

Dynamic Stress-Strain Investigation

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Abstract

An experiment was undertaken, using the finite elements model (FEM) Abaqus, to determine the stresses present in an aluminium plate impacted by a 30g projectile. In this experiment, the projectile wasn't meshed, and the plate was meshed isotopically. Elastic and plastic properties for Aluminium were researched and entered into Abaqus to build the best model possible.

Potential projectile velocities were also researched to provide the range of initial velocities to run the experiment over.

Once the model had been made and the program run, the max principal stress (direct stress) and the shear stress in the S23 plane were compared to determine which stress had more effect at different times throughout the experimental run.

For the experimental runs with velocities of 100 ms^{-1} and 250 ms^{-1} , the projectile failed to fully penetrate the plate. At higher velocities the projectile went through the plate with a significant loss in velocity.

The maximum direct stress was at least a factor of 10 larger than the maximum shear stress and generally, increasing the initial velocity increased the maximum direct stress experienced by the plate. The range of shear stress experienced by the plate reduced, in all three planes, with higher initial velocities.

The peak tension that occurred on the back of the plate created spalling of material which was shown by the ejection of particles from the plates in each experimental run.

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1 Introduction

1.1 Objective

The purpose of this work was to study the differences in the direct and shear stresses induced in an aluminium plate when it was impacted by a 30g projectile with different initial velocities.

1.2 Background Theory

Stress is the force per unit area applied to a material. For most experiments, where the stress is applied centrally, it can be assumed that the direct stress will be uniform throughout the material except for near boundaries [1]. The shear stress however cannot be assumed to have a uniform distribution.

$$\sigma = \frac{F}{A}$$

Equation 1 Stress

In a ballistic impact, the projectile provides the force which creates a stress in the target material. This force can be defined by Newton's second law and the area can be taken to be the entire plate.

$$F = ma$$

Equation 2 Newton's 2nd Law

When the stress is higher than the ultimate tensile strength of the target material, the target will be fractured allowing the projectile to pass through.

1.2.1 Abaqus

Abaqus is a Finite Element Model (FEM) for analysing the stress and strain of different materials. To run the simulation in Abaqus, values for four different parameters were required to properly define the material of the plate and how it would react during the experiment. The material selected for the plate was aluminium which is manufactured to numerous different grades and used in many alloys. Whilst it has been used extensively over the last few decades for manufacturing and building, there are still differences in the values for the required parameters in the available literature. This can be seen in the attached annexe in Table 7: Values for General and Elastic Region Variables.

The material properties are split into three sections that are required to complete the experiment: General, Elastic and Plastic. The first variable required by Abaqus, and the only one in the General section, was the materials' density: the mass per unit volume of a material [2].

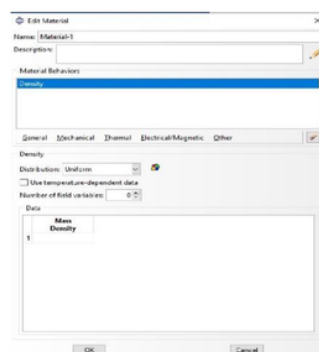


Figure 1: General Property Input Menu

1.2.2 Elastic Property Variables

Abaqus required values for two variables which defined the elastic region of the material's response to stress: Poisson's Ratio and Young's Modulus (E) to be entered by the user. Abaqus used these variables to create a linear model. This linear model, which determines how the material would react with increasing and decreasing loads throughout the simulation, was a representation of the elastic region of the materials full stress-strain curve. The Elastic region of a stress-strain curve is the area before the yield stress is exceeded where a material will act elastically; meaning that once the stress is removed, the strain in the material would reduce to zero. [1]

Poisson's ratio is the ratio of transverse strain to longitudinal strain [3] which causes a "necking" of the material where it thins as it expands. Young's Modulus (E) is a measure of how well a material is able to withstand changes in length when under longitudinal tension and compression [3]. It is the gradient of the line in the elastic region of the materials stress-strain curve.

Stress-strain curves are created by plotting the stress applied to an item against the strain experienced by the item in a tensile test. Strain is the deformation per unit length of an object [1]. The curves are characteristic to the properties of a material which is independent of the dimensions of the specimen under test [1] but due to the different conditions in which tests are performed there can be differences in the curves produced.

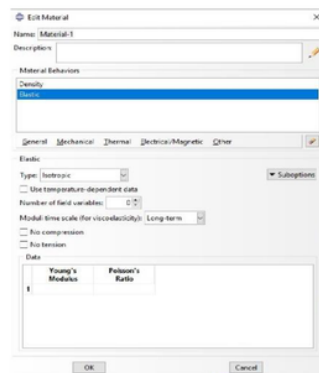


Figure 2: Elastic Property Input Menu

Figures for the variables required were obtained from several sources and compared by looking at the type of aluminium specified and then the mean, mode and median calculated from the supplied values. The range of the values found for the density of aluminium is reasonably small, only 0.8% of the largest value found, however, both Poisson's ratio and Young Modulus have ranges of at least 10% of the largest value. This will affect the accuracy of the results obtained in the experiment by increasing the final uncertainty. The observed variances are possibly due to different types of aluminium from different manufacture processes, rounding of figures and undefined uncertainties at the time of measurement, such as temperature.

For this experiment the values for elemental Aluminium from MatWeb [4] were used as this source had a complete set for the data required and was for pure aluminium. The uncertainty quoted in the table below is the standard deviation of the results collected in Table 7: Values for General and Elastic Region Variables in the annexe.

Table 1: Values for General and Elastic Variables supplied to Abaqus for the Experiment

	DENSITY (KG/M ³)	YOUNG'S MODULUS, E (MPa)	POISSON'S RATIO
VALUES USED [4]	2698.9	68000	0.36
UNCERTAINTY	107	2000	0.02

1.2.3 Plastic Property Variables

To get a more accurate result from the Abaqus simulation, the plastic portion of the materials' stress-strain curve was taken into account. The Plastic region of the stress-strain graph depicts the area where the material behaves with plastic deformation. This means once the stress has been removed the strain does not return to zero but to a value of permanent deformation. [1]

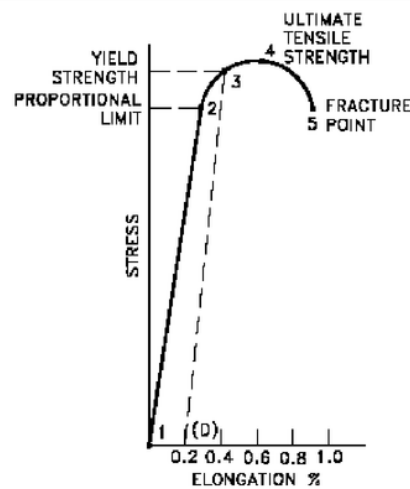


Figure 3: Brittle Material Stress-Strain Curve [5]

Abaqus asked for a value for the yield stress and corresponding strain. The Yield Stress is the end of the elastic deformation of a material, and so occurs at 0.0 plastic strain. Any further stress applied to the material will result in a permanent deformation once the stress is removed. [1]

As can be seen in Figure 3 and Figure 4, the change in gradient at the end of the elastic region (the yield stress) is not a sudden change, there is a gradual curve which is characteristic of ductile materials. 0.2% yield stress is often quoted as the yield stress for ductile materials and is defined as the stress that corresponds to a line parallel to the elastic portion of the materials' stress-strain curve which starts at 0.2% of the strain and intersects the curve. [6]

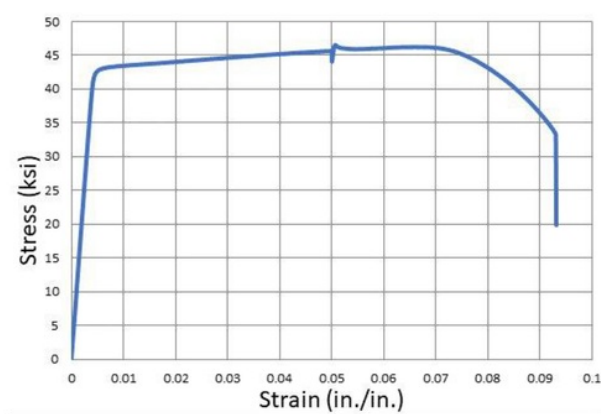


Figure 4: Stress-Strain curve for Aluminium [7]

Entering in a value for the Yield Stress created a bi-linear model in Abaqus which would allow the material to behave elastically and plastically in the simulation as defined by the inputted variables.

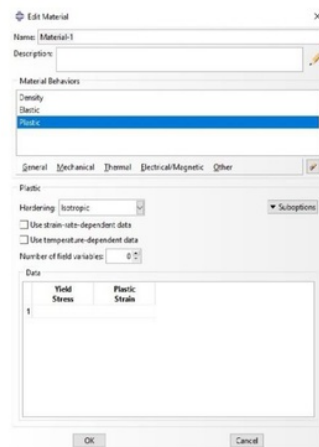


Figure 5: Elastic Property Input Menu

To create a more accurate model than the bi-linear, more rows were entered into the table from the material's stress-strain curve covering the plastic region up to the ultimate stress or the materials fracture point. A materials' Ultimate stress is the absolute maximum value of stress that can be applied to the item and result in a positive gradient for the increase in the strain. [1]

Table 2: Stress-strain values for plastic region [8]

YIELD STRESS (MPa)	PLASTIC STRAIN
350	0
368.71	0.001
376.5	0.002
391.98	0.005
403.15	0.008
412.36	0.011
422.87	0.015

444.17	0.025
461.5	0.035
507.9	0.070
581.5	0.150
649.17	0.250
704.22	0.350
728.78	0.400
751.85	0.450
773.68	0.500
794.44	0.550
814.28	0.600

1.2.4 More Complex Models

There are several Johnson-Cook Material Models which represent the flow stress and unlike the bi-linear model they take into account work hardening and temperature dependence so that the material properties are dependent on strain, strain rate and temperature [9]. Examples are the plastic and the Elasto-viscoplastic models, but all are used for high strain and high impact loading problems. The Mie-Gruneisen Equation of state Model defines the pressure volume relationship of a metal at different temperatures. And is often used in conjunction with a Johnson-Cook materials model [10].

The Johnson Cook Dynamic Failure Model also applies to high strain problems and characterizes the damage occurred in metals after impact [10].

Values for Abaqus for Johnson-Cook models can be found in the Appendix in Table 8.

1.2.5 Ballistic Velocities

Muzzle velocities vary widely as there is a large variety of weapons and bullets of different masses. The University of Utah, provides a range of muzzle velocities for a variety of handguns, rifles and shotguns. The slowest quoted velocity is a handgun with a muzzle velocity of 248ms^{-1} and the fastest is a rifle with a muzzle velocity of 987ms^{-1} [11]. Following this guide of bullet velocities, it was decided to take a range of 100ms^{-1} to 1000ms^{-1} for the experiment.

1.3 Expectations

Aluminium has both an elastic and plastic reaction to stress. For low strain events, the plate may react elastically, showing no permanent damage until the strain caused by the projectile exceed the yield stress. Above this stress, there would be permanent deformation of the plate over a range of strains until the strain was large enough to fracture the plate and allow the projectile to pass through. Increasing the velocity of the projectile further would increase the residual velocity of the projectile once it has passed through the plate.

2 Experimental Procedure

Once all the required values for the material property had been decided on, the experiment could be written into Abaqus. A bi-linear elastic/plastic model, rather than a Johnson-Cook model, was chosen and programmed using the values obtained in a literature research and displayed in Table 2 and Table 7. The file for the experiment had been pre-written so for this report only the material property values and impact velocity were entered by the user before creating and running a job. Five jobs were created with impact velocities at 100ms^{-1} , 250ms^{-1} , 500ms^{-1} , 750ms^{-1} and 1000ms^{-1} .

At the start of the experiment, the parts were inspected.

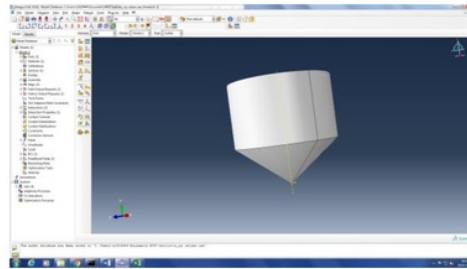


Figure 6 Projectile

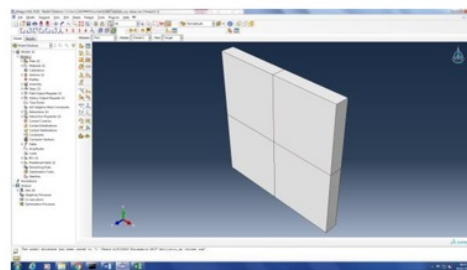


Figure 7 Target

Then the property values could be entered using the properties editor.

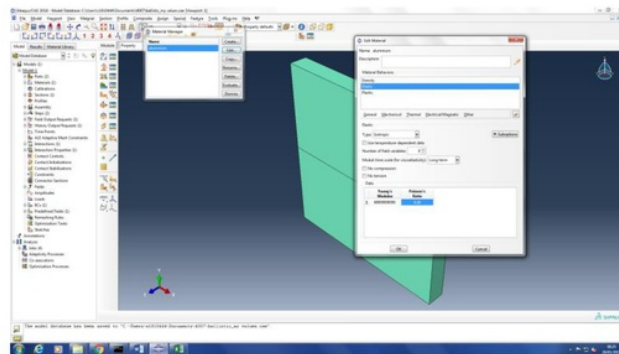


Figure 8 Property Values

The target had been partitioned to allow for a denser mesh to be focused on impact site in the experiment and provide optimised use of the nodes. This assumed that the property values for the target are isotropic.

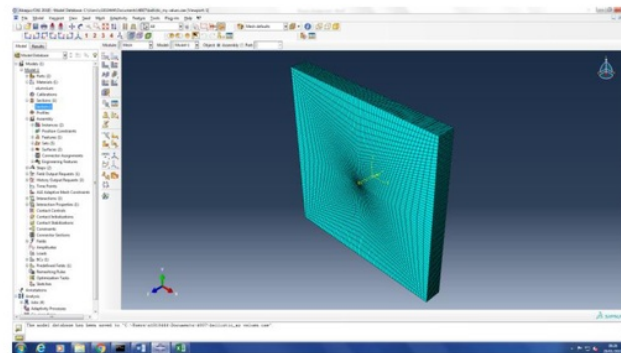


Figure 9 Mesh

The time scale of the experiment could be adapted as required in the Step Manager.

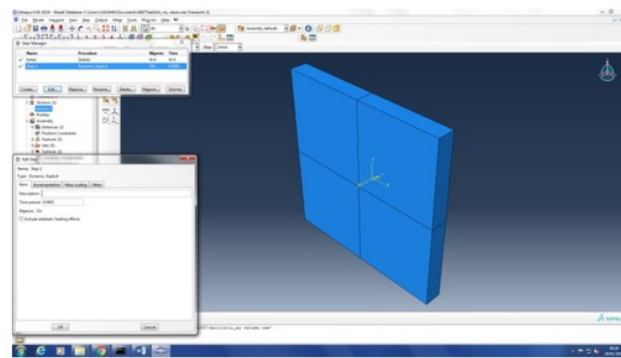


Figure 10 Time Period

The velocity of the projectile was changed in the Predefined Fields Manager. As stated in the Introduction, a range from 100ms^{-1} to $1,000\text{ms}^{-1}$ was studied.

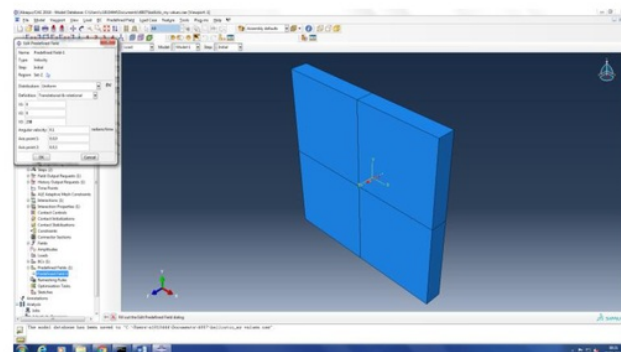


Figure 11 Projectile Velocity

Each velocity was run as a separate job and the results analysed to compare the direct and shear stresses as well as the residual velocities of the projectile.

3 Results

3.1 Residual Velocities

With an initial velocity of up to 250ms^{-1} the projectile failed to pass through the plate. For the experiments with an initial velocity for the projectile of 500ms^{-1} and higher the projectile passed through the plate with a residual velocity, lower than the initial.

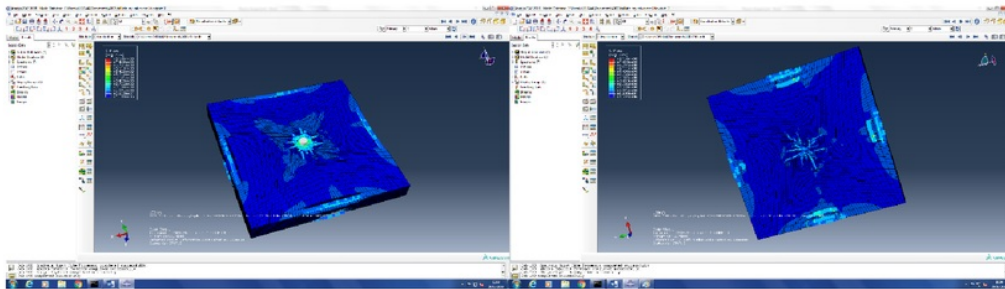


Figure 12 Initial Velocity of 100m/s

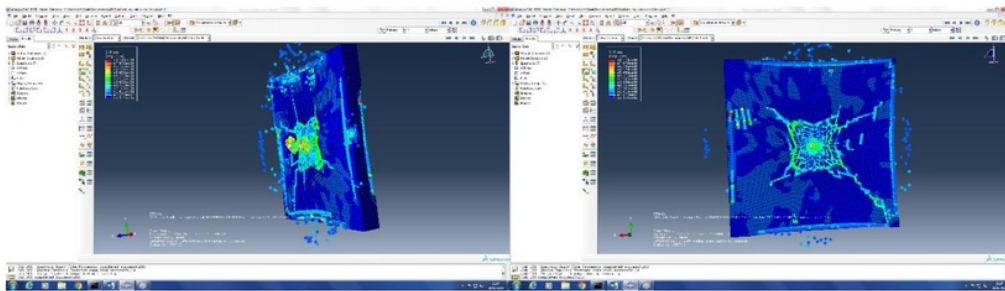


Figure 13 Initial Velocity of 250m/s

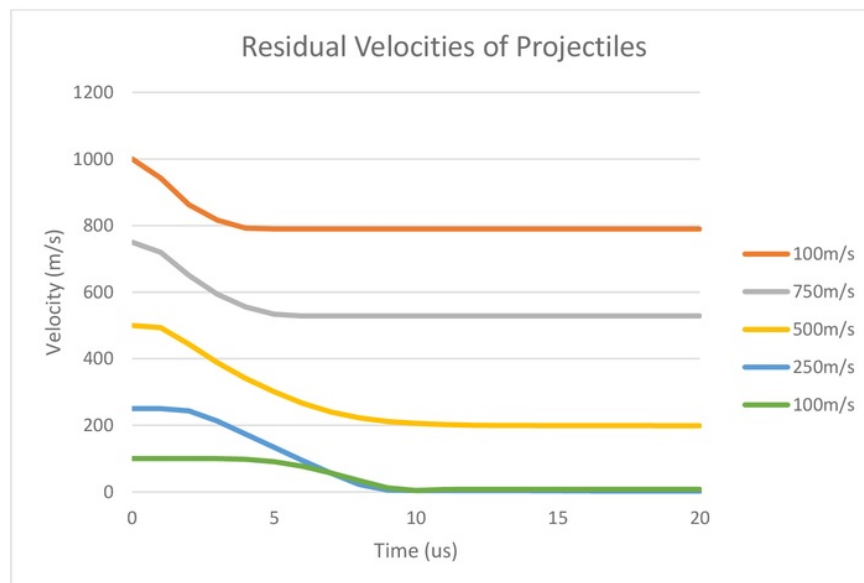


Figure 14 Graph of the residual velocities of the projectiles

Table 3 Residual Velocities

INITIAL VELOCITY (MS ⁻¹)	RESIDUAL VELOCITY (MS ⁻¹)
100	0.0
250	0.0
500	199
750	528
1000	790

3.2 Stress

In Abaqus, Max Principal, S11, S22 and S33 represent different direct stress values; S12, S13 and S23 represent different shear stress values. Where 1, 2 and 3 represent the x, y and z directions respectively. For the direct stress, positive values represent tensile and negative values represent compressive stress. Whereas for shear stress, the positive and negative values represent the direction the stress is acting.

Table 4 Maximum Tensile Direct Stress Values

VELOCITY (MS ⁻¹)	MAX PRINCIPAL (NM ⁻²)	S11 (NM ⁻²)	S22 (NM ⁻²)	S33 (NM ⁻²)
100	3.17×10^9	3.17×10^9	3.10×10^9	2.53×10^9
250	4.24×10^9	3.88×10^9	4.05×10^9	3.91×10^9
500	8.04×10^9	8.03×10^9	8.01×10^9	7.44×10^9
750	9.47×10^9	9.21×10^9	9.36×10^9	9.02×10^9
1000	1.07×10^{10}	1.04×10^{10}	1.00×10^{10}	1.05×10^{10}

Table 5 Maximum Compression Direct Stress Values

VELOCITY (MS ⁻¹)	MAX PRINCIPAL (NM ⁻²)	S11 (NM ⁻²)	S22 (NM ⁻²)	S33 (NM ⁻²)
100	-5.00×10^9	-8.95×10^9	-5.10×10^9	-5.42×10^9
250	-8.21×10^9	-8.97×10^9	-8.52×10^9	-8.85×10^9
500	-1.35×10^{10}	-1.37×10^{10}	-1.37×10^{10}	-1.41×10^{10}
750	-1.71×10^{10}	-1.72×10^{10}	-1.74×10^9	-1.76×10^{10}
1000	-1.22×10^{10}	-1.24×10^{10}	-1.25×10^{10}	-1.27×10^{10}

Table 6 Maximum Shear Stress Values

VELOCITY (MS ⁻¹)	S12 (NM ⁻²)	S13 (NM ⁻²)	S23 (NM ⁻²)
100	4.61×10^8	4.41×10^8	4.31×10^8
250	4.586×10^8	4.49×10^8	4.582×10^8
500	4.59×10^8	4.62×10^8	4.58×10^8
750	4.64×10^8	4.66×10^8	4.55×10^8
1000	4.64×10^8	4.59×10^8	4.64×10^8

Screenshots of the results from each of the runs showed cracks along the plate, the stresses moving through the plate with time and the difference between the shear and direct stresses.

For a projectile moving at 100ms^{-1} the projectile got stuck in the plate, cracks can be seen having formed across the plate and the scales showed that the direct stress was larger than the shear stress.

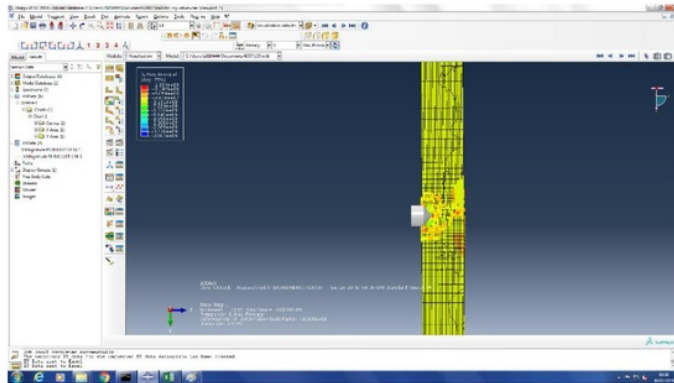


Figure 15: Direct Stress for projectile travelling 100m/s

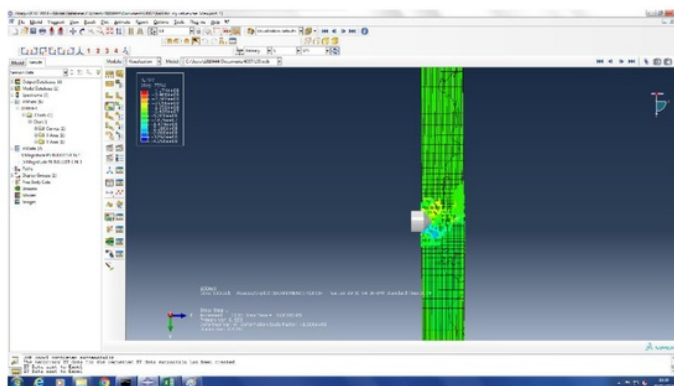


Figure 16: Shear Stress for projectile travelling 100m/s

The scale for Max Principal can be altered to highlight the waves of positive (compressive) direct stress early on in the run, emanating from the impact site.

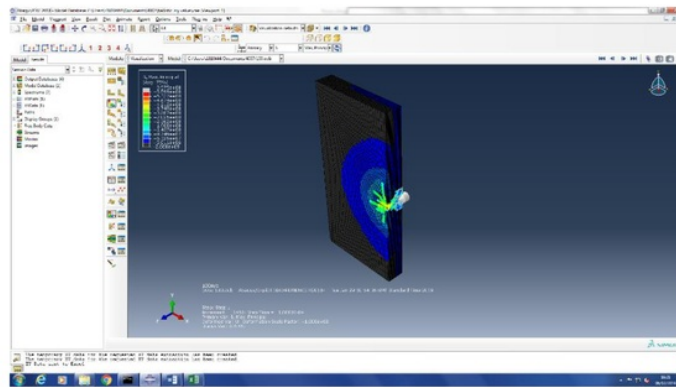


Figure 17: Direct Stress for projectile travelling 100m/s (adapted scale)

For a projectile moving at 250ms^{-1} the projectile, again, got stuck in the plate, cracks can be seen having formed across inside of the plate and the scales showed that the direct stress was larger than the shear stress.

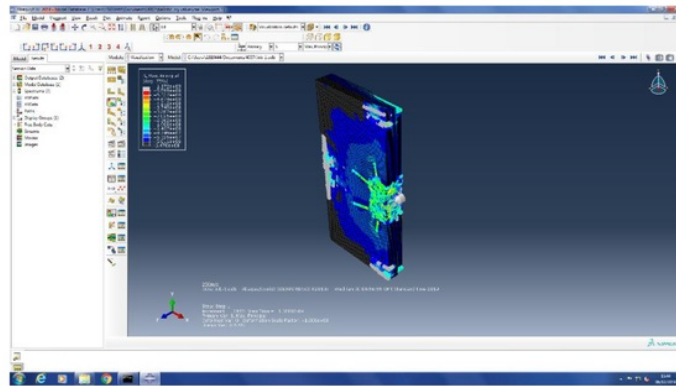


Figure 18: Direct Stress for a projectile travelling at 250m/s (adapted scale)

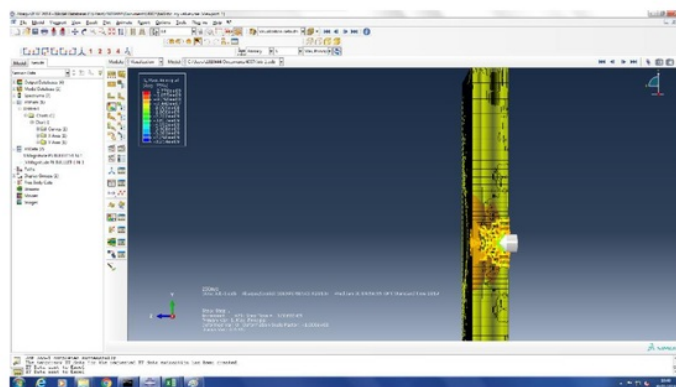


Figure 19: Direct Stress for a projectile travelling at 250m/s

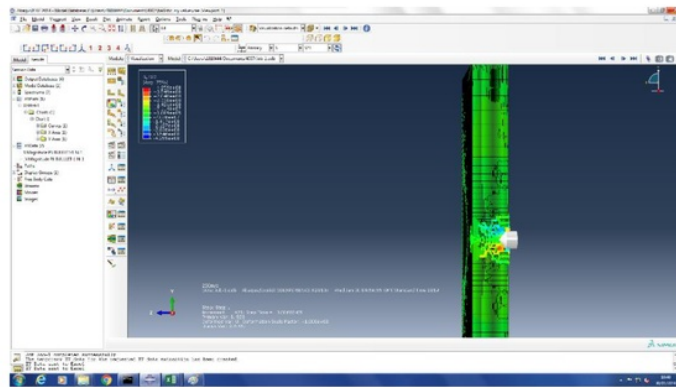


Figure 20: Shear Stress for a projectile travelling at 250m/s

At 500ms^{-1} the projectile penetrated through the aluminium plate with residual velocity. Black was compression stress and the other colours were tensile stress in the below figure (Figure 21). This showed waves of tension emanating from the impact site where it met the compression at the edges of the plate.

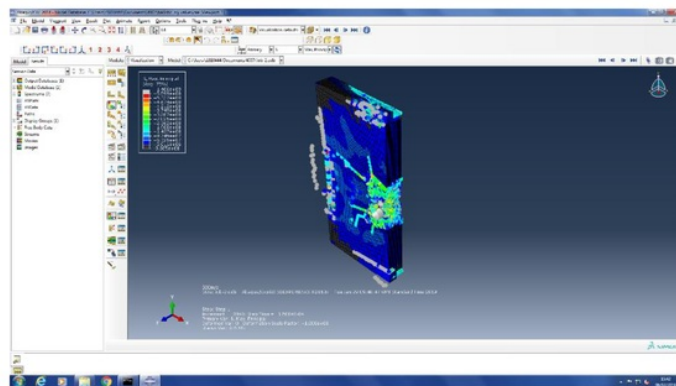


Figure 21: Direct Stress for a projectile travelling at 500m/s (adapted scale)

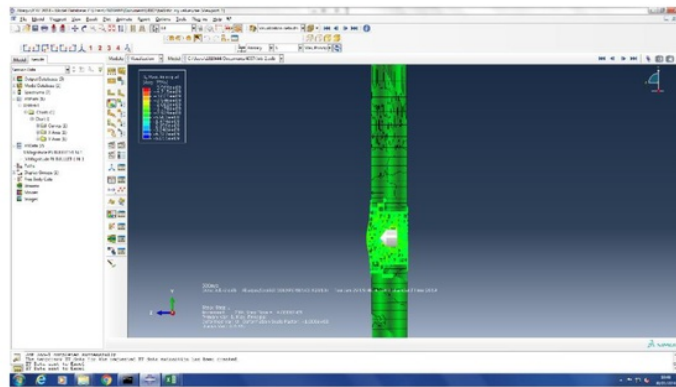


Figure 22: Direct Stress for a projectile travelling at 500m/s

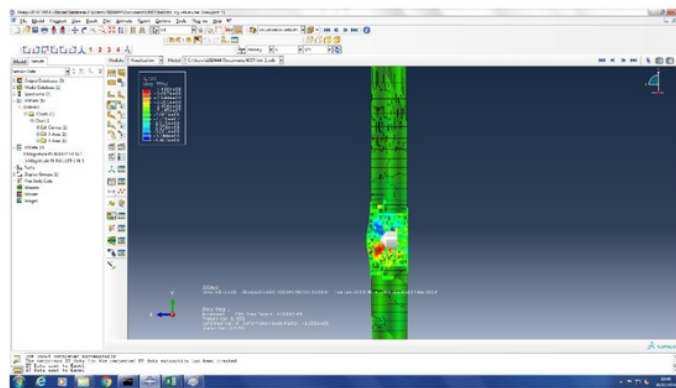


Figure 23: Shear Stress for a projectile travelling at 500m/s

There were more cracks visible in the plate where the projectile had penetrated deeper into the plate.

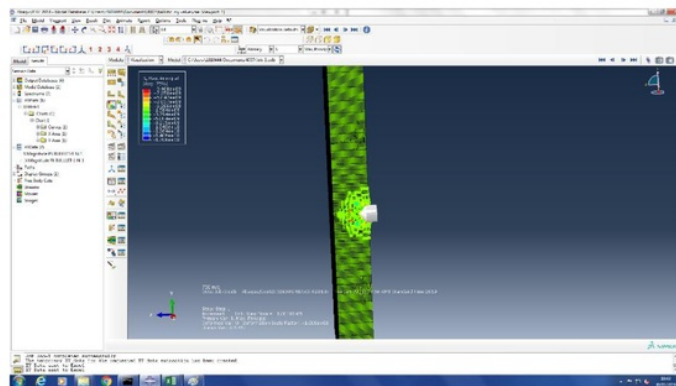


Figure 24: Direct Stress for a projectile travelling at 750m/s

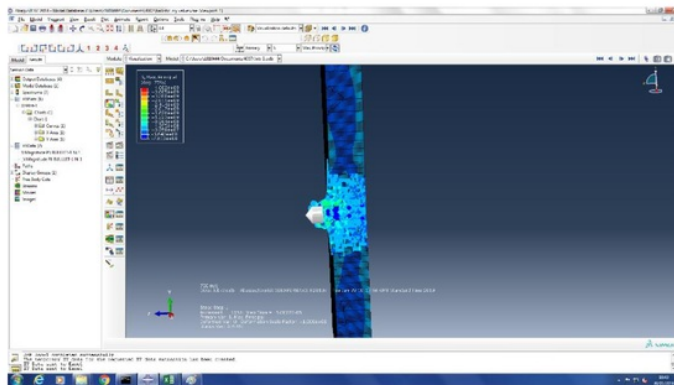


Figure 25: Direct Stress and spalling for projectile travelling at 750m/s

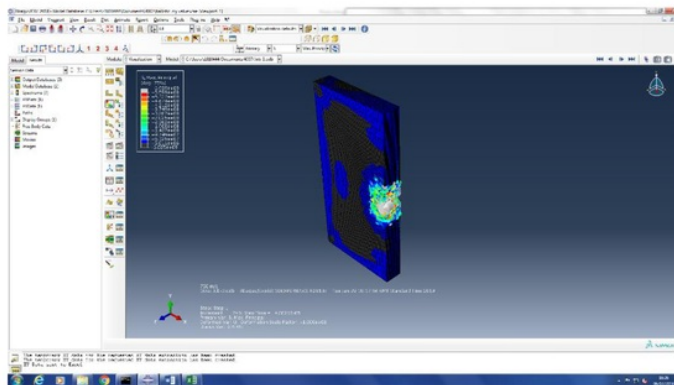


Figure 26: Direct for a projectile travelling at 750m/s

The black primarily denoted the compression with the other colours denoting tensile stress. There is a very high tensile stress around the impact site surrounded by superimposed waves of tension and compression in the remainder of the plate.

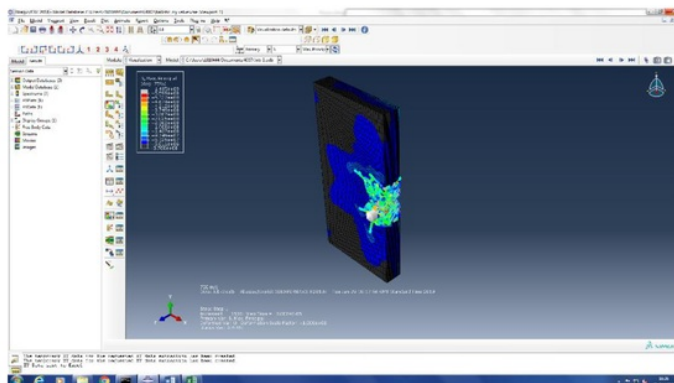


Figure 27: Development of tensile fractures for a projectile travelling at 750m/s

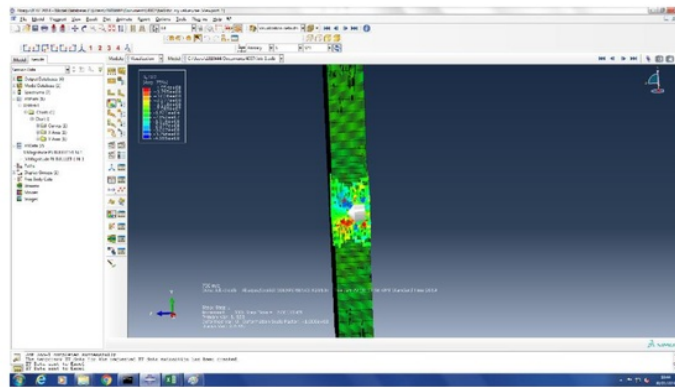


Figure 28: Shear Stress for a projectile travelling at 750m/s

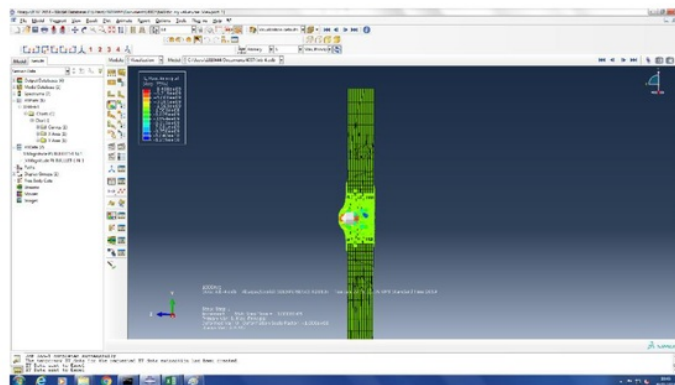


Figure 29: Direct Stress for a projectile travelling at 1,000m/s

There was compression stress moving ahead of the projectile with tension stress appearing directly around the projectile and behind it. As the projectile moves material out of its path, it was compressing some particles and then stretching those in the projectiles immediate vicinity leading to tensile stress.

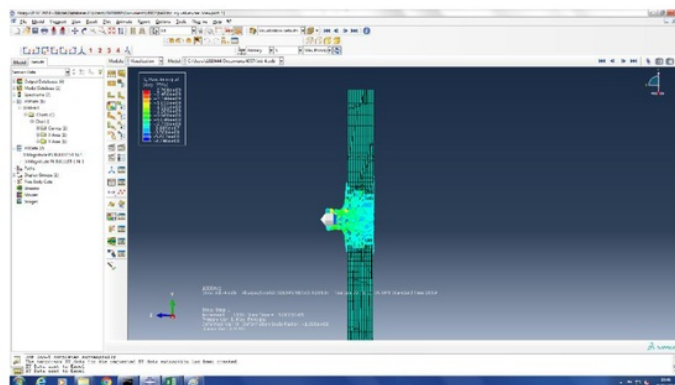


Figure 30: Direct tensile stress in the spalling material for a projectile travelling at 1,000m/s

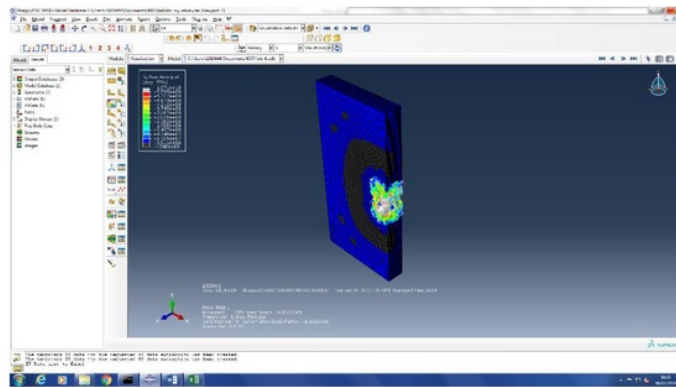


Figure 31: Direct stress waves for a projectile travelling at 1,000m/s

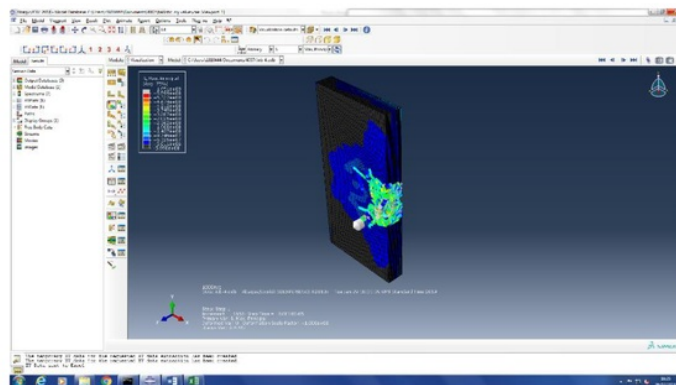


Figure 32: Developing direct stress waves for a projectile travelling at 1,000m/s

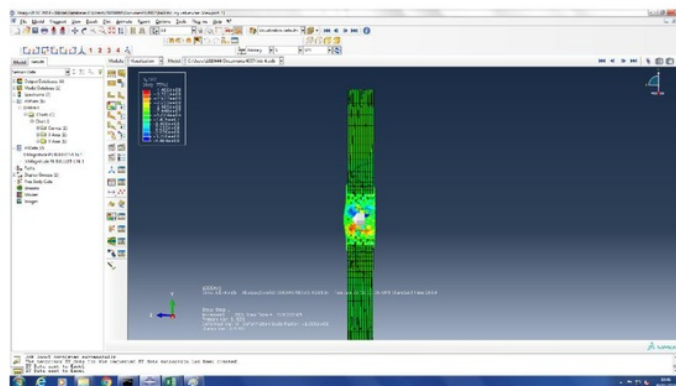


Figure 33: Shear Stress for a projectile travelling at 1,000m/s

Increasing the number of steps in the experimental run reduced the time between frames available in the results, allowing the fast living waves to be better visualised. In Figure 34 to Figure 37 the time steps were increased by a factor of 10 for the projectile impacting at 250m/s^{-1} .

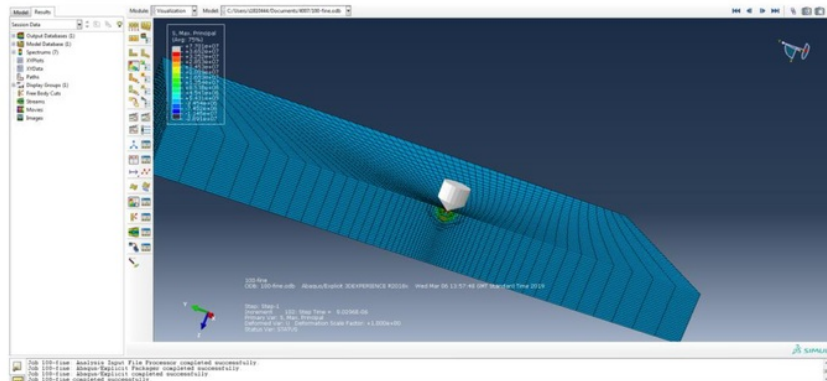


Figure 34: Direct Stress for a projectile travelling at 250m/s with increased time steps

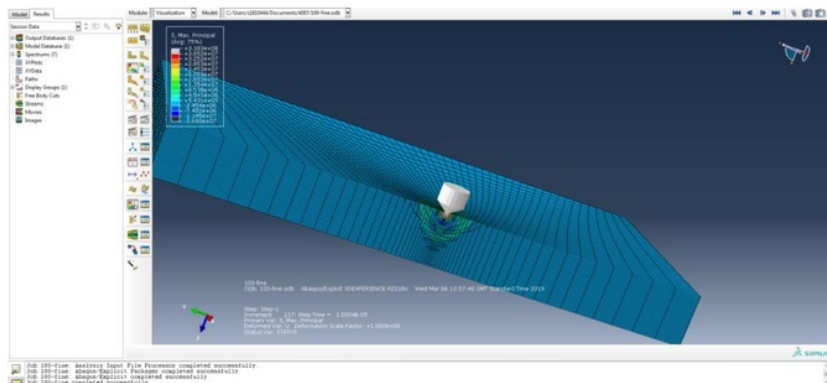


Figure 35: Direct Stress for a projectile travelling at 250m/s with increased time steps

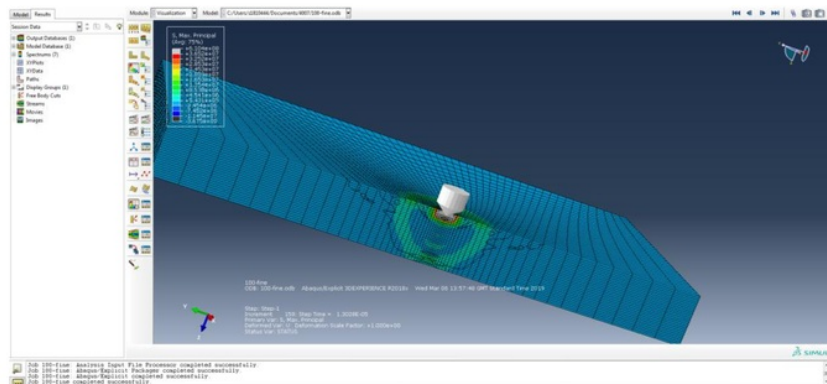


Figure 36: Direct Stress for a projectile travelling at 250m/s with increased time steps

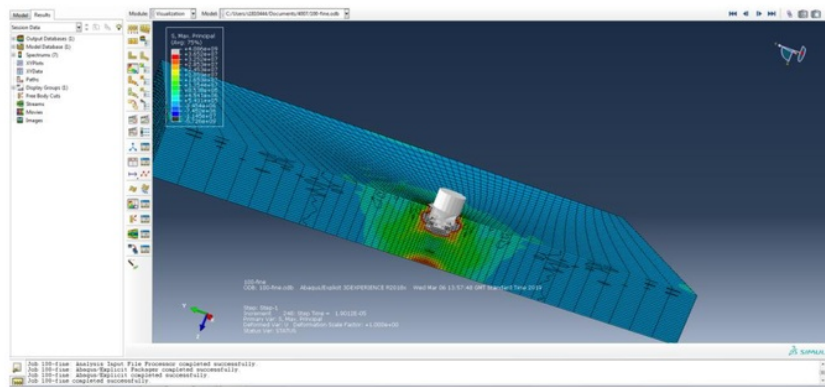


Figure 37: Direct Stress for a projectile travelling at 250m/s with increased time steps

4 Analysis

4.1 Residual Velocities

Although the velocity traces generated in Abaqus showed residual velocities for the 100ms^{-1} and 250ms^{-1} experiments, in both the projectile didn't break through the plate and the residual velocities should have been thought of as zero.

Where the projectile hadn't penetrated through the plate, all the energy of the projectile had been transferred to the plate.

The velocity drop for the runs with initial velocities of 500ms^{-1} , 750ms^{-1} and 1000ms^{-1} were 60%, 30% and 21% respectively. This shows the start of a possible trend of diminishing returns. Once the initial velocity is high enough for the projectile to penetrate through the plate, increasing the velocity produced a large drop in the percentage difference between initial and residual velocities. As the initial velocity moves to higher speeds, the percentage difference between the initial and residual velocities changes less.

4.2 Stress

As could be seen in Table 4 and in Figure 38 to Figure 47 in the Appendix, the maximum direct stress was at least a factor of 10 larger than the maximum shear stress in each experimental run, throughout the entirety of each run. Generally, increasing the initial velocity increased the maximum direct stress experienced by the plate but not the maximum shear stress.

Therefore the fracture cracks visible in the screenshots were probably due to the direct stresses.

Although peak shear stress didn't vary significantly with initial velocity, the range of shear stress reduced from 2.0×10^8 to 6.5×10^7 , in all three planes, with higher initial velocities. Suggesting the shear stress occurred over shorter timescales with increasing impact velocity. Shear stress is caused with the movement of the material past itself which occurs as the projectile pushed through the plate. As the projectile moves faster, this shear stress occurs faster.

Tension and compression waves passed through the plates in each run and reflected off the back side of the plate. The peak tension that occurred on the back of the plate created spalling of material which was shown by the ejection of particles from the plates in each experimental run.

A large, short-lived spike in the compression stress occurred in the beginning of each run. Whilst the compression stress appeared larger when looking at just Table 4 and Table 5, the peak compression stress was short and the tensile stress remained higher than the compression for the majority of the experimental runs, as can be seen in Figure 48 to Figure 52 in the Appendix. The compression peak was shorter lasting for the higher velocity impacts as the projectile passed through the plate quicker. The tension stress was created by material being pulled apart during spalling and as the projectile forced material out of its way. Initially the projectile compressed the material and sent a compression wave through the plate, the material behind this wave was then subjected to tensile stress. The waves reverberated through the plate, superimposing on one another throughout the run leading to moving areas of compression and tension. If the tensile stress at the edges of the plate was large enough the ultimate tensile stress was exceeded leading to the breaking of the material and spalling of particles into free space.

5 Conclusions

It could be concluded that for an aluminium plate with the properties as used in this experiment, in Abaqus, that tension and compression was the main driver for damage within the plate and tension was the main driver for spalling from the plate.

The velocity required to penetrate through the aluminium plate for a projectile of 30g is between 250ms^{-1} and 500ms^{-1} . Increasing the initial velocity of the projectile increased the percentage of the velocity still present with the projectile after it had exited the plate.

The compression and tension stresses were a factor of 10 larger than the shear stresses throughout each experimental run, suggesting the majority of the damage seen throughout the plate was due to compression and tension stress rather than shear.

For the majority of length of each of the runs, tension stresses within the plate were larger than the compression stresses. Each experimental run showed a peak in the compression stress early in the run which was larger than the tension stress at that time.

A peak in tension stress present in the plate accounted for spalling of material from the plate during and after impact.

6 Recommendations

6.1 Limitations

The main limitations of using Abaqus are the mesh, the boundary conditions and the material properties. The more nodes added to the mesh the longer it takes each job to run but the greater detail can be achieved in the results.

The boundary conditions applied in Abaqus can have an effect on the ballistic limit of the plate [12] where the higher the percentage of clamping, the lower the ballistic limit of the target.

Material properties can have a large impact on the results and as the literature review showed, there is a large variance in the values available for aluminium and its alloys. There are also numerous more complex models which can be combined to take account of more properties of the materials.

6.2 Further Work

It is recommended that further investigation is conducted with:

- more runs at different speeds to confirm diminishing returns explored in the residual velocities,
- different materials,
- different shaped mesh elements,
- varying the position of impact on plate,
- a meshed projectile,
- different material properties using a range of the values to measure their effect on the results and
- increasingly complex models.

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8 Appendix

8.1 Introductory Research

Table 7: Values for General and Elastic Region Variables

MATERIAL NAME	INFORMATION SOURCE	DENSITY (KG/M ³)	E (GPA)	POISSON'S RATIO	CITATION
ALUMINIUM, AL	MATWEB	2698.9	68.0	0.36	[4]
1000 SERIES ALUMINIUM	MATWEB	2700 – 2710	62.0 – 69.0	0.33	[13]
ALUMINIUM	NPL		70.3	0.345	[14]
AL (MP-134)	MATERIALS PROJECT	2720		0.37	[15]
AA 1000 SERIES ALUMINIUM	MAKEITFROM.COM		68.0 – 69.0	0.33	[16]
ALUMINIUM	ASM INTERNATIONAL	2720			[17]
2024-O AL ALLOY	SCIENCE DIRECT	2710	71.0	0.33	[18]
1100-H12 AL	SCIENCE DIRECT	2700	65.762	0.3	[12]
RANGE (% OF LARGEST VALUE)		0.8	12	10	
MEAN		2705	68.1	0.35	
MODE		2720	N/A	0.33	
MEDIAN		2712	68.3	0.35	
STANDARD DEVIATION		10.7	2.0	0.02	

Table 8 Johnson Cook Model Parameters

SYMBOL	DESCRIPTION	AL 6061-T6 [10]	2024-O [18]	ALUMINIUM [19]
ν	POISSON'S RATIO		0.33	0.3
YOUNG'S MODULUS	E		71000	65762
ρ (KG/M ³)	DENSITY	2700	2710	2700
A (MPa)	YIELD STRESS	324.1	369	148.361
B (MPa)	HARDENING CONSTANT	113.8	684	345.513
n	HARDENING EXPONENT	0.42	0.73	0.183
m	TEMPERATURE SOFTENING EXPONENT	1.34	1.7	0.859
T _{MELT} (K)	MELTING TEMPERATURE	925	893	893

T _{TRANSITION} (K)	REFERENCE TEMPERATURE	293.2	293	293
C	STRAIN RATE CONSTANT	0.002	0.0083	0.001
$\dot{\epsilon}_0$ (s ⁻¹)	REFERENCE STRAIN RATE	1	1	1
D1	FAILURE PARAMETER	-0.77	0.13	0.071
D2	FAILURE PARAMETER	1.45	0.13	1.248
D3	FAILURE PARAMETER	0.47	-1.5	-1.142
D4	FAILURE PARAMETER	0	0.011	0.147
D5	FAILURE PARAMETER	1.6	0	0

8.2 Full Results Table

Table 9 Maximum Stress Values at each frame

FRA ME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
V = 100M/s																				
MAX PRIN CIPAL			- 9. 77 E+ 08	- 2. 38 E+ 09	- 4. 56 E+ 09	- 4. 18 E+ 09	- 5. 00 E+ 09	- 3. 59 E+ 09	- 2. 85 E+ 09	- 2. 21 E+ 09	- 1. 08 E+ 09	- 4. 68 E+ 08	- 4. 52 E+ 08	- 4. 34 E+ 08	- 7. 39 E+ 08	- 5. 76 E+ 08	- 8. 39 E+ 08	- 6. 63 E+ 08	- 6. 42 E+ 08	- 7. 67 E+ 08
S11			- 1. 08 E+ 09	- 2. 50 E+ 09	- 4. 99 E+ 09	- 4. 90 E+ 09	- 5. 50 E+ 09	- 3. 91 E+ 09	- 3. 35 E+ 09	- 2. 69 E+ 09	- 1. 74 E+ 09	- 8. 95 E+ 08	- 8. 39 E+ 08	- 8. 48 E+ 08	- 8. 51 E+ 08	- 8. 71 E+ 08	- 9. 59 E+ 08	- 8. 33 E+ 08	- 8. 05 E+ 08	- 9. 57 E+ 08
S22			- 1. 24 E+ 09	- 2. 47 E+ 09	- 4. 78 E+ 09	- 4. 62 E+ 09	- 5. 10 E+ 09	- 3. 80 E+ 09	- 3. 20 E+ 09	- 2. 40 E+ 09	- 1. 62 E+ 09	- 8. 39 E+ 08	- 8. 29 E+ 08	- 8. 39 E+ 08	- 8. 59 E+ 08	- 1. 07 E+ 09	- 7. 96 E+ 08	- 7. 65 E+ 08	- 8. 22 E+ 08	- 8. 22 E+ 08
S33			- 1. 04	- 2. 76	- 4. 79	- 4. 74	- 5. 42	- 4. 30	- 3. 38	- 2. 73	- 1. 44	- 5. 81	- 5. 88	- 5. 69	- 1. 11	- 9. 30	- 8. 82	- 9. 99	- 9. 13	- 1. 11

			E+ 09	E+ 09	E+ 09	E+ 09	E+ 09	E+ 09	E+ 09	E+ 09	E+ 09	E+ 08	E+ 08	E+ 08	E+ 09	E+ 08	E+ 08	E+ 08	E+ 08	E+ 09
MAX PRIN CIPAL			3. 40 E+ 08	1. 32 E+ 09	2. 93 E+ 09	3. 17 E+ 09	1. 74 E+ 09	1. 83 E+ 09	1. 49 E+ 09	1. 00 E+ 09	7. 38 E+ 08	6. 94 E+ 08	6. 92 E+ 08	6. 91 E+ 08	1. 28 E+ 09	1. 60 E+ 09	1. 58 E+ 09	1. 58 E+ 09	1. 42 E+ 09	1. 36 E+ 09
S11			1. 17 E+ 08	1. 30 E+ 09	2. 83 E+ 09	3. 17 E+ 09	1. 53 E+ 09	1. 60 E+ 09	1. 37 E+ 09	8. 31 E+ 08	6. 37 E+ 08	6. 76 E+ 08	6. 49 E+ 08	6. 76 E+ 08	1. 18 E+ 09	1. 55 E+ 09	1. 48 E+ 09	1. 48 E+ 09	1. 30 E+ 09	1. 30 E+ 09
S22			1. 32 E+ 08	1. 24 E+ 09	2. 85 E+ 09	3. 10 E+ 09	1. 51 E+ 09	1. 58 E+ 09	1. 47 E+ 09	9. 86 E+ 08	7. 02 E+ 08	6. 79 E+ 08	6. 92 E+ 08	6. 74 E+ 08	1. 25 E+ 09	1. 22 E+ 09	1. 53 E+ 09	1. 53 E+ 09	1. 37 E+ 09	1. 27 E+ 09
S33			6. 82 E+ 07	8. 11 E+ 08	2. 38 E+ 09	2. 53 E+ 09	1. 32 E+ 09	1. 41 E+ 09	1. 13 E+ 09	6. 99 E+ 08	5. 65 E+ 08	5. 24 E+ 08	4. 45 E+ 08	4. 60 E+ 08	5. 15 E+ 08	1. 20 E+ 09	1. 06 E+ 09	1. 06 E+ 09	1. 01 E+ 09	1. 22 E+ 09
S12			2. 15 E+ 08	2. 59 E+ 08	2. 11 E+ 08	2. 44 E+ 08	4. 61 E+ 08	3. 94 E+ 08	3. 45 E+ 08	3. 19 E+ 08	2. 67 E+ 08	2. 47 E+ 08	2. 70 E+ 08	2. 78 E+ 08	2. 67 E+ 08	2. 64 E+ 08	2. 50 E+ 08	2. 63 E+ 08	2. 67 E+ 08	2. 58 E+ 08
S13			2. 56 E+ 08	3. 56 E+ 08	4. 41 E+ 08	4. 09 E+ 08	3. 70 E+ 08	4. 01 E+ 08	4. 33 E+ 08	2. 82 E+ 08	2. 96 E+ 08	4. 04 E+ 08	4. 33 E+ 08	3. 26 E+ 08	3. 40 E+ 08	3. 70 E+ 08	3. 62 E+ 08	4. 28 E+ 08	4. 43 E+ 08	4. 53 E+ 08
S23			2. 65 E+ 08	3. 67 E+ 08	4. 21 E+ 08	4. 31 E+ 08	4. 97 E+ 08	4. 41 E+ 08	4. 34 E+ 08	3. 04 E+ 08	3. 60 E+ 08	3. 70 E+ 08	3. 94 E+ 08	3. 57 E+ 08	3. 45 E+ 08	3. 59 E+ 08	3. 70 E+ 08	3. 73 E+ 08	3. 78 E+ 08	3. 80 E+ 08
V = 250M/s																				
MAX PRIN CIPAL	- 3. 54 E+ 09	- 6. 28 E+ 09	- 8. 21 E+ 09	- 5. 98 E+ 09	- 4. 03 E+ 09	- 3. 85 E+ 09	- 2. 22 E+ 09	- 3. 45 E+ 09	- 3. 01 E+ 09	- 1. 88 E+ 09	- 1. 18 E+ 09	- 8. 99 E+ 08	- 8. 92 E+ 08	- 1. 28 E+ 09	- 1. 96 E+ 09	- 2. 47 E+ 09	- 2. 59 E+ 09	- 2. 50 E+ 09	- 2. 27 E+ 09	- 1. 66 E+ 09
S11	- 3. 65 E+ 09	- 6. 80 E+ 09	- 8. 97 E+ 09	- 6. 37 E+ 09	- 4. 05 E+ 09	- 3. 90 E+ 09	- 3. 28 E+ 09	- 3. 53 E+ 09	- 3. 32 E+ 09	- 2. 56 E+ 09	- 2. 06 E+ 09	- 1. 76 E+ 09	- 1. 75 E+ 09	- 1. 91 E+ 09	- 2. 20 E+ 09	- 2. 55 E+ 09	- 2. 69 E+ 09	- 2. 57 E+ 09	- 2. 37 E+ 09	- 2. 04 E+ 09
S22	- 3. 65 E+ 09	- 6. 37 E+ 09	- 8. 52 E+ 09	- 6. 42 E+ 09	- 4. 32 E+ 09	- 4. 02 E+ 09	- 3. 71 E+ 09	- 3. 79 E+ 09	- 3. 16 E+ 09	- 2. 19 E+ 09	- 1. 65 E+ 09	- 1. 66 E+ 09	- 1. 55 E+ 09	- 1. 61 E+ 09	- 2. 05 E+ 09	- 2. 50 E+ 09	- 2. 65 E+ 09	- 2. 57 E+ 09	- 2. 30 E+ 09	- 1. 87 E+ 09
S33	- 3. 95 E+ 09	- 6. 48 E+ 09	- 8. 85 E+ 09	- 6. 46 E+ 09	- 4. 85 E+ 09	- 4. 22 E+ 09	- 3. 88 E+ 09	- 3. 98 E+ 09	- 3. 27 E+ 09	- 2. 07 E+ 09	- 1. 25 E+ 09	- 1. 16 E+ 09	- 1. 17 E+ 09	- 1. 45 E+ 09	- 2. 09 E+ 09	- 2. 65 E+ 09	- 2. 83 E+ 09	- 2. 62 E+ 09	- 2. 27 E+ 09	- 1. 78 E+ 09

MAX PRIN CIPAL	3. 18 E+ 08	3. 61 E+ 09	4. 24 E+ 09	3. 77 E+ 09	3. 17 E+ 09	3. 16 E+ 09	2. 46 E+ 09	2. 45 E+ 09	1. 35 E+ 09	9. 48 E+ 08	1. 37 E+ 09	1. 28 E+ 09	1. 19 E+ 09	1. 32 E+ 09	1. 24 E+ 09	1. 50 E+ 09	1. 58 E+ 09	1. 46 E+ 09	1. 57 E+ 09	1. 76 E+ 09
S11	2. 42 E+ 08	3. 29 E+ 09	3. 88 E+ 09	3. 55 E+ 09	2. 93 E+ 09	2. 97 E+ 09	2. 22 E+ 09	2. 15 E+ 09	1. 18 E+ 09	7. 43 E+ 08	1. 32 E+ 09	1. 24 E+ 09	1. 18 E+ 09	1. 28 E+ 09	1. 21 E+ 09	1. 29 E+ 09	1. 29 E+ 09	1. 34 E+ 09	1. 43 E+ 09	1. 42 E+ 09
S22	2. 96 E+ 08	3. 41 E+ 09	4. 05 E+ 09	3. 63 E+ 09	3. 02 E+ 09	2. 40 E+ 09	2. 34 E+ 09	2. 10 E+ 09	9. 82 E+ 08	7. 38 E+ 08	1. 17 E+ 09	1. 02 E+ 09	9. 84 E+ 08	1. 08 E+ 09	1. 22 E+ 09	1. 25 E+ 09	1. 53 E+ 09	1. 24 E+ 09	1. 32 E+ 09	1. 34 E+ 09
S33	1. 75 E+ 08	3. 60 E+ 09	3. 91 E+ 09	3. 08 E+ 09	2. 71 E+ 09	3. 00 E+ 09	2. 09 E+ 09	1. 82 E+ 09	8. 69 E+ 08	7. 54 E+ 08	8. 99 E+ 08	8. 14 E+ 08	8. 26 E+ 08	8. 74 E+ 08	1. 03 E+ 09	1. 42 E+ 09	1. 12 E+ 09	1. 32 E+ 09	1. 40 E+ 09	1. 75 E+ 09
S12	6. 90 E+ 07	2. 43 E+ 08	3. 68 E+ 08	4. 07 E+ 08	3. 67 E+ 08	4. 41 E+ 08	4. 13 E+ 08	4. 23 E+ 08	4. 27 E+ 08	3. 72 E+ 08	3. 3. E+ 08	3. 22 E+ 08	2. 92 E+ 08	2. 85 E+ 08	2. 98 E+ 08	2. 96 E+ 08	3. 27 E+ 08	2. 99 E+ 08	4. 10 E+ 08	4. 53 E+ 08
S13	1. 66 E+ 08	3. 94 E+ 08	4. 18 E+ 08	4. 37 E+ 08	4. 46 E+ 08	4. 48 E+ 08	4. 45 E+ 08	4. 49 E+ 08	4. 22 E+ 08	4. 14 E+ 08	4. 00 E+ 08	3. 67 E+ 08	3. 64 E+ 08	3. 72 E+ 08	3. 73 E+ 08	3. 79 E+ 08	3. 68 E+ 08	3. 81 E+ 08	3. 75 E+ 08	3. 74 E+ 08
S23	1. 57 E+ 08	3. 92 E+ 08	4. 64 E+ 08	4. 50 E+ 08	4. 40 E+ 08	4. 51 E+ 08	4. 52 E+ 08	4. 55 E+ 08	4. 14 E+ 08	4. 41 E+ 08	4. 21 E+ 08	4. 30 E+ 08	4. 25 E+ 08	3. 68 E+ 08	3. 57 E+ 08	3. 49 E+ 08	3. 31 E+ 08	3. 35 E+ 08	3. 42 E+ 08	3. 47 E+ 08
V = 500M/s																				
MAX PRIN CIPAL	- 7. 41 E+ 09	- 1. 35 E+ 10	- 6. 53 E+ 09	- 5. 01 E+ 09	- 5. 62 E+ 09	- 4. 72 E+ 09	- 2. 90 E+ 09	- 1. 89 E+ 09	- 2. 36 E+ 09	- 2. 00 E+ 09	- 8. 28 E+ 08	- 1. 07 E+ 09	- 7. 18 E+ 08	- 6. 90 E+ 08	- 9. 37 E+ 08	- 1. 32 E+ 09	- 9. 25 E+ 08	- 1. 26 E+ 09	- 1. 48 E+ 09	- 2. 24 E+ 09
S11	- 7. 66 E+ 09	- 1. 37 E+ 10	- 7. 00 E+ 09	- 5. 36 E+ 09	- 5. 72 E+ 09	- 4. 85 E+ 09	- 3. 23 E+ 09	- 2. 12 E+ 09	- 2. 95 E+ 09	- 2. 14 E+ 09	- 1. 64 E+ 09	- 1. 73 E+ 09	- 1. 01 E+ 09	- 9. 48 E+ 08	- 1. 05 E+ 09	- 1. 34 E+ 09	- 9. 97 E+ 08	- 1. 54 E+ 09	- 1. 75 E+ 09	- 2. 40 E+ 09
S22	- 7. 95 E+ 09	- 1. 37 E+ 10	- 6. 73 E+ 09	- 5. 20 E+ 09	- 6. 07 E+ 09	- 4. 87 E+ 09	- 3. 27 E+ 09	- 2. 34 E+ 09	- 2. 70 E+ 09	- 2. 86 E+ 09	- 1. 23 E+ 09	- 1. 54 E+ 09	- 1. 09 E+ 09	- 1. 05 E+ 09	- 1. 13 E+ 09	- 1. 48 E+ 09	- 1. 09 E+ 09	- 1. 58 E+ 09	- 1. 83 E+ 09	- 2. 88 E+ 09
S33	- 7. 74 E+ 09	- 1. 41 E+ 10	- 7. 04 E+ 09	- 5. 64 E+ 09	- 6. 24 E+ 09	- 5. 14 E+ 09	- 3. 35 E+ 09	- 2. 46 E+ 09	- 2. 54 E+ 09	- 2. 36 E+ 09	- 1. 24 E+ 09	- 1. 38 E+ 09	- 1. 20 E+ 09	- 1. 20 E+ 09	- 1. 25 E+ 09	- 1. 95 E+ 09	- 1. 23 E+ 09	- 1. 87 E+ 09	- 1. 78 E+ 09	- 2. 39 E+ 09

MAX PRIN CIPAL	8. 04 E+ 09	6. 76 E+ 09	6. 30 E+ 09	5. 60 E+ 09	5. 82 E+ 09	5. 10 E+ 09	4. 84 E+ 09	5. 05 E+ 09	3. 44 E+ 09	2. 62 E+ 09	2. 93 E+ 09	1. 83 E+ 09	1. 41 E+ 09	1. 35 E+ 09	1. 47 E+ 09	2. 58 E+ 09	2. 12 E+ 09	2. 49 E+ 09	2. 40 E+ 09	2. 41 E+ 09
S11	8. 03 E+ 09	6. 33 E+ 09	5. 54 E+ 09	4. 85 E+ 09	5. 10 E+ 09	4. 61 E+ 09	4. 32 E+ 09	4. 27 E+ 09	3. 19 E+ 09	2. 07 E+ 09	2. 29 E+ 09	1. 82 E+ 09	1. 41 E+ 09	1. 33 E+ 09	1. 32 E+ 09	2. 50 E+ 09	2. 00 E+ 09	2. 37 E+ 09	2. 28 E+ 09	2. 28 E+ 09
S22	8. 01 E+ 09	6. 72 E+ 09	5. 95 E+ 09	5. 14 E+ 09	4. 94 E+ 09	4. 35 E+ 09	4. 30 E+ 09	4. 29 E+ 09	2. 67 E+ 09	2. 10 E+ 09	2. 35 E+ 09	1. 46 E+ 09	9. 40 E+ 08	1. 17 E+ 09	1. 47 E+ 09	2. 32 E+ 09	1. 81 E+ 09	2. 14 E+ 09	2. 08 E+ 09	2. 10 E+ 09
S33	7. 44 E+ 09	6. 68 E+ 09	5. 79 E+ 09	5. 39 E+ 09	5. 81 E+ 09	5. 09 E+ 09	4. 64 E+ 09	5. 01 E+ 09	3. 05 E+ 09	2. 50 E+ 09	2. 76 E+ 09	1. 12 E+ 09	1. 00 E+ 09	9. 94 E+ 08	1. 41 E+ 09	1. 90 E+ 09	1. 40 E+ 09	2. 77 E+ 09	2. 07 E+ 09	2. 07 E+ 09
S12	2. 82 E+ 08	4. 52 E+ 08	4. 40 E+ 08	4. 15 E+ 08	4. 37 E+ 08	4. 26 E+ 08	4. 46 E+ 08	4. 51 E+ 08	4. 58 E+ 08	4. 59 E+ 08	4. 58 E+ 08	4. 58 E+ 08	3. 84 E+ 08	3. 66 E+ 08	3. 78 E+ 08	4. 15 E+ 08	4. 33 E+ 08	3. 92 E+ 08	3. 61 E+ 08	3. 62 E+ 08
S13	4. 15 E+ 08	4. 00 E+ 08	4. 51 E+ 08	4. 61 E+ 08	4. 59 E+ 08	4. 60 E+ 08	4. 62 E+ 08	4. 55 E+ 08	4. 33 E+ 08	4. 50 E+ 08	4. 28 E+ 08	4. 17 E+ 08	4. 60 E+ 08	4. 22 E+ 08	3. 66 E+ 08	3. 73 E+ 08	3. 92 E+ 08	3. 66 E+ 08	3. 68 E+ 08	3. 97 E+ 08
S23	4. 28 E+ 08	4. 47 E+ 08	4. 49 E+ 08	4. 50 E+ 08	4. 57 E+ 08	4. 58 E+ 08	4. 57 E+ 08	4. 48 E+ 08	4. 49 E+ 08	4. 48 E+ 08	4. 37 E+ 08	4. 20 E+ 08	4. 52 E+ 08	3. 80 E+ 08	3. 64 E+ 08	3. 72 E+ 08	3. 72 E+ 08	4. 18 E+ 08	4. 26 E+ 08	4. 11 E+ 08
V = 750M/s																				
MAX PRIN CIPAL	- 1. 71 E+ 10	- 8. 10 E+ 09	- 6. 71 E+ 09	- 6. 03 E+ 09	- 5. 53 E+ 09	- 7. 61 E+ 08	- 5. 89 E+ 08	- 4. 29 E+ 08	- 6. 29 E+ 08	- 5. 50 E+ 08	- 5. 16 E+ 08	- 5. 62 E+ 08	- 8. 76 E+ 08	- 1. 59 E+ 09	- 7. 54 E+ 08	- 7. 54 E+ 08	- 1. 01 E+ 09	- 9. 20 E+ 08	- 8. 45 E+ 08	- 8. 13 E+ 08
S11	- 1. 72 E+ 10	- 8. 26 E+ 09	- 6. 81 E+ 09	- 6. 42 E+ 09	- 5. 70 E+ 09	- 1. 44 E+ 09	- 8. 81 E+ 08	- 9. 12 E+ 08	- 9. 37 E+ 08	- 9. 11 E+ 08	- 9. 03 E+ 08	- 9. 19 E+ 08	- 1. 29 E+ 09	- 2. 00 E+ 09	- 1. 23 E+ 09	- 1. 23 E+ 08	- 1. 03 E+ 09	- 1. 10 E+ 09	- 1. 01 E+ 09	- 1. 01 E+ 09
S22	- 1. 74 E+ 10	- 8. 23 E+ 09	- 6. 92 E+ 09	- 6. 24 E+ 09	- 5. 99 E+ 09	- 1. 56 E+ 09	- 1. 15 E+ 09	- 1. 01 E+ 09	- 9. 64 E+ 08	- 9. 17 E+ 08	- 9. 33 E+ 08	- 9. 25 E+ 08	- 1. 14 E+ 09	- 1. 60 E+ 09	- 3. 38 E+ 08	- 9. 47 E+ 08	- 1. 06 E+ 09	- 1. 00 E+ 09	- 9. 33 E+ 08	- 1. 03 E+ 09
S33	- 1. 76 E+ 10	- 8. 81 E+ 09	- 7. 35 E+ 09	- 6. 51 E+ 09	- 5. 48 E+ 09	- 1. 35 E+ 09	- 1. 13 E+ 09	- 9. 06 E+ 08	- 1. 05 E+ 09	- 9. 00 E+ 08	- 8. 69 E+ 08	- 8. 98 E+ 08	- 8. 78 E+ 08	- 1. 61 E+ 09	- 1. 22 E+ 09	- 1. 22 E+ 09	- 1. 42 E+ 09	- 1. 29 E+ 09	- 1. 02 E+ 09	- 1. 15 E+ 09

MAX PRIN CIPAL	9. 47 E+ 09	8. 25 E+ 09	6. 99 E+ 09	7. 85 E+ 09	7. 76 E+ 09	9. 34 E+ 09	2. 42 E+ 09	1. 44 E+ 09	1. 16 E+ 09	1. 18 E+ 09	9. 80 E+ 08	1. 20 E+ 09	1. 38 E+ 09	1. 28 E+ 09	1. 87 E+ 09	1. 76 E+ 09	2. 40 E+ 09	1. 52 E+ 09	1. 30 E+ 09	1. 43 E+ 09
S11	9. 12 E+ 09	7. 61 E+ 09	6. 31 E+ 09	7. 11 E+ 09	7. 21 E+ 09	9. 21 E+ 09	2. 10 E+ 09	1. 02 E+ 09	9. 91 E+ 08	1. 06 E+ 09	9. 56 E+ 08	9. 79 E+ 08	1. 29 E+ 09	1. 02 E+ 09	1. 65 E+ 09	1. 52 E+ 09	2. 40 E+ 09	1. 31 E+ 09	1. 12 E+ 09	1. 28 E+ 09
S22	9. 36 E+ 09	7. 87 E+ 09	6. 36 E+ 09	7. 80 E+ 09	7. 05 E+ 09	8. 63 E+ 09	2. 09 E+ 09	1. 29 E+ 09	8. 78 E+ 08	8. 41 E+ 08	8. 00 E+ 08	1. 16 E+ 09	1. 32 E+ 09	1. 25 E+ 09	1. 77 E+ 09	1. 69 E+ 09	2. 36 E+ 09	1. 32 E+ 09	1. 27 E+ 09	1. 27 E+ 09
S33	9. 02 E+ 09	7. 74 E+ 09	6. 97 E+ 09	7. 42 E+ 09	7. 67 E+ 09	8. 96 E+ 09	1. 82 E+ 09	1. 17 E+ 09	1. 04 E+ 09	9. 84 E+ 08	8. 20 E+ 08	8. 82 E+ 08	1. 05 E+ 09	7. 94 E+ 08	1. 49 E+ 09	1. 31 E+ 09	1. 09 E+ 09	1. 31 E+ 09	1. 13 E+ 09	1. 28 E+ 09
S12	3. 48 E+ 08	4. 41 E+ 08	4. 63 E+ 08	4. 43 E+ 08	4. 44 E+ 08	4. 48 E+ 08	4. 64 E+ 08	4. 34 E+ 08	4. 30 E+ 08	3. 85 E+ 08	3. 22 E+ 08	4. 10 E+ 08	3. 30 E+ 08	2. 93 E+ 08	3. 39 E+ 08	3. 34 E+ 08	3. 34 E+ 08	2. 96 E+ 08	3. 41 E+ 08	3. 26 E+ 08
S13	4. 39 E+ 08	4. 29 E+ 08	4. 50 E+ 08	4. 42 E+ 08	4. 50 E+ 08	4. 65 E+ 08	4. 66 E+ 08	4. 31 E+ 08	4. 39 E+ 08	4. 46 E+ 08	3. 63 E+ 08	3. 60 E+ 08	3. 79 E+ 08	3. 88 E+ 08	3. 78 E+ 08	3. 57 E+ 08	3. 68 E+ 08	3. 76 E+ 08	3. 63 E+ 08	3. 75 E+ 08
S23	4. 31 E+ 08	4. 55 E+ 08	4. 55 E+ 08	4. 51 E+ 08	4. 52 E+ 08	4. 38 E+ 08	4. 43 E+ 08	4. 50 E+ 08	3. 90 E+ 08	4. 00 E+ 08	3. 90 E+ 08	3. 84 E+ 08	3. 71 E+ 08	3. 66 E+ 08	3. 70 E+ 08	3. 66 E+ 08	3. 84 E+ 08	3. 78 E+ 08	3. 61 E+ 08	3. 86 E+ 08
V = 1000m/s																				
MAX PRIN CIPAL	- 1. 09 E+ 10	- 9. 21 E+ 09	- 1. 22 E+ 10	- 4. 54 E+ 09	- 1. 56 E+ 09	- 6. 43 E+ 08	- 6. 53 E+ 08	- 6. 53 E+ 08	- 7. 80 E+ 08	- 5. 87 E+ 08	- 1. 39 E+ 09	- 1. 55 E+ 09	- 3. 38 E+ 09	- 1. 05 E+ 09	- 7. 28 E+ 08	- 1. 24 E+ 09	- 9. 99 E+ 08	- 1. 59 E+ 09	- 1. 38 E+ 09	- 1. 38 E+ 09
S11	- 1. 10 E+ 10	- 9. 60 E+ 09	- 1. 24 E+ 10	- 5. 19 E+ 09	- 2. 28 E+ 09	- 1. 13 E+ 09	- 9. 76 E+ 08	- 9. 69 E+ 08	- 9. 10 E+ 08	- 9. 55 E+ 08	- 1. 67 E+ 09	- 1. 64 E+ 09	- 3. 43 E+ 09	- 1. 28 E+ 09	- 9. 32 E+ 08	- 1. 25 E+ 09	- 1. 24 E+ 09	- 2. 31 E+ 09	- 2. 06 E+ 09	- 2. 06 E+ 09
S22	- 1. 17 E+ 10	- 9. 32 E+ 09	- 1. 25 E+ 10	- 5. 19 E+ 09	- 1. 99 E+ 09	- 1. 06 E+ 09	- 1. 04 E+ 09	- 1. 15 E+ 09	- 9. 63 E+ 08	- 9. 44 E+ 08	- 1. 62 E+ 09	- 1. 70 E+ 09	- 3. 79 E+ 09	- 1. 43 E+ 09	- 1. 13 E+ 09	- 1. 25 E+ 09	- 1. 18 E+ 09	- 2. 05 E+ 09	- 1. 86 E+ 09	- 1. 86 E+ 09
S33	- 1. 12 E+ 10	- 9. 95 E+ 09	- 1. 27 E+ 10	- 4. 73 E+ 09	- 1. 78 E+ 09	- 1. 17 E+ 09	- 1. 09 E+ 09	- 1. 03 E+ 09	- 9. 94 E+ 08	- 1. 12 E+ 09	- 1. 40 E+ 09	- 1. 84 E+ 09	- 3. 39 E+ 09	- 1. 56 E+ 09	- 1. 09 E+ 09	- 1. 65 E+ 09	- 1. 42 E+ 09	- 1. 79 E+ 09	- 1. 75 E+ 09	- 1. 75 E+ 09

MAX PRIN CIPAL	1. 06 E+ 10	8. 68 E+ 09	9. 30 E+ 09	1. 07 E+ 10	4. 12 E+ 09	2. 63 E+ 09	2. 08 E+ 09	2. 12 E+ 09	2. 29 E+ 09	2. 48 E+ 09	2. 51 E+ 09	2. 53 E+ 09	2. 48 E+ 09	2. 47 E+ 09	2. 41 E+ 09	2. 32 E+ 09	2. 26 E+ 09	3. 45 E+ 09	3. 44 E+ 09	3. 44 E+ 09
S11	1. 04 E+ 10	8. 57 E+ 09	8. 85 E+ 09	1. 00 E+ 10	3. 20 E+ 09	1. 89 E+ 09	1. 67 E+ 09	1. 80 E+ 09	1. 92 E+ 09	2. 03 E+ 09	2. 04 E+ 09	2. 04 E+ 09	2. 03 E+ 09	2. 04 E+ 09	2. 02 E+ 09	1. 97 E+ 09	1. 93 E+ 09	3. 24 E+ 09	3. 16 E+ 09	3. 16 E+ 09
S22	1. 00 E+ 10	8. 11 E+ 09	9. 26 E+ 09	1. 00 E+ 10	3. 57 E+ 09	2. 28 E+ 09	1. 93 E+ 09	1. 98 E+ 09	2. 09 E+ 09	2. 19 E+ 09	2. 21 E+ 09	2. 18 E+ 09	2. 18 E+ 09	2. 17 E+ 09	2. 13 E+ 09	2. 10 E+ 09	2. 04 E+ 09	3. 04 E+ 09	3. 00 E+ 09	3. 00 E+ 09
S33	1. 05 E+ 10	8. 55 E+ 09	8. 42 E+ 09	1. 05 E+ 10	4. 11 E+ 09	2. 29 E+ 09	1. 67 E+ 09	2. 00 E+ 09	2. 15 E+ 09	2. 32 E+ 09	2. 33 E+ 09	2. 37 E+ 09	2. 35 E+ 09	2. 35 E+ 09	2. 33 E+ 09	2. 23 E+ 09	2. 20 E+ 09	2. 78 E+ 09	2. 90 E+ 09	2. 90 E+ 09
S12	4. 05 E+ 08	4. 39 E+ 08	4. 64 E+ 08	4. 41 E+ 08	4. 56 E+ 08	4. 10 E+ 08	4. 37 E+ 08	4. 45 E+ 08	4. 45 E+ 08	4. 40 E+ 08	4. 38 E+ 08	4. 37 E+ 08	4. 27 E+ 08	4. 31 E+ 08	4. 40 E+ 08	4. 00 E+ 08	4. 30 E+ 08	4. 34 E+ 08	4. 33 E+ 08	4. 31 E+ 08
S13	4. 40 E+ 08	4. 44 E+ 08	4. 59 E+ 08	4. 53 E+ 08	4. 57 E+ 08	4. 33 E+ 08	4. 17 E+ 08	4. 16 E+ 08	4. 23 E+ 08	4. 39 E+ 08	4. 33 E+ 08	4. 15 E+ 08	4. 01 E+ 08	4. 05 E+ 08	4. 04 E+ 08	4. 06 E+ 08	4. 25 E+ 08	4. 23 E+ 08	4. 15 E+ 08	4. 07 E+ 08
S23	4. 45 E+ 08	4. 57 E+ 08	4. 64 E+ 08	4. 45 E+ 08	4. 61 E+ 08	4. 36 E+ 08	4. 59 E+ 08	4. 25 E+ 08	4. 30 E+ 08	4. 16 E+ 08	4. 51 E+ 08	4. 55 E+ 08	4. 42 E+ 08	4. 25 E+ 08	4. 16 E+ 08	4. 57 E+ 08	4. 52 E+ 08	4. 10 E+ 08	4. 01 E+ 08	3. 97 E+ 08

8.3 Results Graphs

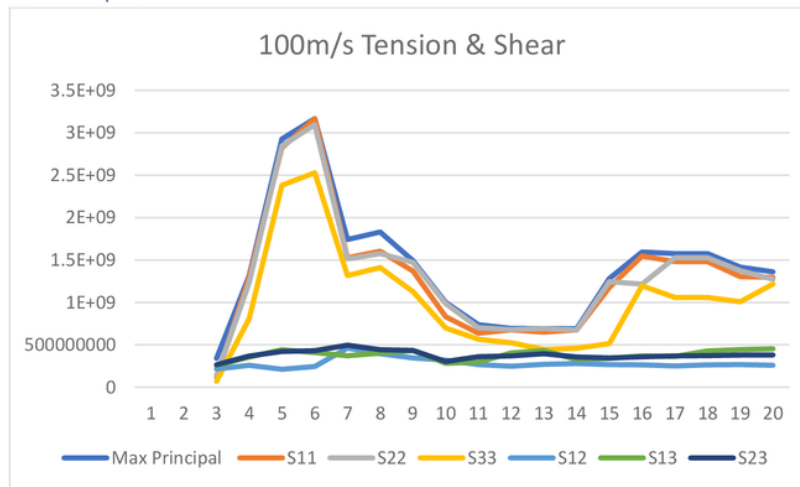


Figure 38: Comparison of Compress and Shear Stresses for a projectile travelling at 100m/s

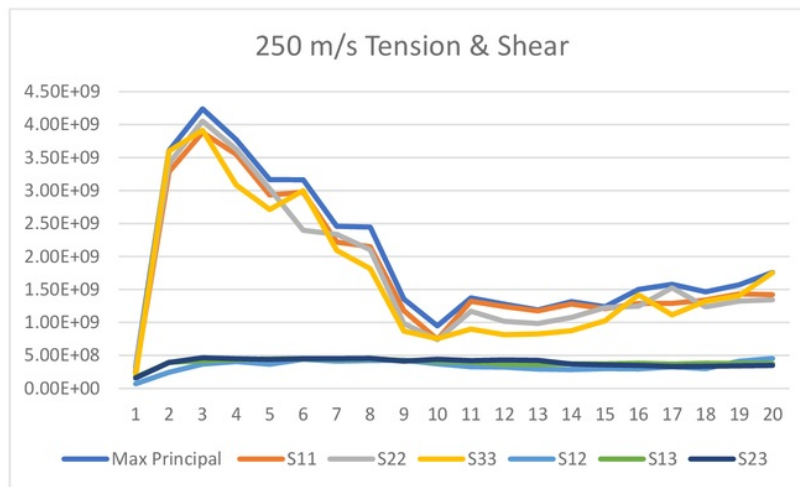


Figure 39: Comparison of Compress and Shear Stresses for a projectile travelling at 250m/s

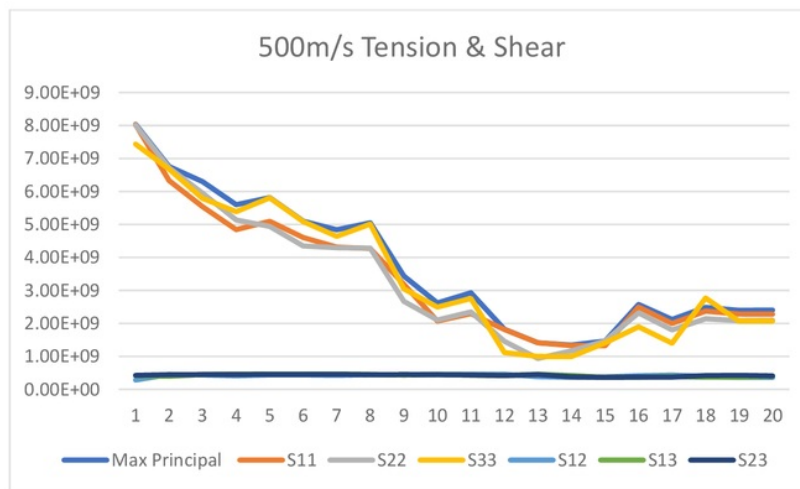


Figure 40: Comparison of Compress and Shear Stresses for a projectile travelling at 500m/s

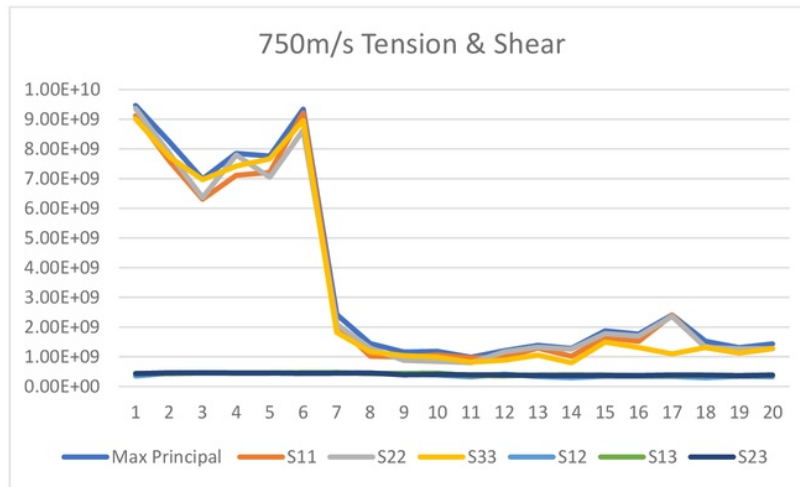


Figure 41: Comparison of Compress and Shear Stresses for a projectile travelling at 750m/s

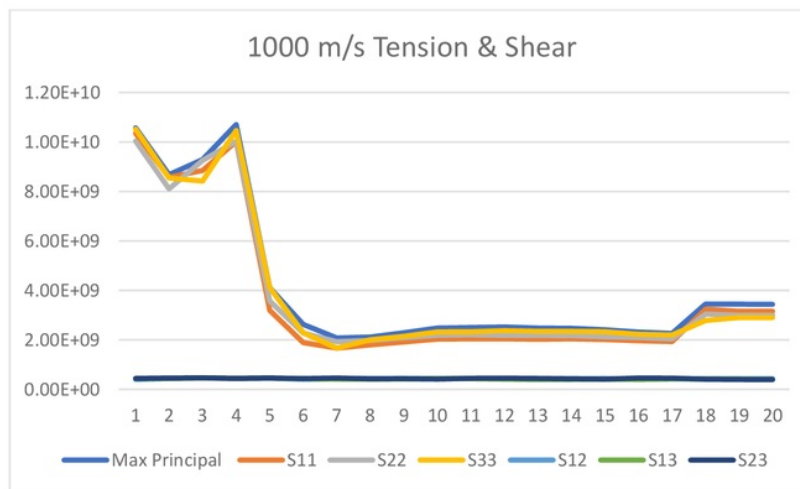


Figure 42: Comparison of Compress and Shear Stresses for a projectile travelling at 1,000m/s

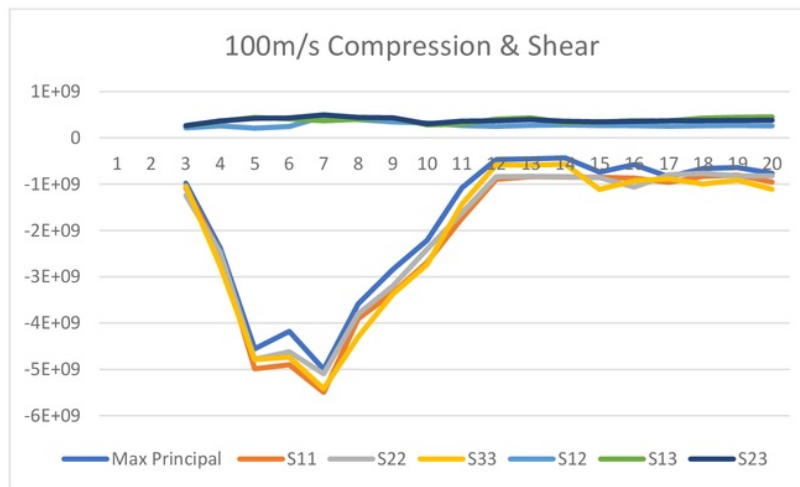


Figure 43: Comparison of Tension and Shear Stresses for a projectile travelling at 100m/s

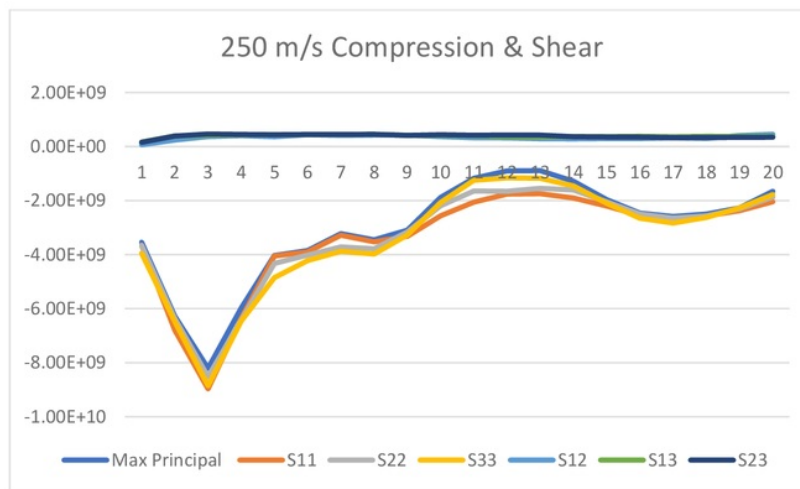


Figure 44: Comparison of Tension and Shear Stresses for a projectile travelling at 250m/s

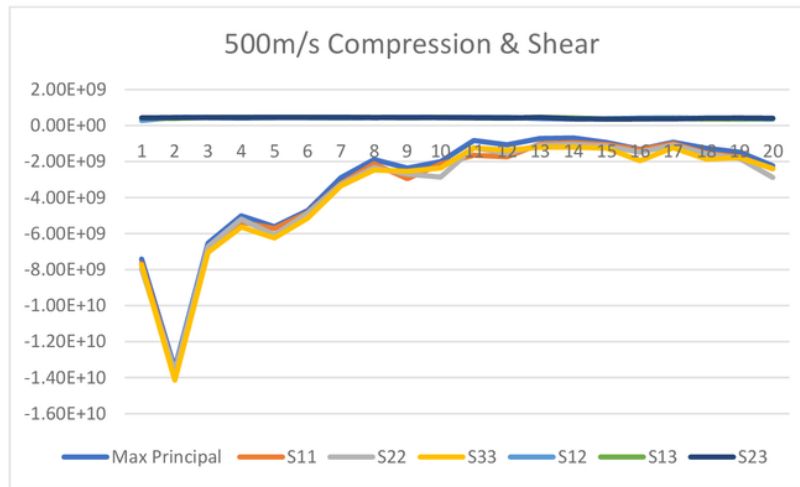


Figure 45: Comparison of Tension and Shear Stresses for a projectile travelling at 500m/s

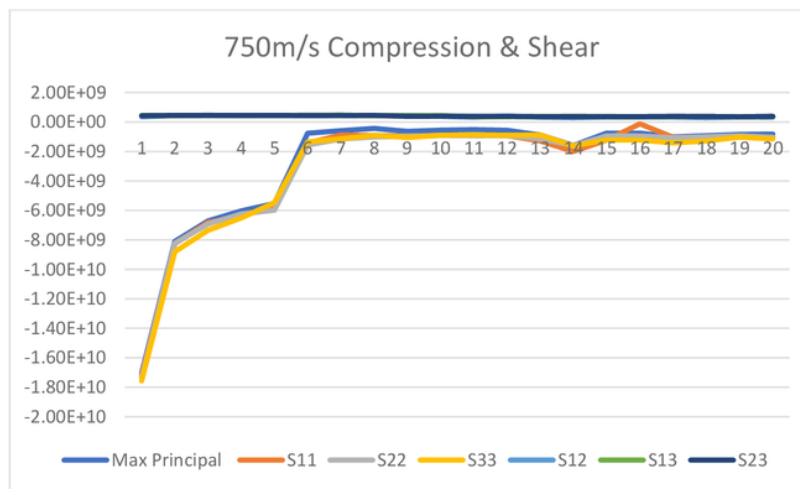


Figure 46: Comparison of Tension and Shear Stresses for a projectile travelling at 750m/s

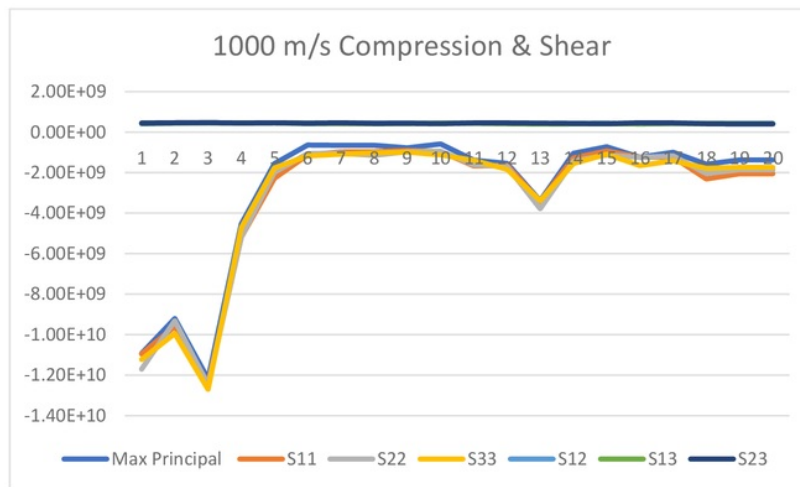


Figure 47: Comparison of Tension and Shear Stresses for a projectile travelling at 1,000m/s

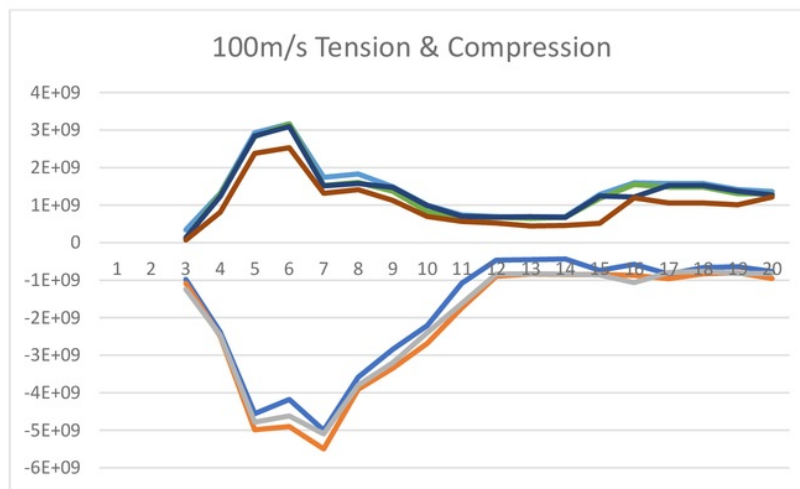


Figure 48: Comparison of Tension and Compression Stresses for projectile travelling at 100m/s

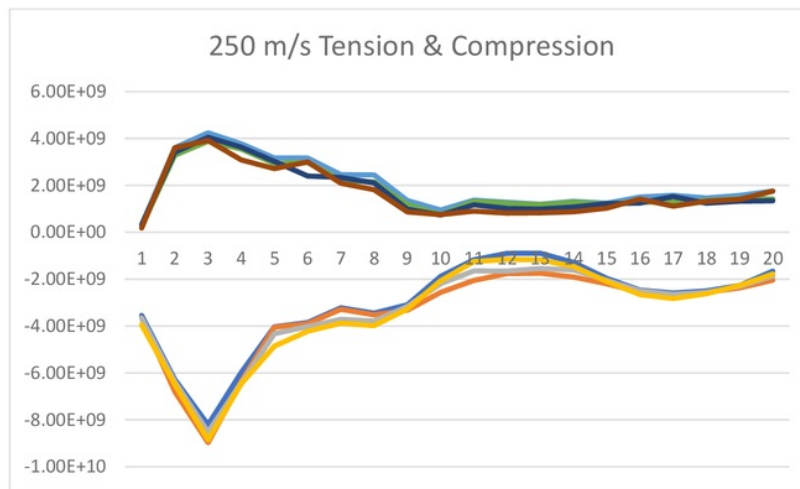


Figure 49: Comparison of Tension and Compression Stresses for projectile travelling at 250m/s

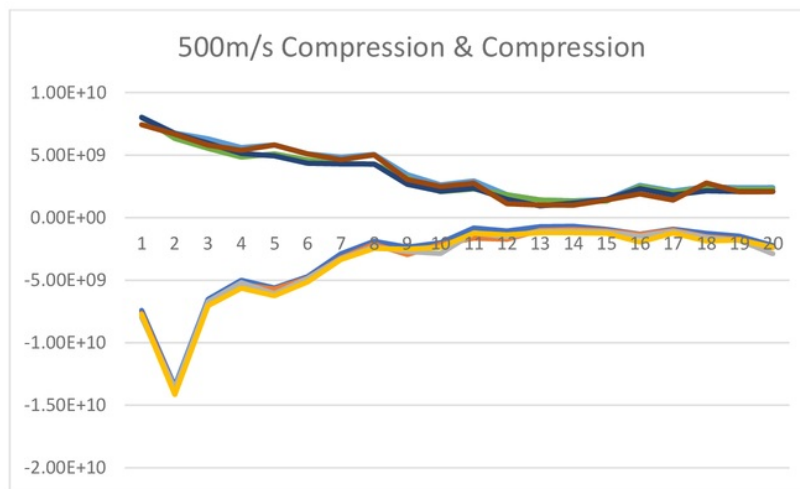


Figure 50: Comparison of Tension and Compression Stresses for projectile travelling at 500m/s

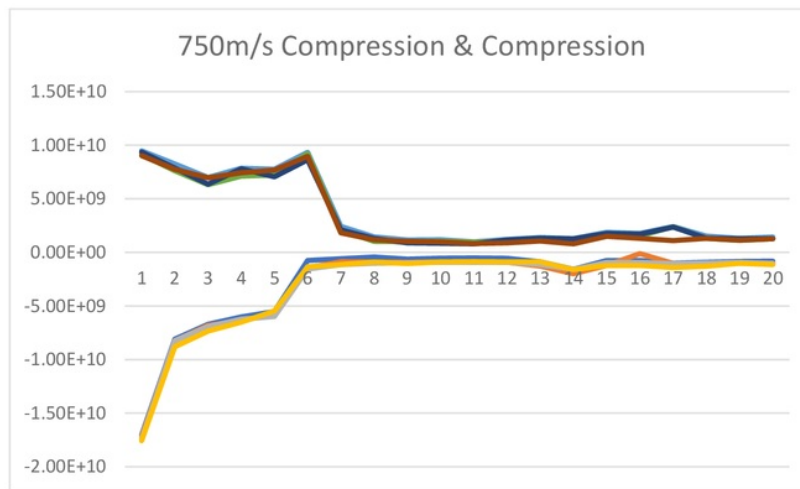


Figure 51: Comparison of Tension and Compression Stresses for projectile travelling at 750m/s

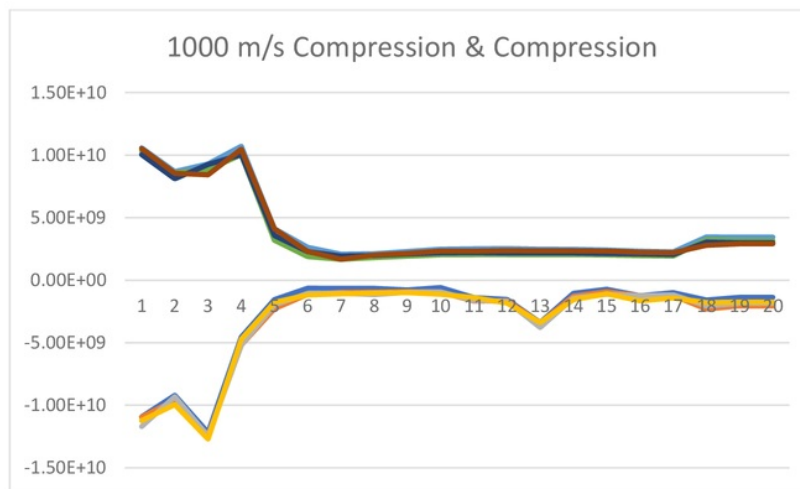


Figure 52: Comparison of Tension and Compression Stresses for projectile travelling at 1,000m/s