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ROAD SAFETY AUDIT FROM CONCEPT TO RESULTS

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Abstract

The main requirement for the upgrading road infrastructure safety is the implementation of a comprehensive analysis in terms of road safety. Greek legislation (Presidential Decree104/2011) in line with the European Directive 2008/96/EC, as amended by Directive 2019/1936/EC, plans to implement Road Infrastructure Safety Management (RISM) for the road network of Greece. To prevent accidents, one of the primary RISM procedures is the Road Safety Audit (RSA) technique. This paper addresses the RSA findings on a national of 4-lane road network in Greece, as a re-active approach to identifying safety issues and infrastructure deficiencies. The interurban road Thessaloniki - Nea Moudania is part of the A24 motorway, which length is 56 km and practically connects the prefecture of Thessaloniki with the prefecture of Halkidiki. The study was at the framework of a graduate thesis of Civil Engineering Department of the Aristotle University of Greece. Following the audit carried out, it was found that most of the problems relate to passive safety systems, signage, visibility issues, the condition of pavement and the characteristics of junctions.

Keywords: road safety audit, freeway, accidents

1 Introduction

A Road Safety Audit (RSA) is a formal examination of an existing or planned road or intersection by an independent, multidisciplinary team. The purpose of the audit is to identify potential safety issues and provide recommendations to improve the road's safety for all users, including pedestrians, cyclists, and motorists. The process involves evaluating various aspects of the road, such as design, signage, markings, and traffic control devices, with the aim of reducing the risk of crashes and minimizing the severity of any potential incidents. This proactive approach to road safety helps to ensure that transportation infrastructure is designed and maintained to the highest possible safety standards [1].
With its EU Directive 2008/96/EC on road infrastructure safety management, published in October 2008, the European Union (EU) made a clear decision that RSA will be mandatory for the Trans-European Road Network in forthcoming years. This Directive contains another tool called Road Safety Inspection (RSI) on safety deficiencies of existing roads. The RSI is very similar to the process of Road Safety Audit in the pre-opening phase of newly constructed roads. RSIs are essential for the redesign and upgrading of existing roads, and these are done in many countries to give the designers insights and direction for safety improvements. The Directive 2008/96/EC was amended in 2019 with the Directive (EU) 2019/1936 which will apply to roads not only which are part of the trans-European road network but to motorways and to other primary roads, whether they are at the design stage, under construction or in operation [2, 3].

This paper addresses the RSA findings on a national of 4-lane road network in Greece, as a re-active approach to identifying safety issues and infrastructure deficiencies. The study was at the framework of a graduate thesis of Civil Engineering Department of the Aristotle University of Greece [4]. The interurban road Thessaloniki - Nea Moudania is part of the A24 motorway, which length is 56 km and practically connects the prefecture of Thessaloniki with the prefecture of Halkidiki. Based on the knowledge and the experience gained from the teaching courses concerning the road safety and human factors issues and RSA procedure, the examination of this road section was a challenge in the educational framework.

2 Road safety audit

In most countries, despite the fact that road design guidelines which are applied include implementation of road safety issues, accidents still occur on new roads. Design standards often contain minimum requirements regarding road safety and sometimes a combination of these elements can lead to dangerous situations. Additionally, there are situations where in difficult terrain, there are reasons which make the application of the standards impossible or too costly solution.

The procedure of Road Safety Audit (RSA) is recognized as one of the most efficient engineering tool for improvement of safety on roads. Road Safety Audit, as procedure for preventing accidents, originated in Great Britain and is now being spread in several countries around the world. Internationally, the main RSA guidelines are those published in the USA (2006) by Federal Highway administration (FHWA) [5], in Britain (2008), published by British Institution of Highways and Transportation (HIT) [6] and in Australia (2009) published by Austroads [7]. The RSA carried out by a multidisciplinary auditing team comprising two or more well trained and accredited road safety engineers who are not part of the design team. It is worth noting that the independence of the auditor team performing the RSA is absolutely necessary. The identification of potentially dangerous features of the roadway environment and potentially misleading or missing information points are the main principles of the procedure. The RSA, as a systematic evaluation of existing or planned road infrastructure to identify potential issues and recommend improvements provide many issues to address:

- Prevention of accidents: identification of potential hazards and safety issues before they lead to accidents and proactive measures which can be taken to address issues and improve the overall safety of the road.
- Reduction in crash risk: by assessing road designs, traffic control devices, signage and other elements road safety audit can mitigate high-risk areas which lead to a safer overall road environment.
- Cost-effective solutions: identifying safety issues early in the planning or design phase is more cost-effective than making retroactive changes after incidents occur.
- Improved road design: Road safety audits contribute to the development of better road designs that consider the needs of all road users creating a more intuitive and safe road environment.
- Enhanced visibility and signage: evaluating the visibility of road signs and markings by adequate and properly placed signage can lead to improved visibility for drivers, reducing the likelihood of confusion and errors.
- Increased road user awareness: the findings of audit may contribute to raising awareness among road users about potential risks and hazards
- Long-term safety benefits: implementing the recommendations contributes to long-term safety improvements and continuous monitoring and evaluation can help maintain and enhance road safety over time

In Greece, for the implementation of integrated RISM, Presidential Decree 104/2011 defines: "specific procedures related to the training and responsibilities of auditors, the data which are collected and utilized, as well as the relevant good practices that should be used to tackle the road safety issues that have been identified". RSA is one of the proposed measures of the Strategic Plan to improve road safety in Greece 2020–2030 and is considered mandatory for the Trans European Road Network (Kehagia et.al, 2022). Regarding to the training of auditors, there was an official effort for the training and certification of highway engineers, working in the private and public sector, from an organized RSA training program in order engineers to be certified as road safety auditors.

3 RSA findings

3.1 Case study

The interurban road Thessaloniki - Nea Moudania is part of the A24 motorway (Figure 1a). It has a total length of 56 km and practically connects the prefecture of Thessaloniki with the prefecture of Halkidiki. It is a road that serves the daily commuting of citizens of both prefectures as well as commercial transport to and from Halkidiki. Its construction started in the early '90s and was completed in stages until 2003. From the Voulgari Street junction to the Airport junction it consists of 3 lanes and an Emergency Lane (LEA) in each direction, while from the Airport junction to Nea Moudania it has 2 lanes and an LEA. Throughout its entire section, the road has a speed limit of 90 km/h in both directions, has a divided road surface. It is considered as an expressway and not as a highway as the road does not satisfy the highway specifications.
In this research, a section of the Thessaloniki-Nea Moudania road is examined, (Figure 1b) which extends from the junction of Neos Rysio to the junction of Lakkoma and has a total length of 12.4 km. The route is characterised by steep longitudinal gradients and has several curves in the topography. It is considered to be a section of the network which presents many problems in terms of road safety and requires particular attention from drivers when driving it as it has many dangerous points. According to data recorded by the Traffic Police of Thermi, between 2017 and mid-2022, a total of 5 fatal accidents and 36 accidents with injuries were recorded in these 25 km.
The execution of the audit commences with a thorough analysis of the available information and drawings. The inspection of the road was carried out in daylight and at night-time, in wet and dry conditions, from the point of view of all road users and included all movements at each interchange. Checklists for the specific roadway were prepared, according to the Greek legislation, checking the conformity of road layout to road design specifications, potential violations of driver expectancies related to roadway design and risk potential accidents points. They are organised along typical safety-relevant dimensions such as the function of the road, cross section, alignment, intersection design, road restraints, traffic signals, service or resting areas, signing, marking and lighting.
After the inspection, it was found that the section of the road exhibits several issues concerning road safety, and that the environment and geometry of the road are particularly hazardous for its users in certain places. The most prominent problems mainly occur between kilometre points 12+700 and 16+400, including inadequate visibility lengths for stopping and decision-making, lack of road lighting and an integrated signalling system, deficient and defective containment systems, as well as the inadequacy of road junctions and accesses. From kilometre point 16+400 up to 25+100 (where the examined section ends), the situation improves but problems persist, as issues related to the pavement, which often shows significant cracks and deterioration, continue. Containment systems remain insufficient and damaged, while the lengths of acceleration and deceleration lanes fail to meet minimum regulatory standards.

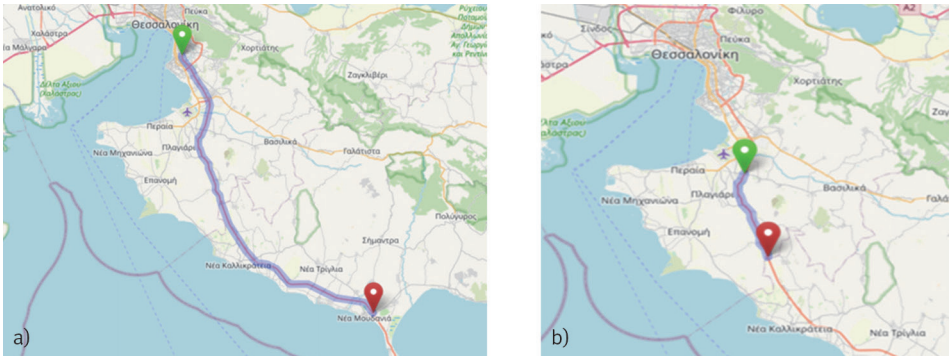

Figure 1 a) The interurban road Thessaloniki-N.Moudania; b) The examined road section

3.2 The role of human factor

Human factors are these pshychological and physiological threshold values that are relevant in operating machines, vehicles and technical facilities. Human factor contributions to an audit might involve evaluation of the design plan, or current configuration of an existing roadway to determine whether driver expectancies are met, sight distances are appropriate, whether there is design consistency, and the appropriateness, placement, visibility of traffic control devices such as signs, lighting at night, potential glare from vehicle headlights, roadside distractions. Of particular concern are complex locations (e.g. intersections) where unfamiliar drivers may become confused or overloaded with information. These situations can lead to stress and driver error. This approach is based on a combination of human factors and traffic engineering. The central principle of this approach is that design according to driver limitations and expectations increases the likelihood of drivers responding to situations and information correctly and quickly. When drivers are not provided with information in a timely phase, or are overloaded with information, or are surprised because their expectations are violated, slowed responses and errors may occur [8-11].

3.3 RSA Findings

3.3.1 Design consistency

The geometric characteristics of the road design were examined by the use of GoogleEarth and AutoCAD. From the review of road design plans, it is remarked that the design of horizontal and vertical element is not compatible with the road design principles. In the horizontal alignment, an inconsistent alignment with a combination of large with small radius horizontal curves makes the road course to be not predictable. Design speed was 90km/h. Following, the main findings of the road safety process in the examined section between kilometre points 12+700 and 16+400 are presented.

3.3.2 Road junctions/accesses

Many uncontrolled access points create serious conflict points and increase the accident possibility and pose significant issues concerning road safety. Closing of direct access to main road and the uncontrolled turning movements to minimize the possibility for accident is important. To address these issues, it is proposed to reconfigure both the junctions and their characteristics individually, as well as the overall philosophy of access to the road. These junctions serve as connections between the main road and adjacent rural roads. All of

them represent highly hazardous positions either due to the lack of entrance and exit configuration or due to reduced visibility for users approaching them from the main road and users entering the main road via these junctions (Figure 2b).

3.3.3 Sight distance (visibility)

It is examined the sites where the stopping sight distance and the passing sight distance are compatible with the recommended visibility by the Road Specifications. A usual critical requirement is that the driver can stop safely and this requires the understanding of speeds, reaction times and deceleration rates. There are many critical sites of the road. There is no sufficient sight distance, in many cases, for overtaking or breaking and stop in case of obstacle. It may be difficult for a driver to estimate the sight distance on a curve crest and he may overtake when he does not have sufficient length to do so safely.Additionally, many problems are appeared concerning the sight distance at junctions, where vehicles on the minor road are encourages to negotiate the junction at speeds higher than is compatible with the available to them (Figure 2a, 2c).

3.3.4 Roadside obstacles

There are many critical sites where roadside obstacles should be separated from the road pavement by barriers. A roadside is defined as the area beyond the edge traffic lanes of roadway. Different single fixed or continuous obstacles at the edge of traffic lanes create potential danger of collisions leading to accidents or increasing accident severity. Some of these obstacles are trees or other vegetation, utility poles, sign and lighting posts and supports, abutments, overpasses, rocks on the nearside, drainage features, embankments and slopes, ditches. The presence of these roadside obstacles increases the collision possibility and the accident severity or obstruct the visibility (Figure 2d).

3.3.5 Barrier system

There are many positions where there are damaged barriers or missed barriers or barriers which are a series of unconnected short pieces or with faulty connection or termination. According to the on-site inspection conducted, it is deemed necessary to install additional safety barriers on the outer boundary (mainly category N2 and in specific cases H4b) for a total of 1,630 meters of road network. These are positions that, due to the road geometry and environmental characteristics, are classified as dangerous. Furthermore, there are many locations where the central island has undergone significant deterioration due to age and its functionality is questionable. Appropriate restrained barrier system installation, along the two sides of the road, according to European Standards EN1317 (Greek guidelines Road Restraint Systems OMOE-SAO) is imperative. According to the technical guideline OMOE-SAO, the installation of safety barriers on the road requires the consideration of the relevant study to determine the obstacles at the edge of the pavement, the critical distance of each obstacle, the required containment level depending on the degree of danger and the permitted speed Figure 2e,2f)

3.3.6 Maintenance of pavement surface

The issues identified in the pavement primarily include longitudinal cracks in the asphalt joints, fatigue cracks, and rutting (mainly in well-maintained surfaces). As there is a risk of significant damage to the underlying layers, it is probable that the restoration of the pavement will require the removal and re-pavement of both the surface and the intermediate lay-

ers. However, as we do not have complete data, further extended evaluation of the damages is recommended, along with sampling and core extraction at critical points, to assess the condition of the underlying layers and determine the depth of restoration. Special attention should be given to the locations where alligator cracking appears extensively (Figure 2g).

3.3.7 Lighting system

The absence of the lighting system reduces the safety level of the road. Lighting should provide a uniformly lit road surface in order to provide visibility of all users. Additionally, the absence of appropriate traffic signs for the orientation of the width of pavement increases the unsafe situation of the road route (Figure 2h).

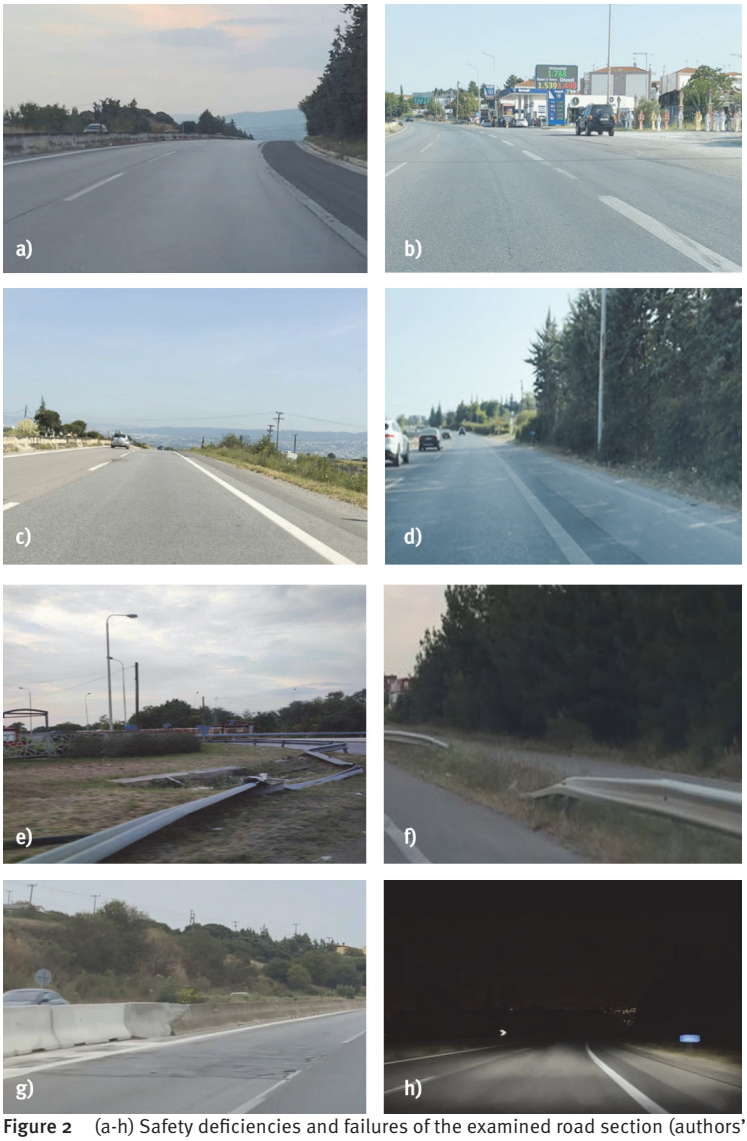

Figure 2 (a-h) Safety deficiencies and failures of the examined road section (authors' property)

4 Conclusions

This paper addresses the RSA findings on a national of 4-lane road network in Greece, as a re-active approach to identifying safety issues and infrastructure deficiencies. Following the audit carried out, it was found that most of the problems relate to passive safety systems, signage and the characteristics of junctions. The combination of longitudinal gradients and 'closed bends' (curves with small radii of curvature) create problems of poor visibility, which are considered critical as they create particularly dangerous situations for drivers. Regarding the operational characteristics of the road, it was found that the equipment and safety systems are inadequate, while in many places they have been seriously damaged, making them dysfunctional. These problems are exacerbated at night, as the geometry of the road is difficult for drivers to see. Finally, it has been established that there are many unnecessary accesses on the road, most of which are considered unsuitable for the category to which they belong and the speeds on the road. The paper is mainly focused on providing the general framework of RSA and a general description of the identified road safety problems. The absence of a cost benefit and cost effectiveness analysis of the countermeasures is the limitation of the research.

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