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Non-Newtonian Fluid Speed Breaker

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"Any sufficiently advanced technology is equivalent to magic."
- Arthur C. Clarke.

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ABSTRACT –Speed bumps, as traffic calming devices, have been extensively used to reduce traffic speed on local streets. This study represents a unique application of Non-Newtonian fluid as Speed Bump. This technical paper relates to a device that reduces the speed of any over speeding vehicles travelling on a roadway. It is formed by a flexible material which consist of Non-Newtonian fluid in it i.e. each receptacle is impregnated with a dilatants shear thickening fluid. The material is placed under compression during impact when the vehicle strikes it and the fluid itself acts as means for controlling the resistance to deformation of the strip. 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. Drivers must always slow down when driving over the conventional speed breakers 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: Speed Bump, Non-Newtonian fluid, Traffic, Vehicles

I. INTRODUCTION

Speed breaker is a device which is used to control the speed of the vehicles passing over them. Speed Ramp, Speed Bump, Speed tables and Speed Hump are the general classifications of speed breaker. It can be used majorly near schools, colleges and hospitals to slow down the speed of the vehicles and, so it is very ease to cross the road for children and senior citizen people. They are also placed near entry points of bridges, narrow roads and toll booths to ensure that drivers reduce their speed. Now a day, there are two forms of speed breaker are mostly used which are conventional speed breaker and plastic speed breaker. The usage of fluid in a speed breaker is not common thing in real time. A Non-Newtonian fluid is a fluid that changes its viscosity with respect to the force applied to them.

Speed bumps (or speed breakers) is the common name for the family of traffic controlling devices that use vertical deflection to slow motor vehicle traffic in order to improve safety conditions. Variations include the speed bump, speed cushion, and speed table. The use of vertical deflection devices is widespread around the world, and they are most commonly found to enforce a low-speed limit. Although speed bumps are effective in keeping vehicle speeds down, their use is sometimes controversial—as they can increase traffic noise, may damage vehicles if traversed at high speeds, and slow emergency vehicles. Poorly designed speed bumps that stand too tall or with too-sharp an angle can be disruptive for drivers and may be difficult to navigate for vehicles with low ground clearance, even at very low speeds. Many sports cars have this problem with such speed bumps. Speed bumps can also pose serious hazards to motorcyclists and bicyclists if they are not clearly visible, though in some cases a small cut across the bump allows those vehicles to traverse without impediment. This Speed Bump is based in Non-Newtonian fluids dynamics in which particles in natural movement as liquid align when receiving an impact, thus entering into a solid state. This fluid is also biodegradable and harmless for human beings. This fluid inside the BIV is the solution to vehicles at sensible speed that will find no obstacle when driving over it

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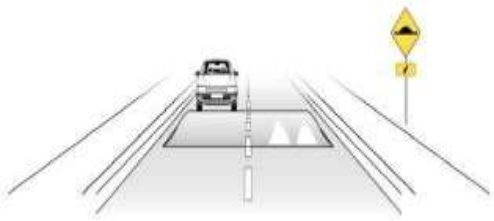

Figure 1: Speed Bump

I. STUDY

A. Basics of Speed Breakers

A speed breaker is a semi-circular shape hump surface across the roadway having width higher than The vehicle wheel base. An ideally designed speed breaker should satisfy the following requirements:

- It should not cause any vehicle damage and does not cause any discomfort to the drivers as well as the passengers those travelling along it.
- The speed breaker should not produce any detrimental vibrations or too much noise to the adjacent buildings.

B. Design of Speed Breakers:

Speed breakers are basically in 3.7-meter width and having a height of 0.7 meter and advisory crossing speed of 25 km/hr., Speed breakers may have to be repeated over a section to keep speeds low throughout in certain locations and it can be built in a regular interval of 0.1 meter to 0.12-meter center to center distance.

C. Problem Associated with Conventional Speed Breakers:

- Conventional speed breaker is naturally an eternal structure on a roadway and it is difficult to remove conventional speed breakers
- The conventional speed breakers are very heavy and, once in place, are typically permanent fixtures on the roadway. In order to remove conventional speed breakers, the speed breakers must be broken up and the roadway repaired where the speed breakers used to be.
- Speed breakers are that they often cause spinal damage or aggravate chronic backache due to the constant shocks suffered while traversing the speed breakers.
- A conventional speed breaker usually consists of a concrete or asphalt hump formed in the road. Drivers must slow down when driving over these speed breakers 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.
- Additional criticism of speed breakers includes their effect on emergency vehicles. Response time is slowed by 3–5 seconds per breakers 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.

II. PRINCIPLE NON-NEWTONIAN FLUID

A non-Newtonian fluid is a fluid that does not follow Newton's Law of Viscosity. Newton's viscosity law states that the shear stress between adjacent fluid layers is proportional to the velocity gradients between the two layers. The ratio of shear stress to shear rate is a constant, for a given temperature and pressure, and is defined as the viscosity or coefficient of viscosity. Most commonly, the viscosity (the gradual deformation by shear or tensile stresses) of non-Newtonian fluids is dependent on shear rate or shear rate history. Some non-Newtonian fluids with shear independent viscosity, however, still exhibit normal stress-differences or other non-Newtonian behavior. Many salt solutions and molten polymers are non-Newtonian fluids, as are many commonly found substances such as ketchup, custard, toothpaste, starch suspensions, maize, honey, paint, blood, and shampoo. Non-Newtonian fluid speed bump is made using a casing in which the fluid is contained with no leakage etc. and is filled 95% to the full capacity of the containment so that when the vehicle is moving smoothly in accordance to the speed limit the liquid could be displaced and vehicle can pass over smoothly. But if the vehicle moves with higher speed it will experience hard contact with the speed bump.

III. DESIGN

The speed bump includes an outer shell and a bottom plate. The bottom plate may include one or more fastening holes so that the device can be either permanently or temporarily mounted to a roadway or other surface such as by bolts, screws, or other conventional devices. The shell can be formed of any conventional material, such as but not limited to flexible or resilient materials including or rubber The shell encloses one or more housings containing a compliant material such as a 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

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filled with a fluid and interconnected by a conduit which enables the controlled flow of the fluid in or out of the chamber If the vehicle travels at a reduced speed, fluid is moved to the adjacent chamber and a 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 pass into the adjacent chambers 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. At high shear rates, the hydrodynamic forces overcome the repulsive inter-particle forces, forming silica hydro-clusters which increase the viscosity of the fluid. Therefore, the non-Newtonian fluid itself acts as means for controlling the resistance offered by the strip to its deformation depending on the speed of impact 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.

IV. WORKING

The speed bump can be either permanently or temporarily mounted at a desired location, such as in a street or roadway. The dilatant material in the tubes can be selected based on a desired shear rate. The shear rate selected will correspond to a predetermined vehicle speed. When a vehicle rolls over the bump below the predetermined speed i.e. below the critical shear rate of the dilatant material, the dilatant material remains in fluid form and the weight of the vehicle compresses the shell and the tubes. This pushes the dilatant fluid out of the shell into the reservoir. When the vehicle has passed over the bump, the shell returns to its initial shape and the pump pushes the dilatant material back into the tubes which also return to their original shape. Thus, below the critical shear rate, 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 bump at a speed above the predetermined speed that is, providing a shear rate above the critical shear rate, the viscosity of the dilatant material increases. The dilatant material acts as a solid and the speed bump substantially retains the speed bump shape. The speed bump in this scenario acts similarly to a conventional speed bump and the driver of the vehicle exceeding the selected speed limit will experience a bump or jolt as would be felt with a conventional speed bump.

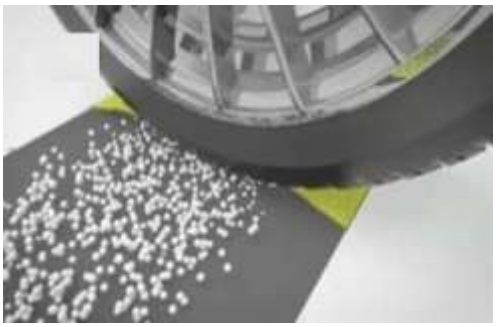

Figure 2: The motion of fluid particles of the viscous fluid when the vehicle is passing at a normal speed. The bump deforms itself to allow easy passage for the vehicle.

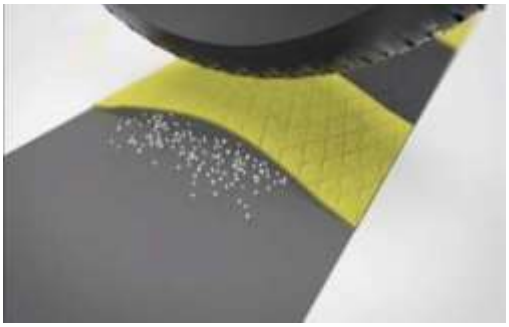

Figure 3: The motion of the fluid particles of the viscous fluid when the vehicle is passing at a higher speed. The bump toughens itself to exert shock on the high speeding vehicle.

V. COMPARISION BETWEEN CONVETIONAL SPEED BREAKER AND NON- NEWTONIAN FLUID SPEED BREAKER

Table 1. Comparison

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	Decrease	Increase

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of Vehicle		
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

Advantages of Speed Bumps with Non-Newtonian Fluid

- All emergency vehicles won't be required to slow down at these speed bumps.
- In normal speed bumps the bus drivers and truck drivers get backache while again and again going on the bumps, this problem can also be solved using speed bumps with non-Newtonian fluid.
- Installation time is quick.
- Maintenance is low.
- Reduces the possibility of traffic accidents.
- Reduces fatigue caused to the shock absorbers.
- Reduces pollution, fuel consumption.
- And noise pollution caused by continuous bumping can be minimized.
- Simple manufacturing and fast manufacturing.
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VI. FUTURE SCOPE

Non-Newtonian fluid can be used in many traditional methods of working we use today so that we can overcome various problems we face today in safety equipment (e.g. Working Jackets, Machine Mount, Damping device, Fluid Dampers).

- Economical
- Suitable at parking of multiplexes, malls, toll booths, signals etc.
- Reduce air and noise pollution
- Increase fuel efficiency in some extent
- Low maintenance cost
- Response time of emergency vehicle not affected

VII. CONCLUSION

The Variable Density Speed Bump can help in increasing the fuel efficiency of vehicles up to a large extent. Vehicles need not come to a complete halt in form of speed bumps, reducing traffic congestion also. It also does not take a toll 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 a technically skilled person.

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