

学 位 論 文 題 名

Determination of Advisory Vehicle Speed Limit in Terms of Road Geometric Design and Social Cost Analysis

(道路幾何設計および社会費用分析からみた
推奨制限速度の決定に関する研究)

学位論文内容の要旨

Speed limit is the most controversial issue nowadays among road users in Hokkaido. As the present speed limit regulation has been applied for decades without any revision, it is recommended to consider the speed limit revision to determine the appropriate speed limit according to the recent development of road technologies and vehicles. Moreover, drivers always drive at their preferred speeds. Thus, the accident is likely to be occurred. Additionally, there is no winter enforced speed limit even though there is a lot of accumulated snow and slippery ice on the roads in Hokkaido. The objectives of this study are to determine the advisory speed limits in views of road geometries and cost analysis on Hokkaido roads for summer and winter as well as advisory speed limits on the selected road sections and to determine the effects of the appropriate speed limits in terms of social economic activities as well as road safety.

Generally, the 85th percentile speed is the most widely used factor for determining the level at which to set the limit. However, it may not be the safe speed for all road classes/conditions. Moreover, it is also not stable as the driving speed is somewhat a function of speed limit. Therefore, two advisory speed limit models were proposed, i.e. 1) advisory speed limit according to road geometry and 2) advisory speed limit according to cost analysis and effects of traffic signal density and traffic congestion. In this study, four types of roads in Hokkaido were involved, i.e. urban national highway, rural national highway (two-lane and multilane), urban expressway, and rural expressway. For the first model, the road geometries were required. In the calculation of advisory speed limit on a long straight road, free flow speed equation was applied to determine advisory summer speed limit. In order to determine advisory winter speed limit, the stopping sight distance equation was applied to the result from the free flow speed equation (effects from accumulated snow). However, for the advisory speed limit on curve, the equation of minimum radius of a circular curve was applied to determine the design speed then the next step was the same as that for long straight road.

For the second model, the concept is that speed limit has an influence on the average speed. Also, the difference between them is derived from the effects of traffic signal density and traffic congestion. Therefore, in order to obtain the optimal advisory speed limit, a cost analysis was applied first to determine the optimal average speed and then the effects from traffic signal density and traffic congestion were introduced by applying regression analysis to determine the optimal advisory speed limit. There were four components in the cost analysis, i.e. travel time cost, vehicle operating cost, emitted pollution cost, and accident cost.

The advisory speed limits from the first model are shown in the range from the best to the worst conditions. The optimal advisory summer speed limits from the second model fall into the range of the results from the first model. However, optimal advisory winter speed limits are in the range and out of range of those from first model.

Comparing with the present speed limits, the advisory summer speed limits from the first model, which have the best condition, are obviously higher than the present ones. While the advisory summer speed limits on urban and rural national highways from the second model are 4-6 km/h higher than the present ones. It is obvious that the optimal advisory summer speed limits on both expressways from the second model are relatively low; approximately 15 km/h lower than the present ones. It is probably affected by the high accident cost. The advisory winter speed limits are somewhat appropriate but the advisory winter speed limits on urban expressways from both models are too low for the actual road condition in winter. Nevertheless, the missing data of winter road possibly lead to the unreliable results.

To regulate the new speed limit appropriately, the public hearing should be taken into consideration. In this study, four questionnaire surveys were conducted. The major findings were that the speed limits in Hokkaido should be revised and winter speed limit should be regulated. However, the speed limits obtained from four questionnaires are different from each other, just some roads that have the same speed limits.

Then, the spot speed studies were introduced in order to reveal the current situation regarding speed limit on Hokkaido roads. The results also confirmed with the questionnaire surveys that most of drivers disobeyed the speed limits, especially on urban and rural expressways. Winter spot speed studies were also conducted. Compare the results in winter with results in summer, it is obvious that drivers increase their awareness while driving on winter roads. Furthermore, the 85th percentile speeds, mostly use for setting speed limit, from spot speed studies were compared with the advisory speed limits from both advisory speed limit models.

To verify the reliability of the advisory speed limit models, four road sections that have possibilities to raise speed limits were selected, which were two rural multilane highways (Route 36: Eniwa bypass, Route 337: near Ishikari port), urban expressways (Teine-Otaru), and rural expressways (Sapporo-Chitose). From the results, the advisory speed limits were obviously higher than the present speed limits but were lower than the design speed (maximum speed limit), except for urban expressways. Therefore, in order to maintain safety level, the road geometries should be improved to increase the design speed. Compare with results from the fourth questionnaire, the results were considered to be appropriate. As the speed limits are higher, the severity will be higher as well when the accident occurs. Moreover, the drivers may drive over than the speed limits again. Therefore, the speed enforcement and management would be recommended to control those problems.

As the speed limit regulation should be revised, the new speed limit would affect the road users in many ways. In terms of safety, it seems that increasing speed limit would affect to the road safety in the negative way. However, this also depends on various factors. Different location of testing would provide results differently. Even though there are many researchers found that negative impacts on safety in the case of raising speed limit, raising the speed limit to the appropriate level would increase the safety level as present speed limit in Hokkaido roads is inappropriate or unrealistic.

In terms of social economic activities, they will be impacted if the speed limits are improved. As the speed limits are higher, this would produce the benefit to road users in terms of time. They could save their travel time. In contrast, lowering speed limit would impact the social economic activities in the opposite ways. The environment is also affected but not so significant due to the nominal change in the travel speed.

In the future study, it would be recommended to classify the road types in Hokkaido as different road types would have the different speed limits. Better data quality would be required to improve the models. The spot speed studies should be conducted as well as more concisely traffic accident analysis to reveal the effect of changing speed limit. The result from second model is likely to be depended on the relationship between accident cost and average speed so better method to reveal its relationship should be determined. Moreover, questionnaire survey is suggested to be conducted to observe the public's opinions if the new speed limit is applied. Furthermore, more cooperation with government as well as national police agency is necessary to support this study.

学位論文審査の要旨

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近年、道路整備技術の向上、高性能自動車の開発等により、自動車の走行性が急激に進歩している。またそれと共に、交通事故による死亡者の減少等、道路交通管理においても変化の兆しがみられる。日本における道路を走行する自動車の制限速度は、その条件に対応して画一的に定められている。しかしながら、その基準については明確なものがなく、より多様で弾力的な考え方が必要であるといえる。ここでは、道路幾何設計及び社会経済的な視点から、総合的な評価指標を提案し、より現実的で推奨できる制限速度について実証的な検討を通して提案することを目的としている。これらの方法論を展開することにより、将来において道路線形、地域特性、あるいは季節特性等によって総合的な評価が可能になり、制限速度の科学的で適正な運用に有益な情報を提供することができるとしている。

論文は、7章から構成されている。第1章は序論であり、研究の背景、問題の定義、研究の目的、論文の構成などからなる。第2章は、研究に関連する文献がまとめられている。それらは制限速度、速度と事故の関係、住民調査、制限速度緩和の問題などの分野で整理されている。第3章は推奨制限速度の決定方法について論じられている。ここでは2つの視点からの方法が提案されている。その1つは、幾何学的な側面であり、都市及び農村部の一般道路、高速道路ごとに複数道路線形要因の総合化による推奨制限速度の決定が整理されている。他の1つは社会費用の側面であり、旅行時間費用、自動車管理費用、大気汚染費用、交通事故損失費用などによる総合費用評価が提案されている。それぞれの費用は、独特の方法を適用することによって算定される。その結果、前者と同様、各道路特性、地域特性による推奨制限速度を総費用最小という評価によって決定する方法を導き出している。第4章は、住民あるいは利用者による制限速度に対する考え方をまとめ、制限

速度が変化した場合の影響について分析している。ここでは実際の制限速度改善に関しての便益分析、いくつかの制限速度の変化による代替案を AHP 手法、トレードオフ分析で評価を行っている。その結果、利用者からみた妥当な制限速度が提案された。第 5 章は、地点観測による実測速度について、地域特性、道路特性に対応した分析を行った。そして得られた結果と、幾何学的側面、社会費用側面で得られて推奨速度について相互の比較を行った。第 6 章は様々な道路特性、地域特性に基づく速度を、提案した推奨制限速度決定方法に基づいて、算定した結果をとりまとめている。第 7 章は結論をまとめている。得られた結果については以下のように要約される。

調査および観察によると、制限速度と実態速度における現状との対応関係は見られず、必ずしも制限速度が適正であるとはいえないことを示された。幾何学的な制限速度は、自由速度式、安全停止視距、円曲線最小半径などの導入によって算出される。また費用分析では、交通信号や、混雑等も組み込まれ、より現実的な検討を行うことができた。ここでの費用は旅行時間費用、自動車管理費用、大気汚染費用、交通事故費用などであり、その総費用最小による推奨制限速度の決定が行われた。これらの算定方法を用いることによって、地域特性、道路特性さらに季節特性ごとの推奨制限速度を提案できた。さらに利用者への、調査とその分析法を新たに開発することによって、代替案評価による社会的最適解を導き出すことができた。以上によって、今後制限速度の適正な基準を策定する場合に資する多様な情報を抽出し、整理統合することが可能となった。

これを要するに、著者は、道路走行上の推奨制限速度に関わる問題について幾何学的視点、社会費用的視点および利用者評価視点からの総合的評価方法確立という点で新知見を得たものであり、交通計画学、交通システム管理工学の分野において貢献するところ大なるものがある。よって著者は、北海道大学博士(工学)の学位を授与される資格あるものと認める。