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A Study on Non-Newtonian Fluid Speed Breaker

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Abstract: The increase in the number of vehicles has led to more traffic problems and road accidents. Conventional speed breakers made of concrete or asphalt are commonly used to control vehicle speed, but poor design often causes discomfort, vehicle damage, and safety issues for both slow-moving and fast-moving vehicles. To address these problems, this study proposes a speed breaker based on non-Newtonian fluid behavior, which changes its stiffness according to the speed of the vehicle. When a vehicle passes at high speed, the material becomes stiff and resists motion, helping to reduce speed. At low speeds, the material behaves like a fluid , allowing the vehicle to pass smoothly with minimal impact. This type of speed breaker can reduce vehicle damage, improve ride comfort for vehicles traveling at safe speeds, and support better fuel efficiency. In addition, it offers benefits such as longer service life and easy relocation compared to conventional speed breakers. The concept was developed through a review of standards and existing studies, followed by the fabrication of a working model to demonstrate its feasibility. The proposed system shows potential as a safer and more flexible alternative to traditional speed breakers.

Key words - Non-Newtonian fluid, speed breaker, shear-thickening fluid, traffic calming, road safety.

I. INTRODUCTION

Rapid growth in vehicle ownership has significantly increased traffic congestion and road safety concerns, particularly in developing countries like India.

In urban and semi-urban areas, congestion is commonly caused by high traffic volume, limited road capacity, poor road conditions, and inadequate traffic control measures. As vehicle density increases faster than road infrastructure, traffic accidents, delays, and vehicle damage become frequent problems, especially at intersections, residential areas, school zones, and hospital zones.

To control vehicle speed and improve pedestrian safety, traffic calming devices such as speed breakers are widely used. Conventional speed breakers made of concrete, asphalt, or plastic are designed to force drivers to reduce speed while crossing them. According to Indian Road Congress (IRC) guidelines, these speed breakers are intended to allow vehicles to cross at a low advisory speed. However, in practice, many speed breakers are improperly designed or poorly maintained, leading to discomfort, mechanical damage to vehicles, increased noise pollution, and safety risks for both slow-moving and fast-moving vehicles.

Conventional speed breakers also have several practical limitations. Their rigid structure causes repeated impact loads on vehicles, which can lead to suspension damage and discomfort for occupants. Emergency vehicles such as ambulances and fire trucks experience delayed response times due to the need to slow down at each speed breaker. Additionally, conventional speed breakers are permanent installations, making relocation difficult and costly when traffic conditions change. Plastic speed breakers, although lighter, often have a short service life and require frequent replacement.

These limitations highlight the need for an improved speed control system that can reduce vehicle speed without causing unnecessary discomfort or damage. An adaptive speed breaker that responds differently to vehicle speed can offer a more effective and safer solution. In this context, materials with non-

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Newtonian fluid behavior present a promising alternative. Non-Newtonian fluids change their mechanical response under applied stress; they behave like a fluid under low stress and become stiff under high stress.

This study explores the concept of a non-Newtonian fluid–based speed breaker that adjusts its stiffness according to vehicle speed. When a vehicle moves slowly, the speed breaker remains soft, allowing smooth passage with minimal impact. At higher speeds, the material becomes stiff and resists deformation, thereby discouraging speeding. The objective of this paper is to present the design concept, material behavior, and feasibility of a non-Newtonian fluid speed breaker as an alternative to conventional rigid speed breakers for improved road safety and driving comfort.

II. LITERATURE REVIEW

A literature survey was carried out to understand the existing research related to non-Newtonian fluid–based speed breakers and to identify the scope for further improvement. Several researchers have studied the application of non-Newtonian fluids as an alternative to conventional rigid speed breakers in order to reduce vehicle damage and improve ride comfort.

Recent studies have focused on the design and performance analysis of non-Newtonian fluid speed breakers using materials such as polyethylene glycol (PEG-400), cornstarch, mild steel plates, and plastic pipes. These studies reported that non-Newtonian fluid speed breakers exhibit speed-dependent behavior, remaining flexible at low vehicle speeds and becoming rigid under high-speed loading. Experimental observations indicated that speed reduction achieved using non-Newtonian fluid speed breakers was higher compared to conventional speed breakers, while also reducing mechanical stress on vehicles. Mobility, lower installation cost, and reduced maintenance requirements were identified as additional advantages.

Comparative studies between conventional and non-Newtonian fluid speed breakers showed that conventional speed breakers are difficult to construct accurately as per standards and often cause discomfort even at low speeds. In contrast, non-Newtonian fluid speed breakers were found to be easier to construct and more adaptable to different road conditions. Design dimensions similar to conventional speed breakers were considered suitable for both urban and rural roads. However, most of these studies were limited to small-scale models and laboratory-level testing.

Earlier research also highlighted the drawbacks of conventional speed breakers, including permanent installation, vehicle damage, passenger discomfort, increased noise, and difficulty for emergency vehicles. Non-Newtonian fluid speed breakers were proposed as a solution to overcome these limitations by providing a flexible and adaptive speed control mechanism.

From the reviewed literature, it is observed that although non-Newtonian fluid speed breakers show promising results in terms of speed control and user comfort, further studies focusing on material selection, durability, and practical implementation are required. The present study aims to build upon existing research by developing and evaluating a working model of a non-Newtonian fluid speed breaker.

III. METHODS AND MATERIALS

A. Materials Used

The non-Newtonian fluid speed breaker model was developed using commonly available, cost-effective, and durable materials. The selected materials and their purpose are described below.

1. Corn-Starch

Corn starch is a white, odorless powder obtained from corn and is widely used in food and industrial applications. When mixed with water, corn starch forms a non-Newtonian fluid whose viscosity changes with applied force. At low stress, it behaves like a liquid, while under sudden or high stress it exhibits solid-like behavior. Due to its non-toxic nature, low cost, and clear non-Newtonian response, corn starch was selected as the primary base material for the fluid.

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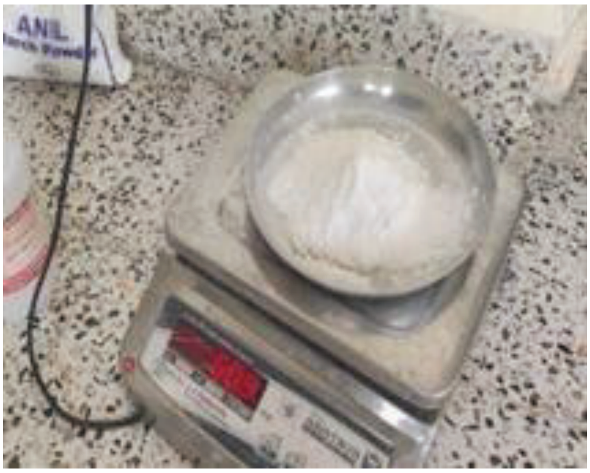

Figure 1. Corn Starch

2. Polyethylene Glycol (PEG-400)

Polyethylene glycol 400 is a low–molecular weight, transparent, and colorless liquid with low toxicity. In this study, PEG-400 was used as a preservative to improve the durability of the corn starch–based non-Newtonian fluid. PEG-400 helps retain moisture in the mixture and reduces degradation over time, making it suitable for prolonged use inside the speed breaker system.

Figure 2. Polyethylene Glycol (PEG-400)

3. PVC Coated Polyester Fabric

PVC coated polyester fabric was used as the outer containment material for the non-Newtonian fluid. This material offers high strength, flexibility, waterproofing, and resistance to chemicals, UV radiation, and environmental exposure. A 900 GSM PVC coated polyester fabric was selected due to its durability and long service life, making it suitable for repeated loading conditions on road surfaces.

Figure 3. PVC Coated Polyester Fabric

4. Aluminum Plate

Aluminum plates were used as supporting structural elements in the working model. Aluminum was chosen due to its light weight, corrosion resistance, sufficient strength, and ease of fabrication. These plates help distribute load uniformly and provide structural stability to the speed breaker assembly.

Figure 4. Aluminum plate

5. Carbon Fiber Tube

Carbon fiber tubes were used as reinforcement members in the model. Carbon fiber was selected because of its high strength-to-weight ratio, excellent stiffness, and resistance to fatigue. Tubes of 1.2 cm diameter and 1 m length were used to enhance structural support while keeping the overall weight low.

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Figure 5. Carbon fiber tube

6. Bituminous Sealing Tape

Self-adhesive bituminous tape was used for sealing joints and preventing leakage of the non-Newtonian fluid. The tape provides waterproofing, strong adhesion, and resistance to environmental effects, ensuring the integrity of the fluid containment system.

Figure 6. Bituminous Tape

Figure. 7. final working model

B. Preservation Testing of Non-Newtonian Fluid

Objective of the Test

Since cornstarch is a food-based material, preservation of the non-Newtonian fluid is a major concern for long-term application. The objective of this test was to determine a suitable proportion of PEG-400 that can effectively preserve fluid without affecting its non-Newtonian behavior.

Test Procedure

A non-Newtonian fluid was prepared by gradually mixing water with corn starch while stirring slowly until the mixture exhibited liquid-like behavior under slow motion and solid-like behavior under sudden force. PEG-400 was added in different proportions to act as a preservative.

A total of ten samples were prepared using a constant quantity of corn starch (50 g per sample), while varying the proportions of water and PEG-400. All samples were stored under normal room conditions and observed continuously for a period of seven , ten and twenty-one days. Changes in fluid consistency, separation, odor, and performance were monitored.

Figure 8. Test samples

IV. RESULTS AND DISCUSSION

To evaluate the preservation and stability of the non-Newtonian fluid, a total of ten samples were prepared using different proportions of corn starch, polyethylene glycol (PEG-400), and water. All samples were stored at room temperature and observed over different time intervals of 7 days, 10 days, and 21 days. The observations focused on changes in consistency, separation, odor, and overall usability of the fluid.

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No.	Corn Starch(gm)	Water (ml)	PEG-400 (ml)	Result
1.	50	50	0	Failed
2.	50	20	30	Failed
3.	50	25	25	Failed
4.	50	30	20	Failed
5.	50	35	15	Failed
6.	50	40	10	Failed
7.	50	45	5	Failed
8.	**50**	**0**	**50**	**Passed**
9.	50	50	50	Failed
10.	50	0	100	Failed

Table 1. Preservation Test Results of Non-Newtonian Fluid Samples

The results obtained from the preservation test showed that samples containing water exhibited noticeable degradation over time. These samples showed separation of components and loss of non-Newtonian behavior during prolonged storage. In contrast, the sample prepared using equal proportions of corn starch and PEG-400, without the addition of water, demonstrated stable behavior throughout the observation period. This sample maintained its non-Newtonian characteristics and showed no significant changes in consistency or performance even after 21 days of storage.

Based on the observations summarized in Table I, the sample with a 50% corn starch and 50% PEG-400 composition was identified as the most suitable for use in the speed breaker application. The absence of water in this mixture significantly improved preservation and reduced the chances of biological degradation, making it more appropriate for long-term use.

After finalizing the optimal fluid composition, the total quantity of non-Newtonian fluid required for the speed breaker model was calculated based on the internal volume of the pipe used in the setup. Initially, 640 g of corn starch and 540 ml of PEG-400 were mixed thoroughly to prepare the primary batch of fluid. To achieve the required final volume, an additional mixture consisting of 60 g of corn starch and 160 ml of PEG-400 was prepared and added to the system. The prepared fluid was allowed to rest for one day to ensure uniform mixing before being filled into the pipe.

The finalized non-Newtonian fluid exhibited the desired behavior, remaining soft under slow movement and becoming stiff under sudden force. These results confirm that the selected material proportion is suitable for application in a non-Newtonian fluid–based speed breaker and supports the feasibility of the proposed system.

However, long-term field testing under actual traffic conditions is required to validate large-scale implementation.

V. CONCLUSION

This study presented the design and working model of a non-Newtonian fluid–based speed breaker that provides speed-dependent resistance using shear-thickening behavior. The proposed system offers lower installation and maintenance costs compared to conventional speed breakers and reduces mechanical stress on vehicles moving at safe speeds. The mobility of the setup allows easy installation and relocation as required. The developed working model demonstrates the feasibility of using non-Newtonian fluid speed breakers in practical locations such as schools, hospitals, parking areas, and residential zones to improve road safety and driving comfort.

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