



## Supplementary Material

### An optimization scheme for a multilayer armour module against 7.62mm armour piercing projectile

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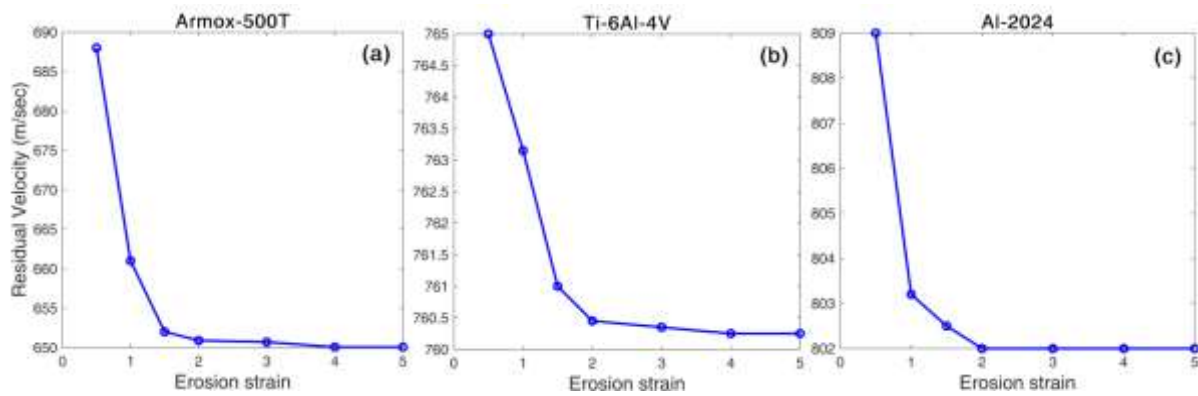
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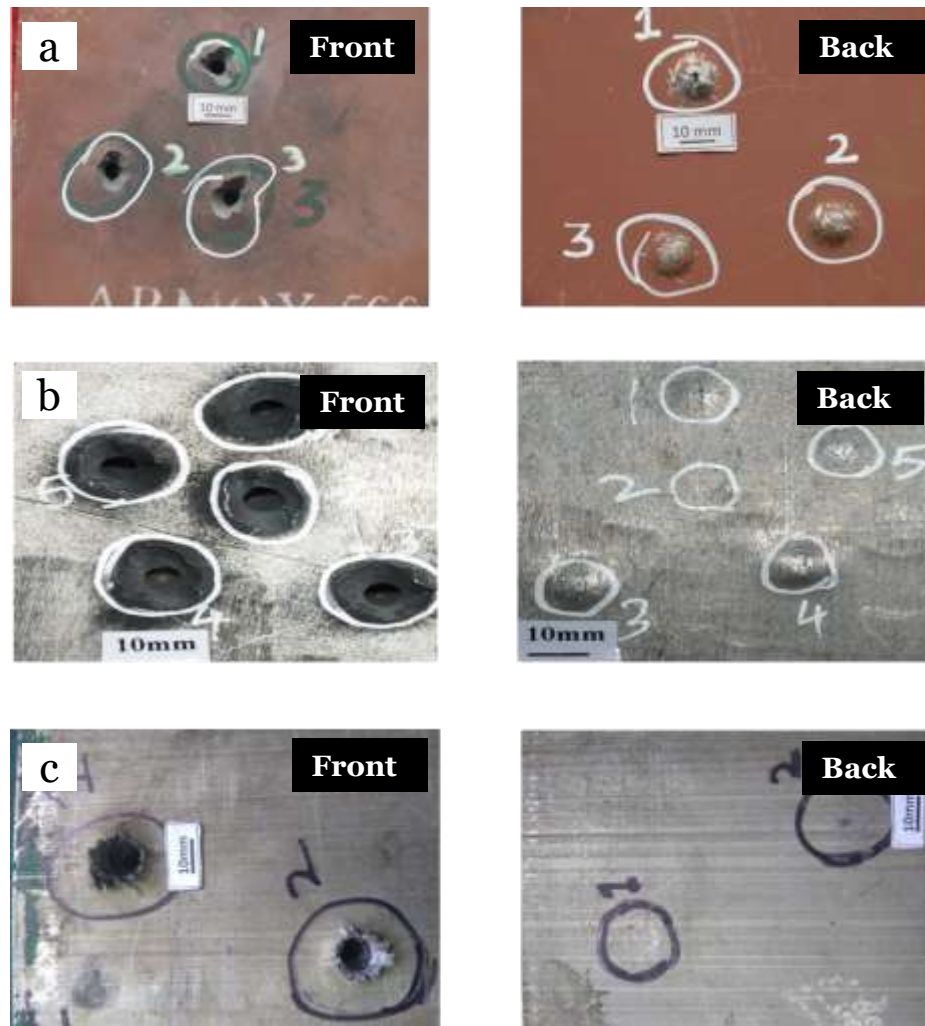
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**Figure S1.** Clamping arrangements for ballistic testing of modules.



**Figure S2.** Variation of residual velocity for 6 mm plate with different erosion strains.



**Figure S3.** Results of ballistic experiments on the monolithic plates: front and back sides of plates with thicknesses (a) 15mm for ArmoX-500T, (b) 25mm for Ti-6Al-4V and (c) 50mm for Al-2024.



**Table S1.** Ballistic performance of the sequence Armox-500T(Front)/Al-2024(Middle)/Ti-6Al-4V(Back).

| S.No. | Thickness of Armox-500T plate<br>$t_1$ (mm) | Thickness of Al-2024 plate<br>$t_2$ (mm) | Thickness of Ti-6Al-4V plate<br>$t_3$ (mm) | Residual velocity<br>RV (m/s) | Depth of penetration<br>DOP (mm) | Back Face Bulge<br>BFB (mm) | Ballistic Performance Parameter<br>BPP |
|-------|---------------------------------------------|------------------------------------------|--------------------------------------------|-------------------------------|----------------------------------|-----------------------------|----------------------------------------|
| 1.    | 2.43                                        | 6.99                                     | 3.95                                       | 635.38                        | FP                               | FP                          | 175.64                                 |
| 2.    | 9.57                                        | 6.99                                     | 3.95                                       | 210.12                        | FP                               | FP                          | 125.01                                 |
| 3.    | 2.43                                        | 6.99                                     | 15.55                                      | 140.12                        | FP                               | FP                          | 116.68                                 |
| 4.    | 9.57                                        | 6.99                                     | 15.55                                      | 0                             | 21.54                            | 0.42                        | 66.22                                  |
| 5.    | 2.43                                        | 27.51                                    | 3.95                                       | 195.15                        | FP                               | FP                          | 123.23                                 |
| 6.    | 9.57                                        | 27.51                                    | 3.95                                       | 0                             | 21.92                            | 0.16                        | 53.22                                  |
| 7.    | 2.43                                        | 27.51                                    | 15.55                                      | 0                             | 34.52                            | 0                           | 75.88                                  |
| 8.    | 9.57                                        | 27.51                                    | 15.55                                      | 0                             | 21.93                            | 0                           | 41.67                                  |
| 9.    | 0                                           | 17.25                                    | 9.75                                       | 367.25                        | FP                               | FP                          | 143.72                                 |
| 10.   | 12                                          | 17.25                                    | 9.75                                       | 0                             | 17.91                            | 0.33                        | 45.54                                  |
| 11.   | 6                                           | 17.25                                    | 0                                          | 335.24                        | FP                               | FP                          | 139.91                                 |
| 12.   | 6                                           | 17.25                                    | 19.5                                       | 0                             | 27.93                            | 0.18                        | 65.06                                  |
| 13.   | 6                                           | 0                                        | 9.75                                       | 354.7                         | FP                               | FP                          | 142.23                                 |
| 14.   | 6                                           | 34.5                                     | 9.75                                       | 0                             | 28.5                             | 0.12                        | 56.58                                  |
| 15.   | 6                                           | 17.25                                    | 9.75                                       | 0                             | 29.15                            | 1                           | 85.74                                  |

**Table S2.** Ballistic performance of the sequence Ti-6Al-4V(Front)/Armox-500T(Middle)/Al-2024(Back).

| S.No. | Thickness of Ti-6Al-4V plate<br>$t_1$ (mm) | Thickness of Armox-500T plate<br>$t_2$ (mm) | Thickness of Al-2024 plate<br>$t_3$ (mm) | Residual velocity<br>RV (m/s) | Depth of penetration<br>DOP (mm) | Back Face Bulge<br>BFB (mm) | Ballistic Performance Parameter<br>BPP |
|-------|--------------------------------------------|---------------------------------------------|------------------------------------------|-------------------------------|----------------------------------|-----------------------------|----------------------------------------|
| 1.    | 3.95                                       | 2.43                                        | 6.99                                     | 649.47                        | FP                               | FP                          | 177.32                                 |
| 2.    | 3.95                                       | 9.57                                        | 6.99                                     | 78.2                          | FP                               | FP                          | 109.31                                 |
| 3.    | 15.55                                      | 2.43                                        | 6.99                                     | 238.05                        | FP                               | FP                          | 128.34                                 |
| 4.    | 15.55                                      | 9.57                                        | 6.99                                     | 0                             | 22.26                            | 0.65                        | 67.95                                  |
| 5.    | 3.95                                       | 2.43                                        | 27.51                                    | 86.1                          | FP                               | FP                          | 110.25                                 |
| 6.    | 3.95                                       | 9.57                                        | 27.51                                    | 0                             | 20.58                            | 0.15                        | 49.98                                  |
| 7.    | 15.55                                      | 2.43                                        | 27.51                                    | 0                             | 26.45                            | 0                           | 58.14                                  |
| 8.    | 15.55                                      | 9.57                                        | 27.51                                    | 0                             | 21.89                            | 0.19                        | 41.44                                  |
| 9.    | 9.75                                       | 0                                           | 17.25                                    | 362.18                        | FP                               | FP                          | 143.12                                 |
| 10.   | 9.75                                       | 12                                          | 17.25                                    | 0                             | 19.78                            | 0.19                        | 50.47                                  |
| 11.   | 0                                          | 6                                           | 17.25                                    | 335.24                        | FP                               | FP                          | 139.91                                 |
| 12.   | 19.5                                       | 6                                           | 17.25                                    | 0                             | 23.7                             | 0.29                        | 55.07                                  |
| 13.   | 9.75                                       | 6                                           | 0                                        | 314.75                        | FP                               | FP                          | 137.47                                 |
| 14.   | 9.75                                       | 6                                           | 34.5                                     | 0                             | 22.98                            | 0                           | 45.73                                  |
| 15.   | 9.75                                       | 6                                           | 17.25                                    | 0                             | 23.97                            | 0.66                        | 71.21                                  |



**Table S3.** Ballistic performance of the sequence Ti-6Al-4V(Front)/Al-2024(Middle)/Armox-500T(Back).

| S.No. | Thickness of Ti-6Al-4V plate<br>$t_1$ (mm) | Thickness of Al-2024 plate<br>$t_2$ (mm) | Thickness of Armox-500T plate<br>$t_3$ (mm) | Residual velocity<br>RV(m/s) | Depth of penetration<br>DOP(mm) | Back Face Bulge<br>BFB(mm) | Ballistic Performance Parameter<br>BPP |
|-------|--------------------------------------------|------------------------------------------|---------------------------------------------|------------------------------|---------------------------------|----------------------------|----------------------------------------|
| 1.    | 3.95                                       | 6.99                                     | 2.43                                        | 640.25                       | FP                              | FP                         | 176.22                                 |
| 2.    | 3.95                                       | 6.99                                     | 9.57                                        | 135.62                       | FP                              | FP                         | 116.15                                 |
| 3.    | 15.55                                      | 6.99                                     | 2.43                                        | 240.21                       | FP                              | FP                         | 128.60                                 |
| 4.    | 15.55                                      | 6.99                                     | 9.57                                        | 0                            | 28                              | 0.73                       | 85.26                                  |
| 5.    | 3.95                                       | 27.51                                    | 2.43                                        | 142.15                       | FP                              | FP                         | 116.92                                 |
| 6.    | 3.95                                       | 27.51                                    | 9.57                                        | 0                            | 36.3                            | 0.81                       | 86.76                                  |
| 7.    | 15.55                                      | 27.51                                    | 2.43                                        | 0                            | 29.08                           | 0.39                       | 63.38                                  |
| 8.    | 15.55                                      | 27.51                                    | 9.57                                        | 0                            | 28.78                           | 0                          | 54.68                                  |
| 9.    | 9.75                                       | 17.25                                    | 0                                           | 362.18                       | FP                              | FP                         | 143.12                                 |
| 10.   | 9.75                                       | 17.25                                    | 12                                          | 0                            | 32.17                           | 0.49                       | 81.46                                  |
| 11.   | 0                                          | 17.25                                    | 6                                           | 291.25                       | FP                              | FP                         | 134.67                                 |
| 12.   | 19.5                                       | 17.25                                    | 6                                           | 0                            | 25.87                           | 0.31                       | 60.08                                  |
| 13.   | 9.75                                       | 0                                        | 6                                           | 314.75                       | FP                              | FP                         | 137.47                                 |
| 14.   | 9.75                                       | 34.5                                     | 6                                           | 0                            | 33.32                           | 0.18                       | 66.07                                  |
| 15.   | 9.75                                       | 17.25                                    | 6                                           | 0                            | 33.54                           | 1.96                       | 95.94                                  |

**Table S4.** Ballistic performance of the sequence Al-2024(Front)/Armox-500T(Middle)/Ti-6Al-4V(Back).

| S.No. | Thickness of Al-2024 plate<br>$t_1$ (mm) | Thickness of Armox-500T plate<br>$t_2$ (mm) | Thickness of Ti-6Al-4V plate<br>$t_3$ (mm) | Residual velocity<br>RV(m/s) | Depth of penetration<br>DOP(mm) | Back Face Bulge<br>BFB(mm) | Ballistic Performance Parameter<br>BPP |
|-------|------------------------------------------|---------------------------------------------|--------------------------------------------|------------------------------|---------------------------------|----------------------------|----------------------------------------|
| 1.    | 6.99                                     | 2.43                                        | 3.95                                       | 647.15                       | FP                              | FP                         | 177.04                                 |
| 2.    | 6.99                                     | 9.57                                        | 3.95                                       | 60.35                        | FP                              | FP                         | 107.18                                 |
| 3.    | 6.99                                     | 2.43                                        | 15.55                                      | 95.75                        | FP                              | FP                         | 111.40                                 |
| 4.    | 6.99                                     | 9.57                                        | 15.55                                      | 0                            | 20.7                            | 0.73                       | 63.03                                  |
| 5.    | 27.51                                    | 2.43                                        | 3.95                                       | 225.25                       | FP                              | FP                         | 126.82                                 |
| 6.    | 27.51                                    | 9.57                                        | 3.95                                       | 0                            | 34.67                           | 1.34                       | 81.83                                  |
| 7.    | 27.51                                    | 2.43                                        | 15.55                                      | 0                            | 35.49                           | 0.62                       | 76.97                                  |
| 8.    | 27.51                                    | 9.57                                        | 15.55                                      | 0                            | 34.51                           | 0.5                        | 64.95                                  |
| 9.    | 17.25                                    | 0                                           | 9.75                                       | 367.25                       | FP                              | FP                         | 143.72                                 |
| 10.   | 17.25                                    | 12                                          | 9.75                                       | 0                            | 27.85                           | 0.61                       | 70.31                                  |
| 11.   | 17.25                                    | 6                                           | 0                                          | 291.25                       | FP                              | FP                         | 134.67                                 |
| 12.   | 17.25                                    | 6                                           | 19.5                                       | 0                            | 28.31                           | 0.41                       | 65.59                                  |
| 13.   | 0                                        | 6                                           | 9.75                                       | 354.7                        | FP                              | FP                         | 142.23                                 |
| 14.   | 34.5                                     | 6                                           | 9.75                                       | 0                            | 38.71                           | 0.18                       | 76.76                                  |
| 15.   | 17.25                                    | 6                                           | 9.75                                       | 0                            | 32.14                           | 3.9                        | 87.10                                  |



**Table S5.** Ballistic performance of sequence Al-2024(Front)/Ti-6Al-4V(Middle)/Armox-500T(Back).

| S.No. | Thickness<br>of Al-2024<br>plate<br>$t_1$ (mm) | Thickness of<br>Ti-6Al-4V<br>plate<br>$t_2$ (mm) | Thickness<br>of Armox-<br>500T plate<br>$t_3$ (mm) | Residual<br>velocity<br>RV(m/s) | Depth of<br>penetration<br>DOP(mm) | Back Face<br>Bulge<br>BFB(mm) | Ballistic<br>Performance<br>Parameter<br>BPP |
|-------|------------------------------------------------|--------------------------------------------------|----------------------------------------------------|---------------------------------|------------------------------------|-------------------------------|----------------------------------------------|
| 1.    | 6.99                                           | 3.95                                             | 2.43                                               | 640.35                          | FP                                 | FP                            | 176.23                                       |
| 2.    | 6.99                                           | 3.95                                             | 9.57                                               | 50.25                           | FP                                 | FP                            | 105.98                                       |
| 3.    | 6.99                                           | 15.55                                            | 2.43                                               | 175.25                          | FP                                 | FP                            | 120.86                                       |
| 4.    | 6.99                                           | 15.55                                            | 9.57                                               | 0                               | 27.18                              | 0.64                          | 82.99                                        |
| 5.    | 27.51                                          | 3.95                                             | 2.43                                               | 224.27                          | FP                                 | FP                            | 126.70                                       |
| 6.    | 27.51                                          | 3.95                                             | 9.57                                               | 0                               | 36.18                              | 0.98                          | 86.12                                        |
| 7.    | 27.51                                          | 15.55                                            | 2.43                                               | 0                               | 35.95                              | 0.61                          | 77.98                                        |
| 8.    | 27.51                                          | 15.55                                            | 9.57                                               | 0                               | 35.03                              | 0.28                          | 66.21                                        |
| 9.    | 17.25                                          | 9.75                                             | 0                                                  | 367.25                          | FP                                 | FP                            | 143.72                                       |
| 10.   | 17.25                                          | 9.75                                             | 12                                                 | 0                               | 31.03                              | 0                             | 79.56                                        |
| 11.   | 17.25                                          | 0                                                | 6                                                  | 291.25                          | FP                                 | FP                            | 134.67                                       |
| 12.   | 17.25                                          | 19.5                                             | 6                                                  | 0                               | 30.38                              | 0.35                          | 70.49                                        |
| 13.   | 0                                              | 9.75                                             | 6                                                  | 314.75                          | FP                                 | FP                            | 137.47                                       |
| 14.   | 34.5                                           | 9.75                                             | 6                                                  | 0                               | 38.89                              | 0.94                          | 75.97                                        |
| 15.   | 17.25                                          | 9.75                                             | 6                                                  | 0                               | 33.97                              | 2.13                          | 96.70                                        |

\*FP=Full Penetration (complete penetration of target)