# NON-NEWTONIAN FLUID SPEED BREAKER

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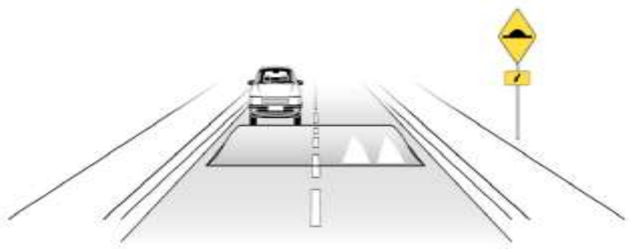
**Abstract -** *A speeding vehicle can be a threat to other road users particularly on roads where connection between motorized and non-motorized traffic is high, such as residential roads, school and community zones. Even though speed limit signs are located, much is left to the ethics of drivers whether they should abide by them. Hence, controlling vehicular speed is an important outcome in traffic management. One way of controlling speed is to use speed breaker which produces distress while driver experiences while crossing over it. It plays a decisive role in implementing speed limits, thereby preventing over speeding of vehicles. It considerably assists to the overall road safety objective through the prevention of accidents. Newtonian fluid speed breaker reduces the speed of any over speeding vehicles travelling on a roadway. It is formed by at least one hollow band of ductile material. Each vessel is filled with a dilatants shear-thickening fluid. If the vehicle travels at a low speed the fluid has a low viscosity and the strip is easily deformed, whereas if the speed of the vehicle is high the viscosity of the fluid is high and as a result has great resistance to deformation, thus forming a rigid obstacle to the movement of the vehicle. Drivers must slow down when driving over the conventional speed breaker to prevent damage to their vehicle. However, the Non Newtonian fluid speed breaker is sensitive to the speed of the vehicle. The vehicle needs to slow down only if it is over speeding.*

***Key Words*: Non Newtonian Fluid Speed Breaker, Speed Breaker, Non –Newtonian Fluid, Advance speed bump, Liquid Breaker, Traffic calming measures.**

## 1. INTRODUCTION

Traffic calming measures are pretty common in modern society. Traffic calming measures are physical design approach that cultivate or force motorists to drive slow and specific speed. They prevent vehicle from speeding and can increase overall road safety. Traffic calming can also make streets more convenient and comfortable for other users such as pedestrians, cyclists and nearby residents. The main purpose of traffic calming measures is to prevent vehicle from speeding and create a safer and secure traffic environment. Speed breakers are type of measures that is constantly used to prevent vehicle from speeding in residential areas. A conventional speed breaker usually consists of a concrete or asphalt hump construct in the road. They are designed to be driven over at a design comfortable speed, while causing exceeding agitate at higher speeds. Drivers must slow down when driving over this speed breaker to prevent damage to their vehicle. However, even if travelling at the design speed limit or below, these conventional speed breakers can take a toll on a vehicle's mechanical components, such as the shock absorbers and steering system.

This research relates to a traffic control device sensitive to the speed of a vehicle. The ideal situation is that if the vehicle travels at a low speed, the stiffness of the non Newtonian fluid speed breaker reduces to ease the vehicles passes without any bounce or jump. However if the vehicle exceeds the design minimum speed the non Newtonian fluid speed breaker stiffness increases and the vehicle receive a considerable jump. This speed control device will also allow emergency vehicles to pass speed breaker without having to reduce their speed which in turn will reduce their response time to emergencies.



### 1.1 BASICS OF SPEED BREAKERS

A speed breaker is a hump surface across the pavement having a rounded shape with width greater than the wheel base of most of the vehicles using road. The various types of speed breakers are:

**a) Speed bump**

Speed bumps are the instruments that use the raised deflection on the road to slow down the moving traffic. They are capable to reduce speeds of the vehicles to around 40 kmph for roads and/or 8 to 16 kmph for car parking. They are normally 1 to 3 feet long and 7 to 15 cm high. The speed bumps reduce speed broadly, avoid accidents and reduce severity of crash. However the provision of bumps may creates significant discomfort to drivers as well as passengers, increased damage to the vehicle, increases response time of emergency services, it requires additional road markings and traffic signs and it increase in traffic noise and pollution.

Fig: Speed bump

**b) Speed hump**

The speed humps are circular, raised areas placed over the roads. They are normally 10 to 14 feet in length in the direction of travel and is 7 to 10 cm high thus making them dissimilar from the speed bumps. The profile of a speed hump can be rounded, parabolic or sinusoidal. They are tapered as they reach the kerb on each end to permit proper drainage. Speed humps are fit where low speeds are desired. Speed humps create a rough ride for drivers as well as passengers and can cause severe pain for people. They enforce large vehicles, such as emergency vehicles and those with rigid suspensions, to travel at slower speeds, they may increase noise and air pollution and have questionable aesthetics.

Fig: Speed hump

## 1.2 Speed Breaker Parameters

Speed breakers can be completely described using several geometric and layout design parameters. Length, height, profile and width are the geometric design parameters. The layout design parameters are speed breaker spacing and type of materials, marking and sign location.

**Profile**

The effects of speed breaker profile, particularly the impacts of varying the slopes of the entry and exit ramps, have not been examined as thoroughly as length or height. Research is ongoing to determine the optimal ramp slopes for various speed bump designs, particularly trapezoidal breakers. Circular, trapezoidal and sinusoidal speed bumps of equivalent dimensions have been found to perform about equally well, although the Dutch regard sinusoidal breakers as having the best dynamic characteristics at higher speeds.

**Length**

Length is the most significant speed breaker geometric design parameter. Effective breakers should be as long as an automobile wheelbase to isolate the impacts of entering and exiting the breakers for these vehicles. Longer speed breakers should be used if heavier vehicles are expected. In general, longer breakers exhibit better characteristics for speed reduction. Longer breakers may be even better suited for heavy loaded vehicles, although upper limits have not been dynamically demonstrate.

**Width**

Speed breakers can either span the entire width of a road or taper short of the curb or road edge. The advantage of the closing approach in an urban setting is that drainage at the curb and gutter is not affected, and installations are therefore less expensive. Drivers can attempt to exploit reduced widths and maneuvers around breakers unless preventative measures are taken.

**Height**

Speed breaker heights can affect the magnitudes of vertical accelerations and the maximum levels of perceived discomfort. High breakers, may cause damage to vehicle undermanage as they exit the measures. Low breakers can be ineffective. Heights range from 50 to 120 mm, with the most common being 75 or 100 mm.

**Spacing**

High breaker crossing speeds can lead to high speeds between breakers, as can large distances between them. Since an objective of traffic calming is to reduce vehicle speeds over entire streets, the layout design or spacing of speed breakers is a key factor to be considered. Previous research from several countries suggests that to achieve overall speeds of 25 to 30 km/h, speed breakers should be placed between 40 and 60 meters apart. Maximum spacing, up to 100 meters, can be used for speeds of 50 km/h. Breakers spacing can be increased with the presence of additional traffic calming measures.

**Materials, Marking and Sign location**

Speed breakers with all speed reducing measures should be highly visible to warn drivers to lower speeds and avoid vehicle damage or loss of control. This critically eliminates the potential for any legal liability on the part of the public road authority. Most countries have developed special signs and markings for their speed breaker installations, and pre-warnings, design speed signs, contrasting materials and protective bollards are usually employed.

### 1.3 Problems associate with conventional speed braker

- The conventional speed brakers are very heavy and, once in place, are typically permanent fixtures on the roadway. In order to remove conventional speed brakers, the speed brakers must be broken up and the roadway repaired where the speed brakers used to be.
- Speed brakers are that they often cause spinal damage or aggravate chronic backache due to the constant shocks suffered while traversing the speed brakers.
- A conventional speed braker usually consists of a concrete or asphalt hump formed in the road. Drivers must slow down when driving over these speed brakers to prevent damage to their vehicle. However, even if travelling at the design speed limit or below, these conventional speed brakers can take a toll on a vehicle's mechanical components.
- Additional criticism of speed brakers includes their effect on emergency vehicles. Response time is slowed by 3–5 seconds per braker for fire trucks and fire engines and up to10 seconds for ambulances with patients on board.
- Also there is an increase in sound pollution from braking and acceleration of vehicles on streets with speed humps, particularly from buses and trucks. They end up increasing noise levels where they are implemented.
- Therefore, it would be advantageous to provide a traffic control device that reduces or eliminates at least some of the problems associated with conventional speed brakers. The “Non Newtonian fluid speed braker” aims to overcome all these short comings of the conventional speed control devices.

### 1.4 AVERAGE SPEED PROFILE

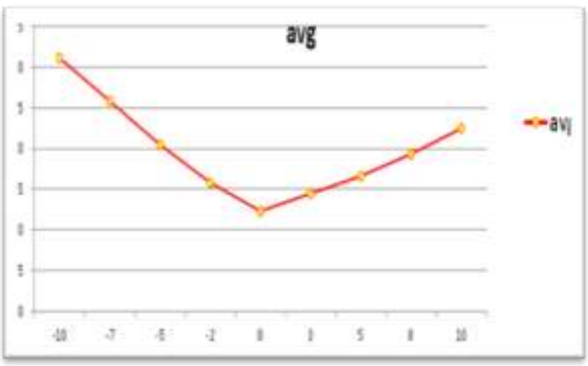



Fig: Average Speed Profile

- For vehicles across speed breaker the speed reduction at breaker is 61.06% whereas at 10 m distance from breaker its 28.8%.

**Speed Reduction Due To Breakers**

Speed depression is the factor or percentage with which the vehicle speed has been reduced from its approaching speed i.e. speed from the distance of 10m away from the speed breaker.

Reduction due to breaker height with respect to vehicles:

| Breaker height | Types of vehicles | Reduction at breaker (in %) | Reduction at 10m away from breaker (in %) |
|---|---|---|---|
| 100mm | 4- wheelers | 69.93 | 33.46 |
| 75 mm | 4- wheelers | 57.02 | 25.15 |
| 100 mm | 2-Wheelers | 62.01 | 31 |
| 75 mm | 2-Wheelers | 60.42 | 33 |

**Reduction due to the type of vehicles:**

| Types of vehicles | Reduction at breaker (in %) | Reduction at 10m away from breaker (in %) |
|---|---|---|
| 4-wheelers | 61.79 | 30.3 |
| 2-wheelers | 61.23 | 32.01 |
| >4wheelers | 57.74 | 19.09 |

**Distribution of Vehicles Against Speed Reduction:**

Cumulative distribution of the vehicles for the different reduction in speed in term of percentage with respect to the approaching speed at the distance of 10m from the bump is shown in figure 6. Almost over 80% of vehicles speed was reduction by 65% with respect to their approaching speed.

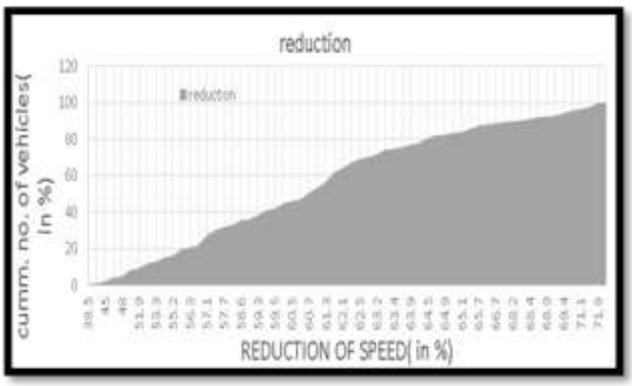



Fig: Distribution of vehicles against speed reduction across breakers

**Graphical Comparisons**

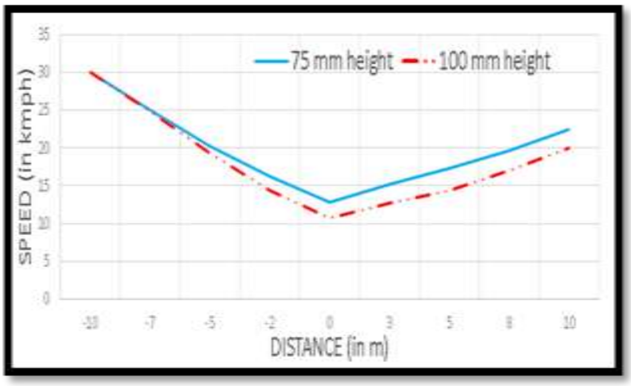



Fig: Wheelers comparison with breaker height

- For cars across 100 mm height breaker the speed reduction at breaker is 63.93% whereas 75 mm height breaker its 57.02%.
- For cars 100 mm height breaker the speed reduction at distance 10m is 33.46% whereas 75 mm height breaker its 25.15%.

**FOR Bikes Comparison With Breaker Height:**

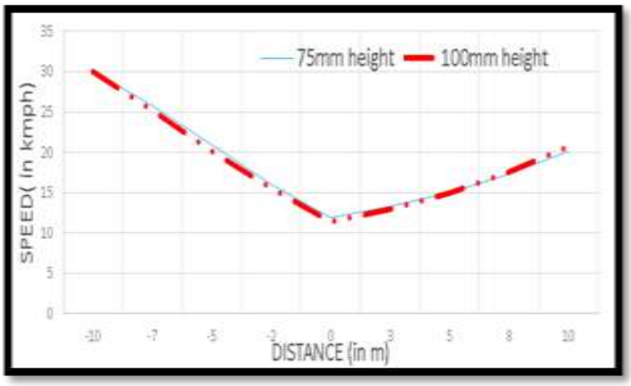



Fig: Reduction due to breaker height for 2-wheelers

- For bikes across 100 mm height breaker the speed reduction at breaker is 62.01% whereas 75 mm height breaker its 60.42%.
- For bikes across 100 mm height breaker the speed reduction at distance 10m is 31% whereas 75 mm height breaker its 33%.

**For Comparison between 4-Wheelers and Bikes:**

- For cars across breaker the speed reduction at breaker is 63.78% whereas for bikes its 61.22%.
- For cars across breaker the speed reduction at distance 10m is 33% whereas for bikes its 32%.

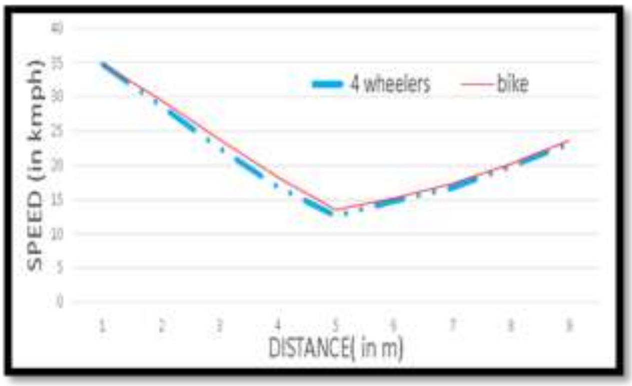



Fig: Reduction due to 2 and 4-wheelers

**For Comparison Between 4-Wheelers And Vehicles> 4-Wheelers:**

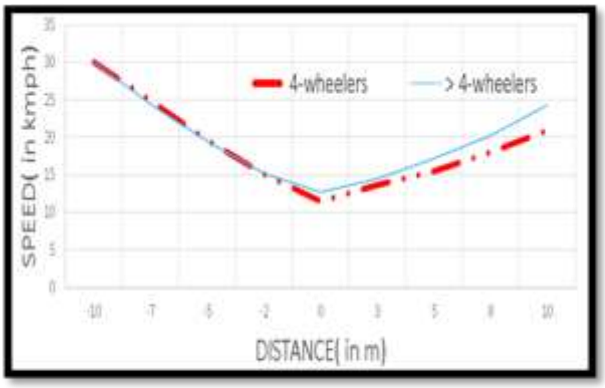



Fig: Reduction due to 4 and >4-wheelers

- For vehicles > 4wheelers across breaker the speed reduction at breaker is 57.74% whereas for 4-wheelers its 61.79%.
- For vehicles > 4wheelers across breaker the speed reduction at distance 10m is 19.09% whereas for 4-wheelers its 30.3%.

**For Comparison Between Bikes And Vehicles> 4-Wheelers:**

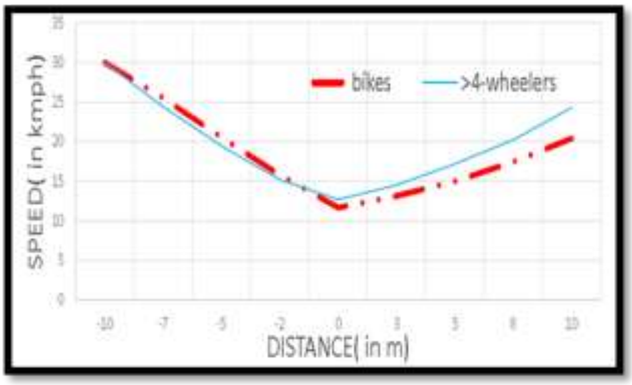



Fig: Reduction due to 2 and >4-wheelers

- For vehicles > 4wheelers across breaker the speed reduction at breaker is 57.74% whereas for bikes its 60.4%.
- For vehicles > 4wheelers across breaker the speed reduction at distance 10m is 19.09% whereas for bikes its 33%.

**Speed Over Breaker**

There is a wide range of speeds when vehicles pass over the road breaker indicating that there is a variation in the response of drivers to the existence of the breaker. The response could range from full compliance to the purpose of having the breaker (i.e. to slow down traffic) to that of utter disregard of the breaker (even though by not slowing down enough may cause a certain level of discomfort to vehicle occupants). The average speed over breaker for cars and motorcycles are illustrated in terms of cumulative frequencies as shown in figure.

In general, it is found that the average speed over breaker differs between types of vehicles. As illustrated in Figure 2, higher percentage of vehicles>4-wheelers is travelling over breakers beyond a certain speed as compared to 4-wheelers and 2-wheelers. For example, about 99% of vehicles >4-wheelers pass over breaker at speeds of 12 Kmph or below while only about 60% of 4-wheelers whereas only 20% of 2-wheeler are in the same category.

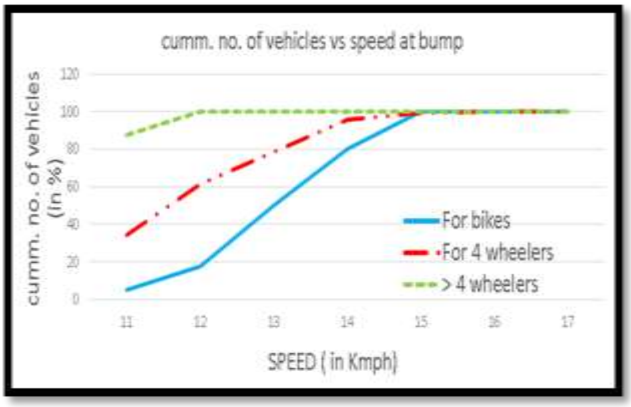



Fig: Vehicles speed distribution over breaker

**Speed On Approaching Breaker**

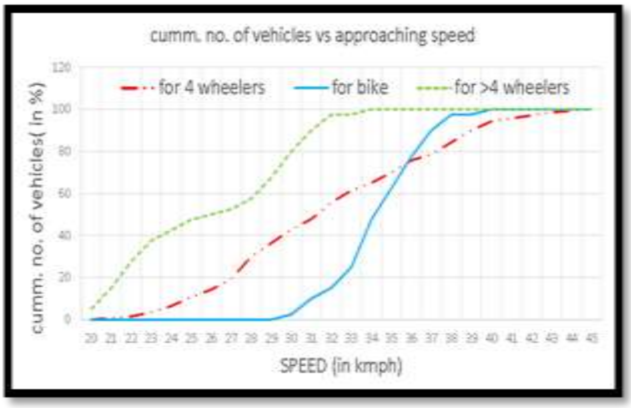



Fig: Vehicles speed distribution for approaching

The distribution of the vehicle speed at the distance of 10m is shown in fig. As illustrated in fig, higher percentage of vehicles>4-wheelers is traveling over breakers beyond a certain speed as compared to 4-wheelers and 2-wheelers. For example, about 60% of 4-wheelers at the distance of 10m from breaker at speeds of 32 kmph or below while only whereas only 20% of 2-wheeler are in the same category.

## 2. LITERATURE REVIEW

**1) Catherine Berthod, Engineer and Urban Planner Minister Des Transports du Qu�ec Annual Conference of the Transportation Association of Canadian Edmonton, Alberta**

To respond to this need, the ministered des Transports du Qu�ec has be gun publishing a series of fact sheets on a variety of traffic calming measures including: speed humps and speed cushions, raised crosswalks and intersections, neck downs (curb extensions at intersections),the reduction of the width of streets, centre islands and chicanes. A general fact sheet present all of the measures and notably outlines the procedure for pre-implementation analysis. Each fact sheet earmark to an individual measure outlines the implementation context, advantages and disadvantages, geometric characteristics, effectiveness at reducing speed, and maintenance requirements, including winter maintenance. The presentation will present the first two published fact sheets: the general fact sheet and the fact sheet on speed breakers and speed cushions. The fact sheets as well as examples of measures implemented in municipalities are available on the ministered des Transports website at under Partenaires – Municipalities – Securities routi�e.Speed control is a key factor in road safety. It is for this reason that the ministered hopes to support municipal initiatives related to the use of traffic calming measures. By issuing these fact sheets, stakeholders will have easy access to pertinent information as well as concrete examples to help them design the solution best suited to every situation. The fact sheet on neck downs (curb extensions at intersections) will be available shortly.

**2) The influence of speed bumps heights to the decrease of the vehicle speed ,Belgrade experience Boris Antić, Dalibor Pešić, Milan Vujanić .Krsto Lipovac**

In the residential zones where a large number of pedestrians and other vulnerable road users are expected, like school zones, it is necessary to decrease the speed to such a level that the risk of susceptibility is the lowest possible. One of the commonly accepted and often implemented speed decrease measures is vertical rising of the road pavement (speed bumps, speed humps, etc.). This work shows the affects of speed bumps of different heights (3, 5 and 7 cm) to the decrease of vehicle speed. Speed measurements had been done before speed breakers were installed, 1 day and 1 month after the installation. Applying ANOVA analysis and post hoc analysis, using Turkey–Kramer's multiple comparison test, a comparison was made of mean, 50th percentile and 85th percentile speed, before and after speed bumps setting. It has been shown that there is a eloquent speed decrease on the places where speed bumps were set, compared to the period before setting. Based on the research results, it was suggested that on the locations where susceptible road users are extremely endangered, speed bumps 5 and 7 cm high should be set, whereas at less endangered locations speed breakers 3 cm high could be set. Also, it has been shown that the effects of speed breakers on speed decrease are enduring, because there has not been any significant deviation in vehicle speeds neither 1 day nor 1 month after speed breakers setting.

## 3. METHODOLOGY

### 3.1 Materials

#### a) Non Newtonian Fluid

A non-Newtonian fluid is a fluid that does not obey Newton's law of viscosity, i.e. constant viscosity independent of stress. In non-Newtonian fluids, viscosity can vary when under force to either more liquid or more solid. For example, **Ketchup** becomes liquid when shaken and is thus a non-Newtonian fluid. Many solutions including salt and molten polymers are non-Newtonian fluids.

Generally, the viscosity the gradual deformation by stresses (shear or tensile) of non-Newtonian fluids is dependent on shear rate. Some non-Newtonian fluids with shear-independent viscosity, however, still show normal stress-differences or other non-Newtonian behaviour. The relation between the stress and the shear rate is linear in a Newtonian fluid, run through the origin, the constant of proportionality being the coefficient of viscosity. The relation between the shear stress and the shear rate is different in a non-Newtonian fluid. The fluids can even show time-dependent viscosity. Therefore, a constant coefficient of viscosity cannot be determined. In fluid mechanics the concept of viscosity is commonly used to characterize the shear properties of a fluid, it can be inadequate to describe non-Newtonian fluids.

#### i) Acrylic

Acrylic is a fast-drying liquid made of pigment suspended in acrylic polymer emulsion. Acrylic is water-soluble, but become water-resistant when dry. Depending on how much the liquid is diluted with water, or modified with acrylic gels, mediums, or pastes, the finished acrylic can resemble a watercolours, a gouache have its own unique characteristics not achievable with other media. Acrylic is typically used for craft or in art classes in schools because it does not require any chemicals, and rinses away with just water.

Fig: Acrylic

#### ii) Oobleck

Oobleck is a fluid material which acts as a suspension of cornstarch and water that can behave like a solid or a liquid depending on how much pressure you apply. If you grab oobleck in your hand, and it feel like a solid ball in your palm after you release the pressure. Then, it will slip out from your fingers. Materials are that behave as non-Newtonian fluid because their flow properties are not described by a constant viscosity. The name Oobleck originated from the 1949 children's book, *Bartholomew and the Oobleck*, by Dr. Seuss.

Fig: Oobleck

#### b) Kevlar

Kevlar is a heat-resistant and strong synthetic fiber, related to other aramids such as Nomex and Technocrat. Kevlar is a replacement for steel in racing tires. Typically it is spunk into ropes or fabric sheets that can be used as such or as an ingredient in composite material components. Kevlar is used in bicycle tyres and racing sails to bulletproof vests, because of its high tensile strength-to-weight ratio by this measure it is 5 times stronger than steel.

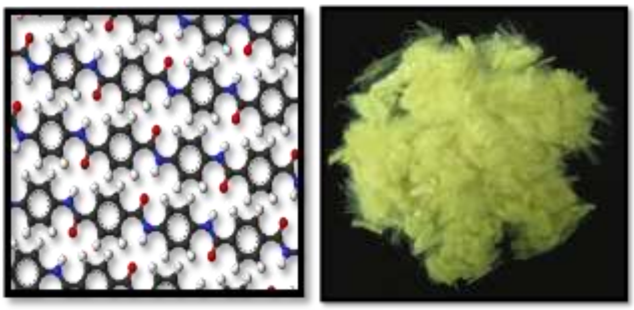


Fig: Kevlar

### c) Synthetic rubber

A synthetic rubber is any artificial elastomer. These are mainly polymers synthesized from petroleum byproducts. Synthetic rubber, like natural rubber, has uses in the automobile industry for tyres, door and window profiles, hoses, belts, matting, and flooring.

Fig: synthetic rubber

## 3.2 Design and Implementation

**Speed Breaker – Body and Containing Fluid**

The speed breaker includes an outer cover and a bottom plate. The bottom plate may include more than one fastening holes. The breaker can be either permanently or temporarily placed to a roadway with bolts, screws. The cover can be formed of reinforced rubber material. The cover encloses with Non Newtonian fluid, which reversibly hardens or stiffens in response to an applied pressure and goes back to its original form when the pressure is relieved. The housings are in the form of elongated, hollow, flexible tubes having closed ends.

The tubes are made up of either polymeric or rubber material. The flexible tubes are filled with a non-Newtonian fluid .If the vehicle travels at a low speed, fluid is moved and breaker is deformed, depression of the strip occurs in the area in which the wheels pass over, forming a small obstacle to the passage of the vehicle. However, if the speed of the vehicle is high then the fluid has no time to displace and a considerably smaller depression occurs. Hence the strip forms a step with greater height, causing the vehicle to jump, warning the driver about his excess speed. The fluids used to fill the housings are non-Newtonian fluids. A non-Newtonian fluid is a fluid the viscosity of which varies with the pressure gradient applied. As a result, a non-Newtonian fluid does not have a defined and constant viscosity value, like a Newtonian fluid. The Non Newtonian fluid acts like a fluid below a critical shear rate but above the critical shear rate, the material acts like a solid.

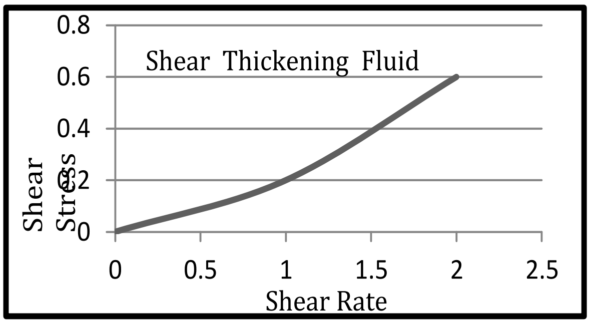



Fig: Shear thickening fluid graph

The non-Newtonian fluid acts as controlling the resistance by the strip to its deformation. It depends on the speed of the wheels of the vehicle on it. Thus, if the vehicle travels at a low speed the fluid has a low viscosity and the strip is easily deformed, whereas if the speed of the vehicle is high the viscosity of the fluid is high and as a result has great resistance to deformation, thus forming a rigid obstacle to the passage of the vehicle. Thus the speed of the vehicle is controlled due to the combined effect of non-Newtonian fluids and their flow via narrow conduits.

Fig: Non – Newtonian fluid speed breaker

**Reflector**

Reflectors are placed on the road leading to the speed breaker. The safety reflector is meant for pedestrians, motorized and non-motorized vehicles. It aids visibility of a person or vehicle, as it reflects light from headlights of vehicles .The reflector is manufactured in the form of a moulded tile of transparent plastic. The outside surface is plane, allowing light, such as from a car's headlights, to enter. Due to the aspect of the other inside surfaces, any light internally reflecting is directed back out the front of the reflector in the direction it came from. This alerts the person close to the light source, in this case, the driver of the vehicle, to the presence of the speed breaker.

**Working of Breaker**

The speed breaker can be either permanently or temporarily placed at a desired location, such as in street or roadway. The material in the tubes can be selected based on a desired shear rate. The shear rate selected will correspond to predetermined vehicle speed. When a vehicle rolls over the breaker below the predetermined speed i.e. below the critical shear rate of the material, the material remains in fluid form and the weight of the vehicle compresses the outer cover and the tubes.

Fig: Deformation of breaker

When the vehicle has passed over the breaker, the breaker returns to its original shape. Thus, below the speed limit, little impact is felt by the driver. Therefore, if the vehicle is traveling under the selected speed limit which will provide a shear rate less than the critical shear rate however, in the event a vehicle impacts the speed breaker at a speed above the predetermined speed that is, providing a shear rate above the critical shear rate, the viscosity of the non Newtonian fluid increases.

The fluid material acts as a solid and the speed breaker substantially retains the speed breaker shape. The speed breaker in this scenario acts similarly to a conventional speed breaker and the driver of the vehicle exceeding the selected speed limit will experience a breaker or jerk as would be felt with a conventional speed breaker.

## 4. COMPARISION BETWEEN CONVETIONAL SPEED BREAKER ANF NON- NEWTONIAN FLUID SPEED BREAKER

| **Characteristics Of Breaker** | **Conventional Speed Breaker** | **Non-Newtonian Fluid Speed Breaker** |
|---|---|---|
| Nature | Permanent | Mobile |
| Sensitivity | Not Sensitive To Speed Of Vehicle | Sensitive |
| Speed Restriction | Slow- Every Condition | Slow – Only When It Over Speeding |
| Fuel Efficiency Of Vehicle | Decrease | Increase |
| Toll On Mechanical Components Of Vehicle | Yes | No |
| Installation Method Requirement | Technical Skilled Labour | No Technical Skilled Labour |
| Installation Cost | High | Low |
| Maintenance Cost | High | Low |
| Medical Problem Arise | Spinal Damage Or Aggravate Chronic Backache | Not Damaged |
| Weight | Heavy | Light |
| Response Time Of Emergency Vehicle | Slow Down (3-10sec /Breaker) | Does Not Affect |
| Traffic Noise Pollution | Increase | Decrease |

## RESULT AND CONCLUSION

- The Non -Newtonian fluid speed breaker help in increasing the fuel efficiency of vehicles up to a large extent.
- Vehicles need not come to a complete halt in from of speed breaker, reducing traffic congestion.
- The installation cost and maintenance cost of non Newtonian fluid speed breaker is comparatively low as compare to conventional speed breaker.
- It does not damage on a vehicle's mechanical components, such as the shock absorbers and steering system if the vehicle is following the speed limit.
- The setup is completely mobile and can be installed within an hour.
- The installation process does not require technically skilled person.
- It helps in reducing traffic noises.

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