SMART SPPED REGULATION SYSTEM USING MODERN SPEED BUMP

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ABSTRACT

The proposed smart speed bump system is designed for roads with a design speed of up to 80 km/h, where conventional speed breakers are not recommended according to guidelines of the Indian Roads Congress. The system uses an Arduino UNO microcontroller integrated with IR sensors to measure vehicle speed using the time–distance principle. When a vehicle exceeds the preset speed limit, a servo motor automatically activates the speed bump, while it remains flat for vehicles moving within the permissible speed limit, ensuring smooth traffic flow and driver comfort. The system also includes emergency vehicle detection using a sound sensor, allowing ambulances and fire brigades to pass without interruption by keeping the speed bump flat. In addition, the system monitors traffic density conditions and keeps the speed bump inactive during heavy traffic to prevent congestion. Real-time information such as vehicle speed and system status is displayed on a 16×2 LCD display, while traffic signal lights and a buzzer provide visual and audible warnings to drivers. Overall, the proposed system is cost-effective, reliable, and suitable for urban roads, school zones, hospital routes, and accident-prone areas, helping to reduce over speeding-related accidents while maintaining smooth and efficient traffic flow.

Keywords : *Smart Speed Bump, Speed Regulation System, Arduino UNO, IR Sensors, Time–Distance Principle, Emergency Vehicle Detection, Traffic Density Monitoring, Road Safety, Intelligent Traffic Control, Smart Transportation System etc.*

I. INTRODUCTION

Transportation infrastructure plays a vital role in the economic and social development of a country. In India, rapid urbanization, increasing population, and growth in vehicle ownership have led to a significant rise in traffic volume on urban and arterial roads. According to traffic safety studies referenced by the Indian Roads Congress (IRC), over speeding is one of the primary causes of serious and fatal road accidents. High vehicle speeds reduce reaction time, increase stopping distance, and significantly increase the severity of collisions.

To control vehicle speed, conventional traffic calming measures such as speed breakers, rumble strips, warning signs, and traffic signals are commonly used. Among these, speed breakers are widely implemented due to their simplicity. However, IRC : 99–2018 clearly states that the use of fixed speed breakers should be restricted and avoided on high-speed and major urban roads, as they adversely affect traffic flow, vehicle performance, and passenger comfort.

IRC emphasizes that speed control measures should be scientifically designed, properly located, and should not create unnecessary obstruction. Therefore, there is a growing need for intelligent and adaptive speed control systems that regulate vehicle speed only when required. A smart speed bump system capable of responding dynamically to vehicle speed, traffic density, and emergency situations aligns well with modern traffic engineering practices and IRC road safety principles.

II. PROBLEM IDENTIFICATION

- Rapid increase in vehicular traffic on Indian roads has raised serious concerns related to road safety, traffic congestion, and accident rates.
- Over speeding is a major cause of road accidents, especially on urban and arterial roads, as highlighted by the Indian Roads Congress guidelines.
- Conventional fixed speed breakers are widely used, but their excessive and improper installation on roads often violates IRC recommendations.
- According to IRC:99–2018, speed breakers should be installed only in low-speed areas such as school zones, residential streets, and pedestrian crossings, and are not recommended on higher design speed roads.
- Improper installation of speed breakers leads to vehicle discomfort, possible vehicle damage, increased fuel consumption, and frequent traffic interruptions.
- Fixed speed breakers do not provide priority for emergency vehicles such as ambulances and fire brigades, which may cause delays in emergency response time.
- Conventional speed breakers do not adapt to real-time traffic conditions, resulting in traffic congestion, increased emissions, and inefficient traffic flow.
- Many speed breakers lack proper warning signs and illumination, which increases the risk of accidents, particularly during night-time or poor weather conditions.

III. EXISTING SYSTEM

- Conventional fixed speed breakers are commonly used as traffic calming measures to control vehicle speed and reduce the risk of accidents caused by over speeding.
- According to the guidelines of the Indian Roads Congress, speed breakers should be installed only at specific low-speed locations such as school zones, residential streets, and pedestrian crossings.
- As per IRC:99–2018, the installation of speed breakers is not recommended on roads with higher design speeds, particularly on urban arterial and major roads.
- In the existing system, speed breakers are permanently installed on the road surface, which means they remain active for all vehicles irrespective of their speed.
- Due to this fixed nature, vehicles traveling within the permissible speed limit are also forced to decelerate, causing unnecessary discomfort to drivers and passengers.
- Conventional speed breakers do not provide priority to emergency vehicles such as ambulances, fire brigades, and police vehicles, which may delay emergency response services.
- In many locations, speed breakers lack proper warning signs, road markings, and illumination, which increases the risk of accidents, especially during night-time or poor visibility conditions.

IV. LITERATURE SURVEY

1) K. S. B. Prasad et al. (2018):

This study reviews recent improvements in speed bump design and traffic calming practices. The authors explain that conventional speed bumps help in controlling vehicle speed in sensitive areas such as residential zones and school surroundings, but they may also result in driver discomfort, additional fuel consumption, and traffic delay.

2) T. Ravi Kumar (2019):

The author introduced a smart speed breaker concept that functions only when a vehicle travels above the specified speed limit. The system uses speed sensing technology so that vehicles moving within the permitted speed range can pass without disturbance.

3) Korra Ravi Kiran (2020):

This research examines the working performance of common speed humps and identifies several operational drawbacks. The study indicates that traditional designs may affect ride comfort and increase travel time, suggesting the requirement of improved traffic calming solutions.

4) R. Prabhu (2022):

The researcher proposed an automated traffic control approach using Internet-based technology. In this system, sensors are applied to detect vehicle speed and activate speed control devices only during over speeding conditions.

5) Poonam Yadav et al. (2022):

This work focuses on regulating vehicle movement in restricted zones such as hospitals and school areas. The proposed smart speed breaker rises from the road surface when a vehicle crosses the allowed speed level and remains flat when the speed is normal.

6) Avishkar Mahadik et al. (2022):

The study presents a system that helps in identifying speed breakers before the vehicle reaches them. By using sensors, the system warns or adjusts the vehicle speed in advance, which can help in avoiding sudden braking and accidents.

7) Melvin Mokhtar (2023):

The author suggested an intelligent traffic calming method using a smart speed bump. The design activates only for vehicles moving faster than the permitted limit, allowing other vehicles to continue their movement without interruption.

8) Tamara Džambas et al. (2023):

This research compares traditional speed bumps with intelligent versions and discusses their safety and environmental impacts. The findings indicate that adaptive systems can reduce unnecessary slowing of vehicles and improve traffic efficiency.

9) Uma Shankar Kurmi et al. (2025):

The paper presents a speed monitoring technique based on infrared sensors. The system determines vehicle speed by measuring the time required for a vehicle to pass between two sensor points.

10) Zeljko Šarić et al. (2025):

This investigation studies the effect of speed bumps on traffic flow within urban streets. The analysis highlights how the design and positioning of speed control devices influence vehicle speed patterns and overall road performance.

V. MATERIAL USED

1. Arduino UNO
2. Infrared (IR) Sensor
3. Sound Sensor Module
4. Servo Motor 90 Degree
5. 16x2 LCD Display (with 12C Module)
6. Buzzer
7. Traffic Signal Light
8. Power Supply (DC Adapter & Power Cable)
9. Jumper Wire

VI. METHODOLOGY

1. The system uses Arduino UNO as the central processing unit which continuously receives data from sensors and makes real-time decisions.
2. IR sensor is used to measure vehicle distance and speed.
3. Sound sensor is used to detect siren signals of emergency vehicles such as ambulance and fire brigade.
4. When a vehicle exceeds the permissible speed limit (as per IRC intent), the speed bump is activated.
5. For emergency vehicles, the bump remains flat to ensure uninterrupted movement. The system also provides visual and audible alerts using LCD, traffic signal lights, and buzzer.
6. This approach supports the IRC objective of speed calming instead of sudden obstruction, especially on high-speed corridors.

VII. CALCULATION

1. Stopping Sight Distance for Major District Road (Design Speed = 65 km/h)

Where:

V = design speed (km/h)
t = perception–reaction time (2.5 s)
f = coefficient of longitudinal friction (≈ 0.35)

Step 1: Lag Distance (Perception–Reaction Distance)

Reaction Distance = 0.278 x Vx t
=0.278 x 65 x 2.5
=45.18m

Step 2: Braking Distance
= V2/254 f
= 652 /254×0.35
= 4225/ 88.9
= 47.52 m
Step 3: Stopping Sight Distance
SSD = Lag Distance + Braking Distance
SSD = 45.18+47.52
SSD = 92.7m

Stopping Sight Distance = 93m

2. Stopping Sight Distance for State Highway (Design Speed = 80 km/h)

Step 1: Lag Distance (Perception–Reaction Distance)
Reaction Distance = 0.278xVxt
= 0.278 x 80 x 2.5
= 55.6m
Step 2: Braking Distance
= V2/254 f
= 802 /254×0.35
= 6400 /88.9
= 72.0 m
Step 3: Stopping Sight Distance
SSD = Lag Distance + Braking Distance
SSD = 55.6+72.0
SSD = 127.6m

Stopping Sight Distance = 128m

FINAL RESULT: -

- Major District Road (65 km/h): Stopping sight distance ≈ 93 m.
- State Highway (80 km/h): Stopping sight distance ≈ 128 m.

VIII. COADING

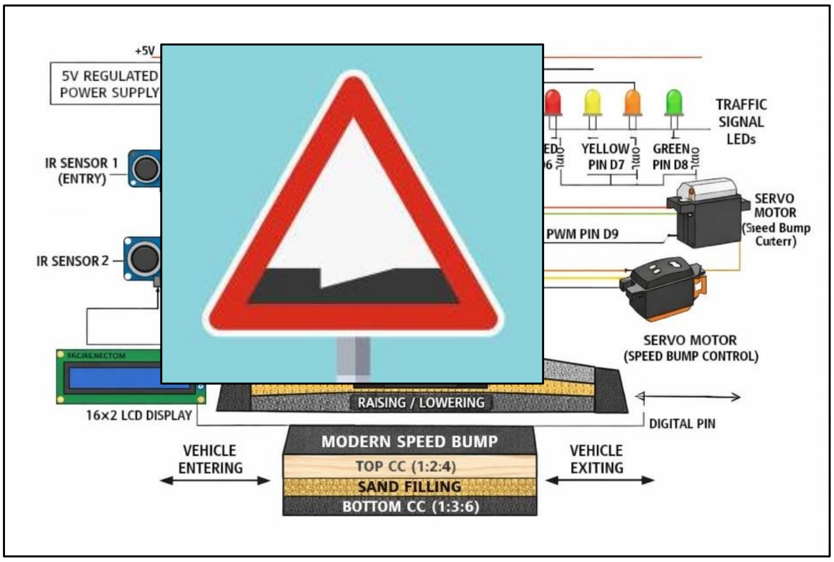
```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <Servo.h>
LiquidCrystal_I2C lcd (0x27, 16, 2);
Servo bump;
const int IR1 = 2;
const int IR2 = 3;
const int sound Sensor = 4;
const int servo Pin = 9;
const int buzzer = 10;
const int red LED = 11;
const int green LED = 12;

unsigned long t1, t2;
float speed;
const float distance = 1.0;   // 1 meter between sensors
const int speed Limit = 90; // km/h
void setup () {
 pin Mode (IR1, INPUT);
  pin Mode (IR2, INPUT);
  pin Mode (sound Sensor, INPUT);
```

```
pin Mode (buzzer, OUTPUT);
  pin Mode (red LED, OUTPUT);
  pin Mode (green LED, OUTPUT);
 bump. Attach (servo Pin);
  bump. Write (0);
 lcd. init ();
  lcd. backlight ();
lcd. set Cursor (0,0);
  lcd. Print ("Smart Speed");
  lcd. set Cursor (0,1);
  lcd. Print ("Breaker Ready");
 digital Write (green LED, HIGH);
  Serial. Begin (9600);
  delay (2000);
  lcd. Clear ();
} void loop ()
 {
 // Emergency Vehicle Detection
  if (digital Read (sound Sensor) == LOW) {
lcd. Clear ();
    lcd. set Cursor (0,0);
    lcd. Print ("Emergency Veh");
    lcd. set Cursor (0,1);
    lcd. Print ("Bump Down");
  bu. writes (0);
digital Write (red LED, LOW);
    digital Write (green LED, HIGH);
    digital Write (buzzer, LOW);
  delay (5000);
    lcd. Clear ();
  }
 // Vehicle Speed Detection
  if (digital Read (IR1) == LOW) {
  t1 = Millis ();
while (digital Read (IR2) == HIGH);
 t2 = Millis ();
float timeSec = (t2 - t1) / 1000.0;
   speed = (distance / timeSec) * 3.6;
lcd. Clear ();
    lcd. set Cursor (0,0);
    lcd. Print ("Speed: ");
    lcd. Print(speed);
    lcd. Print("km/h");
 Serial. Print ("Speed = ");
    Serial.println(speed);
 if (speed > speed Limit) {
 digital Write (red LED, HIGH);
      digital Write (green LED, LOW);
      digital Write (buzzer, HIGH);
  bump. Write (90);
 lcd. set Cursor (0,1);
      lcd. Print("OVERSPEED!");
 }
 else {
   digital Write (red LED, LOW);
    digital Write (green LED, HIGH);
    digital Write (buzzer, LOW);
```

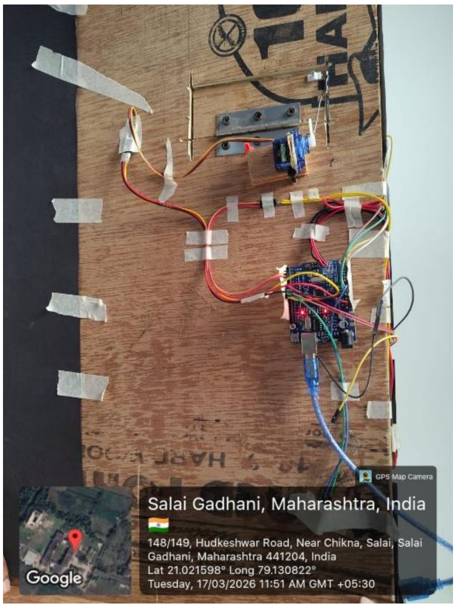
```
 bump. Write (0);
lcd. set Cursor (0,1);
 lcd. Print ("Normal Speed");
   }
 delay (3000);
   lcd. Clear();
   }
   }
```

IX. CIRCUIT DIAGRAM



X. WARNING SIGN

XI. MODEL



XII. METHOD OF ANALYSIS

- The analysis begins by identifying the design speed of the selected road categories, such as Major District Road and State Highway.
- The stopping sight distance (SSD) is calculated using standard highway engineering relationships that consider vehicle speed, driver reaction time, and braking characteristics.
- The calculated SSD helps determine the minimum safe distance required for a driver to stop a vehicle when an obstacle or speed control device appears on the road.
- A sensor-based speed detection system is considered, where two sensors are installed at a fixed distance on the roadway.
- The time taken by a vehicle to travel between the two sensors is measured to determine the vehicle speed using the distance–time relationship.
  The calculated vehicle speed is compared with the permitted speed limit for that particular road section.

XIII. EXPERIMENTAL RESULT OF THE MODERN SPEED BUMP SYSTEM

Trial No.	Vehicle Speed (Km/h)	Speed Limit (Km/h)	Breaker Status	Vehicle Detection Time (Sec.)	Breaker Response Time (Sec.)	Alert Triggered
1	67	80	Not Activated	0.60	0.28	No
2	36	80	Not Activated	0.61	0.29	No
3	88	80	Activated	0.55	0.28	Yes
4	42	80	Not Activated	0.60	0.30	No
5	93	80	Activated	0.53	0.27	Yes
6	81	80	Activated	0.54	0.28	Yes
7	54	80	Not Activated	0.59	0.29	No
8	32	80	Not Activated	0.62	0.31	No
9	89	80	Activated	0.53	0.27	Yes
10	102	80	Activated	0.52	0.26	Yes

XIV. RESULT AND DISCUSSION

- The Smart Speed Regulation System effectively detects vehicle speed using IR sensors. When a vehicle travels within the safe speed limit, the model speed bump remains flat and allows smooth movement. If the vehicle exceeds the limit, the system activates the motor to raise the speed bump and reduce speed.
- The sound sensor detects emergency vehicle sirens and keeps the speed bump flat to allow quick passage. Overall, the system demonstrates reliable speed detection and improves road safety by

controlling over speeding vehicles.

- This system also includes visual indicators such as red, yellow & green LEDs to drive drivers and promote safer driving behavior.
- Overall, this technology works alongside traditional road safety measures and has the potential to cut down over speeding related caused accidents in prone areas such as School Zones, Hospital Areas, Residential Areas, Accident-Prone Locations, Intersections and Blind Spots, Highways without Service Roads reducing the risk of sudden deceleration or rear-end collisions. significantly, making roads safer for everyone.

XV. FUTURE SCOPE

The present work is within time bound frame & hence could not able to study all aspect. The following study may be carried out in future for better understanding. To enhance the effectiveness and scalability of the system, several future improvements can be implemented:

1. AI & Machine Learning for Speed Prediction
2. Renewable Energy Integration
3. Advanced Actuation Mechanisms
4. Implementation in Real-World Scenarios

XVI. CONCLUSION

- The Smart Speed Regulation System Using Model Speed Bump was developed to address the problem of over speeding vehicles and the limitations of traditional speed breakers.
- Over speeding is one of the major causes of road accidents, especially in areas such as school zones, residential areas, hospitals, intersections, and accident-prone locations.
- The proposed system uses IR sensors to detect the movement of vehicles and measure the time taken by the vehicle to travel between two fixed points. Based on this time, the system calculates the vehicle speed using the distance–time formula.
- The calculated speed is then processed by the microcontroller, which compares it with a predefined speed limit. If the vehicle speed is within the allowed limit, the model speed bump remains flat, indicating green light allowing the vehicle to pass smoothly without disturbance.
- However, if the vehicle exceeds the speed limit, the system activates the motor mechanism, which down the speed bump indicating red light and forces the driver to reduce speed.
- An additional feature of the system is the sound sensor module, which detects the siren sound of emergency vehicles such as ambulances, fire trucks, and police vehicles. When an emergency vehicle is detected, the system temporarily disables the speed bump activation and keeps the speed bump flat so that the emergency vehicle can pass without delay.
- Overall, the results show that the proposed system can provide an intelligent and efficient method for controlling vehicle speed while maintaining smooth traffic flow.
- In conclusion, the Smart Speed Regulation System Using Model Speed Bump offers a promising approach for improving road safety and traffic management. With further development and real-world implementation, this system can help reduce accidents, encourage responsible driving behavior, and create safer road environments in urban and rural areas.

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