

Design, Analysis and Fabrication of Anti-Riot Shield with Pepper Spray and Blinding Led

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Abstract—This project focuses on designing, analyzing, and fabricating an anti-riot shield that includes a pepper-spray system and a blinding LED for non-lethal crowd control. The main aim of the work is to give police and security personnel better protection while also providing a safe way to manage aggressive crowds. The shield is made using lightweight polycarbonate material, which is strong enough to resist high impacts and easy to handle during field operations. Basic Finite Element Analysis (FEA) is carried out to study the stress, deformation, and safety of the shield when it is hit by external forces. An Arduino-based circuit is used to operate the servo motor for pepper spray and to control the high-brightness LED. The prototype is fabricated using simple and low-cost components so that it can be used easily in real situations. Testing shows that the shield can handle impact loads while also helping officers control crowds without causing serious injuries. Overall, this project provides an improved, safer, and more practical solution for modern riot-control needs.

I. INTRODUCTION

Riot situations have become common in many parts of the world due to social, political, and economic issues. During such events, police and security personnel need proper protective equipment to handle crowds safely. Traditional riot shields offer only physical protection and do not assist officers in controlling aggressive groups. To improve safety and effectiveness, there is a need for modern shields with non-lethal features. This project focuses on designing and developing an anti-riot shield that includes a pepper-spray system and a blinding LED. The pepper spray helps in temporarily disabling aggressive individuals, while the LED light can reduce their visibility and slow down their actions. The shield is made from lightweight polycarbonate material to ensure strength and easy handling. An Arduino-based system is used to control the spray and LED operation.

The main aim of this work is to create a shield that provides both protection and active crowd-control support. Through basic design, analysis, fabrication, and testing, the project demonstrates a practical and safer solution for modern riot-control needs.

II. PROBLEM STATEMENT

Traditional riot shields only provide basic physical protection and do not offer any active features to control aggressive crowds. As a result, police and security personnel often face difficulty in managing violent situations without causing serious injuries. There is a need for a lightweight, durable, and non-lethal shield that can protect the user while also helping to control and disperse crowds safely. Therefore, the problem addressed in this project is to design and develop an anti-riot shield integrated with a pepper-spray mechanism and a blinding LED system to improve safety, control, and effectiveness during riot situations.

III. OBJECTIVES

- 1) To design a lightweight and durable anti-riot shield using polycarbonate material suitable for field use.
- 2) To integrate a non-lethal pepper-spray mechanism for safe and effective crowd control.
- 3) To install a high-intensity blinding LED system to temporarily disorient aggressive individuals.
- 4) To develop an Arduino-based control unit for operating the spray and LED functions reliably.
- 5) To perform basic mechanical analysis to check the strength and impact resistance of the shield.
- 6) To fabricate a working prototype using low-cost and easily available components.

- 7) To test the shield's performance under practical conditions and evaluate its effectiveness in riot situations.

IV. METHODOLOGY

The methodology followed in this project involves several systematic steps to design, analyse, and fabricate the anti-riot shield. The process begins with identifying the requirements for a modern non-lethal shield and selecting polycarbonate as the main material due to its high impact strength and lightweight nature. A 2D and 3D design of the shield is prepared using CAD software to finalize dimensions, shape, and placement of components.

After the design stage, mechanical analysis is carried out using basic Finite Element Analysis (FEA) to study stress distribution, deformation, and safety under expected impact loads. Parallel to the mechanical analysis, the electronic system is developed using an Arduino microcontroller, a servo motor for pepper-spray activation, and a high-intensity LED module for visual disorientation. The circuit layout is prepared, and components are tested individually.

Once all parts are finalized, the fabrication process is performed by cutting and shaping the polycarbonate sheet, mounting electronic components, and connecting the control unit. The fully assembled prototype is then tested for structural strength, LED brightness, spray operation, and overall handling. Feedback from testing is used to evaluate the effectiveness and practicality of the design in real riot-control conditions.

V. COMPONENT SPECIFICATIONS

1. Polycarbonate Shield Plate
 - Material: Transparent polycarbonate
 - Thickness: 3–4 mm
 - Properties: High impact resistance, lightweight, good visibility
2. MG995 Servo Motor
 - Operating Voltage: 4.8–7.2 V
 - Rotation: 0–180 degrees
 - Application: Activates pepper-spray trigger
3. Pepper Spray Bottl
 - Capacity: 55 ml
 - Range: Approximately 4 feet

- Weight: 35 g
 - Effect Duration: 30–45 minutes
4. High-Intensity LED Module
 - Type: High-brightness white LED
 - Operating Voltage: 12 V
 - Purpose: Blinding/disorientation effect
 5. Arduino Nano Microcontroller
 - Operating Voltage: 5 V
 - Processor: ATmega328P
 - Functions: Controls LED and servo motor
 6. Battery Pack
 - Type: Rechargeable Li-ion
 - Voltage: 12 V and 5 V regulation
 - Purpose: Power supply to electronics
 7. Trigger Buttons/Switches
 - Type: Push-button or toggle switch
 - Function: Manual activation of spray and LED
 8. Wiring and Connectors
 - Type: Copper wires, soldered joints
 - Purpose: Connect electronic components to Arduino
 9. Mounting Frame/Brackets
 - Material: Aluminium or plastic
 - Purpose: To securely attach electronics to shield

VI. DESIGN OF ANTI-RIOT SHIELD

The design of the anti-riot shield is developed to provide maximum protection to the user while integrating non-lethal crowd-control features. The shield is designed using polycarbonate material due to its high impact strength, transparency, and lightweight handling. A standard rectangular curved profile is selected to cover the upper body and provide a wider protective area during riot situations. The design process begins with preparing a 2D layout in AutoCAD to finalize the overall shape, dimensions, and mounting positions for electronic components. The shield typically measures around 900 mm in height and 500 mm in width, with smooth edges for safe handling. A curvature is provided along the width to improve strength and deflect impact forces efficiently. Handles and arm straps are positioned ergonomically on the inner side to ensure a firm and comfortable grip.

A separate compartment is designed on the front side to fix the high-intensity LED unit at eye level for maximum disorienting effect. Another mounting bracket is placed near the lower center to hold the pepper-spray bottle, which is linked to a servo motor

for controlled spraying. The electronic components, including the Arduino Nano, wiring, and battery pack, are positioned on the backside of the shield in a sealed casing to protect them from external damage. Finite Element Analysis (FEA) is applied to the 3D model to evaluate stress distribution and deformation under impact loads. The results help refine thickness, curvature, and mounting points to ensure safety and durability. The final design ensures a balance between protection, weight, and the integration of active non-lethal systems.

VII. ANALYSIS OF COMPONENTS BY ANSYS 15.0 SOFTWARE

Finite Element Analysis (FEA) is carried out using ANSYS 15.0 software to evaluate the structural strength and safety of the anti-riot shield under impact conditions. The analysis focuses on the polycarbonate shield, mounting brackets, and critical points where electronic components are attached.

Steps followed in ANSYS analysis:

1. Model Import: The 3D CAD model of the shield is imported into ANSYS.
2. Material Properties: Polycarbonate material properties, such as Young's modulus, Poisson's ratio, and density, are defined.
3. Meshing: The model is divided into small elements to create a finite element mesh. A fine mesh is applied at areas of expected high stress, such as handle positions and component mounts.
4. Boundary Conditions: The inner side of the shield, where the arm straps are fixed, is constrained to simulate real handling conditions.
5. Load Application: Impact forces are applied to the front surface to simulate forces encountered during riot situations.
6. Analysis: Static structural analysis is performed to determine stress distribution, deformation, and factor of safety (FOS).

Results:

- 1) Maximum stress is observed near the handle and pepper-spray mounting area.
- 2) Maximum deformation is within safe limits, confirming that the shield can withstand typical impact loads.
- 3) The factor of safety is greater than 2, ensuring reliability during operational use.

VIII. CALCULATIONS

- 1) Shield Load Analysis
 - Weight of polycarbonate shield: 2.5 kg
 - Maximum impact force assumed: 150 N (typical force in riot conditions)
 - This stress is well below the yield strength of polycarbonate (~70 MPa), ensuring safety.
- 2) Servo Motor Selection for Pepper Spray
 - Pepper spray bottle weight: 35 g = 0.035 kg
- 3) Arduino Circuit Load
 - LED current: 0.5 A
 - Servo motor current: 1.2 A
 - Total current: 1.7 A
 - Battery selection: 12 V, 2 Ah rechargeable Li-ion battery ensures enough operation time.
- 4) Deformation Check (from FEA)
 - Maximum deformation at impact: 1.2 mm
 - Acceptable limit: <5 mm
 - Conclusion: Shield deformation is within safe limits.

IX. LITERATURE SURVEY

Effective crowd-control and riot management have become critical concerns in modern law enforcement. Traditional riot shields offer passive protection against projectiles and physical attacks but do not provide active mechanisms for non-lethal crowd deterrence. Recent research emphasizes the integration of non-lethal devices such as pepper spray, high-intensity strobe or LED lights, and acoustic deterrents to improve operational efficiency while minimizing harm. Material selection is a key focus in contemporary studies. Lightweight, high-impact materials such as polycarbonate and reinforced plastics have been shown to provide adequate protection with improved manoeuvrability compared to conventional metal shields. Several investigations highlight the importance of ergonomic design to reduce operator fatigue and enhance control during dynamic situations.

The adoption of microcontroller-based automation, particularly Arduino platforms, has enabled precise control of integrated systems like servo-operated pepper sprays and LED modules. These developments facilitate rapid response, reduce manual effort, and increase the effectiveness of non-lethal interventions.

Overall, the reviewed literature suggests a growing need for integrated, multi-functional anti-riot shields that combine structural protection, ergonomic design, and automated non-lethal systems. This project builds upon these findings to develop a shield capable of offering both safety and tactical crowd-control capabilities, meeting the operational demands of modern law enforcement.

X. CONCLUSION

The project focuses on the design, analysis, and fabrication of an anti-riot shield integrated with a pepper-spray system and high-intensity LED for non-lethal crowd control. The shield, made from lightweight polycarbonate, provides adequate protection while remaining easy to handle. Finite Element Analysis (FEA) confirms that the shield can withstand expected impact loads, and all components, including the Arduino-controlled servo and LED system, operate reliably. The prototype demonstrates that integrating non-lethal deterrent features with traditional riot shields enhances operational safety and efficiency for law-enforcement personnel. The combined use of pepper spray and blinding LED increases the effectiveness of crowd-control measures while minimizing physical harm.

Overall, the project successfully delivers a functional, cost-effective, and practical solution for modern riot-control applications. Future improvements may include wireless control, sensor-based activation, and enhanced ergonomics to further increase the shield's versatility and operational effectiveness.

XI. FUTURE SCOPE

The anti-riot shield developed in this project provides a functional and practical solution, but there are several areas for improvement to make it more advanced and effective. Future enhancements can include wireless or remote operation of the pepper spray and LED system, allowing the user to maintain a safe distance. Sensors such as motion, proximity, or infrared detectors can be added for automatic threat detection and activation of non-lethal features. Using advanced composite or multi-layered materials can increase the strength of the shield while keeping it lightweight. Ergonomic improvements, such as adjustable straps, better grip design, and optimized

weight distribution, can reduce fatigue and improve manoeuvrability during prolonged operations. Incorporating high-capacity rechargeable batteries or energy-efficient electronics can increase operational time. Integration with wearable cameras, GPS, or communication modules can enhance situational awareness and coordination during riot control. Finally, a modular design can allow the addition or removal of non-lethal features depending on the operational need, making the shield versatile for multiple scenarios. These improvements can transform the anti-riot shield into a smart, multifunctional, and highly effective tool for modern law enforcement and security operations.

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