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Preliminary Investigation on Behavior of Non-Newtonian Fluid for Its Application in Speed Breakers

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***Abstract*—This paper presents the preliminary findings from a study investigating the potential application of non-Newtonian fluid in speed breakers. The focus is on publishing the results derived from experimental tests conducted to evaluate their performance in terms of adaptability of fluid to various load, thermal durability & cost efficiency of non-Newtonian fluid-based speed breaker. These results provide foundational insights for further research and development of non-Newtonian speed breakers.**

***Index Terms*—Experimental results, non-Newtonian fluids, Oobleck, speed breakers, shear-thickening.**

I. INTRODUCTION

The idea of exploring non-Newtonian fluids for potential use in speed breakers comes from their fascinating property of variable viscosity, which allows them to respond differently under varying forces or conditions. This unique behavior makes them an exciting alternative to traditional materials. In this preliminary study, we conducted tests on the fluids (Mixture of Cornstarch & Water) to analyze it's Shear-Thickening behavior, durability under varying temperature, and cost-effectiveness of Non-Newtonian fluid based speed breaker . The results of these tests provide valuable insights into the behavior of these liquids and their potential applications in innovative speed breaker designs.

II. OBJECTIVE

1. To evaluate optimal Water – Cornstarch mixture ratio.
2. To assess the performance and durability of the fluid used under varying temperature and loading condition.
3. To compare cost-effectiveness and maintenance requirements against traditional speed breakers.

III. TESTS CONDUCTED AND RESULTS

1. Water– Cornstarch Mixture Ratio Test

Objective: To find the optimal cornstarch-to-water ratio for the non-Newtonian fluid mixture.

Method: Different ratios of water to cornstarch were tested, with a fixed amount of 150 grams of cornstarch. The tests were conducted to observe how the mixture's flow and resistance properties changed with varying water content, aiming to identify the ratio that strikes the best balance.

Results: It was found that the optimal moisture content for the mixture is 100 ml of water for every 150 grams of cornstarch. At this ratio, the mixture showed a well-balanced consistency, with good flow properties while still maintaining enough resistance for potential applications. This ratio was considered ideal for further testing.

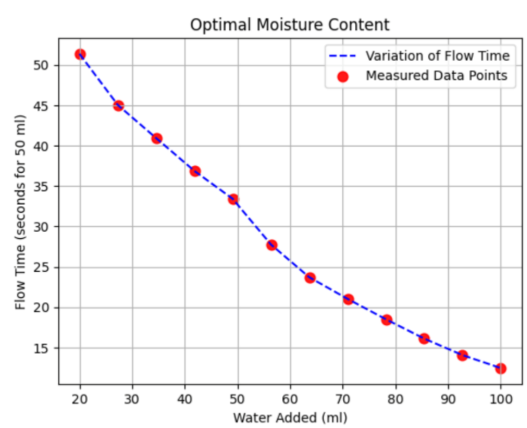

Fig 1: Water added (ml) vs. Flow Time Time graph

Cornstarch (gm)	Water (ml)	Consistency
150	10	No flow
150	20	Very dry
150	30	Moldable

150	40	Thick dough
150	50	Begins to deform
150	60	Semi – solid
150	70	Starts to flow slowly
150	80	Thick paste
150	90	Semi- - liquid
150	100	Low Resistance

Table 1: Observation and Result

Fig 2: Optimal Mixture of Water & Cornstarch

Fig 3: Sherar-Thickening Effect Demonstration

Fig 4: Shear-Thickening Effect Demonstration

2. Small-Scale Resistance Test with Heating Bag

Objective: To simulate a real-world scenario and evaluate the resistance offered by the non-Newtonian fluid mixture prepared with the optimal moisture content.

Method: To test the resistance properties of the fluid, bags were filled with the non-Newtonian mixture prepared using the identified optimal ratio of water and cornstarch (100 ml water to 150 grams cornstarch). These bags were then placed on a flat surface and subjected to the load of a moving two-wheeler. This was done to observe the fluid's response to the dynamic weight and speed of the vehicle, simulating conditions similar to those experienced by a speed breaker.

Results: The test revealed that the resistance offered by the fluid increased significantly when the two-wheeler crossed speeds of 30 km/h. At lower speeds, the fluid exhibited minimal resistance, allowing for smoother movement over the surface. This transition in behavior, based on speed, demonstrated the shear-thickening properties of the fluid. The results further confirmed that the non-Newtonian fluid mixture is capable of providing effective resistance, making it a suitable for speed breaker applications.

Fig 5: Resistance Test Using Heating Bag Under Bike Load

Fig 6: Resistance Test Using Heating Bag Under Bike Load

3. Thermal Testing Using Redwood Viscometer

Objective: To evaluate the durability and performance of the non-Newtonian fluid mixture when exposed to varying temperature conditions.

Method: The flow time of the fluid was measured at different temperatures, ranging from 25°C to 60°C, to observe how temperature changes affected its resistance and flow properties.

Results: The fluid maintained its resistance effectively up to 60°C, showcasing good thermal durability. As the temperature increased, a gradual decrease in flow time was observed, reflecting a predictable and consistent thermal behavior. These results indicate that the fluid can perform reliably across a wide temperature range, making it suitable for outdoor use in diverse conditions.

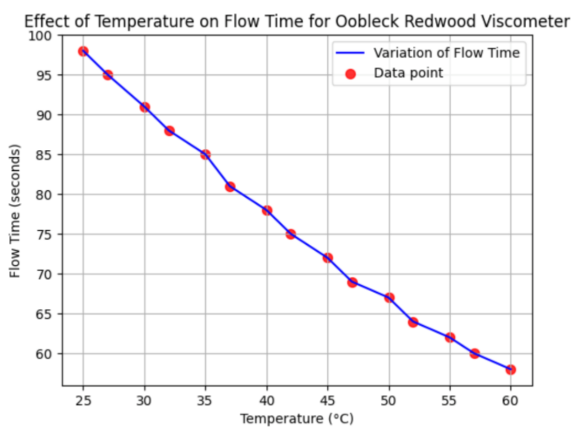

Fig 7: Temperature vs. Flow Time Graph

Temperature (°C)	Flow Time (sec.)
25	98
27	95
30	91
32	88
35	85
40	78
42	75
45	71
50	67
52	63
55	62
57	60

Table 2: Observation and Result

4. Cost Feasibility Assessment

Objective – To Compare cost-effectiveness of No-Newtonian fluid-based speed breaker with traditional speed breakers.

Method – Costs of construction of non-Newtonian fluid based and traditional speed breakers were analyzed based on material, labor, and maintenance expenses. (Cost analysis is done for a length of 1 m)

Results – Non-Newtonian (Oobleck) speed breakers cost approximately 10% or less over a period of 5 years of time. For traditional Speed Braker is Rs.5,800 and cost for non-Newtonian fluid-based speed breaker is Rs. 5,200. Long-term maintenance costs were lower for non-Newtonian fluid-based speed breaker due to material durability.

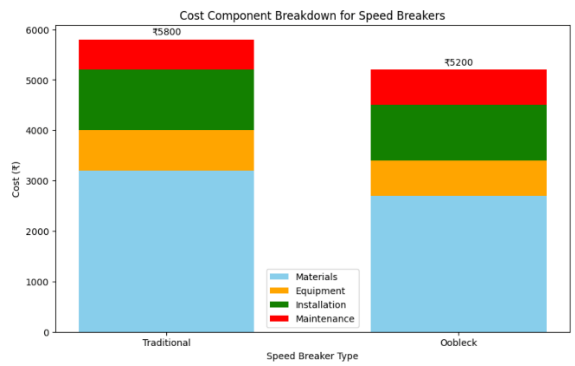

Fig 8: Total cost comparison

Speed Breaker	Cost Component	Details	Cost
Conventional	Material	Asphalt	3200
	Equipment	Roller	1200
	Installation	Labor	800
	Operation & Maintenance	Repair	600
	Life Span	5 Years	
	Total Cost		Rs.5,800

Table 3: Cost of Conventional Speed breaker

Speed Breaker	Cost Component	Details	Cost
Non-Newtonian fluid based	Material	Cornstarch, Water	2700
	Equipment	Mould	700
	Installation	Labor	1100
	Operation & Maintenance	Replacement	700
	Life Span	5 Years	
	Total Cost		Rs. 5,200

Table 4: Cost of non-Newtonian fluid-based speed breaker

IV. DISCUSSION

The test results indicate that non-Newtonian fluid-based speed breakers have significant potential for practical application. While this study focuses only on publishing the outcomes of the tests conducted, the findings show adaptability to various load, thermal stability, and cost-efficiency as key advantages.

V. CONCLUSION

Based on the tests conducted, we can draw some promising conclusions about the potential use of non-Newtonian fluids in speed breaker applications. First, the optimal moisture content for the fluid mixture was determined to be 100 ml of water for every 150 grams of cornstarch. This specific ratio achieved a balance between flow and resistance.

when this fluid was tested under real-world conditions using a two-wheeler load, it demonstrated significant resistance at speeds above 30 km/h. This behavior confirms its potential for use in speed breakers where higher speeds require stronger resistance to ensure traffic control.

Thermal durability tests showed that the fluid maintained its resistance up to 60°C, even as flow time decreased with rising temperatures. This indicates that the fluid can perform reliably under varying temperature conditions, which is crucial for outdoor applications.

A cost analysis revealed that non-Newtonian fluid-based speed breakers are approximately 10% cheaper than traditional speed breakers over a five-year period, with lower long-term maintenance costs due to the durability of the material.

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