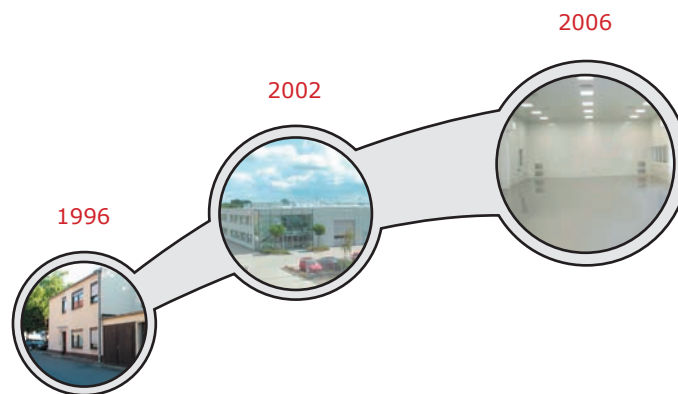




INNOVATIVE COMPOSITES

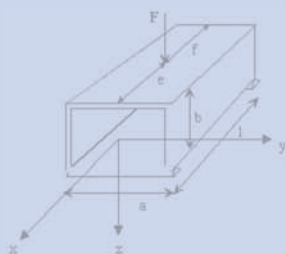
INVENT GmbH COMPANY HISTORY

INVENT GmbH was founded in 1996 as a spin-off of the German Aerospace Centre (Deutsches Zentrum für Luft- und Raumfahrt e. V.). After starting off as a service business for the **realisation and marketing of fibre composite technology**, the business continuously developed itself in the following years and today offers product development right through to series production. The building of the current company premises in 2002 and their extension in 2006 are further milestones in the history of the business.



A fundamental part of the company philosophy is the fulfilment of high quality standards and determination to continually improve and optimise processes and procedures. This quality vision is documented by the DIN ISO 9001 certification awarded in 2002. The higher level DIN EN 9100 qualification in 2005 came as result of increased involvement in the development and series production of aircraft and spacecraft parts and the increased quality requirements on production and organisation which arose from this.

In order to bundle acquisition and development activities in space technology, the company HPS GmbH "High Performance Space Structure Systems" was founded in the year 2000 as an INVENT GmbH subsidiary. This step opened fields of competence which today put INVENT GmbH in a position to develop and manufacture components for satellite systems and space structures.

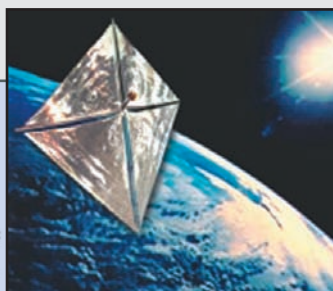
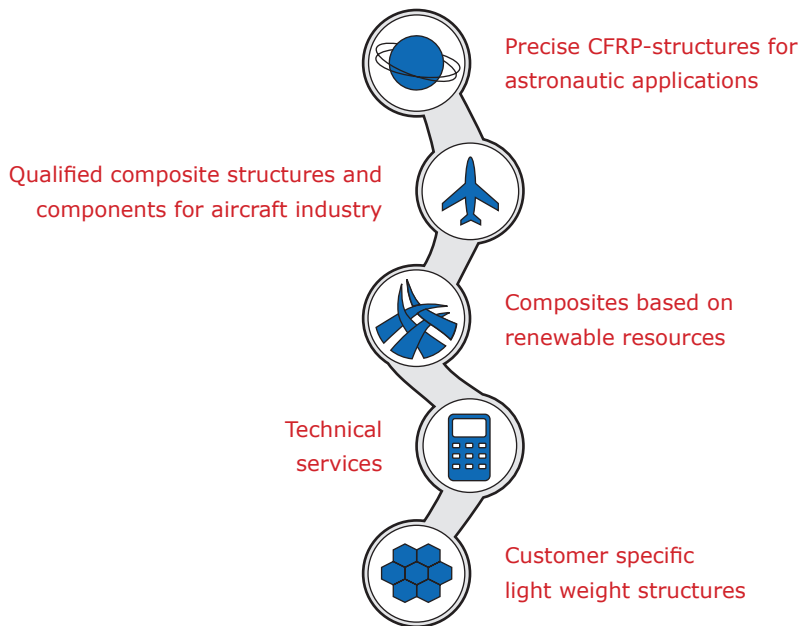


$$\begin{aligned} & \cos^2 \psi + \beta_2 \cdot \sin^2 \psi \\ & \sin^2 \psi + \beta_2 \cdot \cos^2 \psi \\ & (\beta_1 - \beta_2) \cdot \sin \psi \end{aligned}$$

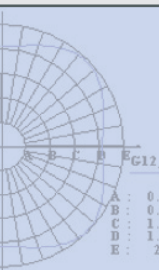


BUSINESS FIELDS

The fields of application for fibre composite materials are widely spread due to their various possible uses. INVENT GmbH’s business fields are correspondingly extensive. In the area of **aerospace**, the classic light-weight construction concept plays a central role in the realisation of products. The high technical requirements demand qualified personnel in development and production, the most modern production equipment and also a functioning quality management system. Based on this specialised know-how, applications in the business fields of **natural fibre reinforced products, technical services** and **customised light weight construction products** can be developed. In doing this, construction methods, dimensioning concepts and production technology from the hi-tech aerospace industry are transferred to other industrial areas. Complimenting the outstanding light weight construction properties, additional advantages of fibre composite materials are specifically utilised, such as media durability, directionally dependent material properties and good absorption values. A detailed knowledge of the material and the qualification of the personnel are the basis of the realisation of technically high-quality products in all business fields.



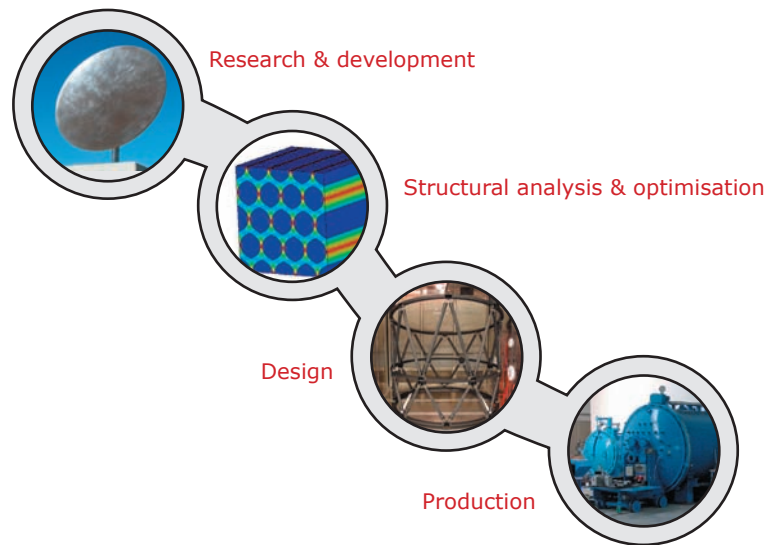
$$\begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_3 \\ \epsilon_{23} \\ \epsilon_{13} \\ \epsilon_{12} \end{bmatrix} = \begin{bmatrix} S_{11} & & & & & \\ & S_{12} & & & & \\ & & S_{12} & & & \\ & & & 0 & & \\ & & & & 0 & \\ & & & & & 0 \\ & & & & & & S_{\infty} \end{bmatrix} \begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \\ \sigma_{23} \\ \sigma_{13} \\ \sigma_{12} \end{bmatrix}$$



TOMOTIVE ENGINE
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 CONSTRUCTION

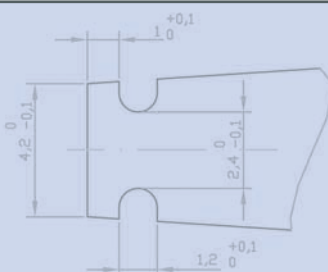
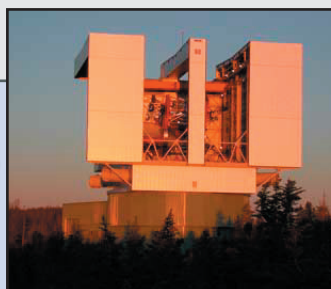
INVENT GmbH COMPETENCES

INVENT GmbH's areas of competence are divided up into **structural analysis and optimisation**, **construction method development** and **the production of fibre composite and light-weight construction structures**. INVENT GmbH carries out research and development in the areas of material and process technology and component development with the aim of continuously developing itself further in these prioritised areas of competence and thus being able to offer the client the cutting edge of technology.

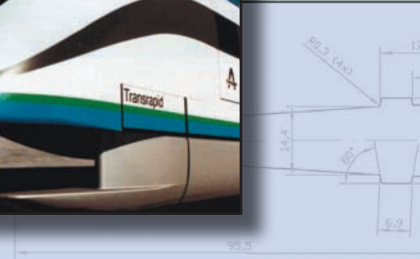


The R&D activities are primarily carried out in joint research projects in which we collaborate with renowned research institutes (Fraunhofergesellschaft, Max Planck Society, German Aerospace Centre). Part of INVENT GmbH's work for the European Space Agency (ESA) is the creation of development and design studies for future space applications.

Besides these main activities, INVENT GmbH is involved in various **innovation and knowledge networks** such as "CFK Valley StadteM", "Riko - Realisierung innovativer Konstruktionswerkstoffe aus nachwachsendem Rohstoff" (Realisation of Innovative Construction Materials from Renewable Resources), "N.M.N. - Neue Materialien Niedersachsen e.V." (New Materials Lower Saxony) and "ECAS - European Centre of Adaptive Systems".



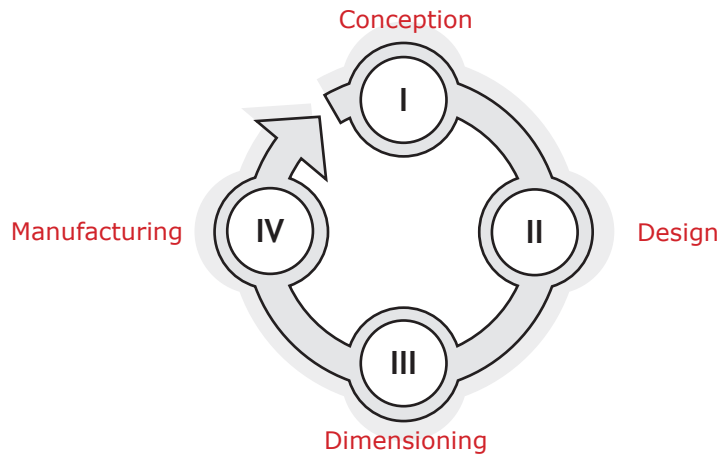
$$\begin{bmatrix} \sigma_{12} & 0 & 0 \\ 0 & \epsilon_1 \\ 0 & \epsilon_2 \\ Q_{66} & \epsilon_{12} \end{bmatrix}$$



INVENT GmbH

COMPREHENSIVE PRODUCT DEVELOPMENT

With its services, INVENT GmbH offers **comprehensive product development and realisation**. In this, the entire development chain from conception to design and dimensioning and on to prototypes and series production is covered.



One or several links in the chain can be offered as required. INVENT GmbH places particular emphasis on the targeted and customer-oriented management of the projects and can apply its experience from over ten years in product development.

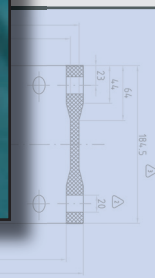
I CONCEPTION

The basis for successful product development is the creation of detailed **development logic**. This firstly involves an exact specification of the part or product properties such as the geometry, load and function.

Solution approaches are worked out based on this information. This includes the selection of suitable fibre and matrix semi-products and the identification of possible construction methods and methods of structural analysis. If the product development is carried out with the aim of prototype or series production, the selection of the production equipment and the appropriate tooling concept is of fundamental importance.



$$S_{11} = -\frac{v_{12}}{E_{11}}$$
$$S_{11} = \frac{1}{G_{12}}$$
$$S_{21} = -\frac{v_{21}}{E_{22}}$$



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COMPREHENSIVE PRODUCT DEVELOPMENT

II DESIGN

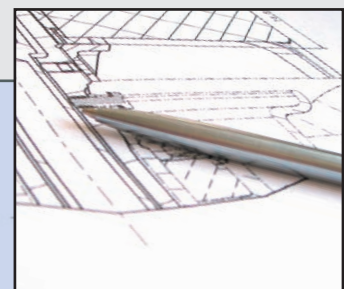
Fibre composite materials are constructable materials. This means that the properties of the parts can be specially adjusted through the choice of fibre material (roving, weave, lay-up) and the orientation of the fibres. By using these directionally dependent material characteristics, a better utilisation of the material can be achieved, with which lighter and more effective structures can be realised. The design and the exact description of layering and product characteristics takes place here with appropriate CAD software. INVENT GmbH uses Autodesk Inventor®, Catia and AutoCAD® for this.

III DIMENSIONING

Structural analysis forms an important part in the development of high performance composite materials. Due to the numerous influencing variables, the structural analysis of fibre composite materials requires special expertise. INVENT GmbH can apply its many years of experience in this context. The portfolio offered here comprises statistical verification processes, dynamic analyses and stability calculations. The aim is generally the **optimisation of the structures** with regard to mass and function. Both analytical calculation software such as ESA-Comp® and Lamtech®, two special programmes for calculating composite structures, and Ansys® for finite element analysis are applied.

IV PROTOTYPE MANUFACTURING & SERIES MANUFACTURING

After initially working exclusively in the area of component and prototype manufacturing, INVENT GmbH achieved the **entry into series production** in 1998 with the manufacture of engine panelling for the Dornier 328 jet. This development was driven on by the building of the current company premises and its extension with the result that today, series components are manufactured for example for civil and military aircraft, satellite technology and also the innovative field of natural fibre reinforced plastics. The realisable piece quantities number several thousands.



$$[T]^{-1} \begin{pmatrix} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_{xy} \end{pmatrix} = [S] [T]^{-1} \begin{pmatrix} \sigma_x \\ \sigma_y \\ \sigma_{xy} \end{pmatrix}$$

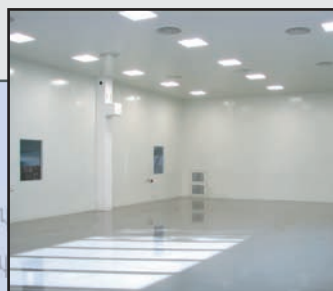
$$\begin{bmatrix} Q_{11} & Q_{12} & 0 \\ Q_{12} & Q_{22} & 0 \\ 0 & 0 & Q_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_{12} \\ \varepsilon_{13} \end{bmatrix}$$

PROCESSES & TECHNICAL EQUIPMENT

A considerable competitive advantage of INVENT GmbH is that **all common production techniques for manufacturing fibre composite parts** can be offered. On one hand, this comprises of processes with sophisticated machinery and control equipment such as injection and winding technology, and on the other hand the more conventional processes such as pre-preg, press and vacuum technology.

	Aerospace	Astronautics	Natural fibre	Lightweight structures
Resin infusion				
Filament winding				
Vacuum bagging				
Press moulding				
Prepregs				

The corresponding technical equipment consists of two certified autoclaves, a winding machine, two presses and various vacuum systems as well as an ISO class 8 certified clean room. Additionally, there are numerous auxiliary devices such as two ovens, cutters, special saws, a CNC milling machine and machines for mechanical finishing.



$$\begin{bmatrix} \cos^2 \psi & \sin^2 \psi \\ \sin \psi \cos \psi & -\sin \psi \cos \psi \end{bmatrix} = \begin{bmatrix} \cos^2 \psi & \sin^2 \psi \\ \sin \psi \cos \psi & -\sin \psi \cos \psi \end{bmatrix} \begin{bmatrix} \cos^2 \psi & \sin^2 \psi \\ \sin \psi \cos \psi & -\sin \psi \cos \psi \end{bmatrix}$$

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INVENT GmbH

QUALITY ASSURANCE

The realisation of ever more complex structures and the continual expansion of the product spectrum put ever higher demands on quality assurance. The development and series production of fibre composite structures for aerospace require particularly secure and transparent processes and procedures. In order to achieve our self-imposed quality targets, we place particular importance on

Regular
employee training

Continuous
process improvement

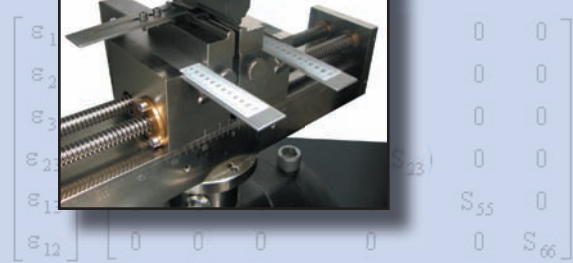
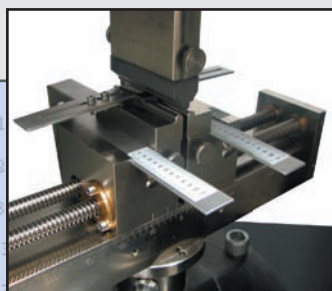
Detailed
process documentation

Certified equipment
and production means

Modern production
technologies

The basis for the implementation of this quality concept is our quality management system certified in accordance with DIN ISO 9100.

Carrying out both internal and external quality audits guarantees continuous further development of the quality standards and thereby forms the basis for the optimisation of the quality management system through inclusion of all employees.



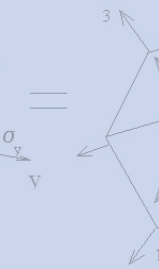
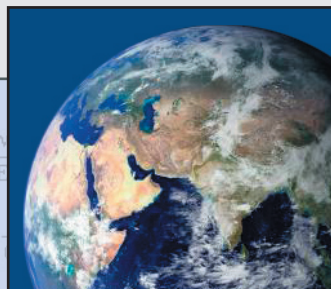
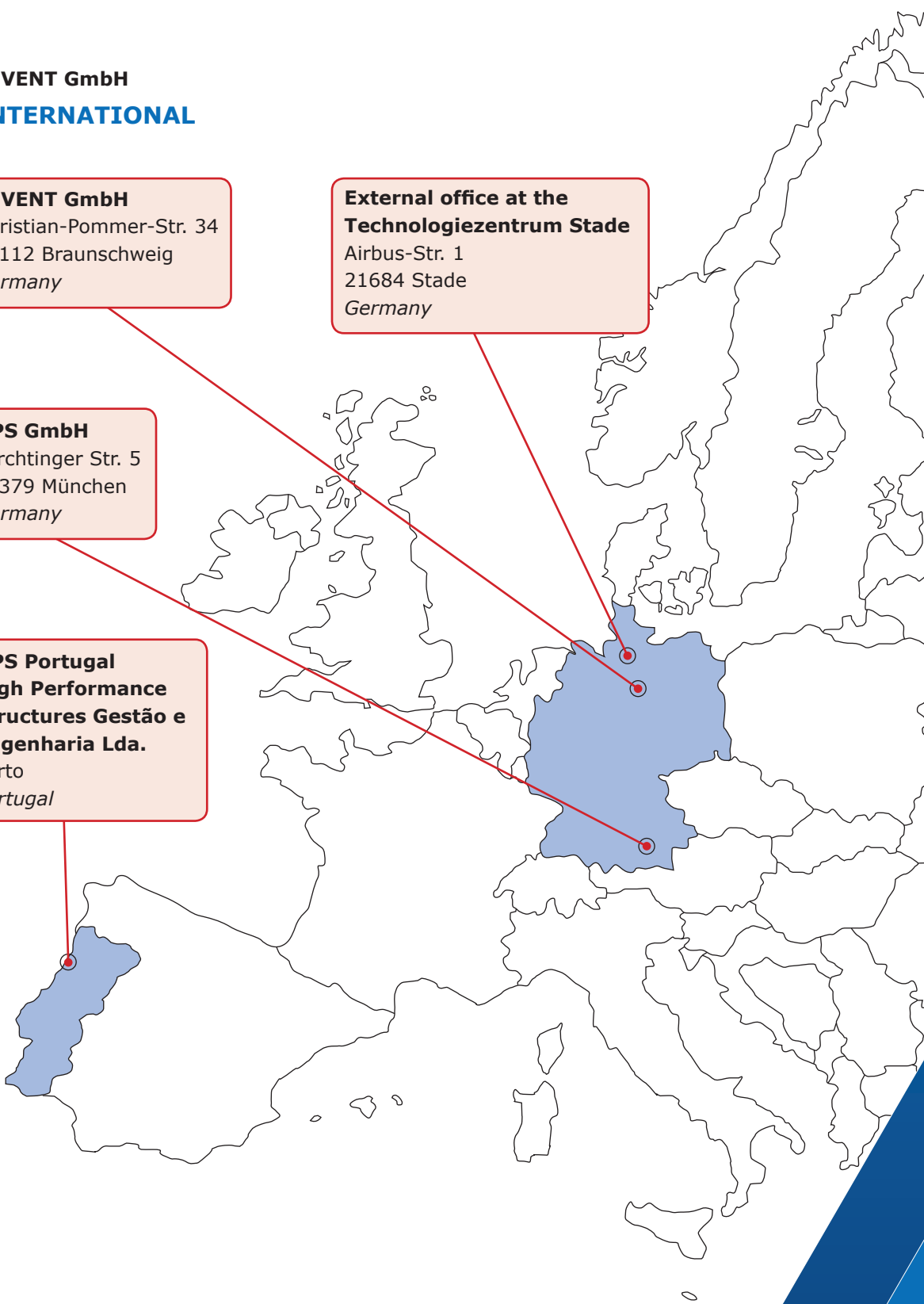
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HPS Portugal
**High Performance
Structures Gestão e
Engenharia Lda.**
Porto
Portugal



$$\sigma_{xy,x} = E_{yz} \left[\left(\frac{2}{E_1} + \frac{2\nu_{12}}{E_1} - \frac{1}{G_{12}} \right) \sin \psi \cos^3 \psi - \left(\frac{1}{E_1} + \frac{\nu_{12}}{E_1} - \frac{1}{G_{12}} \right) \sin^3 \psi \cos \psi \right]$$
$$\sigma_{yy} = E_{zz} \left[\frac{2}{E_1} + \frac{2}{E_2} + \frac{4\nu_{12}}{E_1} - \frac{1}{G_{12}} \right] \cos^4 \psi$$
$$\sigma_{zz} = E_{zz} \left[\frac{1}{G_{12}} - \frac{2\nu_{12}}{E_1} - \frac{1}{E_1} \right] \sin^4 \psi + \left(\frac{1}{G_{12}} - \frac{2\nu_{12}}{E_1} - \frac{1}{E_1} \right) \sin^2 \psi \cos^2 \psi$$

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