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Designing of Rehabilitations of Urban and Non-Urban Roads

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Abstract

Considering the relatively good condition of the urban and non-urban roads in Macedonia on the one hand, and the level of damage of the pavements on the other hand, there is an emerging necessity to invest considerable financial amounts on their maintenance. The pavement rehabilitation is a measure of the maintenance level intended to eliminate all damages of the pavements incurred in time and under the influence of traffic and climate, as well as to adjust the bearing capacity of the pavement on the increasing traffic load. Therefore, it is especially important to correctly plan and carry out these activities.

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1. Introduction

The rehabilitation of urban and non-urban roads is important for the development and reconstruction of urban areas. The rehabilitation of urban and non-urban roads is a basic civil engineering activity carried out in road network of Macedonia, and shall be the dominant one in the forthcoming years as well, considering the road condition, and before all, their safety as well as the available financial resources. Considering the condition of the roads of our state and urban networks, urgent rehabilitation measures are necessary in order to provide for some acceptable conditions in order to avoid the decrease of security level and overall destruction of the existing road networks [1-9].

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2. Rehabilitation design methodology

Road rehabilitation belongs to the category of civil engineering maintenance (Fig. 1) and importantly differs (in the scope, means and procedures) from reconstruction or construction. The road and street rehabilitation activities (functional or civil engineering ones) refer to those road directions and sections on which there is no capacity insufficiency so that the activities for the change of the geometric elements on the road are reduced to a minimum, and all civil engineering activities take place within the framework of the available (existing) road (street) belt, without any new or subsequent expropriation. This attitude may be altered only in cases when, within one road direction or section, there is a dangerous spot which must be rehabilitated (reconstructed) of safety reasons and it can not be considered as rehabilitation. The very process of maintenance is divided into two main parts: the first one includes the so-called functional maintenance, that is maintenance of the road in winter and summer conditions as pursuant to the defined conditions and the relevant legal and technical regulations and the second one which includes the so-called civil engineering maintenance (rehabilitation) in three levels. These three levels include: resealing (reinforcing) the pavement, renewal of the pavement construction of the road (the pavement and the ancillary elements of the pavement) within the limits of the road belt. The decision about whether to carry out rehabilitation, reconstruction or construction of a new section is brought as on the basis of a comprehensive analysis on the level of the general road network plan, that is, on the level of mid-term plans of the needs and available financial resources (Fig. 2).

Fig. 3 illustrates the steps in the elaboration of the design documentation on different levels of activity of the road network (new construction, reconstruction and rehabilitation). As it can be seen, the elaboration of the design documentation on rehabilitation includes a study of the conception of the design and a basic rehabilitation design. Upon the performance of the works an archive design is elaborated serving to a final calculation of the works and for upgrading of the integrated road or street information system. Upon the completion of the works a “before and after” study is elaborated in order to analyse the carried out works and the spent funds. The data of the said analysis include the time interval of three years before and three years after the performance of the works. In general, rehabilitation is considered separately for highways, two-lane roads and urban roads.

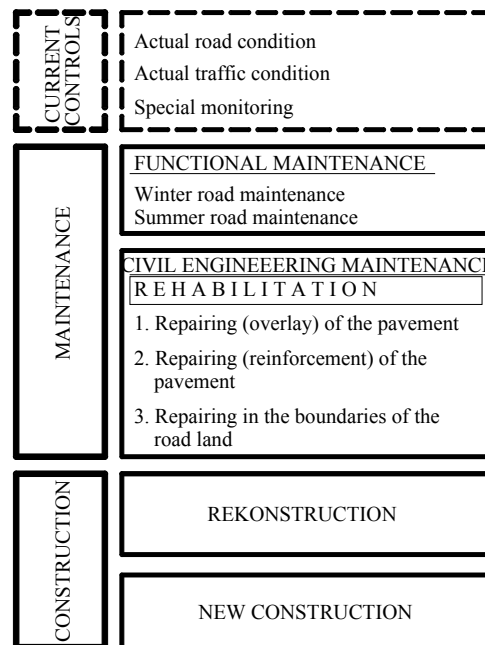


Fig. 1. Systematisation of the notions in road engineering (maintenance, reconstruction and construction)

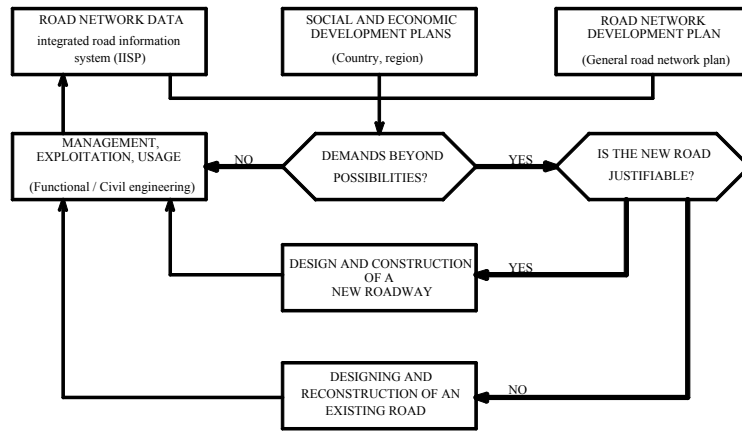


Fig. 2. Algorithm on decision making on the level of intervention on the road network

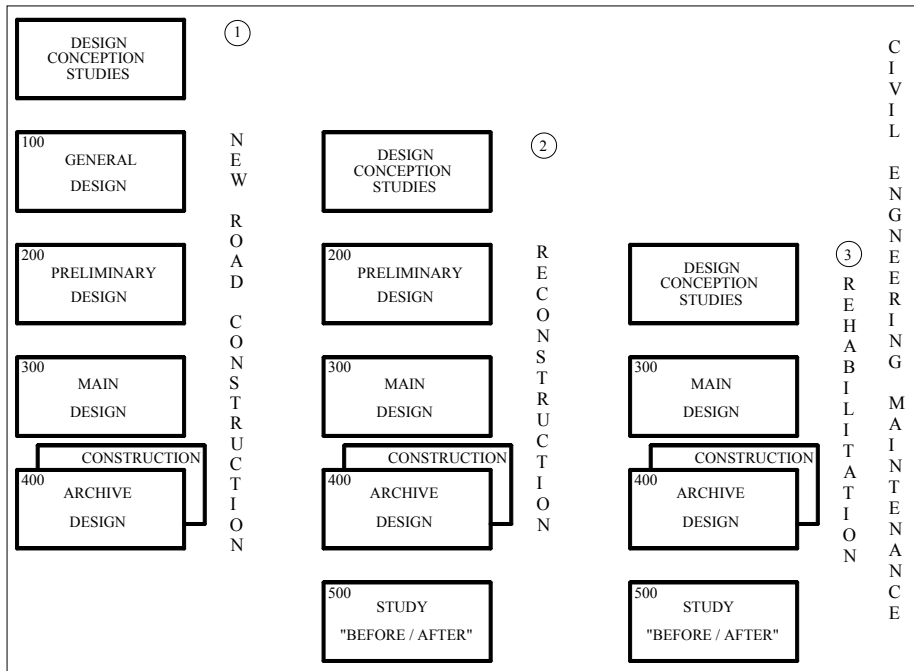


Fig. 3. Steps in the elaboration of design documentation of urban and non-urban roads

3. Designing process

3.1. Design conception study

The primary purpose of this study is to establish the priorities and levels of rehabilitation, form the program parameters and a design task on the elaboration of the main rehabilitation design. This study is an initial step in the overall process and is based on relevant data from the integrated road information system (IISP), of the defined needs and clearly established purposes of rehabilitation.

The basic IISP elements are the database on the spatial and physical structure of the road and road constructions,

the traffic load, accidents, maintenance and other relevant parameters indispensable in the elaboration of the said study. Nowadays it is possible to efficiently use the World Bank HDM-4 system (Highway Development and Management System) regardless of whether the whole road network or a road section is dealt with. It is not necessary to emphasise the importance of quality and precision of the data provided by permanent collection from the whole national road network and urban streets network. If there are not enough quality data available regarding the previously mentioned analyses, it is necessary to perform a field prospection at the appropriate level.

As it has already been said, the final result of the cited activities within the framework of the study of the project's concept is the establishment of program parameters and a design task referring to the elaboration of a new design for rehabilitation of certain road sections or streets of the national, regional or urban road network.

3.2. Main rehabilitation design

Hits purpose is the unilateral definition of the methods and procedures of physical realisation of the rehabilitation on the optimum requirement level. Within this project, the analysis of the actual situation of the identified shortcomings leads to the definition of appropriate levels of rehabilitation (resealing, renewal of the pavement construction and renewal of the road).

4. Analysis of the actual situation

The initial activity in the elaboration of the basic design in rehabilitation is the analysis of the actual situation of the spatial and the physical structure of the road within the framework of the road belt on the basis of archive data and the immediate data gathered on the geometric features of the road in all three projections of the undercarriage, the pavement construction (bearing capacity, roughness (longitudinal and cross-sectional), friction capacity, condition of the pavement surface (degree of damage), the ancillary road elements (shoulders, berms, inclinations, sidewalks), the drainage, road constructions, crossroads, access control, safety, traffic and technical equipment, urban equipment, possible hazards to the environment etc. In rehabilitation of non-urban roads certain parameters as for example the design geometry, should be dealt with more flexibly than in case of reconstruction or construction of a new building. This means that some elements will not comply with the perscribed and recommended values.

In order to gain some insight in the existing road condition it is necessary to construct a resulting diagram of drainage of the surface waters from the pavement, which indirectly defines the degree of discrepancy among the elements of the situation plan and the longitudinal profile. An important characteristic of the actual condition of the non urban road is the visibility, before all, the available visibility, as it is crucial to the safety of the traffic. It is established for both directions of driving by field measuring by two passenger vehicles and with appropriate measuring devices. Besides the available visibility this process includes an analysis of the available horisontal and vertical signaling as well as an analysis of the entire traffic and technical equipment.

As for the urban road network it is important to mention that the rehabilitation must not disturb the leveling relations of the street and its surroundings. Thus, the leveling relations must be maintained within the framework of the existing ones, with possible minor deviations where it is possible. The rhythm and the system of the crossroads is crucial for the efficient and safe traffic. It is necessary to include a wider range of the crossroad zones.

Besides the cited analyses it is necessary to analyse the actual condition of the pavement construction, the ancillary elements of the pavement, the road constructions, the environment etc. These analysis are carried out by especially established procedures in order to be standardized and unified, which directly reflects the final attitudes and estimations important for the determination of the necessary level of rehabilitation.

Pursuant to a comprehensive analysis of the actual situation of all relevant parameters a necessary level of rehabilitation is established by certain sections and/or road directions. These analyses are the framework for the establishment of possible sections on which a higher level of intervention-reconstruction is necessary due to the insufficient capacity or considerable risk to the safety of driving – a dangerous spot or a black spot.

The final establishment of the level of rehabilitation and possibly, of the reconstruction section is carried out within the process of continuous auditing of the basic design pursuant to the Investor

5. Relevant velocities

The establishment of the relevant velocities, as the basic dynamic module for the dimensioning and inspection of the applied design elements, is one of the most important features in the overall process of rehabilitation designing. Unlike the designing of new road sections or the reconstruction of the existing ones, with rehabilitaitons it is impossible to define the relevant calculation velocity but those velocities are established within the frameworks of an iterative procedure of analysis of the actual situation and of the decision on the level of rehabilitation. Therefore, different velocity models are established and they are supposed to reflect as trully as possible the real condition in driving. It is important to emphasise the need to measure velocities in free traffic flow.

In urban roads the velocity is more or less unified (limited to the value identical for the whole agglomeration). Considering that, velocity does not have any important role in the definition of the relevant parameters for designing of rehabilitations.

6. Traffic loading

For the needs of rehabilitation of urban and non-urban roads, the traffic load is established for the planning period of 10 years. Thereby it is necessary to define, by one of the verified methods, the relevant load as per intensity and structure (AADT/ADT, % Passeneger cars, % Trucks, % BUS, public service vehicles, supply vehicles, fire extinguishing vehicles...).

In case of designing crossroads and appropriate ancillary constructions, it is also necessary to elaborate the relevant traffic flow distribution scheme for motorized vehicles as well as for pedestrian and bikers.

7. Design elements and parameters

7.1. Cross-section profile

The cross-section profile is the first projection and one of the most important design elements. The width of the lanes, the board lanes, the shoulders for non-urban roads, or sidewalks and bike tracks for urban roads, is connected with the relevant design velocity of a given road section or with the role of the road in the network. But rationality is necessary here for the determination of the necessary widths considering the method and the possibilities of performance of the widenings. As for the pavement inclinations in a curve it is necessary to fullfill the conditions related to the movement safety of the vehicles.

7.2. Alignment

The elements of a situation plan (directions and curves) are inspected from the viewpoint of the dynamic, constructive and esthetic criteria. Considering that the rehabilitation procedure does not importantly change the elements of the design geometry, for non-urban roads the problem of velocity discrepancy is solved by appropriate traffic signalling and traffic and technical equipment.

7.3. Longitudinal profile

The attitudes presented on the elements of the situation plan count also with the elements of the longitudinal profile. In this projection it is especially important to fullfill the conditions related to the necessary sight distance for non-urban roads and the surrounding buildings and the roadside contents on urban roads.

7.4. Sight distance

The sight distance problem should be given special attention upon the elaboration of the main design. This refers to the use of the available sight distance. The sight distance analysis is closely related to the applied concept of

velocities and the specificities of rehabilitation, which does not imply important interventions of the geometric elements on the situation plan and on the longitudinal profile. The analyses of sight distance are especially important in the elaboration of the traffic management design (traffic signalling and equipment etc.)

Upon rehabilitation of urban roads it is important to provide for visibility of the pedestrian crossings, for drivers as well as for pedestrians. The visibility on the surface crossroads is also important

7.5. Pavement

The pavement construction rehabilitation generally takes place on two levels: resealing of the existing pavement with the purpose of improvement of the fraction condition and the renewal of the pavement construction in order to fulfill the requirements related to the bearing capacity, roughness and surface characteristics. In both cases the planned period is of 10 years. Special attention should be paid to the efficient drainage and on the arrangement of the boarding belt, as the quality and permanency of the pavement construction largely depend on these factors.

7.6. Crossroads and access control

The safety and efficiency of the road traffic largely depend on the distribution and the system of crossroads, that is, on the access control. The distances between the crossroads primarily depend on the road level and on the traffic load of the joining roads.

7.7. Road constructions

The rehabilitation of road constructions (bridges, tunnels etc.) requires special attention within the framework of rehabilitation of a road section. If the constructions are small, the design of their rehabilitation is a constitutive part of the design of the rehabilitation of the respective road section. In case of larger constructions it is necessary to perform special analyses and independent designs of their rehabilitation.

8. Conclusions

The basic purpose of this paper is to emphasise the importance of the methodology of designing the rehabilitations of the urban and non-urban roads, which is a dominant process on our road network, and to promote a hierarchy system of management of the elaboration of the design documentation starting from a Study of the Design Concept until the elaboration of the Main Design.

What should be especially emphasised is the necessity to bring appropriate regulations on this specific field of road engineering, above all considering the scope of these activities and the especially high financial amounts which should be provided in the forthcoming period. Only in this way shall the quality of the road network as well as for the urban networks in Macedonia be improved to a functional level acceptable for the road users.

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