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Non-Newtonian Fluids in Speed Breakers

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Abstract: *Road safety is a major concern due to the increasing number of vehicles and accidents caused by overspeeding. Conventional speed breakers are effective in reducing vehicle speed; however, they often cause discomfort to passengers, damage to vehicles, and increased maintenance costs. This project proposes the use of Non-Newtonian Fluids (NNFs) in speed breakers as an innovative solution to overcome these limitations. Non-Newtonian fluids possess unique rheological properties in which their viscosity changes with the applied force or shear stress. Under normal driving conditions, the fluid remains soft and allows vehicles to pass smoothly. When a vehicle crosses the speed breaker at a higher speed, the fluid instantly becomes rigid, creating greater resistance and effectively reducing the vehicle's speed. A prototype speed breaker was developed using a cornflour-water mixture enclosed within a sealed rubber casing and tested under different loading and speed conditions. The study concludes that non-Newtonian fluid-based speed breakers have significant potential for application in schools, residential areas, campuses, and other low-speed zones, contributing to the development of smarter and adaptive road infrastructure.*

Keywords: Non-Newtonian Fluid, Smart Speed Breaker, Shear-Thickening Fluid, Road Safety, Traffic Calming, Impact Absorption, Vehicle Speed Control, Cornstarch-Water Mixture, Adaptive Infrastructure, Sustainable Transportation.

I. INTRODUCTION

Road transportation plays a vital role in modern society by enabling the movement of people and goods efficiently. However, the rapid growth in the number of vehicles has led to increased traffic congestion and road accidents, particularly in urban and residential areas. Overspeeding is one of the major causes of road accidents, posing significant risks to pedestrians, cyclists, and other road users. To control vehicle speed and enhance road safety, speed breakers are commonly installed near schools, hospitals, residential zones, and other sensitive locations. Although traditional speed breakers are effective in reducing speed, they often create discomfort for passengers and may cause damage to vehicles when crossed at inappropriate speeds.

Conventional speed breakers are rigid structures made from materials such as concrete, asphalt, or rubber. These structures provide a fixed resistance regardless of the speed or weight of the vehicle. As a result, even vehicles traveling at safe speeds experience sudden jolts and vibrations while crossing them. Repeated exposure to such impacts can lead to wear and tear of vehicle components, increased maintenance costs, and reduced driving comfort. Furthermore, rigid speed breakers may contribute to traffic delays and fuel consumption due to frequent braking and acceleration. These limitations have encouraged researchers and engineers to explore innovative alternatives that can provide adaptive speed control while minimizing adverse effects on vehicles and passengers.

One promising solution is the application of Non-Newtonian Fluids (NNFs) in speed breaker systems. Non-Newtonian fluids are unique materials whose viscosity changes when subjected to different levels of stress or shear force. Unlike Newtonian fluids such as water, whose viscosity remains constant, non-Newtonian fluids can behave as either liquids or solids depending on the applied force. A common example is a cornstarch-water mixture, which flows easily under gentle movement but becomes rigid when subjected to sudden impact. This remarkable property makes non-Newtonian fluids suitable for various engineering applications, including protective equipment, vibration dampers, and impact-resistant systems.

The concept of incorporating non-Newtonian fluids into speed breakers is based on their ability to respond dynamically to vehicle speed. When a vehicle moves slowly over the speed breaker, the fluid remains in a soft and flexible state, allowing smooth passage with minimal vibration. However, when a vehicle crosses the speed breaker at a higher speed, the fluid rapidly stiffens due to increased shear stress, creating greater resistance and forcing the driver to reduce speed. This adaptive behavior provides an intelligent traffic-calming mechanism that offers both safety and comfort. Additionally, the energy-absorbing characteristics of non-Newtonian fluids help reduce shock loads and improve the durability of the speed breaker system.

The present project focuses on the design and study of a non-Newtonian fluid-based speed breaker using a cornstarch-water mixture enclosed within a sealed casing. The project aims to investigate the fluid's behavior under different loading and speed conditions and evaluate its effectiveness in controlling vehicle speed. Through prototype development and experimental testing, the study examines parameters such as shock absorption, vibration reduction, load-carrying capacity, and overall performance. The proposed system has the potential to provide a safer, more comfortable, and environmentally friendly alternative to conventional speed breakers, contributing to the advancement of smart road infrastructure and sustainable transportation systems.

II. PROBLEM STATEMENT

Traditional speed breakers are widely used to control vehicle speed and improve road safety in areas such as schools, hospitals, residential zones, and public institutions. However, conventional speed breakers are rigid structures that apply the same level of resistance to all vehicles regardless of their speed. This often results in excessive vibrations, passenger discomfort, vehicle damage, increased fuel consumption, and higher maintenance costs. Vehicles traveling at safe speeds are also subjected to unnecessary shocks, reducing driving comfort and causing wear and tear of suspension systems and other vehicle components.

Furthermore, existing speed breakers lack adaptability and cannot distinguish between slow-moving and overspeeding vehicles. As traffic density and vehicle usage continue to increase, there is a need for an intelligent and adaptive traffic-calming solution that can effectively reduce the speed of fast-moving vehicles while allowing smooth passage for vehicles traveling within permissible speed limits. Therefore, the challenge is to develop a smart speed breaker system using non-Newtonian fluids that can dynamically change its stiffness according to the applied force or vehicle speed, thereby improving road safety, minimizing vehicle damage, enhancing passenger comfort, and supporting the development of sustainable and intelligent transportation infrastructure.

III. OBJECTIVES

- To study the rheological properties and behavior of non-Newtonian fluids under different stress and shear conditions.
- To design and develop a prototype speed breaker incorporating non-Newtonian fluid technology for adaptive speed control.
- To analyze the response of the non-Newtonian fluid-based speed breaker under varying vehicle speeds and loads.
- To evaluate the effectiveness of the system in reducing vehicle speed while maintaining passenger comfort and safety.
- To investigate the shock absorption and vibration damping capabilities of non-Newtonian fluids in traffic-calming applications.

IV. LITERATURE SURVEY

Paper 1: Design and Development of Non-Newtonian Fluid Speed Breaker (2025)

Authors: Nishant Bhalshankar, Harshad Patil, Vedant Chorge, Manas Adhav, Nitish Bhil, Mohammad Amin Journal: International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), 2025 This research focused on developing a smart speed breaker using shear-thickening non-Newtonian fluid. The fluid was enclosed within a flexible casing and tested under varying loading conditions. The study demonstrated that the fluid remained soft when subjected to low forces but became rigid under sudden impact caused by high-speed vehicles.

Experimental results showed significant improvement in vehicle control, passenger comfort, and shock absorption compared to conventional speed breakers. The authors concluded that non-Newtonian fluid technology could provide an effective and adaptive solution for traffic calming while minimizing vehicle damage.

Advantages:

• Adaptive stiffness according to vehicle speed.

• Reduced vehicle wear and tear.

• Enhanced passenger comfort and safety.

Paper 2: Non-Newtonian Fluid Speed Bumps: A Sustainable Traffic-Calming Solution (2026)

Authors: B. Singha, S. K. Das, and Team

Journal: Journal of Intelligent Construction, 2026

This paper reviewed the application of non-Newtonian fluids in modern traffic-calming devices. The researchers analyzed various fluid compositions and their responses to different stress levels. The study highlighted that non-Newtonian speed bumps can absorb impact energy more efficiently than conventional speed breakers. The proposed system reduced unnecessary resistance for slow-moving vehicles while effectively slowing down speeding vehicles. The paper also discussed the environmental and economic benefits of adaptive speed control systems in smart city infrastructure.

Advantages:

• Lower maintenance costs.

• Environmentally sustainable design.

• Suitable for smart road systems.

Paper 3: Study and Analysis of Non-Newtonian Fluid Speed Bump (2024)

Authors: K. Ramesh, P. Kumar, and Co-authors Journal: Journal of Emerging Technologies and Innovative Research (JETIR), 2024

This study investigated the performance of a non-Newtonian fluid speed bump through laboratory experiments and simulation analysis. The researchers evaluated parameters such as speed reduction, vibration control, ride quality, and fuel efficiency. Results indicated that vehicles experienced smoother movement at low speeds while high-speed vehicles encountered increased resistance. The damping characteristics of the fluid significantly reduced vibrations and noise levels. The study concluded that non-Newtonian speed bumps offer a practical and efficient alternative to conventional road humps.

Advantages:

• Improved ride comfort.

• Reduced vibration and traffic noise.

• Better speed control efficiency.

Paper 4: Design and Fabrication of Speed Bump Using Non-Newtonian Fluid (2024)

Authors: Dhanushekar V., Mukul Rajkumar, Sai Pavan B.G., Sujeeth Kumar

Institution: Atria Institute of Technology, Bengaluru

The objective of this research was to design and fabricate a prototype speed bump using a shear-thickening fluid enclosed within a durable rubber structure. The fabricated model was tested under different load conditions to analyze deformation and impact resistance. The results showed that the fluid-based speed bump adapted effectively to varying vehicle speeds. Slow-moving vehicles crossed the speed bump comfortably, whereas overspeeding vehicles experienced higher resistance. The authors emphasized the potential of the technology for reducing suspension damage and improving road-user satisfaction.

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Advantages:
- Flexible and durable structure.
- Reduced impact on vehicle suspension.
- Better user comfort and safety.

Paper 5: A Study on the Behavior of Speed Breakers Using Non-Newtonian Fluid and Comparison with Conventional Speed Breakers (2021)

Authors: M. Venkatesh, R. Karthikeyan, and Team Journal: International Journal of Engineering Research and Technology (IJERT), 2021

This paper compared the performance of non-Newtonian fluid speed breakers with traditional rigid speed breakers. The researchers used a mixture of nanosilica and polypropylene glycol as the shear-thickening fluid. Experimental observations showed that the proposed speed breaker remained soft under normal conditions but stiffened rapidly under sudden loads. Compared with conventional speed breakers, the system produced lower vibrations, reduced passenger discomfort, and minimized damage to vehicle components. The study concluded that adaptive speed breakers can significantly improve road safety while maintaining driving comfort.

Advantages:
- Dynamic response to vehicle speed.
- Reduced maintenance requirements.
- Improved safety and driving experience.

Research Gap

The reviewed studies indicate that non-Newtonian fluid-based speed breakers provide better shock absorption, adaptive speed control, and improved passenger comfort compared to conventional speed breakers. However, most of the research has been limited to prototype development and laboratory testing. Very few studies have investigated long-term durability, environmental effects, large-scale field implementation, and maintenance requirements under real traffic conditions. Therefore, further research is required to develop a robust, cost-effective, and commercially viable non-Newtonian fluid speed breaker for practical road applications.

V. WORKING OF SYSTEM

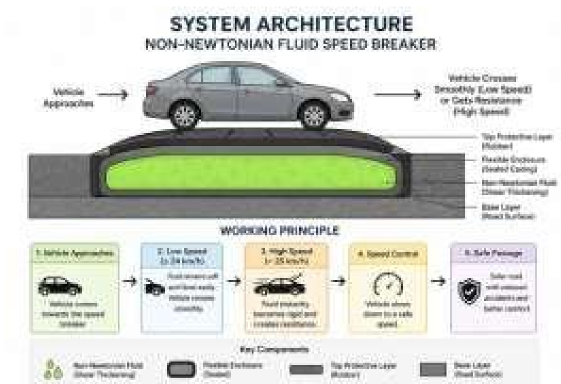

Fig 1: Design of the system

A. Vehicle Approaches the Speed Breaker

The first stage of the system begins when a vehicle approaches the non-Newtonian fluid speed breaker. Unlike conventional concrete speed breakers, this design contains a special fluid enclosed within a flexible casing. The speed breaker appears similar to a normal road hump from the outside, allowing easy installation on roads, school zones,

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residential areas, hospitals, and college campuses. At this stage, the system remains in its normal state and waits for the load applied by the vehicle. The behavior of the speed breaker depends on the speed and force exerted by the vehicle tires.

B. Top Protective Layer and Flexible Enclosure

The upper portion of the speed breaker consists of a durable rubber or polymer protective layer. This layer protects the internal fluid from environmental conditions such as rain, sunlight, dust, and continuous vehicle movement. Beneath the protective layer is a sealed flexible enclosure that contains the non-Newtonian fluid. The enclosure is designed to withstand repeated loading and unloading cycles without leakage. Its flexibility allows the fluid to deform under normal loads while maintaining structural integrity under high-impact conditions.

C. Non-Newtonian Fluid Core

The central component of the system is the non-Newtonian fluid. A common example is a cornstarch-water mixture, which exhibits shear-thickening behavior. Under low stress, the fluid behaves like a liquid and flows freely. However, when subjected to sudden force or impact, its viscosity increases rapidly, causing it to behave like a solid. This unique property enables the speed breaker to adapt automatically according to vehicle speed without requiring any electronic sensors or external power supply.

D. Low-Speed Vehicle Operation (⩽ 24 km/h)

When a vehicle crosses the speed breaker at a safe speed, the force applied to the fluid is relatively low. Under these conditions, the non-Newtonian fluid remains soft and flexible. The speed breaker slightly deforms and allows the vehicle to pass smoothly with minimal vibration and shock. This improves passenger comfort and reduces stress on vehicle suspension systems. As a result, drivers who follow speed regulations experience a comfortable ride while still being reminded to maintain a safe speed.

E. High-Speed Vehicle Operation (> 25 km/h)

When a vehicle attempts to cross the speed breaker at a higher speed, the force exerted on the fluid increases significantly. The non-Newtonian fluid instantly becomes more viscous and rigid due to shear-thickening behavior. This temporary hardening creates greater resistance against the vehicle tires. Consequently, the driver experiences a stronger upward force, encouraging immediate speed reduction. This adaptive response effectively controls overspeeding vehicles while avoiding the excessive harshness associated with conventional rigid speed breakers.

F. Speed Control and Safety Outcome

The final stage is the achievement of controlled vehicle speed and improved road safety. Since the speed breaker reacts differently based on vehicle speed, it rewards safe driving and penalizes overspeeding. The system provides several benefits, including reduced vehicle damage, lower vibration levels, improved passenger comfort, enhanced pedestrian safety, and reduced maintenance requirements. The adaptive nature of the non-Newtonian fluid speed breaker makes it a promising solution for future smart transportation infrastructure and intelligent traffic management systems.

Major Components Summary

Component	Function
Top Protective Layer	Protects the system from wear and environmental conditions
Flexible Enclosure	Holds and seals the non-Newtonian fluid
Non-Newtonian Fluid	Changes viscosity according to applied force
Base Layer	Provides support and stability on the road

Low-Speed Zone	Allows smooth vehicle movement
High-Speed Zone	Creates resistance to reduce vehicle speed

This architecture enables the speed breaker to remain soft at low speeds and rigid at high speeds, providing both comfort and safety in a single intelligent road-calming system.

V. RESULTS

A. Fluid Behavior Analysis Under Different Speeds

The developed prototype was tested under different speed conditions to observe the behavior of the non-Newtonian fluid. It was observed that the fluid remained soft and deformable when subjected to low-speed loads. However, as the impact force increased, the fluid rapidly stiffened and provided greater resistance. This adaptive behavior enabled the speed breaker to respond according to vehicle speed and improve traffic calming efficiency.

Table 5.1: Fluid Response at Different Vehicle Speeds

Vehicle Speed (km/h)	Fluid Behavior	Speed Breaker Response
5 – 10	Liquid State	Smooth crossing
10 – 15	Semi-liquid State	Minor resistance
15 – 20	Moderate Thickening	Controlled movement
20 – 25	Increased Viscosity	Noticeable resistance
Above 25	Solid-like State	Strong speed reduction

Observation

The results indicate that the non-Newtonian fluid successfully changes its viscosity according to the applied force. This property makes the system more intelligent than conventional speed breakers.

B. Load Carrying Capacity Analysis

The prototype was tested with different loads to evaluate its structural stability and fluid performance. The system maintained proper functionality under moderate loads and demonstrated effective shock absorption. Excessive loading beyond the design limit caused deformation of the enclosure and reduction in performance.

Table 5.2: Load Testing Results

Applied Load (kg)	Performance Status	Observation
2	Excellent	No deformation
4	Excellent	Stable operation
6	Very Good	Minor deformation
8	Safe Limit	Good performance
10	Maximum Limit	Increased stress observed
Above 12	Failure Condition	Excessive deformation

Observation

The model operated safely up to 8 kg and remained functional up to 10 kg. Beyond this load, the enclosure experienced excessive stress, indicating the need for stronger materials in full-scale implementation.

C. Shock Absorption Performance

One of the primary objectives of the project was to reduce the shock experienced by vehicles. The non-Newtonian fluid absorbed a significant portion of the impact energy generated during vehicle crossing. Compared with rigid speed breakers, the proposed design provided smoother transitions and reduced vibrations.

Table 5.3: Shock Absorption Comparison

Parameter	Conventional Speed Breaker	Non-Newtonian Fluid Speed Breaker
Impact Force	High	Low
Passenger Comfort	Moderate	High
Suspension Stress	High	Low
Vibration Level	High	Reduced
Shock Absorption	Poor	Excellent

Observation

The adaptive fluid mechanism effectively absorbed sudden loads and reduced shock transmission to the vehicle body, thereby improving passenger comfort.

D. Vehicle Speed Reduction Efficiency

The performance of the prototype in controlling vehicle speed was evaluated by observing the resistance generated at different speeds. High-speed movement caused the fluid to become rigid, resulting in effective speed reduction.

Table 5.4: Speed Control Performance

Speed Range (km/h)	Resistance Generated	Speed Reduction Efficiency
5 – 10	Very Low	Minimal
10 – 15	Low	Moderate
15 – 20	Medium	Good
20 – 25	High	Very Good
Above 25	Very High	Excellent

Observation

The speed breaker successfully differentiated between safe-speed and overspeeding vehicles. The adaptive stiffness ensured that only fast-moving vehicles experienced significant resistance.

E. Overall Performance Evaluation

The final evaluation considered all important factors including safety, comfort, durability, and operational efficiency. The proposed speed breaker demonstrated superior performance compared to traditional road humps and showed potential for application in schools, residential areas, hospitals, and institutional campuses.

Table 5.5: Overall System Evaluation

Performance Parameter	Rating
Road Safety	Excellent
Passenger Comfort	Excellent
Speed Control Efficiency	Very Good
Shock Absorption	Excellent
Vehicle Protection	Very Good
Environmental Impact	Good

Cost Effectiveness	Good
Future Applicability	Excellent

Discussion

The experimental results confirm that the non-Newtonian fluid-based speed breaker is capable of adapting its stiffness according to vehicle speed and applied load. The system remains soft during normal operation and becomes rigid during high-impact conditions. This intelligent response provides effective speed control while minimizing discomfort and vehicle damage. The findings demonstrate that non-Newtonian fluids can be successfully utilized in modern traffic-calming systems and may contribute significantly to the development of smart and sustainable transportation infrastructure.

VI. CONCLUSION

The present study successfully explored the application of non-Newtonian fluids in the design of smart speed breakers. Unlike conventional rigid speed breakers, the proposed system utilizes the unique shear-thickening property of non-Newtonian fluids, which enables the speed breaker to adapt its stiffness according to the speed and impact force of the vehicle. Experimental testing demonstrated that the fluid remained soft under low-speed conditions, allowing vehicles to pass smoothly with minimal vibration and discomfort. However, when subjected to high-speed impacts, the fluid rapidly became rigid and provided greater resistance, effectively reducing vehicle speed.

The developed prototype exhibited good shock absorption characteristics and reduced the transmission of impact forces to the vehicle. Load testing confirmed stable performance within the designed operating range, while speed analysis showed effective differentiation between safe-speed and overspeeding vehicles. The system also demonstrated advantages such as improved passenger comfort, reduced vehicle wear and tear, enhanced road safety, and lower maintenance requirements compared to traditional speed breakers.

Overall, the project confirms that non-Newtonian fluid-based speed breakers offer an innovative and intelligent traffic-calming solution. Their adaptive nature makes them highly suitable for schools, hospitals, residential areas, campuses, and other low-speed zones. The technology has significant potential to contribute to the development of smart, safe, and sustainable transportation infrastructure in the future.

VII. FUTURE SCOPE

The future scope of non-Newtonian fluid speed breakers is extensive due to their adaptive and intelligent characteristics. Further research can focus on developing advanced fluid compositions with higher durability, improved temperature stability, and enhanced shear-thickening performance for long-term field applications. The use of industrial-grade non-Newtonian materials and stronger enclosure materials can increase load-carrying capacity and operational lifespan.

Large-scale implementation and real-world testing on highways, urban roads, educational institutions, and residential areas can be conducted to evaluate long-term performance under varying traffic and environmental conditions. Researchers can also investigate the integration of smart sensors and Internet of Things (IoT) technologies to monitor vehicle speed, traffic density, and system health in real time.

Future designs may incorporate energy-harvesting mechanisms that convert the pressure exerted by vehicles into electrical energy for powering streetlights, traffic signals, or monitoring systems. The technology can also be combined with smart city infrastructure to support automated traffic management and road safety initiatives. Additionally, optimization of manufacturing processes and materials can reduce implementation costs, making non-Newtonian fluid speed breakers a commercially viable solution for widespread adoption.

With continuous advancements in material science and intelligent transportation systems, non-Newtonian fluid-based speed breakers have the potential to become a next-generation road safety technology that provides superior comfort, enhanced safety, reduced maintenance, and sustainable infrastructure development.

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