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A Systematic Review of the Impact Overload on Road Pavement Batu City, Indonesia

Alfi Nurhidayat[1*], Khairul Hisyam Bin Kamarudin[2]

[1] Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Kuala Lumpur 54000, Malaysia
[2] Urban and Regional Planning Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia

Corresponding Author Email: alfinurhidayat@umm.ac.id

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ABSTRACT

Batu City, a premier tourist destination in Indonesia, has experienced a significant influx of tourists, leading to an upsurge in vehicular traffic. This increase in vehicular load has precipitated premature deterioration of the city's road pavements. A systematic approach to addressing this degradation is imperative for the refinement of road planning strategies, tailored to the pavement's lifespan, and for the development of a holistic road construction policy that aligns with the actual traffic load. This study employs a systematic literature review (SLR) to investigate the effects of vehicle overloading on the structural longevity of road pavements in Batu City. A keyword-driven search was conducted, resulting in the selection of 50 pertinent articles which were scrutinized to determine the extent of the impact that overloaded vehicles have on road infrastructure within tourist-heavy urban centers and to identify effective management solutions. The findings from the SLR indicate that excessive vehicle axle loads, or the presence of cities with high vehicular traffic, considerably expedite pavement damage and diminish the structural lifespan, as supported by evidence from 48% of the analyzed journals. These insights have practical implications for the assessment of road geometric designs, the examination of construction techniques and materials, and the formulation of models or policies that are congruent with the functional requirements of the city.

1. INTRODUCTION

Roads are land transportation infrastructure covering all parts of the road, including supporting buildings and equipment intended for traffic on the ground surface, above ground level, underground and/or water level, and above water level, except for railroads. and cable roads. Based on the Law of the Republic of Indonesia Number 38 of 2004, roads are classified based on their designation, encompassing public roads with functions categorized as arterial roads, collector roads, local roads, and environmental roads. Additionally, special roads are designated for specific purposes such as the distribution of goods and services, and are not intended for general traffic. According to Mohamed et al. [1] for the core transportation infrastructure, the road network has an intrinsic role in developing social and economic growth for each region and country. In addition, the existence of roads is also very important to support the growth of agriculture, culture, and other sectors [2]. Methodological gaps in addressing problems related to overloading, caused by heavy loads or an increase in the number of vehicles in several large cities in Indonesia, are often rooted in the lack of awareness among the public as road users. For instance, there is a significant gap in the predominant preference of the community for private vehicles over public transportation. These factors undoubtedly contribute to the heightened risk of premature damage to road pavements. Despite the government's efforts to enact regulations to tackle these issues, the cultural inclination in Indonesia remains resistant to swiftly comprehending and adhering to new regulations. Consequently, their implementation tends to be a time-consuming process.

Roads are currently often damaged in a relatively very short time (early damage), both roads that have just been built and roads that have just been repaired (overlay). According to Zainal et al. [3] basically, the road will experience a decrease in its structural quality by the increasing age of the road, especially if it is passed by vehicles with heavy loads and tends to exceed the provisions. According to Romadhoni et al. [4] the development and movement of people from one place to another in Indonesia is currently very high, making an efficient and well-maintained road network a very urgent need. Along with the increased movement of people and goods, increasing the concentration of people, especially in strategic areas, many vehicles also use these main roads over the planning limit [5]. In addition, there are physical and environmental developments of the metropolitan area [6], the distribution of the population that forms an urban sprawl result in unplanned and uncontrolled growth on the outskirts of the city, often characterized by low-density housing, single-use zoning, and increased reliance on private cars for transportation [7]. The

population of Indonesia is increasing every year, reaching a notable growth rate of 1.13% in 2023 [8] is accompanied by a rising number of vehicles, reaching 153.40 million units [9]. Consequently, there is a substantial demand for road transportation. According to a study by Arifin [10], road construction is intended to provide services based on planned longevity. However, in reality, many sections experience a reduction in service life due to damage to road pavements. The most dominant factor causing rapid road damage is the excessive load received by road construction, exceeding the planned load.

Tourist mobility is a central concern in planning, urban spatial planning, and tourism activities, as well as in maintaining the quality of life for various groups involved. Tourist cities with high visitor potential must organize urban areas by adjusting road user patterns to prevent the blockage of movement circulation [11]. Tourists in Indonesia seek a more flexible mode of travel to accommodate their diverse travel needs, primarily opting for private vehicles [12]. The visiting pattern of tourists in Batu City shows a preference for private vehicles such as cars, motorcycles, or native city buses, as opposed to public transportation options like city buses or local public transport, resulting in an increased traffic load. The number of road users to and from the Batu City area continues to rise annually, leading to frequent vehicle congestion and traffic jams due to the growth of vehicles that is not proportionate to the existing lanes [13]. When examined from a mechanical perspective, the high volume of vehicles entering Batu City leads to the stress experienced by the road structure surpassing the planned capacity. This excess stress can be likened to the stress induced by overloading a vehicle axle, as it produces similar effects, notably resulting in permanent deformation of the road pavement structure. Consequently, the material is prone to cracking at an accelerated rate. The combination of wheel load and high tire pressure that is ignored can damage the surface layer and the overall pavement structure [14]. Regional policy formation greatly influences travel patterns in a city [15]. The local government of Kota Batu has developed and implemented regulations and official frameworks, such as Local Regulation No. 3 of 2011 regarding Permits for Public Transport Routes. This regulation supersedes Regional Regulation No. 10 of 2010, which pertains to Parking Fees on Public Road Sides. Additionally, odd-even rules have been applied to regulate vehicle traffic in Batu City. However, it is perceived that these regulations are still suboptimal in addressing traffic congestion and the growing number of excess vehicles in Batu City. Drawing insights from other tourist cities in Indonesia, such as Bogor, Bali, or Yogyakarta, an emphasis is placed on urban planning and traffic flow management to mitigate road-related issues. Potential strategies include increasing road capacity, redirecting traffic, improving and promoting public transport, and leveraging real-time traffic flow technology.

In connection with the advancement of vehicle overload theory, this research aims to provide an update through an analysis of the impact of overload resulting from the increasing number of vehicles in the research area, thereby generating comprehensive data. This data will serve as valuable input for road pavement life plan engineering to enhance its effectiveness in accommodating vehicular movements. Additionally, the research will formulate policies within a sustainable operational framework at the Batu City government level. These policies will be utilized for the planning and development of tourist areas, incorporating optimal city planning and traffic management practices.

Research on the impact of overloaded vehicles on road damage has been carried out and published in several journals over the last few years. The overload in question is a vehicle with a load that exceeds the Heaviest Axle Load (MST) limit which affects the value of the Equivalent Standard Axle Load (ESAL) and causes road damage to occur more quickly (cutting the actual road plan life) [3, 4, 16-18]. In operational terms, the damage factor represents the number of passes equivalent to one standard axle producing the same wear effect as one truck pass [19]. Adopting from these studies, a journal article on this topic will raise the issue of the effect of excess traffic/number of vehicles going in and out of Batu City on flexible pavement structures which have an impact on reducing the plan life of the road using case studies of tourism cities in Indonesia. The following questions aim to discuss and synthesize open issues relating to future research directions:

1. What are the main causes of the occurrence of the road load phenomenon related to the age of the road/pavement and the planning of the road network in Batu Tourism City?
2. What is the impact on the road/sidewalk planning scheme for Kota Wisata Batu due to the increasing number of vehicles using the road in the tourist city?

Specifically, this research will focus on qualitatively identifying the results of data analysis. The methods or approaches employed for data analysis encompass vehicle volume analysis, axle load analysis, the AASHTO method for calculating remaining pavement due to overload [16, 20], the linear regression method for comparing the equivalent value of passenger cars, and the IRI (International Roughness Index) method for assessing road surface conditions. The examination of causal factors will facilitate the determination of the relationship between vehicle growth and its impacts, aiming to propose an operational framework as the primary target for improving policies [21] and road planning in the current and future context of the study area.

2. METHODOLOGY

This research aims to measure the impact of increasing the number of vehicles on the design life of roads, identify methods and approaches to overcome these problems, and propose an operational framework to improve road management. In line with these aims and objectives, this research employs a systematic literature review as the most appropriate method to establish a theoretical foundation by drawing on various studies conducted previously. This approach supports the resolution of the researched problem, enhances the understanding of the context based on a scientific framework, and ensures that the research incorporates the latest updates.

In conducting a literature review, this research synthesized the current body of knowledge by following the steps outlined by the studies [22, 23]. After formulating the problem, the subsequent stages included (1) Article identification; (2) Article selection and study evaluation; (3) Data analysis and screening; and (4) Reporting and utilizing results. It is important to note that this study did not include a separate assessment of the quality of the reviewed articles. Instead, the focus was on reviewing the most relevant literature of vehicle overload and government policies impacting road pavements in tourist cities. Thus, the discussion, implications, and conclusions can be presented at the end of the study.

Understanding the workflow through the methodology adopted in this research is explained in Figure 1 above with the following description:

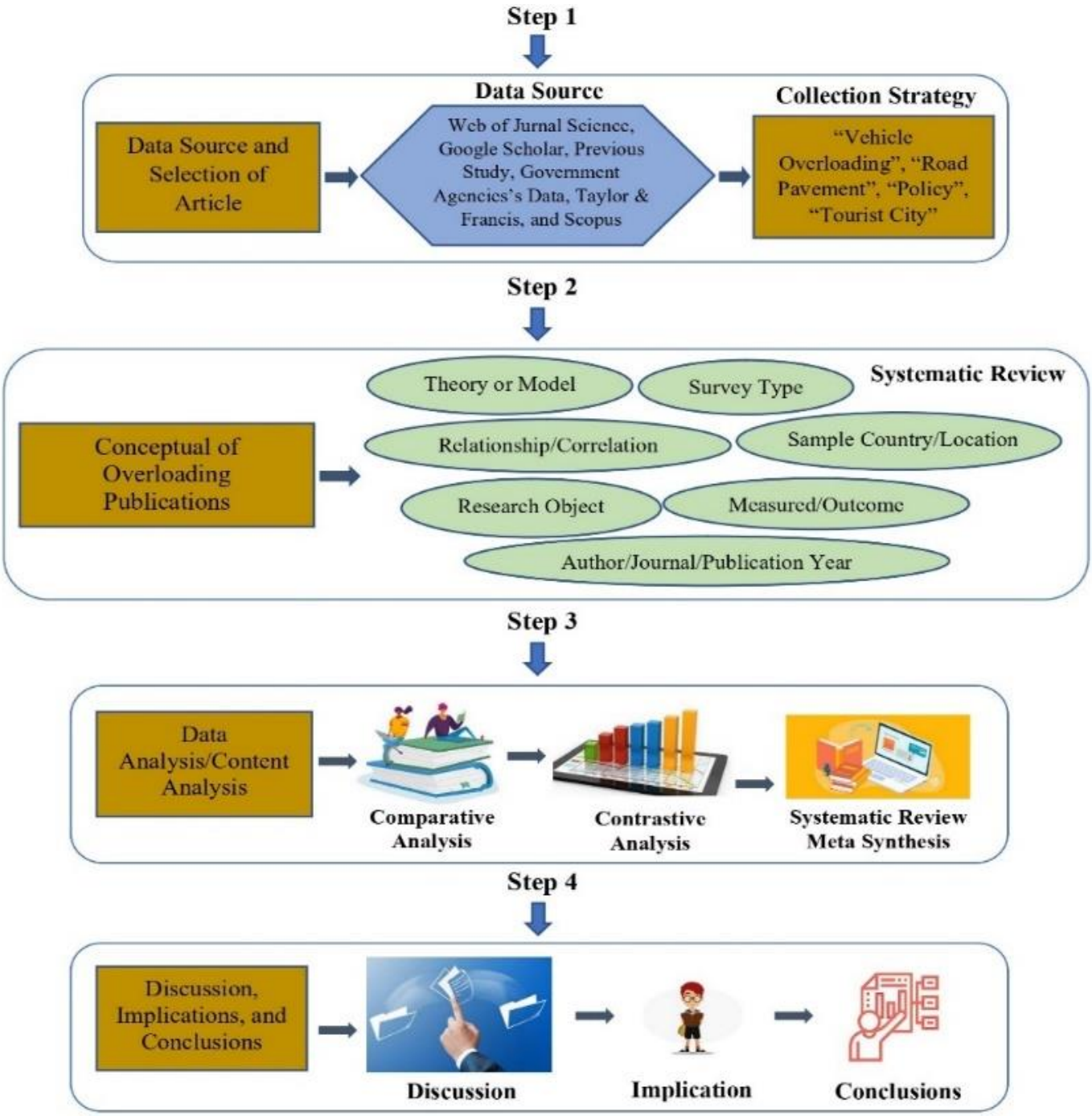

Figure 1. Research methodology

2.1 Article identification

In this study, article identification was carried out by searching using the right keywords to compile a literature review. This study chose "Vehicle Overloading", "Road Pavement", "Policy", "Tourist City " as keywords. Similar words were identified and used as alternative words during the search process, such as those relating to “Sustainable Road Construction”, “Sustainable Road Transport”, “Highway Damage”, “Age of Road Pavement Plans”, “Tourism City Growth”, “Urban Sprawl”, “Vehicle Mobility”. The search was conducted on September 7, 2021 and renewed on March 9, 2023.

2.2 Article selection and study evaluation

In Figure 2, it is explained that the keywords mentioned are used in databases such as Science Direct, Google Scholar, Journal of Science Publishing, and Taylor & Francis. After looking through some of these databases, about 200 have been found. Exclusion criteria apply to articles under 2010, using Indonesian or English with appropriate keywords (e.g. "Vehicle Overloading" in Science Direct, Journal of Science Publishing, or Taylor & Francis). The study evaluation was carried out in relation to the contributions that were dismissed during the "title analysis" then "abstract analysis" until the 50 most suitable articles were obtained.

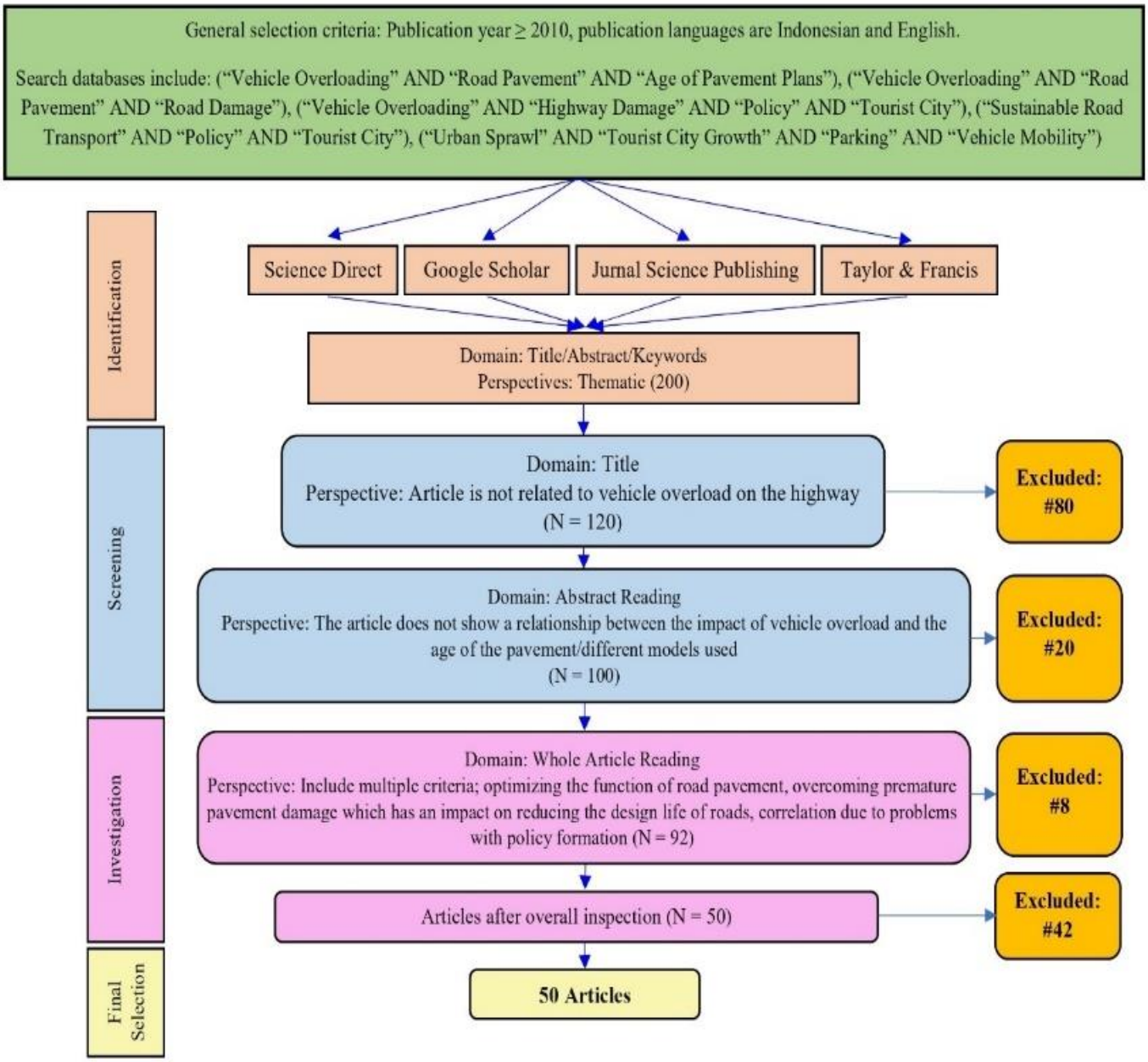

Figure 2. Article selection and study evaluation

2.3 Data analysis and screening

Data analysis and filtering is done by taking relevant information based on the research discussed. Identification is done by looking at things that are needed for further research. Data analysis details several aspects in the article as comparison material using descriptive analysis methods (general information and content) as well as data collection using comparative analysis, contrastive analysis, and systematic review meta synthesis methods which can be described as follows:

2.3.1 Comparative analysis

Comparative analysis is a method of looking at two or more similar objects to see the differences and similarities they have [24]. This study employs comparative analysis to explore similarities and differences within the same research object, such as overloading on road pavements, which can impact the condition or design life of the pavement, as well as data analysis methods and anticipated problem-solving.

2.3.2 Contrastive analysis

Contrastive analysis is a systematic method used to identify structural differences and similarities of two particular things [25]. Through contrastive analysis, data can be discerned by examining the distinctions among the selected journals, enabling the drawing of conclusions. Differences between journals in this study can be identified based on overloading resulting from an increase in the number of vehicles, road functions, city functions, and policies implemented to address various road-related issues.

2.3.3 Systematic reviews meta-synthesis

This method is used to present results by combining data from various studies conducted on similar research topics [26]. In this study, data were obtained online or digital libraries by searching and selecting journals/articles using keywords as well as several predetermined exclusion and inclusion criteria so that new ideas for research could be obtained [27]. The compilation of various data for the overload topic involved incorporating traffic analysis data, road infrastructure

planning data, and several methods used. To address potential contradictions or gaps in the findings, the combined data will be adjusted to the specific conditions of the city or region that is relevant or closely aligned with the study area.

2.4 Reporting and using results

The articles used will be arranged in a recapitulation table based on the contents of the description that contributed to the research.

3. RESULTS AND DISCUSSION

3.1 Descriptive analysis

3.1.1 General information analysis

Based on literature analysis from several journal articles, it is known that interest and attention in conducting research related to the topic of overloading has been carried out continuously since 2013 until now due to population growth factors accompanied by increasing vehicle ownership in various parts of the world. This topic is generally discussed by journals related to the field of study of Transportation and Civil Engineering.

3.1.2 Content analysis

Based on the analysis of the main themes from the journal articles that have been collected, most of the research contributions reviewed discuss phenomena that occur in traffic and flexible road pavements with an outline of the discussion containing the influence/impact of vehicle overloading on construction or pavement life (n=19), review of models or control efforts in overcoming road problems and overloading that occur (n=16), development of urban areas from urbanization factors (n=1), phenomena and development of cities as tourist attractions (n=5), transportation strategies sustainable (n=1), and policy implications or enforcement for transport within an urban area (n=8). Table 1 contains the contributions considered for the literature review and provides specific knowledge which contains Main Themes, Theoretical Lenses based on the author's report, Methods used, and Sectors Investigated.

Table 1. Summary of selected articles, methods and research sector prior to the screening process

General Information		Fill		
Aut.	**Journal**	**Journal Themes and Theoretical Lenses**	**Method**	**Research Sector**
[28]	J. Procedia Social and Behavioral Sciences	Urban freight transport policy oriented model	Operational policy-oriented model analysis, methodological approach to urban goods movement survey	Urban Area
[29]	J. Urban Studies	Urban transport policy – New Urban Politics	Interview, quantitative and qualitative analyzes of urban policy, and the NUP literature	Manchester Olympics and Commonwealth Games Project
[21]	J. Transportation Research Part E: Logistics and Transportation Review	Overloading control for optimizing road handling costs – road transport interaction model	Two-level model approach (representing the interaction between vehicle loading practices and road planning authority policies)	Mexico
[30]	J. Procedia-Social and Behavioral Science	Controlling vehicle overloading – BOT	Existing condition axle load survey, identification of overload effect, overload control	New Delhi, India
[14]	J. Procedia Engineering	Durable and sustainable road construction – geometric design, road UR and axle loads	Axle load analysis, quality of construction against UR, analysis of recycled materials for pavement	Developing country
[31]	J. Transportation Engineering	Impact of excess traffic on road performance	Analysis of toll road traffic database for 5 years, UR and ESAL	Toll road
[17]	J. Works of Civil Engineering	Effect of overloading – road performance – road UR	supply demand analysis (road performance, flexible pavement, overloading)	Pringsurat Highway Section, Ambarawa-Magelang, IDN
[16]	J. Civil and Environmental Engineering	Effect of vehicle loads – degree of damage & road UR	Data collection and analysis of the remaining UP & DKJ from overloading	Prabumulih Street KM 32 Indralaya, South Sumatra, IDN
[32]	International Journal of Civil & Structural Engineering Research	Parking patterns for different parking facilities	Survey of variations of vehicles in parking lots, t tests, and parking patterns	India
[33]	J. of Economics and International Business Management	Traffic violations in urban areas a management perspective	Descriptive statistics and non-parametric tests	City of Windhoek Namibia

[34]	J. Construction and Building Materials	Asphalt pavement rutting behavior	Generalized Kelvin model, proposed new method, tangential stiffness matrix and vehicle load mode selection, and constant power in limited model.	Mountain Road, China
[35]	International Journal of Pavement Engineering	Effect of overloaded vehicles – road UR	Analysis of moving load data by WIM, asphalt pavement analysis, and fatigue life of pavement structures	Poland
[3]	J. Online Student of Civil Engineering	Effect of vehicle load – road damage	Data collection and analysis of MST & UR roads	Pahlawah Street Section, Citeureup, Bogor, IDN
[36]	J. Ghana Institute of Journalism	Overloaded goods trucks on toll roads	Fgd, interview, distribution of questionnaire and observation	West African Highway
[37]	J. Bridge Engineering	Characteristics and impact of overloaded extra heavy truck	Statistical monitoring of traffic data, classification of typical vehicle types, analysis of traffic scenarios, chi-square test, and comparison of Chinese and AASHTO codes	Xuanda Highway, China
[38]	J. Transportation Research Prodia	Enforcement of overload regulations on commercial vehicles – WIM	Determination of project location, implementation time, due diligence on WIM's response value and performance, evaluation and enforcement of regulations	Nantes, France
[39]	International Journal of Advance Research in Science and Engineering	Study of traffic and transport elements – medium urban planning approach	Traffic statistics survey and analysis, speed study, parking demand analysis, integration of multimodal transport, and model simulation with SUMO	India
[2]	J. Infrastructure	Study of early pavement damage factors – handling costs	Comparison of damage with previous research, classification of damage factors (fishbone diagram), identification of damage factors, analysis of the relationship between KPJ and handling costs (IRI and SDI)	Indonesia
[4]	J. Pakuan University	Influence of vehicle load – road UR	Data collection and analysis of MST, TP & UR roads	Mesuji Street, Lampung, IDN
[40]	J. Science and Civil Engineering Applications	Influence of vehicle load – road UR	Data collection and analysis of TP, UR roads & MST	Section Gusig-SP3 Blusuh, West Kutai, East Kalimantan IDN
[41]	J. Sustainability	The impact of tourism in the context of cities – the concept of overtourism	Tourism investigation, identification of managers, determination of respondents, interview, identification of perception patterns and management of overtourism	13 Tourist Cities in Europe
[42]	J. of Destination Marketing and Management	Overtourism and city survival	Ambidextrou management approach (exploitation & exploration)	City of Venice, Italy
[43]	J. Civil Static	Overload effect – road UR	ADT and vehicle overload data collection, VDF analysis and its increase due to overload, and ESAL analysis for road UR	Manado-Bitung Road Section, IDN
[44]	International Journal of Pavement Engineering	The impact of traffic loads on flexible pavements	Determination of typical fleet composition at the study site and simulation of heavy traffic flow with two scenarios	City of Portoviejo, Ecuador
[45]	J. Road Materials and Pavement Design	Effect of vehicle speed and overload on road pavement	Stress-strain response simulation, pavement transient dynamic analysis, and implicit dynamic analysis	China
[7]	J. of Urban and Regional Planning	The phenomenon of urban sprawl to changes in land use on the outskirts of the city	Literature review and urban sprawl analysis	Suburban Area, IDN
[46]	J. Transportation Research Procedia	Pavement damage – overloaded vehicles	Pavement structural analysis (Brazilian Method), HDM-4 Models analysis, and life cycle cost analysis for 30 years	Brazil
[12]	J. Transportation Research Part A: Policy and Practice	Policies on travel behavior of workers by public transport	Identification of dominant travel patterns by transit commuters and analysis of household travel activity surveys	US residents in all 50 states and the District of Columbia
[47]	J. Transportation Research Part A	Evaluation of city-scale built environment policies with new mobility	Nested logit mode choice modeling methods and synthetic population analysis	New York City, USA

[48]	J. Construction and Building Materials	Rutting resistance factor – multi sequence repeated loading test	MSRL test (specimen depth, separated layers, stress strain rate correlation, Compound Strain Rate (ec) indication, distribution analysis, and ANOVA	Jiangsu Province, China
[49]	J. Tourism Management	Development of road and transportation infrastructure for tourism	Data collection by online survey using a questionnaire (n = 350 people)	China-Pakistan Economic Corridor
[50]	J. Sustainability	Smart tourism city	A conceptual approach to the definition of a smart tourism city	Smart Tourism City concept
[51]	J. Frontiers in Sustainable Cities	Traffic calming on mobility, road safety, and pavements	Measuring spot speed and vehicle speed profile, visual inspection, geodetic laser leveling instrument	Abuakwa-Bibiani Toll Road
[52]	J. Engineering, Mathematics and Computer Science	Modification of the impact of the zero overloading policy on road UR	Comparison of CESA with 4 policies and policy changes	Java North Coast Road (Pantura), IDN
[53]	Proceedings of the 4th International Conference on Indonesian Social and Political Inquiries	Sustainability of road infrastructure – weigh bridge policy	Qualitative descriptive by obtaining information from related parties	Central Java and the Special Region of Yogyakarta IDN
[54]	J. Infrastructures	Futue mobility overview – smart roads	Assess the characteristics of smart roads by considering their advantages and disadvantages	Highway Infrastructure
[55]	J. Transportation Research Part A	Legal establishment of commercial vehicle weight limits – WIM & the Act	WIM trend analysis, administrative survey (n = 37) of road transport operators, respondent characteristic survey, binomial regression test, overload mitigation and regulation, regulatory recommendations	Abu Dhabi, Emirates
[56]	J. of Traffic and Transportation Engineering (English Edition)	Pavement engineering and material innovation – pavement engineering research review 2021	Performance analysis and modeling of asphalt binder, mix performance and modeling of pavement materials, multi-scale mechanics, green and sustainable pavements, and strong pavements	China
[57]	Simulation Modeling Practice and Theory	Urban transport simulation model specifications – travel and tour based models to convert deliveries into vehicle flows.	Travel-based model analysis, tour formation heuristics, and delivery sequencing models	Comparative Models; Singapore Vehicle Operations Data
[58]	International Journal of Environ mental Research and Public Health	Tourism urbanization factors in tourist cities	State space analysis method, standard deviation ellipse, and spatial autocorrelation analysis	35 Major Tourist Cities, China
[59]	J.E3S Web of Conferences	Sustainable transportation strategy	Identification and evaluation of city conditions, population, number of vehicles, and transportation infrastructure	Riyadh, Saudi Arabia
[60]	Thesis	Impact of traffic loading on the road	Shaft load measurement with static axle weighing machines and moving weighing machines with visual inspection and questionnaire	Cabanas Highway, Kenya
[61]	International Journal of Geotechnique Construction Materials and Environment	Impact of overload on pavement design life - WIM	WIM and VDF surveys, as well as a comparison of Cumulative ESAL and Pavement Damage Ratio	Lampung and Palembang, IDN
[62]	J. Engineering Failure Analysis	Pavement structure failure – overload	Discussion with stakeholders, visual route survey of the road, conduction of test pits in the most severely damaged sections of the road, collection of soil samples, & generation of soil profiles	Minna-Kateregi-Bida Road, Nigeria
[63]	J. Transportation Geotechnics	Effect of overload and road pavement sealing conditions – road UR	Stress-strain analysis with AEMC, pavement condition analysis with FWD, deflection simulation with BackMeDiNa	BR-116/BA, Brazil
[64]	J. Construction and Building Materials	Investigation of early failure mechanisms of national roads – pavement bonding, overloading, and layer stiffness	Numerical parametric study with variable bonding conditions between pavement, overloading and layer stiffness, laser crack measurement system, and variation of base layer stiffness from DCP test	Bangladesh National Highway

[65]	J. of Regional and Rural Development Planning	Urban sprawl recommendations for controlling space utilization and development	Analysis of urban sprawl adoption from related research, analysis of autocorrelation of Moran and LISA indices, analysis of alignment of land use and spatial pattern of RTRW, and overlay	Karawang Regency, West Java, IDN
[66]	J. Research in Transportation Business and Management	Tourist mode of transport	Multinomial logit regression analysis	Barcelona
[67]	J. Earth and Environmental Science	Transportation infrastructure development	Spatial concentration analysis using the LQ index approach and assessing the direction of spatial planning policies	East Kalimanta IDN
[68]	J. Omega	Road network restoration efficiency – an integrated framework	Model-based data analysis for interdependent coordination "damage assessment", "road restoration" and "aid distribution" and integrative frame work development	Miami-Dade and Broward Highways USA

Notes: ADT = Average Daily Traffic; DKJ = Degree of Road Saturation; UR = Planned Age; UP = Pavement Age; US = United States of America; CESA = Cumulative Equivalent Single Axle Load; BOT = Built Operational and Transfer; WIM = Weight in Motion; LQ = Location Quotient; MST = Heaviest Axle Load; ANOVA = Analysis of Variance; MSRL = Multi-Sequenced Repeat Load; NUP = New Urban Politics; KPJ = Road Pavement Damage; TP = Pavement Thickness; RTRW = Regional Spatial Plan; IDN = Indonesia; PSO = Particle Swarm Optimization; SUPAS = Inter-Census Population Survey; VDF = Vehicle Damage Factor; LISA = Local Indicator of Spatial Association; ESAL = Equivalent Standard Axle Load; DCP = Dynamic Cone Penetration; SUMO = Simulation of Urban Mobility; FWD = Falling Weight Deflectometer.

3.2 Literature review results

Based on the literature review summary for this study, 30 out of 62 studies, or 48% of the most relevant journals, indicate that vehicle loads exceeding specified limits can notably impact the condition of the structure or the lifespan of highway pavement and potentially lead to an increase in traffic accidents. As explained by Santana et al. [63] overloading the vehicle axle accelerates pavement damage and has an impact on the structure's lifespan, establishing a close relationship between the prediction of pavement life and the increase in the percentage of vehicle load on the road. A total of 14 studies explained that vehicle overload can be identified from normal vehicles and heavy vehicles with loads that exceed the heaviest axle load (MST) limit of each Axle Standard Equivalent Load (ESAL). The extensive variations found in the literature reviewed above contribute to a comprehensive perspective. The benefit obtained from this examination is that the advantages and disadvantages of prior research can be identified, aiding in achieving objectives and enhancing the current research. Generally, the AASHTO method is commonly employed in designing roads, and it provides empirical evidence of traffic loads over the design life. Although this method is widely used and considered the best for problem-solving in road pavement, there has been no update to the method to reflect current times. Nevertheless, other research introduces various methods, particularly the Weigh In-Motion (WIM) analysis, which is recommended and considered more efficient, especially in urban areas with high vehicle intensity. This analysis facilitates the accurate collection of vehicle load data through a sophisticated system. However, the implementation of this method remains uncommon due to its high costs and the need for experienced and professional regulators.

Most of the articles that have been reviewed (as many as 80%) indicate problems related to traffic and roads, including overloading which often occurs in big cities with rapid development and population growth followed by high vehicle movements. The countries with the greatest number of discussions related to problems that occur on the road pavement include China, India, Arabia, and Indonesia. Based on the review of the article above, addressing road problems, especially overloading, can be approached through various means. This includes evaluating the geometric design of the road and reviewing the techniques and materials used in planning road pavements. Furthermore, existing issues serve as a basis for enhancing discipline by establishing models, regulations, or policies that coordinate all activities within a city. This involves considering multiple aspects such as the city's function, roads as infrastructure, accessibility, and vehicles as means of transportation. The implications of such policies generally involve interventions such as simulating travel models or altering the function of vehicles in the city, with an emphasis on promoting the use of public transportation as a primary driving force. Local governments, as stakeholders, play a crucial role in conducting focus group discussions and formulating policies. Notable examples include New York City implementing a smart city approach to realize its built environment policy, the United Arab Emirates formulating and implementing an effective weight limit law for road safety, and China planning the layout of a tourism toll road network.

3.3 Key findings and discussion

This research in the context of the discussion will discuss the current limitations with ongoing research flows in the future for investigations between policy enforcement and the impact of vehicle overload on road pavement. Table 1 provides a summary of several forms of problem-solving efforts related to the impact of overloaded vehicles in urban areas. However, there are still many deficiencies in analyzing the problem in question, including a lack of supervision of vehicles crossing urban roads, a lack of firmness towards road users, drainage or supporting road bodies that are not functioning properly, and pavement construction that is not strong and easily damaged to support the vehicle load [3, 4, 16, 17, 40, 43]. However, so far there has been no research related to vehicle overloading that examines the number of vehicle movements. This research will encourage further efforts to overcome existing problems by establishing policies that are sought directly from the city government of the research location.

Contextual factors that influence overloading include: First, the results are affected by the context of vehicle overload

which can reduce the life of the pavement plan so that the road will be damaged more quickly [40]. There are other factors that might influence this, so the literature suggests considering the types of vehicles that pass with a tendency to exceed the maximum provisions [3, 16, 63] checking the large vehicle [3, 4, 61, 69] measuring the reproducibility of the vehicle flow model between zones or adopting a choice of sequential destinations [57, 70] maintenance costs and overloaded vehicles [31, 46, 55] vehicle speed and design of pavement structures or mixes [45, 51, 64, 71], geometric design of roads [14] replacement of vehicle equipment [72] maintenance of waterways (drainage) [2, 4] or modification of road pavement forming materials [48, 64, 71].

Second, discussion of the city context from a socio-economic perspective is as a center for tourism activities which is very dependent on road, transportation, and communication infrastructure [67]. In addition, the high level of urbanization causes the intensity of urban growth concentration to also increase [73]. Future issues related to urbanization suggest the need for a direction to improve spatial planning based on city conditions [65] and provide easy accessibility, topography, availability of vacant land, transportation routes and land prices [7] while issues related to the activities of tourist cities, namely changing the pattern of visiting tourists by public transportation [12] collecting lots of data from different cities and find scope for several factors in capturing the overall characteristics of tourism activities [74] develop a tourism mobility plan [29, 58, 66], overcome overtourism and support tourism development [42] or developing the integration of expressway networks and tourism resources [49, 75].

Third, the context that leads to organizational and policy implications can be seen from the relationship between personality and road and traffic safety behavior [76]. Several literatures provide input to overcome the problem of road maintenance and enforcement of overload control [21, 60] by means of cost optimization and setting fines [21] provision of separate special vehicle operating environments with an effective framework [55] installation of weighbridges [30] or weigh in motion (WIM automatic) [38] pavement rehabilitation [77] traffic control [33] zero overloading policy [52] or a proposed discrete choice model to determine community location choices and departure times [47].

In order to overcome the phenomenon of overload due to the very high number of vehicle movements at the study site and investigate the questions raised for future research, it is necessary to carry out an important combination of theoretical studies and empirical studies. This is done because there has not been found similar research or research that is relevant to similar case studies based on the literature that has been collected. From this point of view, the existing literature shows that there are many factors that cause premature pavement damage due to the phenomenon of vehicle overload (most of them are trucks, tow trucks, and semi-trailers [3, 4] problem analysis was also carried out using various types of methods adapted to the conditions of the study area and the supporting equipment available in the city or country concerned (interview/questionnaire [28, 49] simulated traffic movements [44] visual observations with weighbridges or WIM motion sensors [30, 38] or track data from GPS [57, 70, 77]. Apart from that, decision/policy making really needs to be done, one of which is for the sustainability of road transportation [53] and smart transportation innovation [54]. This innovation is possible because many big cities in the world have invested in and recognized the concept of smart tourism cities and strategies relate to optimizing a sustainable environment [50]. Methods from the literature have their respective weaknesses including in terms of time, cost, and other aspects. This weakness underlies researchers to carry out developments in the hope that implementation can function not only at the study site but globally.

4. CONCLUSION

The key findings supporting the research objectives indicate that the rise in the number of vehicles correlates with an escalation in the load exerted on road pavements. Consequently, the percentage of premature damage to road pavements also increases. Additionally, addressing the issue of overload can be mitigated or reduced by implementing policies in a phased manner, tailored to the specific conditions of the study area. The objective of specialization is to obtain the whole atlas of specialization chains (graphs) by assigning various types of members and joints to each available generalized chain (graphs) subject to the design requirements and design constraints specified above. Various types of theories, models, and policy implementations have been used to examine the impact of vehicle overload which will affect the pavement structure and the design life of the road itself. The literature review that has been reviewed conducts research based on problems that occur in each country or city with different pavement and environmental conditions so that the aspects discussed are quite broad but not far from the core/themes carried out in this study. The process of selecting and filtering articles, as illustrated in Figures 1 and 2, forms the foundation of the literature review in this research. It aims to contribute to an enhanced understanding of issues related to policies for excessive vehicle numbers, assumed to have similar implications as excess vehicle loads on road pavement. This undoubtedly influences the strength of the pavement structure and its overall lifespan.

Study literature review is carried out to obtain theoretical foundations that can be used to support solving problems that occur. In this case, the case study was conducted in Batu City, East Java, Indonesia. As a result of the city being known as one of the leading tourist cities because of its potential for extraordinary natural beauty, the growth of this area also encourages economic growth. The surge in tourists (inter-city and foreign) that occurs at any time can cause excessive road loads, the impact that will be felt if this problem continues is premature damage to road pavement causing congestion and even accidents. Seeing the existing conditions, the most efficient method is used, namely the analysis of the heaviest axle load by calculating each ESAL value but based on the number of vehicle movements in and out of Batu City, as well as the pavement assessment and the plan age of the road using the AASHTO method. After analyzing traffic and road pavement, the obtained results will serve as recommendations for policy formation. The proposed primary policy initiates with focus group discussions and the engagement of stakeholders in Batu City. Formulation follows the policy preparation guidelines set by the Indonesian Government. This policy includes regulations such as the expansion of main roads to facilitate vehicle movement, encouraging the shift from private vehicle use to public transportation in Batu City, expanding and developing terminals, and implementing traffic management measures. Therefore, establishing a policy to

address the issue of excessive vehicle numbers in Batu City can serve as a reference for discussions, promoting the sustainability of street life in line with planning needs. This policy model can also be applied in similar cases in other areas. Future research should delve into vehicle load calculations, particularly involving the increasing number of motorized vehicles (two-wheeled), and explore more efficient structuring of tourist city areas.

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