Research Proposal

# “Study of high velocity Impact on shear thickening fluid impregnated UHMWP Composite for Ballistic Application”

## ABSTRACT

Ballistic amours are designed to provide protection not only against attack by a sharp object such as knives or spikes but also provide protection against impact by handguns fired at impact velocity less ≤ 500 m/s. The conventional ballistic amours are made from metals that are bulky and provide discomfort to the wearer, especially in a combat situation. However, with the development of advanced fiber s such as Kevlar, UHMWP, an effort is made to make the protective armour lighter without compromising its performance. The combination of low density and high strength makes UHMWP superior over other materials such as aramids, E-Glass, and S-glass fiber s. In the present study, an effort is made to improve the ballistic performance of woven UHMWP fabric composite with shear thickening fluid (STF) impregnation.

The fabrication of UHMWP composite laminate for the ballistic study is going to prepare the sample from bulk material and then the layers of UHMWP are impregnated with shear thickening fluid solution. These STF treated panels are later bonded through a polyurethane matrix.

It is also proposed to perform a numerical simulation to study the failure mechanism of both neat and STF impregnated UHMWP composite and also, the comparison of experimental results with the numerical simulation using ANSYS Autodyn.

**Keywords**: UHMWP, Ballistic test, Shear thickening fluid, Silica nanoparticles, ANSYS

# 1. INTRODUCTION

Ultra-high molecular weight polyethylene (UHMWP) fibers are the strongest and lightest fibers on account of their high strength and low density. The foundation for the development of high-strength UHMWP fibers was laid down in the 1960s by the discovery in the DSM research laboratory of a new fibrillar crystal form for UHMWP called shish-kebabs (Pennings and Kiel, 1965). In the 1970s, UHMWP fibers were obtained directly from stirred solutions (Zwijnenburg, 1978) with a tensile strength of 2.9 GPa and a Young's modulus of 101 GPa.

The man-made ballistic fibers have unique properties which set them apart from other man-made fibers used for industrial applications. The ballistic fibers show inherent resistance to a number of chemicals, industrial solvents and lubricants used by automotive and aerospace industries. Each high-performance ballistic fiber has a certain unique property because of the polymer used to manufacture the fiber and the unique spinning process.

High-strength fibers can be used in ballistic applications in principle in the form of woven fabrics or in unidirectional form. woven fiber -based composites are easy to manufacture and incur low cost compared to unidirectional fibers. The ballistic protection industry largely relied on conventional aramid fibers (Kevlar) / glass fiber s in making personal protection armors.  Material with high Impact resistance and high strength/weight ratio is the primary choice in making of with personnel and vehicle armour for increased maneuverability. Superior mechanical properties UHMWP fiber over Kevlar including other material such as E glass and S –glass fibers

When an individual is hit by a bullet, the extent of the injury sustained depends on where the bullet strikes the body and the path or trajectory of the bullet into or through the body. Thus, the armour's primary and main purpose is to prevent a bullet from penetrating as it requires the high-performance fiber s such as UHMWP based composites are used in the protective amours. These UHMWP fibers absorb and disperse the impact energy that is transmitted to the vest from the bullet, causing the bullet to deform, `Additional energy is absorbed by each successive layer of material in the vest, until such time as the bullet has been stopped.

Soft body armour is made of multiple layers of high-performance fabrics, making it lighter in weight and more flexible. Police, security personnel, riot officers, etc., use this type of armour against low velocity projectile attacks from handguns, pistols, shotguns, etc., for lower levels (NIJ levels II-A, II, and III-A) of ballistic protection.

## 1.1 Problem Statement:

The research work is to perform the ballistic evaluation of (energy absorption, ballistic limit etc.) of neat and STF impregnated woven fabric UHMWP composite by using a two-stage light gas gun setup at various high velocities up to 450m/s and observe the damage characteristics of the material under the scanning electron microscope on post impact. It is also required to performed the numerical simulation to study the failure mechanism of neat and STF impregnated composite and compare the results with the experiment data.

## 1.2 Challenges:

The major challenges are

1. Presence of porosity during fabrication of composite.
2. Ensure uniform impregnation of STF over woven fabrics
3. Fabrication cost.

## 1.3 Motivation for the research:

The lightweight amour in the ballistic application provides easier mobility to the wearer especially in a combat situation and also protect the military soldiers and police personnel on the battlefield from ballistic threats such as bullets fired from handguns or rifles, and attack by sharp object such as knives or spikes. There is a room for making the ballistic armour lighter without comprising the strength and ballistic performance. Therefore, study is proposed the present work to improve the ballistic performance of woven UHMWP fabric composite with shear thickening fluid (STF) impregnation.

## 1.4 Objective of the proposed work:

1. Prepare the neat and STF impregnated woven fabric UHMWP composite.
2. Surface characterization of STF impregnated UHMWP composite
3. Ballistic evaluation (energy absorption, ballistic limit on neat and STF impregnated composite.
4. Performed the numerical study to study the failure mechanism of neat and STF impregnated composite and compare the results with the experiment data.

## 1.5 Research methodology:

Based on the review of literature the following are the methods that has been set for the proposed research.

1. Fabrication of both neat and STF impregnated UHMWP composite sample laminate with 30-40 layers by using the compression molding technique.
2. Conduct experimental test on Ballistic evaluation such as energy absorption, the ballistic limit on both prepared neat and STF impregnated UHMWP composite samples.
3. The study experimental results in which the damage of the microscopic nature of both prepared neat and STF impregnated UHMWP composite samples are characterized using a scanning electron microscope (SEM).
4. Numerical simulation is to perform to study the failure mechanism of both neat and STF impregnated UHMWP composite and
5. Finally, the comparison of experimental results with the numerical simulation using ANSYS Autodyn.
6. Use of SEM image to study the influence of STF impregnation on the surface morphology of neat UHMWP woven fabric. (to fulfill as second objective)

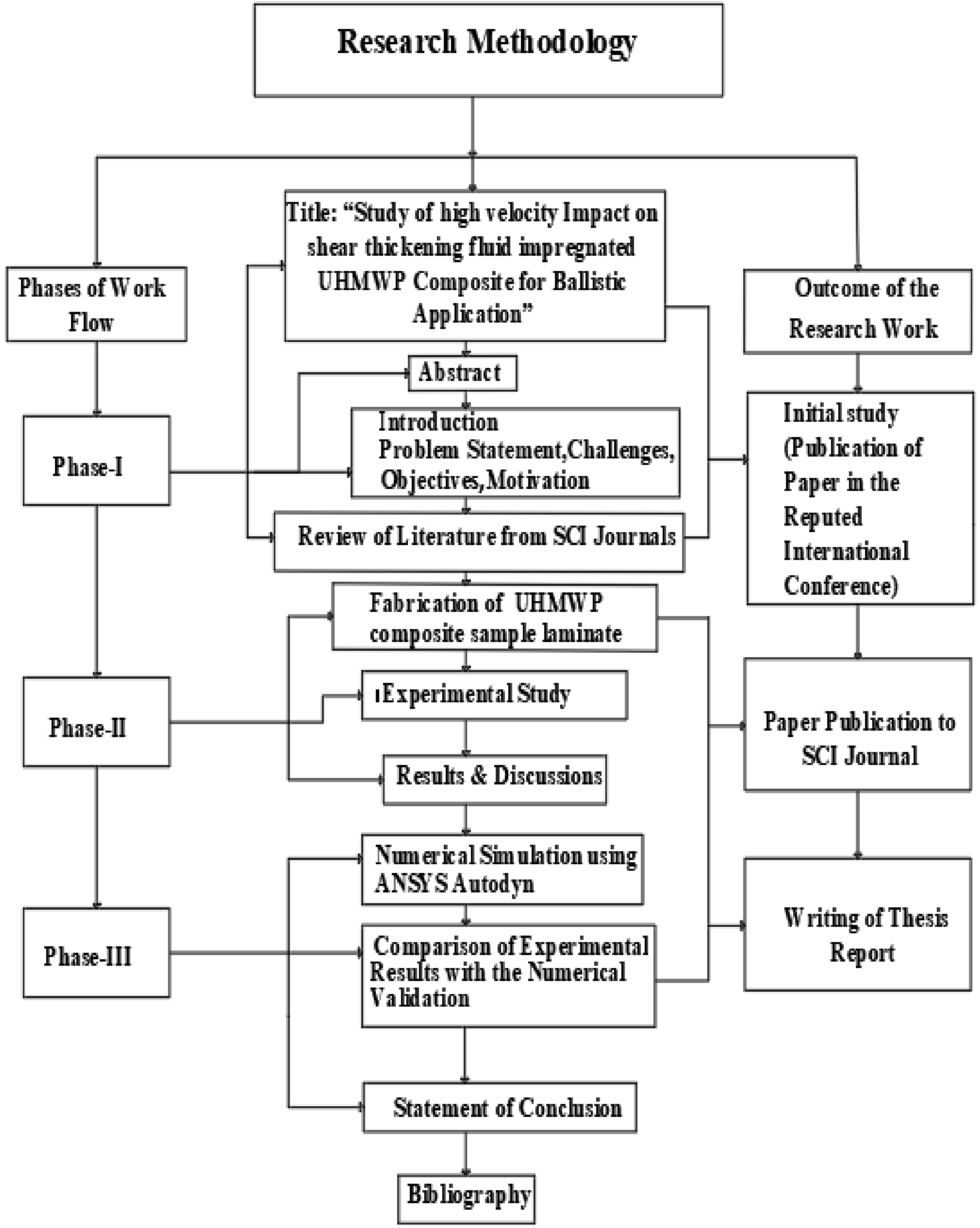



Figure: Schematic Work Flow Diagram

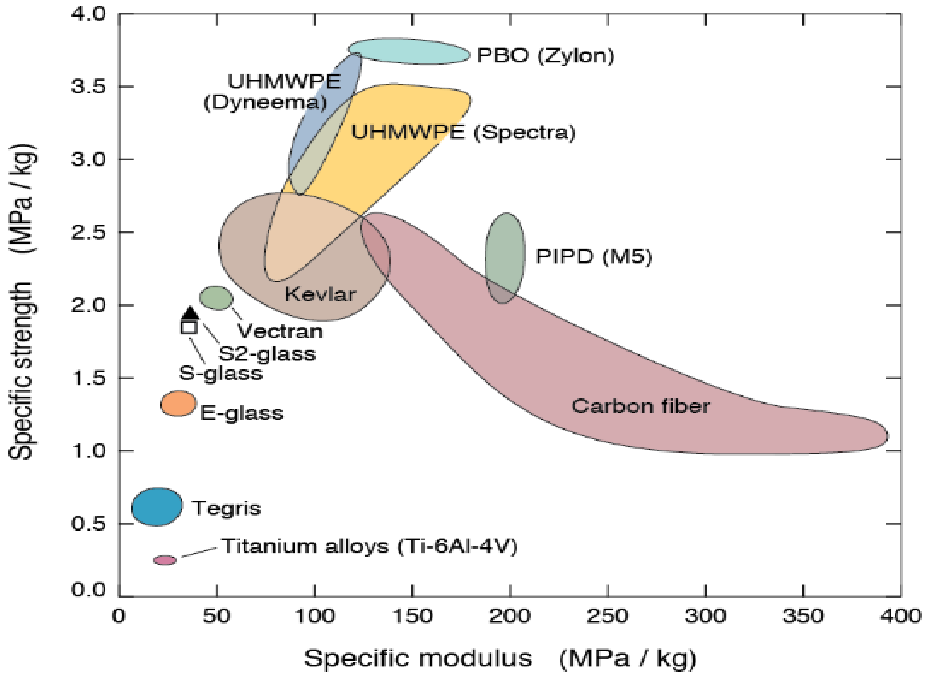
# 2.LITERATURE REVIEW

The material (fiber) and structural (yarn and fabric) parameters influencing impact energy absorption and Standards for evaluation of soft body armour. The Mechanism of impact energy absorption. Finally, a detailed review of approaches to enhance the performance of soft body armour materials some of the future trends in soft armour development.

## 2.1. Material properties.

2.1.1 Density, tenacity and modulus.

**(Mawkhlieng, 2020).** Fiber properties are of paramount importance for soft body armour. As mentioned earlier, fiber s to be used for armour applications must have low density, high tensile modulus, high tenacity and low elongation at break.




Ref: Image Source: Liu, 2019

Figure.1 Relationship between specific tensile modulus and specific tensile strength of high-performance fiber s

For example, p-aramid fiber, Kevlar 49 (elastic modulus, 113 GPa; tensile strength, 2.96 GPa) is recommended for use in ropes, cables, and composites for marine, aerospace and sport goods applications whereas Kevlar129, which has relatively lower modulus (96 GPa) and higher tensile strength (3.39 GPa) and lower elongation (3.5%), is recommended for impact and soft armour applications.

In general, 20–40 layers of woven fabrics, made from high-performance fiber s, are stitched together to prepare the soft body armour panels.

High-performance fiber s used for such purposes include p-aramid (Kevlar®, Technora®, Twaron® etc.), ultra-high molecular weight polyethylene or UHMWP (Dyneema®, Spectra® etc.), The essential properties of the above fiber s are low density (0.97 to 1.6 g/ $cm^3$), high tenacity (2.5–5.8 GPa) and high modulus (70–270 GPa). Several attempts have been made by fiber manufacturers and material researchers to develop new materials and improved structures. In the last two decades, the idea of using shear thickening fluid (STF) to improve the energy absorption capability of soft body armour has interested many researchers. The pioneer work in this area was done by Lee et al.in the early 2000s.

UHMWP fiber s have a significantly lower density (0.97 g/ $cm^3$) than those of aramid fiber s (1.44 g cm/3) which makes the former a better alternative where armour mass is a critical design parameter. Another fiber with ballistic potential is Zylon, which shows much better tensile properties (tenacity, 5.8 GPa) than p-aramid and UHMWP fiber s.

The ballistic performance of woven fabric may be evaluated from its single yarn component. When a single fiber is hit by a projectile transversely, two waves simultaneously propagate- one, longitudinally and the other, transversely as shown in Fig. 2.

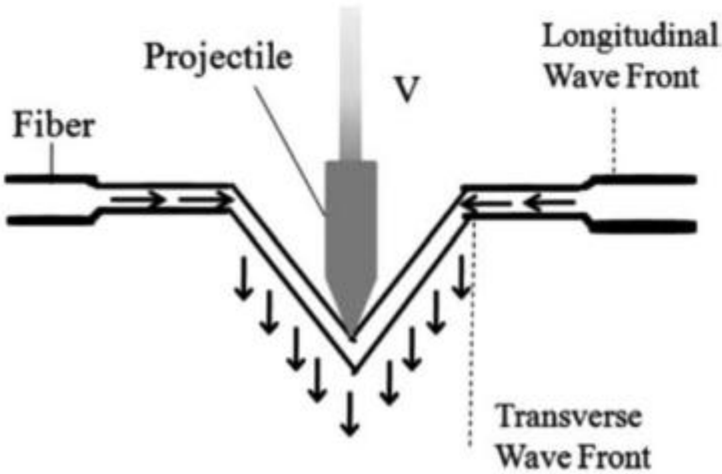



Figure.2 Pictorial representation of projectile impacting a single yarn (Ref image: elsveir)

where C is the speed of the longitudinal wave, E is the initial modulus and ρ is the density of fiber.

2.1.2 Friction.

Friction between the yarns and between the yarn and the projectile at the time of impact plays an important role in determining the impact performance of fabrics
when yarn breaks, energy absorption is enhanced. The role of friction is not only to enhance energy through frictional sliding but also through increased yarn kinetic energy as well as through improved yarn strain energy. With this understanding in mind, many researchers worked towards improving the friction by using resins, polymeric coatings, and additives such as nanostructures for more energy absorption. As a matter of fact, the use of STF itself, as

believed by many researchers helps in improved performance majorly through friction enhancement. Nanorods of metal oxides are also used to intensify friction between yarns.

## 2. 2 Structural parameters

2.2.1 Yarn twist.

Most high performance as-received multifilament yarns are twistless, making their handling a little difficult due to tendency of defilamentation. Therefore, twist may be applied for ease of operation and better performance.

2.2.2 Fabric structure.

The different fabric structures, such as unidirectional (UD), 2D woven, 3D woven, multiaxial, warp knitted and nonwoven (as cushion layers), used as soft body armour materials, also affect the ballistic performance of the panels.

For ballistic applications, fabrics must have an optimum level of thread density. Very tight fabrics will cause the yarns to deteriorate during weaving, while too loose a construction will not be able to stop the bullet from piercing through; a phenomenon commonly called as 'wedge through'. In fact, it has been reported that fabric cover should have a value ranging from 0.6 to 0.95 for effective ballistic performance.

2.2.3 Crimp.

Yarn crimp is known to slow down the speed wave propagation in ballistic impact. When a projectile strikes a fabric having high crimp, the fabric shows less resistance against the projectile as yarn stretching occurs without much difficulty. This is because the crimped yarns in the fabric take more time to absorb energy. It is interesting to note that the experimental results of **Laha et al.** showed that plain woven outperformed the other weaves in terms of impact resistance performance. Logically speaking, a more feasible approach is to develop fabrics with same amount of crimp in both directions.

2.2.4 Number of fabric layers and stitching

A single layer of high-performance fabric is insufficient to ensure protection against high velocity impact. Soft body armour against high velocity impact is generally comprised of several layers of high-performance fabrics sewn or stitched together.

the number of layers increases, the trauma depth and diameter decrease. The supportive findings of Karahan et al.53 also showed that with the increase in the number of layers (from 20 to 32),

2.2.5 Orientation of fabric layers

The multiple layers of high- performance fabric are required to get enough protection against high velocity impact. Stacking of multiple layers to make a single panel can be done in different ways. They found that impact energy absorption was always lower when all the fabric layers were aligned in $0^0$. The highest impact energy absorption was obtained for two, three, four and eight layered fabric panels using the angle of orientations [0/45], [0/30/60], [0/22.5/45/67.5] and [(0/22.5/45/67.5) x 2], respectively.

Hence, if there are more than two sets of perpendicular axes, as in the case of a multi- layered fabric with angle ply orientation, the base may tend to be circular, so that the pyramid approximately becomes a cone and hence, the energy absorption increases.

**2.3 Standards for body armour evaluation**

**(Mawkhlieng, 2020).** The body armour is categorised into five classes based on the level of protection they provide – IIA, II, IIIA, III and IV. Type IIA, II and IIIA provide lower level of protection corresponding to different projectile type and mass and different new unworn armour is subjected to higher velocity as compared projectile velocities of 355 m /s ± 9m/s1 to 448 ± 9m/s. The permissible BFS as per the requirement of Indian army is 25 mm.
During ballistic evaluation, energy absorption by the test panel can be determined by using pre-impact and post-impact residual velocities of the projectile which are measured with the help of two chronographs positioned before and after the panel being tested.
The energy absorbed by the test panel is calculated by using eqn

$$E = \frac{1}{2}m\left(v_1{}^2 - v_2{}^2\right)$$

where, E is the energy absorbed, $v_1$ is the pre-impact velocity and $v_2$ is the residual velocity of projectile.

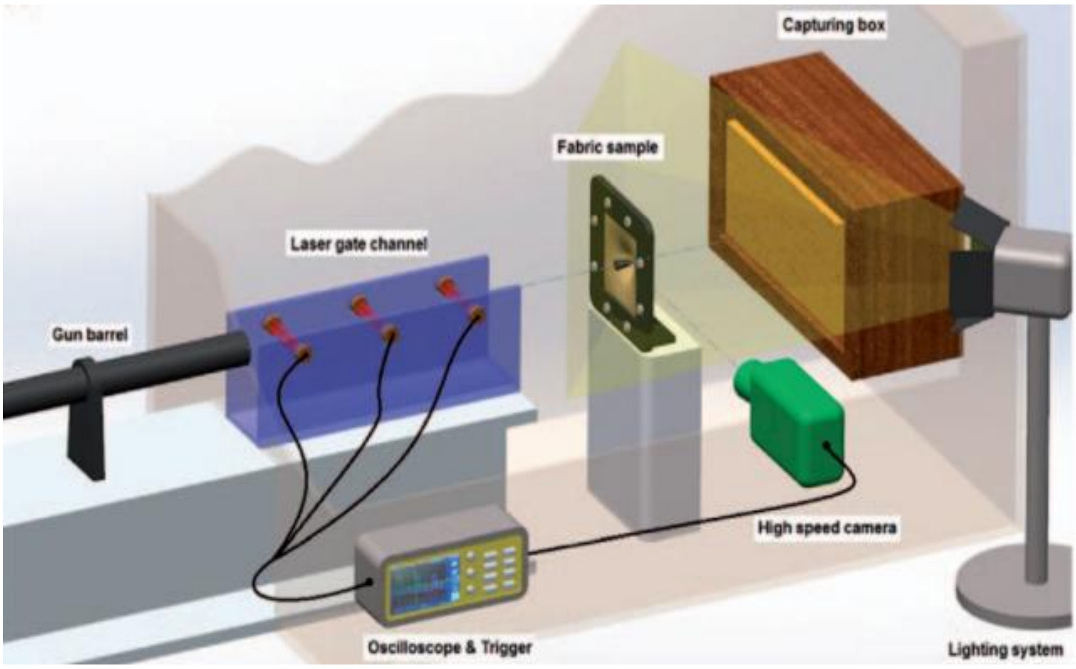



Figure 3. Schematic of actual experimental setup (Ref Image: International Journal of Damage Mechanics)

### 2.4. Energy absorption mechanisms of soft body armour

**(Mawkhlieng, 2020).** When a high-performance fabric is hit by a projectile, energy is absorbed through various mechanisms, depending on both material and projectile parameters During impact, the bullet can either completely or partially pierce through or can be entirely halted by the target. The fabric target absorbs energy through the following mechanisms:

1. Yarn decrimping
2. Fiber and yarn extension
3. Yarn pull-out
4. Fiber and yarn rupture

The relationships between these mechanisms and the ultimate ballistic performance of high-performance fabrics are yet to be understood fully. When a bullet strikes a fabric, crimp removal, yarn extension, pyramid formation by primary and secondary yarns, fibrillation and fiber breakage happens in sequence absorbing significant amount of energy.

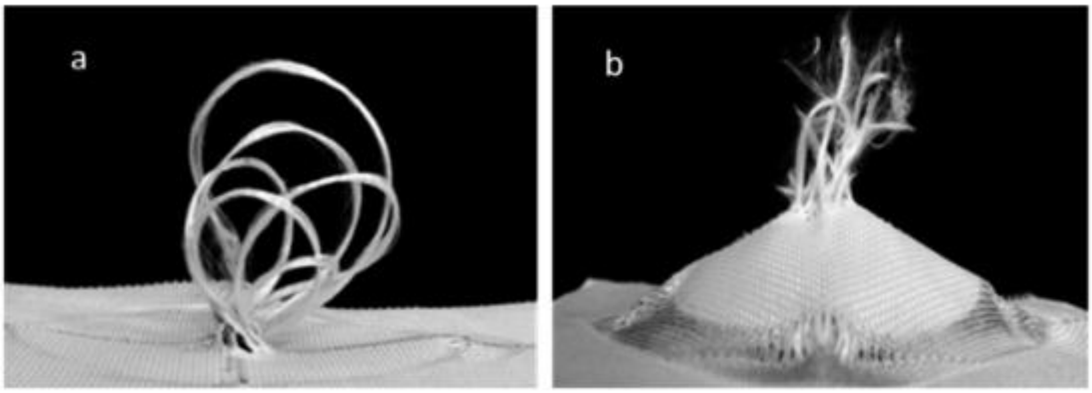



**Figure 4.** Fabric failure mechanisms during impact (a) yarn pull-out and (b) fiber and yarn rupture (Ref Image Elsevier).

Fiber fusing is also observed in case of thermoplastic materials. It is generally accepted that yarn pull-out the above fig. It is a consequence of low yarn to yarn friction and hence, yarn pull-out test is a good step towards understanding the role of friction during impact.

### 2.5 Approaches to improve the impact resistance

To improve the impact resistance of woven fabrics as soft body armour material. Among these approaches, use of natural latex, use of shear thickening fluid (STF), fabric surface modification by developing nanorods of metal oxides and use of 3D woven fabrics are the few important ones. The idea of using STF or even surface modification is to enhance structural integrity through friction. the purpose of employing 3D woven structures is to enhance through-thickness mechanical properties.

### 2.6 Use of shear thickening fluids (STF)

**(Wang et al., 2020)** has thoroughly reviewed the applications of STF for protective applications and therefore, the present work will only briefly describe this aspect. STF has been explored and used for low velocity impact applications, stab and spike protection as well as for high velocity ballistic impact applications.

Shear thickening fluid (STF) is a non-Newtonian fluid having two phases, namely dispersed phase and dispersion medium. Initially with the application of shear, STF shows shear thinning behaviour. However, after achieving a particular shear rate, called critical shear rate, viscosity increases abruptly and the liquid suspension attains an almost solid like state.

**2.7 Why Plain weave pattern for ballistic applications?**

**(Tran et al., 2014)** Plain weave is the most common and tightest of basic weave structures. The plain weave structure of the 2D fabric is to have more advantage in designing soft body armor to protect the human body, helmets, and various ballistic applications.
At the time of the impact loading, the projectile is imparted into the fabric the crimp and spaces between the warp and weft yarns interlacing architecture, the fabric turns more flexible and shear off before locking at the crossover points of the warp and weft yarns,

On another aspect, the shearing activity of the yarns during the impact makes use of friction between the yarns and the energy dissipation mechanism. Fiber pull-out at the impact point is an example of a fracture influenced by friction between the fiber and the matrix So, the plain weave pattern gives the higher strength but lower air permeability.

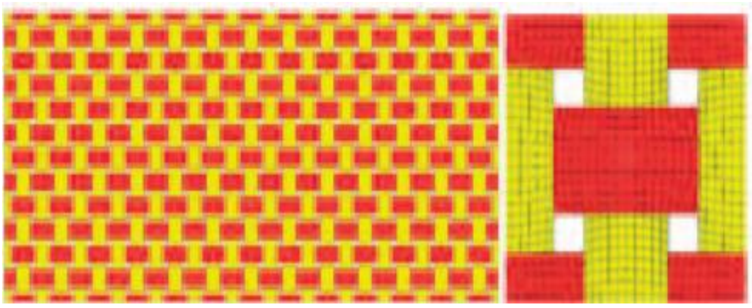


Figure.5 Plain weave Pattern (Ref Image: International Journal of Damage Mechanics)

The friction has an important effect on the ballistic performance of the fabric and the main reason for the difference in resultant velocity between the plain weave and among the various woven structures, the failure mechanism may not be useful for designing the single layer fabric when it is stack into multilayer fabrics could help to minimize the penetration, the dynamic reactions, and wave propagation and maximize energy absorption.

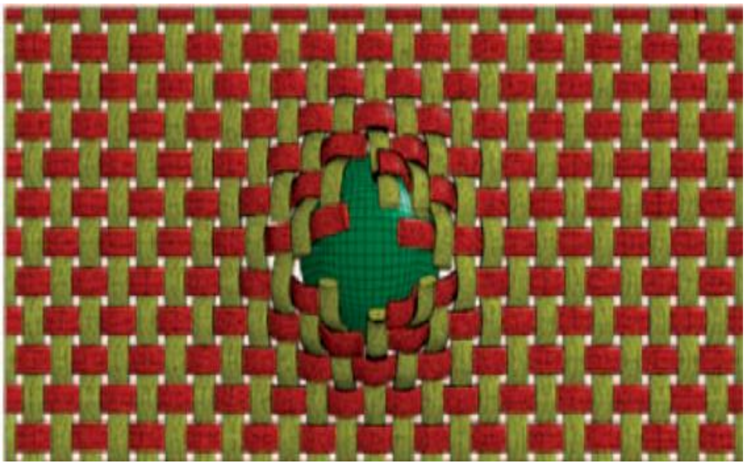


Figure.6 plain weave Pattern is subjected to ballistic impact (Ref Image: International Journal of Damage Mechanics)

The amount of energy dissipated through frictional sliding of yarns could be attributed to the size of the contact zone, which is directly related to yarn count per unit area and frictional coefficient

**Damage mechanisms of composite fabrics are subjected to ballistic impact (such as plain weave, knitted fabrics and basket weave**)

The energy dissipated of friction in the knitted fabric is prominently less than that of plain weave one, revealing another reason is the poor performance of the knitted structure.

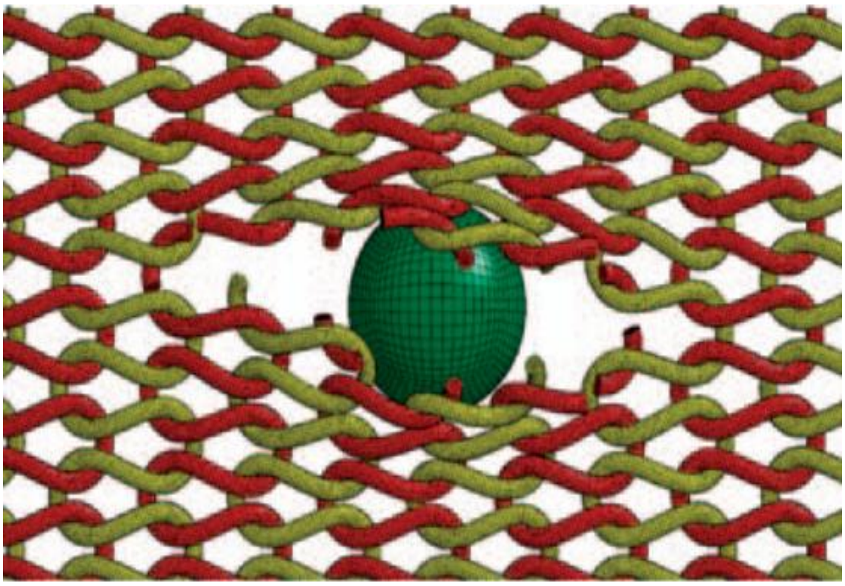


Figure.7 Knitted fabric is subjected to ballistic impact (Ref Image: International Journal of Damage Mechanics)

The failure mechanisms of the fabric architectures of plain weave, basket weave and knitted textiles into the influences of yarn arrangements to the ballistic performance of the fabrics. the process of yarn breaking due to transverse shear loading of knitted fabrics.

The basket weave shows similar ballistic resistance compared to the knitted fabrics and provided more shearing and flexibility for fabrics, the two main common impact resistance mechanisms of fabric structures were interpreted, including energy absorption through deformation and energy dissipation through frictional activities.

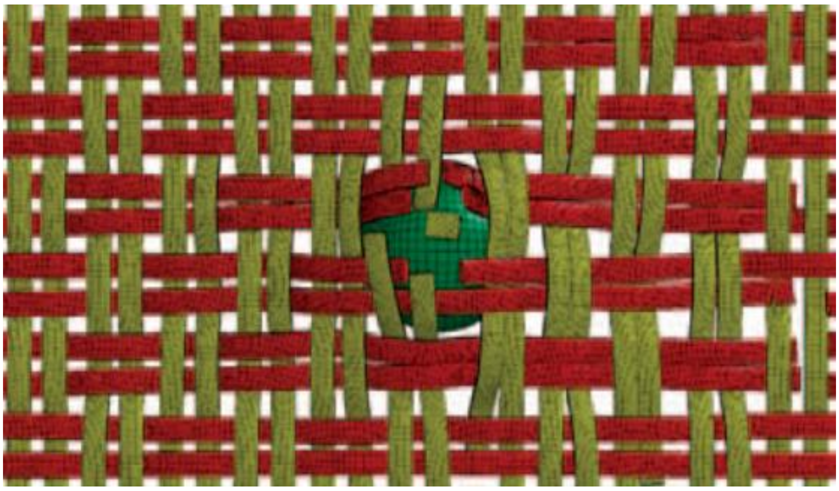


Figure.8 Basket weave is subjected to ballistic impact (Ref Image: International Journal of Damage Mechanics)

**(Mawkhlieng, 2020).** The analyses of research to understand the roles of fibrous materials on ballistic impact resistance behaviour of soft body armour. Fiber and yarn properties are of paramount importance and UHMWP fiber s, due to their low density and very high modulus, seem to surpass aramids.

Fabric constructions also play decisive roles as UD, 2D,3D, triaxial and knitted fabrics behave differently during impact. For impact applications, crimpless UD fabric structures facilitate faster and wider dissipation of stress waves and the former is replacing the woven 2D fabrics to a great extent.

Standards and evaluation techniques have also progressed to keep pace with the stringent requirement of body armour users. The use of shear thickening fluids has shown promising results at least against low velocity impact as well as against stab and puncture. Surface modification by developing nanorods of metal oxides have also shown potential in imparting additional energy absorption capacity to the base fibrous structure.

**Beer (2017)** The mechanical properties of UHMWP composite material depends on various parameter, Viz. matrix type, fiber orientation, interface properties, processing technique and thickness of layer, Also, Simulation study on UHMWP woven fabric reinforced composites being impacted by a 12 mm steel sphere at a velocity of 469 m/s were run using ANSYS Autodyn.

This study focuses on the relationships between the tensile properties and impact behaviour of various woven UHMWP fabric reinforced composites in contribution to the bridging of the strength gap between UD composites and fabric reinforced composites.

**Li, Cuiyu et al 2019, Heimbs 2019** Extensive studies conducted to find the Influence of matrix type on toughness of UHMWP composite

**Thomas L et al. 2019** Very limited studies conducted on influence of polyuria coating on Composite plates, especially E-glass epoxy. However, no studies are found for the UHMWP fiber composite and concluded that location and thickness of polyurea coating influence the toughness and penetration resistance of composite.

**(Wang et al., 2020)** The improvement of impact resistance performance of aramid fabric could be achieved by confining the relative mobility of fibers or yarns. Reasonably, it will be more effective and easier to use the adhesive to confine relative mobility instead of STF. Intriguingly, inspecting abundant literature of aramid fabric soft armor system, there is not any adhesive being introduced at all. Presumably, conceiving the aramid fibers immersed in the adhesive generates an impression of fiber-reinforced resins (epoxy, phenolic) which are widely used in aviation, aerospace, automobile and architecture industry to substitute metals.

shear thickening fluid (STF) is utilized to impregnate fabrics to improve the friction between yarns. Many re- searchers have reported that STF can improve the stab resistance and ballistic performance of fabrics. STF is universally composed of stabilized dispersions of concentrated rigid micro-nano size particles in a Newtonian fluid. the influence of STF's
parameter on the ballistic performance of fabrics, such as shape, stiffness, diameter and mass fraction of suspended phase and constitution of STF.

**(Tran et al., 2014)** The importance of high strength, high modulus properties of the individual fibers/yarns, and the combination of these filaments into a fabric structure also contributes remarkably to the overall impact response. For ballistic applications, the woven fabrics are widely used in typical plain and basket weave patterns. The density of the weave, which is determined from the width and pitch of the warp and weft yarns, designate the coverage factor of the fabric,

The 2D fabrics (such as plain weave) possess several distinct advantages designed for personal protective soft armor. During the impact event, due to the crimp and spaces between the warp and weft tows, the fabric becomes flexible and shearable before locking at the crossover points of the warp and weft yarns, which is critical for the fabric to adjust around the human body or to protect the object's boundary while ensuring comfort of the clothing. On another aspect, the shearing activity of the yarns during the impact makes use of friction between the yarns considerably, which is a very important energy dissipation mechanism.

The plain weave has evidently shown the capability to absorb more impact energy, while the strain energy levels are quite similar for all three cases.

**(Gautam et al., 2018)** Safeguard articles- In the field of safeguard articles, UHMWP fiber reflects excellent properties including high impact toughness. It absorbs impact energy is the highest among advanced composites and 2.6, 3 and1.8 times higher than aramid fiber, carbon fiber and E glass fiber composite materials. Due to its high impact resistance and bulletproof property, it can be made into bulletproof vest, helmet and armor, etc. UHMWP fiber composite armor's bulletproof property is 2.5 times higher than aramid fiber, so it can be made into the lightest but strongest armor. Its U/P is 10 and over 2 times greater than steel and glass and aramid fiber respectively, so it can be used for soft bulletproof vest and bulletproof steel plate, as well as armor and impact resistance plate for racers and alpinists.

Therefore, it can be said UHMWP fiber has great potential in life protection. Besides bulletproof vest and helmet, it can be made into bulletproof armor, banknote carrier, armored car, bulletproof car and armed helicopter as well as anti-explosion liner, all of which should attribute to its light weight property. Because of good textile processing performance, it can be made from stab-resistant and scrape-resistant fabrics.

Aerospace material- Due to light weight, high strength and high impact resistance, composites made by UHMWP fiber can be widely used for wingtip structure, inner wall structure, landing system and salvage and recovery system of aero-space instrument. The shell materials of gunship and battle plane are bulletproof, too. Today, UHMWP fiber plates have been compulsorily used in civil plane cabins by USA as well as Europe.

Cable products- Cable products include those widely used in ship, marine engineering, land and other fields. Because of its high strength, high modulus, wear resistance, corrosion resistance and age resistance, UHMWP fiber is universally suitable for all kinds of cables and ropes. Compared with aramid fiber, cables made by UHMWP fiber is 12% thinner in diameter, 52% lighter in weight but 10% stronger in strength. The breaking length of UHMWP fiber cable is larger than aramid one and steel one. Because its specific gravity is less than 1 and its breaking length is unlimited in water, it's especially fit for cables of marine engineering, including super tanker, offshore oil platform and light tower. In aerospace industry, it's widely used in reducing parachute suspended cable of airplane and based materials and slings of high-altitude balloon.

Fishing net- today, synthetic fiber becomes the most popular material for fishing net. In China, net material is nylon and polythene, whose consumption amount is 6,000 tons and 20,000 to 30,000 tons per year respectively. Under same mesh strength, the fishing net made by UHMWP fiber is 50% lighter than that made by polythene fiber. When weight is the same, specification of the former is larger, which can increase catching amount and reduce net weight and water resistance so as to enhance trawling speed and decrease energy consumption.

**(Tam & Bhatnagar, 2016)** High-performance ballistic fibers and ballistic tapes are engineered for lightweight ballistic fabrics, composites, and other industrial applications. These are generally used for niche life-saving products such as flexible body armor, molded breastplates, and molded ballistic helmets and panels for armoring helicopters, military cargo planes, the hulls of navy ships, high-speed coast guard boats, and military ground vehicles.

The UHMWP fiber is a type of polyolefin fiber. The fibers are made up of extremely long chains of polyethylene, which are aligned in the same direction. Each chain is bonded to the other with many vander Waals bonds. This provides the superior physical properties attractive for a number of military and industrial applications. The UHMWP fiber polymer chains can attain an orientation greater than 95% and a level of crystallinity of up to 85%. The weak bonding between olefin molecules allows local thermal excitations to disrupt the crystalline structure and therefore UHMWP fibers have lower heat resistance than other high-strength fibers. The melting point of UHMWP fibers is around 144-152C and, generally, UHMWP fibers are not used at temperatures exceeding 80-100C for long periods of time. However, the UHMWP fibers maintain performance at below 50C.

UHMWP thin tapes and ribbons are made by solid-state extrusion of special-grade low-entangled UHMWP polymers. The molecular structure after solid-state extrusion and drawing is not perfectly aligned as achieved by the gel-spinning process. This results in lower performance compared to UHMWP tapes. UHMWP tapes and ribbons exhibit low shrinkage, high abrasion, high strength and modulus, and excellent chemical resistance. The main features of UHMWP tapes and ribbons are high dimensional stability, low creep resistance, translation efficiency (polymer molecular weight vs tape molecular weight), and ease of surface modification for higher adhesion, and increased UV stability. The density of UHMWP tapes and ribbon is 0.97 g/$cm^3$

**(Kartikeya et al., 2020)** A little effort and reliable technique for conducting a tensile test on UHMWP reinforced composite fiber is proposed which needs for minimum specimen preparation. The approach eradicated ILS failure absolutely which become an assignment in the checking out of UHMWP reinforced composite fiber material for decades. The fixture developed to hold single-ply of composite material in the UTM may be without difficulty in fabrication. The tensile strength reached at some point of testing become closer to the theoretical quantity for the tested fabric. The sub-laminate modeling technique is popular for numerical simulation of excessive-speed impact issues in composite materials. The single-ply test method can thus provide direct input to composite material for the use of the sub- laminate technique.

## Tentative Chapter Plan:

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| Chapter I | Introduction |
| Chapter II | Literature Review |
| Chapter III | Material and geometry specification |
| Chapter IV | Experimental Test & Investigations |
| Chapter V | Numerical Analysis |
| Chapter VI | Numerical Validation |
| Chapter VII | Results & Discussions |
| Chapter VIII | Conclusion |
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**Test Facilities Required**

- Two-Stage Light Gas Gun (TSLGG) Ballistic Test setup
- Compression molding setup for sample Fabrication
- Universal Testing Machine (UTM)
- Three-point Bending setup.
- Hardness testing Machine.
- Scanning electronic Microscope (SEM)
- ANSYS Software Research version

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