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Geometric design of range roads

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RESUME. – *"Tracé géométrique des routes des parcours". Les parcours en Grèce on une valeur économique certaine à cause des vastes surfaces qu'ils occupent. L'aménagement de l'accès aux parcours par un réseau de routes est une voie d'amélioration de la gestion de ces parcours. Le réseau de routes doit être localisé, aménagé et entretenu. Dans cette optique ces accès facilitent le transport des animaux, population, fourrages, produits laitiers, etc., fournit la recréation, améliore la protection contre les incendies. Le présent papier traite les éléments nécessaires pour le tracé géométrique des routes.*

Mots-clés : *Routes forestières, tracé géométrique, aménagement des parcours.*

Introduction

Rangeland has a significant economic value in Greece because of the large area covered as part of the productive land (Nastis, 1984). The basic presupposition for rational development and management of these areas is the construction of the necessary technical works of infrastructure. However, unfortunately, funds for that purpose have been very limited. Therefore, nowadays, only a small percentage of rangelands have basic infrastructures, such as access roads, watering points, etc.

Opening up of rangelands (comprising subalpine and upper mountain areas) by construction of proper range roads network is now considered necessary. The density of road network can be 7-12 m/ha (Papanastasis, 1986; Nikou, 1988). Basic elements of geometric design of these roads are described in this paper, together with a few words about drainage and paving.

Geometric design of road

The design of a forest road should take into account the design vehicle (D.V.), which in the case of range roads would be a 2-axis truck (Nikou, 1988; Karayiannis and Karayiannis, 2001). The design speed would be between 20-30 km/h.

Horizontal alignment

The centre line should be drawn as close as possible to the grade line, in order to minimize the size of cuts and fills, i.e. the volume of earth works, particularly in steep, rocky terrain (Nikou *et al.*, 2000).

Curves, as for all forest roads, are exclusively simple circular arcs. The radius of curvature (R) should be determined by taking into account the design speed (V), the design vehicle, the type of terrain and the angle of the polygon. The radius R is chosen such that the centre line will be as close as possible to the grade line, particularly in rocky terrain and in steep slopes (Nikou *et al.*, 2000).

In order to avoid serious damage in the natural landscape, location of switchbacks must be carefully determined. Stable earth, gentle slopes (less than 40%) in steep terrain may be chosen, when hairpins are inevitable.

In the case of successive curves turning in the same direction, short straight sections (less than 10 m long) between these curves should be avoided for aesthetic reasons. What is preferable is that the end of the first curve will coincide with the beginning of the next one, and the ratio of their radii may be between 1 and 1.5.

In the case of successive curves turning in the opposite direction, straight sections between them are necessary, at least long enough to accommodate the length of runoff of super elevation and widening.

Vertical alignment

In the case of vertical alignment the centre line should be drawn as close as possible to the ground line, as for horizontal alignment. In order to avoid unacceptably large cuts and fills, the height difference (Δh) between the heights of these two lines (in the same cross section) should not exceed specific limits (Nikou, 1995).

Regarding longitudinal gradients (i), they should be kept within the following limits (Nikou, 1988):

i_{min}	=	1 - 2%		
i_{max}	=	6%	for	R < 30 m
	=	7 - 8%	for	R = 30-50 m
	=	9-11%	for	R > 50 m
Preferable values i	=	3 - 6%		

Successive longitudinal gradients must be connected by vertical circular arcs or parabolas.

Cross section

Range roads are characterized by low traffic intensity and light loads, and they are frequently done in steep terrain. The consequence of this is a great loss of productive area, high cost of construction, serious damage to the amenity and environment of the rangeland. These negative effects lead to the construction of single lane roads with intervisible passing places (about 5 per km) and turning places (about 3 per km), with ramps where it is considered necessary and convenient.

According to the above, the formation width should be 4.0m and the pavement width 3.0m, increased on curves by a widening: $w = 17/R$ (Nikou, 1988).The surface of the road should be crowned (cross slope : 3-4%), super elevated at bends (Nikou, 1996).

Regarding the side slopes, generally the gradients of fills are gentler than those of cuts. In practice, mainly 1: 1.5 should be used for fills, except in special cases, where we can accept a gradient of 1: 1.33. The gradient of cuts vary from 2:3 for loose, susceptible to slide ground, to 10:1 in the case of rock. Side slopes can be read from relevant tables (Nikou, 1996).

Visibility

For safety reasons, it is necessary to provide at least the minimum safe stopping sight distance D(m), which may be determined by the formula (Nikou, 1988 and 1990):

$D = 0.0022V^2 + 0.834V + 5$ where : V = design speed (km/h)

Drainage

Roads are as good as their drainage. Proper drainage of a range road (as for all types of roads), is one of the main criteria for a complete design and an artistic construction. The drainage system consists of drainage ditches (along the road) and culverts (across the road). Ditches should be of proper size and gradient, and must be cleared regularly.

Culverts at streams are of concrete pipe or slab. In the case of pipe culverts, the use of other materials such as corrugated steel should be examined (Hafner, 1972). In order to reduce the cost of relieving (intermediate between creeks) culverts of ditches, the possibility of construction of open top culverts in the shape of W (Lafayette, 1985) should be examined. Spacing of culverts: for longitudinal gradients i = 5%, the average spacing should be less than 150 m (Nikou, 1988).

For i > 5, it should be equal to 800/i (Heinrich, 1985; Nikou, 1991).

Paving

Taking into account the traffic conditions on range roads (low volume, light loads), the type of pavement will depends on a series of other important factors as well, such as: purposes of the road, type of subgrade, climatic conditions, duration of service around the year, availability of funds etc.

Machinery

Machinery for the construction of a range road must be chosen with special care, taking into account the type of terrain and the consistency of the ground. Today in most developed countries, use of an excavator has replaced the traditional methods of road construction (by bulldozer), particularly in steep terrain, mainly because of the advantages regarding damage and impact on the environment.

Conclusions and recommendations

Despite the fact that natural ranges in Greece have a significant economic value (because of the extensive areas they cover, only a small percentage have some type of infrastructure mainly access roads and not in good condition. Therefore, construction of a proper network of roads is considered necessary, for rational development of these rangelands.

The basic design elements may be the following:

Density of range road network	7-12 m/ha
Design vehicle	2-axis truck
Design speed	20-30 km/h
Formation width	4.0 m
Pavement width	3.0 m

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