# BRIEF TECHNICAL DESCRIPTION

**Introduction**: Polymer matrix composites (PMCs) are finding increasing number of applications in both defence and civilian sectors because of their light weight, durability and aesthetic appearance. Among various PMC, epoxy matrix composites are more popular due to following reasons.

I. Low cost of epoxy resin,
II. Ease of processability,
III. Ability to give component without any shrinkage.
IV. Compatibility with commercially available fibers like carbon/ Glass fibersetc--.

Following two classes of PMCs are popular which use epoxy as the matrix system

I. Carbon fiber reinforced epoxy composites (C-epoxy composites)
II. Glass fiber reinforced epoxy composite (G-epoxy composites)

**Areas of applications:** C-epoxy composites are widely used in various defence and civilian applications, while G-epoxy composites are used mainly in civilian applications. Some of the applications are mentioned below.

Defence applications: Structural subsystems of air crafts (wings, fuselages, airframes), UAVs
Structural subsystems of missiles (Composite rocket motor casing)
Armours of tanks, light weight composite bridges

Civilian applications: Automobile, Civilian aircrafts, industrial structures, wind blades, Boat hulls.

**Drawbacks of existing (regular) epoxy systems**: Most of the commercially available CFRPs and GFRPs are made with epoxy resin system having DGEBA (Diglycidyl ether of bisphenol – A) as resin and DETA (Diethyl tolune diamine) as hardener. However, the mechanical properties of the both C – epoxy and G- epoxy composites are lower compared to the theoretically possible mechanical properties due to **brittle nature of the epoxy resin system**. Though there are some new formulations of toughened epoxy resin systems available commercially which can give better mechanical properties, they suffer from low glass transition temperature (Tg) and also high cost.

Special features of the epoxy formulation of ASL: ASL has developed a toughened epoxy formulation with following features.

I. Approximately 20-30% improvement in the most of the mechanical properties(Properties are shown in Table.1) for both C-epoxy composites with a glass transition temperature (Tg) of $96^0$C.
II. This formulation involves adding certain additives to DGEBA and DETDA at defined quantities which modifies the toughness and crosslink density of the epoxy system. The epoxy modification process is simple without need of any machinery. Hence the process don't call for any capital investment.

**Cost implications**: Overall cost of the epoxy resin system with these additives will be approximately the same as that of conventional epoxy (DGEBA: DETDA) system.

**Mechanical properties:** ASL has extensively tested various mechanical properties of the C- epoxy composites using these new epoxy formulations. Mechanical properties obtained for the new epoxy formulation as against conventional epoxy (DGEBA: DETBA without additives) are mentioned in Table.1.

**Table.1: Mech. properties of C-epoxy/G-epoxy with new epoxy formulation @ 61%Vf, (±1%)**

| Property Measured* (ASTM standard Followed) | C-epoxy UD composite (with T-700 carbon fibers) | | C-epoxy 2D-Compostie (with 8H-S weave T-300 fabric composite) | | Glass-Epoxy 2D- composite | |
|---|---|---|---|---|---|---|
| | Regular epoxy | ASL Formulation | Regular epoxy | ASL Formulation | Regular epoxy | ASL Formulation |
| Tensile strength (MPa) (ASTM D 3039) | 1600 | 2000 | 730 | 900 | 430 (E-glass) | 500 (E-glass) |
| Tensile Modulus (GPa) (ASTM 3039) | 120 | 125 | - | - | - | - |
| Hoop Tensile strength (MPa) (ASTMD 2290) | 1550 | 1950 | - | - | - | - |
| Flexural strength (MPa) (ASTM D 790) | 900 | 1200 | 650 | 850 | 420 ( E-glass) | 550 (E-glass) |
| | | | | | 550 (S-glass) | 670 (S-glass) |
| Inter Laminar shear strength (MPa) (ASTM D 2344) | 58 | 63 | 34 | 38 | 30 (E-glass) | 34 (E-glass) |
| | | | | | 28 (S-glass) | 32 (S-glass) |
| Compressive strength (MPa) (ASTM D 3410) | - | - | 290 | 310 | - | - |
| Impact strength (ASTMD 256/5628 FD) | - | - | 11kN | 16kN | 140 Joules (S-glass) | 150Joules (S-glass) |
| Damping (ASTM D 5023) | - | - | 0.014 | 0.017 | - | - |

*Approximately 5-10% deviation is possible

Other Miscellaneous information:

1. Mix viscosity : 1500cP at RT
2. Cure cycle : 80°C for 30minutes 120°C two hours and 160°C for five hours
3. Pot life : 24 hours
4. Tg : $96^0$C