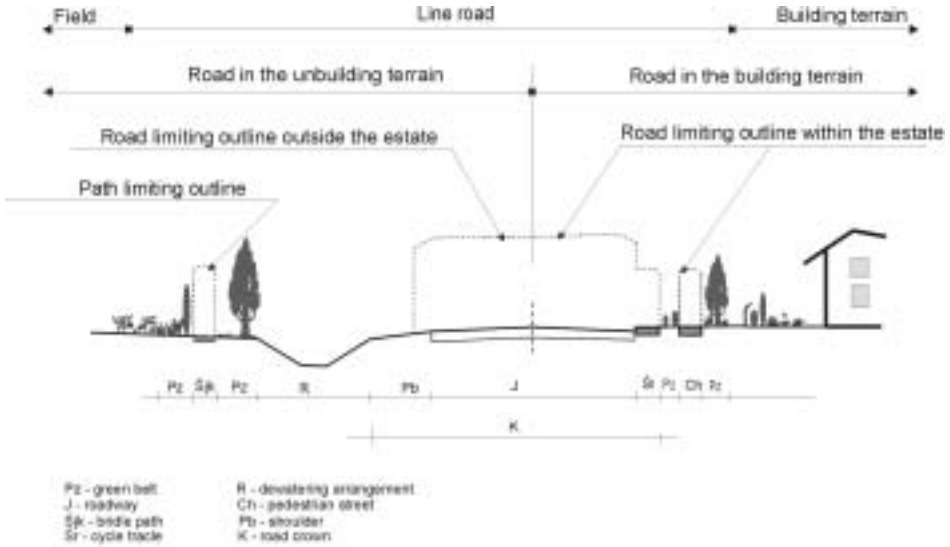

Fig. 2. Suggested cross-section design of rural road within the area of protected landscape.

Literature and own investigations arise that transverse inclinations on agricultural roads can be two-sided or one-sided. Bilateral inclinations appear on two-roadway roads, whereas one-sided – on single-roadway roads. The numerical values of inclinations in worked out conceptions, designed to the relation of the kind of surface and inclination of road formation line are given in table 2.

The remarks in subject of surface of agricultural roads on areas of protected landscap. On upland terrains where roads become periodically impassable, tendency occurs aiming at making surface – foundations from local material, stabilised with binding hydraulic agents (cement, lime, ashes from lignite) or from natural and broken aggregates, stabilized mechanically. Carriageable layers (if they appear) are oftener built from thin bituminous layer or superficial bituminous consolidation. These solutions are applied so far on agricultural roads fulfilling simultaneously the function of burghal roads. It seems, that at present on protected areas (and others) it is possible to apply prefabricated concrete bricks to carriageable layers. Such surfaces may be applied on terrain of antique town-planning arrangement of cities, settlings being commune seats and agro - touristic villages. They may be used to harden the roads, representative municipal squares, crossings, bus lay-bies, the bicycle paths, side – spaces,

park avenues, sidewalks and foot paths, footbridges, car parks, sport fields as well as car - foot draws in protected gullies. The efficient adaptation of colour of the road surface to surroundings can increase aesthetical values, adding trumps, like: durability, facility in maintenance and the resistance to influence of atmospheric conditions.

Table 2

Cross slope of roof-shade road

Kinds of road structure	Gradient of formation line, %		
	0–2	2–4	>4
	Cross slope, %		
Improved and hardened (to be improved before winter)	2,0–1,5	2,0–1,0	1,0
Hardened	3,5–3,0	3,0–2,5	2,5–1,5

On non built-up areas one may resign from executing carriageable layers to lower the costs of building roads. The hardened surfaces, devoid form carriageable layers are however susceptible to excessive dusting in time of immoderate overdrying, however by excessive moisture local deformations and strokes in road plane occure, influencing unfavourably their technical and aesthetical condition.

In the technical process of road belt organisation one can not omit the road drainage measures, which lie in shaping its frame with suitable longitudinal and transverse slopes, simultaneously elevating over adjoining terrain, the realization of wayside ditches, sewages as well as roll passes and storm sewage system. However draining devices have to be ruthlessly secured with different methods prior to destructive impact of superficial waters [1, 6]. Among existing methods special attention deserves fixing turf on artificial subsoil [6].

The conducted investigations broadened the data base of spatial and technical condition of lattices of agricultural roads in upland terrains of protected landscape menaced with erosion. The obtained qualitative and quantitative data were used particularly with the aim of optimizing the principles of locating and geometrical projecting agricultural roads on steep terrains.

The investigation results show, that the best location of agricultural roads in terrains of diverse relief are watersheds borders or dorsal parts of slopes, in other words, the places without any inflow of superficial waters, as well as in mid-slope valleys apart from range of flowing superficial waters.

The investigation results show that agricultural roads with longitudinal slope of formation line up to 4% do not require hardening. They may be improved by making the correction of ground texture covering the road to so-called optimum mixture or by soding. However, in the case of longitudinal formation line slope over 6%, application of hardened roadways and secured draining devices became ruthless.

The geometrical elements of agricultural roads (straight lines segments, transitory straight lines, horizontal circular arcs, formation line inclination and vertical arcs) should be projected depending on function of the road as well as on traffic velocity – from 20 up to 40 km/h.

Correctly developed road belt of agricultural road on the protected areas should consist of road with hardened or improved surface, ground or hardened side – space (gauge), bicycle path, walking draws, path to horsemanship, draining devices as well as safety two-sided earth belts separating the road from adjacent terrain.

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ВИВЧЕННЯ ПЛАНУВАННЯ І ПРОЕКТУВАННЯ ОКРЕМИХ ЕЛЕМЕНТІВ СІЛЬСЬКОГОСПОДАРСЬКИХ ДОРІГ У МЕЖАХ ВИСОЧИН ЗАПОВІДНИХ ТЕРИТОРІЙ

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Відображено головні принципи планування і проектування окремих елементів сільськогосподарських доріг, що будуть прокладені на височині в межах заповідної території. З'ясовано особливості локалізації доріг та вибору розміру геометричних елементів. Проаналізовано різноманітні поверхневі технології, які використовують на локальних та внутрішніх сільськогосподарських дорогах сьогодні. Запропоновано шляхи вдосконалення поверхневих технологій у прокладенні сільськогос-подарських доріг.

Ключові слова: сільськогосподарські дороги, заповідні території, височини, планування, проектування.

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