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Development of an Adaptive Speed Breaker System Using Non-Newtonian Fluid for Improved Ride Comfort and Vehicle Safety

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Abstract: *The increase in accidents due to overspeeding on the roads indicates the need to improve the efficiency of traffic calming devices. The traditional speed breakers are stiff, leading to passenger comfort, damage to vehicles, and noise pollution. In this paper, a novel solution to this problem is proposed by designing a flexible speed breaker with the help of non-Newtonian fluids. A prototype model of the speed breaker is designed by choosing a mixture of cornstarch, water, glycerin, salt, and vinegar as the non-Newtonian fluid. The model will be soft under normal conditions of vehicle speed, providing a smoother drive, and stiffer during high-speed impact, restricting the speed of the vehicle. A casing will be designed to house the non-Newtonian fluid and withstand repeated impact. The proposed model of the speed breaker will be flexible and suitable for modern traffic management systems by reducing sudden shocks and noise pollution. The proposed system will provide a cost-effective solution to the problem of speed breakers.*

Keywords*:* Non-Newtonian Fluid, Shear thickening fluids, Adaptive speed Bumps , Vehicles Protector, passenger comfort , Smart city

I. INTRODUCTION

Safety on roads has become a major concern in recent years, as the number of accidents caused by excessive speeding has been on the rise. Speed breakers are used as a traffic calming device for controlling the speed of vehicles in sensitive zones such as residential areas, schools, and hospital campuses. Though speed breakers are effective in controlling speed, they are rigid in nature and, in turn, cause passenger discomfort, damage to vehicles, and unwanted noise, especially when driven over at higher speeds. During the study of existing systems, it has been observed that speed breakers are not adaptive to varying speeds of vehicles. They offer the same resistance at all speeds, which makes them inefficient in balancing safety and comfort. This has created a need for an efficient system. To overcome the limitations of traditional speed breakers, the concept of non-Newtonian fluids has been introduced. Non-Newtonian fluids are those fluids whose viscosity varies, acting as a liquid under normal circumstances and as a solid when subjected to sudden impacts or stress.To solve this, the idea of non-Newtonian fluid is introduced. Non-Newtonian fluid is a substance with a variable viscosity value. It is in liquid form at normal conditions and turns into a semi-solid state when subjected to sudden impact. This property makes non-Newtonian fluid suitable for use in situations where adaptability is needed. In this project, a flexible speed breaker model is designed and implemented using a non-Newtonian fluid mixture of cornstarch, water, glycerin, salt, and vinegar. The model is designed in such a way that it stays in soft form at normal driving speeds, providing a smooth driving experience, and becomes stiffer at a sudden impact of a speeding vehicle, thereby restricting overspeeding. The main aim of this project is to develop an efficient and adaptive model of a speed breaker that minimizes discomfort and damage. In this regard, the designed model is

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expected to provide an alternative solution that is cost-effective and easier to implement in comparison with the traditional speed breaker. To solve this, the idea of non-Newtonian fluid is introduced. Non-Newtonian fluid is a substance with a variable viscosity value. It is in liquid form at normal conditions and turns into a semi-solid state when subjected to sudden impact. This property makes non-Newtonian fluid suitable for use in situations where adaptability is needed. The main aim of this project is to develop an efficient and adaptive model of a speed breaker that minimizes discomfort and damage. In this regard, the designed model is expected to provide an alternative solution that is cost-effective and easier to implement in comparison with the traditional speed breaker.

Fig. 1. Problem with Convention Speed breakers

The proposed non-Newtonian fluid-based speed breaker, once developed, would be an improvement over the existing rigid speed breaker, as the existing rigid speed breaker offers constant resistance, which may cause discomfort, damage, and increased noise levels irrespective of the vehicle's speed. However, the proposed system would be able to adjust according to the applied load and speed, i.e., it would be soft during normal driving and would be stiff for some time when the speed of the vehicle is high, thus regulating the problem of overspeeding in an efficient way, providing not only comfortable driving but also reducing the mechanical stress and noise levels.

II. LITERATURE REVIEW

Sr. No.	Paper Title	Author(s)	Key Points	Remarks
1	Studying the Oobleck with Video Analysis	E.A. Lima, R.S. Dutra, P.V.S. Souza	Oobleck (cornstarch + water) shows dual behavior (liquid at low force, solid at high force). Video analysis used to study shear thickening behavior.	Useful to understand fundamental behavior of non-Newtonian fluid used in speed breaker design.
2	Critical Analysis of Speed Hump and Speed Bump	Korra Ravi Kiran, M. Kumar, B. Abhinay	Conventional speed breakers increase travel time, fuel consumption, emissions, and discomfort.	Justifies need for improved and adaptive speed breaker system.
3	Geometric Design of Speed Control Humps	P.K. Sahoo	Speed humps control speed but lack proper universal design; geometry affects vehicle speed and safety.	Shows limitations of traditional design and need for innovation.
4	Non-Newtonian	Prof. Pooja J.	Fluid-based breaker adapts to speed:	Directly supports concept of

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	Fluid Speed Breaker	Chavhan et al.	soft at low speed, stiff at high speed. Reduces damage and improves comfort.	smart speed breaker system.
5	Non-Newtonian Fluid Speed Bump	Tanmay Mhatre, Sumit Maji	Oobleck-based speed bump reduces accidents, vehicle damage, and improves safety using shear thickening property.	Confirms feasibility of non-Newtonian fluid in real applications.
6	Study and Analysis of Non-Newtonian Fluid Speed Bump	Adesh Jambhule et al.	Provides experimental and simulation-based analysis of fluid-based speed bumps and their performance.	Helps in understanding performance evaluation and testing methods.
7	Rheological Properties of Corn Starch	Ojewumi Modupe et al.	Corn starch behaves as non-Newtonian fluid; viscosity changes with shear rate and temperature.	Supports material selection for fluid mixture in project.
8	Application of Shear Thickening Fluid in Impact Resistance	Minghai Wei et al.	STF absorbs high impact energy and becomes rigid under stress.	Proves effectiveness in impact control (useful for speed breaker concept).
9	Study and Utilization of Oobleck Speed Breaker	Bhavika Devikar et al.	Oobleck-based speed breaker reduces noise, improves safety and is eco-friendly.	Shows environmental and practical benefits.
10	Study and Analysis of Non-Newtonian Fluid Speed Bump	Atul Bamborde et al.	Non-Newtonian speed bumps provide smoother ride, less noise and better fuel efficiency.	Strengthens advantages over conventional speed breakers.
11	Non-Newtonian Fluid Speed Breaker using Oobleck	S. Revathi, A. Senthil Kumar	Oobleck mixture used in speed breaker; low cost and speed-sensitive behavior observed.	Highlights cost-effectiveness and practical implementation.

III. MATERIALS

A. Cornstarch

Fig. 2. Cornstarch

The reason why cornstarch is preferred as a main ingredient is because it has a significant shear-thickening property, which is required for a non-Newtonian fluid. Cornstarch is mostly made up of amylose and amylopectin, which when mixed with water, form a suspension. In this project, a 1:1 ratio of cornstarch to water is used as the main fluid. When subjected to low levels of stress, cornstarch acts as a liquid because the particles are able to move freely. On the other hand, when subjected to shock, the particles get close to each other, thereby restricting their movement. The ability of cornstarch to change from a liquid to a solid state makes it appropriate for use in adaptive devices such as speed breakers.

B. Glycerin

Glycerin is added to the non-Newtonian fluid to improve its stability, flexibility, and consistency. It is a viscous, colorless, and non-toxic liquid that helps in maintaining uniform dispersion of cornstarch particles within the mixture. The presence of glycerin reduces rapid drying and prevents cracking of the fluid structure during repeated loading conditions. In this project, glycerin is used in a small proportion (approximately **5–8%**) **3 liter** to enhance the smooth flow behavior at low stress while supporting controlled thickening under high impact. It also improves the durability and reusability of the fluid by retaining moisture and ensuring consistent performance over time.

Fig. 3 Glycerin

C. White vinegar & salt

Salt is added in a small proportion to improve the consistency and density of the non-Newtonian fluid. It enhances the interaction between cornstarch particles and the liquid medium, which helps in achieving better shear thickening behavior. The presence of salt also contributes to maintaining uniformity in the mixture during repeated loading conditions. In this project, salt is used in a proportion of approximately **2–3%** to ensure stable performance and improved response under applied stress.

White vinegar is added to improve the durability and shelf life of the non-Newtonian fluid. It acts as a mild preservative, preventing microbial growth and maintaining the chemical stability of the mixture over time. Additionally, it helps in maintaining the pH balance of the fluid, ensuring consistent behavior during usage. In this project, white vinegar is used in a small proportion of approximately **1–2%** to enhance the longevity and reliability of the fluid.

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Fig. 4 Salt

Fig. 5. White Vinegar

D. Internal Structure

The internal structure of the developed speed breaker is such that it will provide strength, durability, and proper containment of the non-Newtonian fluid. In this speed breaker system, plywood is used as the base material because it has good load-bearing capacity, is lightweight, and is easy to fabricate. In this system, a metal plate is provided on the top surface, which will provide impact resistance and protect the internal fluid chamber from the effects of external forces. The metal plate will provide durability and will not allow structural damage during repeated loading conditions. The metal plate will also help in proper transfer of load to the non-Newtonian fluid, thus ensuring proper activation of shear thickening. The plywood and metal plate hybrid structure will provide strength and will be cost-effective. The structure will provide proper integrity and will ensure proper efficiency of the non-Newtonian fluid. The structure is simple, durable, and suitable for practical use.

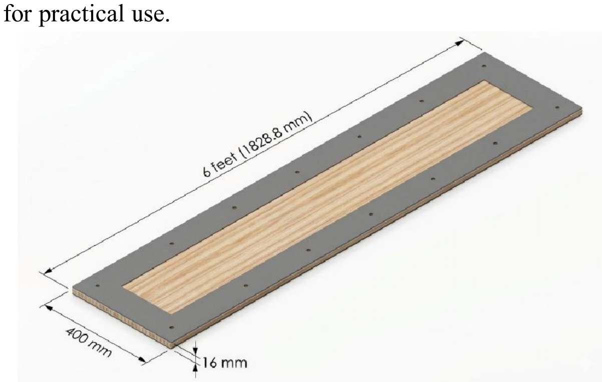

Fig. 6 Internal Structure

E. Flexible Fluid Chamber

The non-Newtonian fluid is contained within a flexible and sealed chamber made of PVC-coated fabric sheet material of **1 mm thickness.** The PVC-coated fabric is chosen for its high flexibility and its ability to resist water and last longer even after being subjected to repeated loading. The material is capable of withstanding the pressure of the fluid that is created during high-speed impact. The flexible nature of the material ensures that the chamber can easily deform when subjected to low-speed conditions and remain comfortable. The material is also able to resist stiffness when the non-Newtonian fluid is subjected to shear thickening. The chamber is designed to have a semi-cylinder shape and is **6 feet in length and 400 mm** in width to ensure proper distribution of the load.

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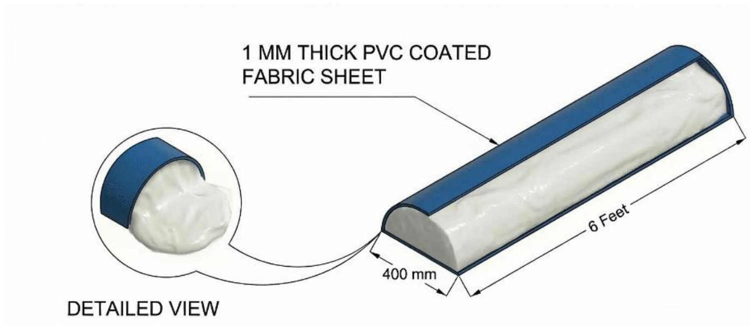

Fig. 7. Flexible Fluid Chamber

IV. TESTING

A. Testing on Different Type of ratio

For ascertaining the most appropriate composition of the proposed speed breaker design, different combinations of cornstarch and water were tested. The behavior of each of these mixtures was tested under both low and high-impact conditions.

Ratio 1 (2:1 – Cornstarch:Water):

This composition of the mixture was found to have high shear thickening properties. However, this composition was found to be too thick and lacked fluidity. The high rigidity of this composition made it inappropriate for use as a speed breaker.

Ratio 2 (1:1.25 – Cornstarch:Water):

This composition of the mixture was tested and validated according to the research findings of S. Revathi and A. Senthil Kumar. The composition of this mixture was found to have non-Newtonian properties. However, it was found to be too thick and lacked fluidity.

Ratio 3 (1:1.5 – Cornstarch:Water):

This mixture was more inclined to behave as a liquid because of the high proportion of water. The mixture had lesser resistance to impact and did not possess the desired stiffness at high speeds.

Ratio 4 (1:1 – Cornstarch:Water):

A prototype chamber was created for this mixture and tested in real-time conditions. The mixture behaved as a fluid at low pressure and was extremely stiff at high-speed impact. The desired shear thickening was achieved.

From the experiments conducted, it was evident that the **1:1 ratio** was the ideal composition for the speed breaker.

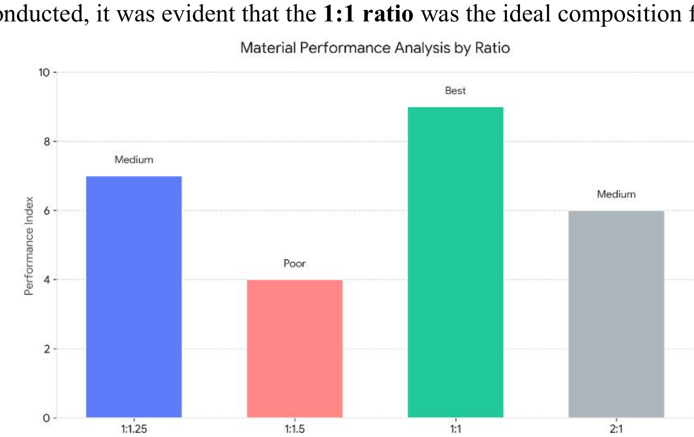

Fig. 7. Ratio comparison Graph

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B. Impact test on speed breakers

The impact test of the developed non-Newtonian fluid speed breaker was conducted in a certified laboratory to assess its strength under impact loading. The test was carried out at a **height of 660 mm**, simulating the actual impact conditions.

As per the laboratory report, the model was able to withstand the impact equivalent to **4000 kg** falling load and **5500 kg** static load without structural failure. The test was conducted under controlled conditions with a temperature of **24°C** and **humidity of 54%.** The test results show that the developed system is strong enough and durable for use in road conditions. The structural design and non-Newtonian fluid behavior ensure the reliability of the system under varying load conditions.

Parameter	Value	Observation / Remark
Test Type	Impact Test	Standard lab testing performed
Test Height	660 mm	Simulates real impact condition
Falling Load	4000 kg	No structural failure observed
Static Load	5500 kg	Withstood load successfully
Temperature	24°C	Controlled environment
Humidity	54%	Stable testing condition
Result	Pass	Suitable for practical application

V. WORKING DEMONSTRATION

In order to analyze the real-time performance of the developed non-Newtonian fluid speed breaker, a working demonstration of the system has been conducted using various categories of vehicles. The categories of vehicles used were two-wheelers like Splendor, Scooty, and four-wheelers like WagonR, Nexon. During the testing of the system, it has been observed that when the vehicles are moving at regular speeds, all the vehicles move smoothly over the speed breaker without any discomfort, thus simulating the non-Newtonian fluid. However, when the vehicles move at higher speeds, the system becomes stiffer due to the shear-thickening property of the non-Newtonian fluid, thus causing resistance. The non-Newtonian fluid speed breaker has been found to work well with both two-wheelers, which move smoothly at low speeds, and four-wheelers, which show deceleration with better load interaction.

Fig. 7. Deformation of Breaker By 2&4 Wheeler

VI . CONCLUSION

In the present work, a non-Newtonian fluid-based speed breaker has been successfully developed and tested using various fluid ratios. Among all the ratios, the cornstarch and water mixture at a ratio of 1:1 has shown the best result, as it provides the best balance between fluidity and stiffness. The system has also shown the property of adaptation, as it remains soft at normal driving speeds and stiff at high speeds. The structure has also passed the lab test, as it can bear high impacts without any damage. In real-world testing, the speed breakers have shown smooth movement of vehicles at low speeds, as well as proper control of speed at higher velocities.Thus, the speed breakers developed have shown the potential of being a simple, cost-effective, efficient, safe, and comfortable option.

V. ACKNOWLEDGMENT

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