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10

EMPIRICAL COMPARATIVE STUDY OF STRUCTURAL CFRP SANDWICH STRUCTURE INSERTS FOR OUT-OF-PLANE LOADS

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Abstract

Lightweight-design is a key feature of modern vehicle development and a central focus for achieving sustainable mobility in the transportation sector. Current trends towards electrification, reducing fuel and energy consumption as well as raising efficiency highlight the need for further enhancement in lightweight-design through known and new approaches. As the mass of a vehicle fundamentally affects its energy efficiency, fibre reinforced polymer (FRP) materials are essential to applications where high-performance material characteristics are sought for strengthening structures with minimal additional weight. However, using FRP parts alone or in combination with other materials raises the question of joining technology. As composite sandwich structures tend to easily fail under concentrated local loads, introducing the forces into the structure relies on proper inserting technology where bolted connections are used. Several kinds of inserting strategies are known, but as the number of use cases are so diverse, inserts are often uniquely engineered. The current study aims to examine some different types and materials used for inserts in CFRP sandwich structures. For this comparative study, six different types of bolted connection applications were chosen for empirical pull-out tests. Overall, three test samples were laminated for each of those types, then tested on a certified tensile testing machine. Beyond the recorded force-displacement data, further non-destructive examinations were carried out to analyse the failure of the composite test panels. The force-displacement graphs show very different characteristic behaviour of the inserts. Fully potted and in-laminated aluminium inserts showed the highest stiffness, while monolithic-type inserts offered the highest ultimate tensile strength, although at nearly double deformation levels. On the x-ray images several different kinds of material failures were visible in different cases individually or simultaneously. Several characteristic out-of-plane load bearing behaviours and failure modes were recorded successfully. As expected, the effect of thickness of the sandwich structure at the load bearing point was validated by the results, but also features of the structural integrity of the insert in the sandwich structure become visible both qualitatively and quantitatively.

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Fully potted and in-laminated inserts offer the highest rigidity, but monolithic types reach the same or higher tensile strength. The core material fundamentally affects both failure modes and structural integrity.

Keywords: CFRP, sandwich structure, insert, bolted connection, empirical test

I. INTRODUCTION

Fiber-reinforced polymer (FRP) materials are widely used in various industries, such as energy, transportation, space, and defense. Both stationary and mobile machines utilize the advantages these materials offer. Such structures are wind turbines in the infrastructure, supplying the grid with green electricity, several types of airplanes in passenger and cargo utilization, and also ground-based vehicles, such as passenger trains and trams or road vehicles, typically buses and road cars. Although the current financial burden of FRP applications is high, mass production examples include the Boeing 787 airplanes and freighter UAVs from the aerial sector, the Candela P-12 electric ferry from the marine sector, and multiple road vehicles like the Volta Zero and Hyundai Creta for personal or VDL Citea and Ebusco 3.0 for public transport solutions. FRPs' exceptional mechanical properties make them strong candidates in materials engineering for durable structures with high mechanical resistance capabilities in every prior mentioned use case, significantly affecting the life cycle assessment studies of those in a positive way. The high specific strength and superior fatigue resistance of FRPs may double the design service life of structural components compared to counterparts made from conventional materials. The most significant aspect when using FRPs is often their relatively minimal contribution to the mass increase to the structures in which they are incorporated in. This represents a crucial benefit for the energy efficiency of mobile structures in the daily operation.

A widely used solution in composite structures for higher rigidity of relatively large and flat surfaces is a sandwich structure. While sandwich structures concentrate material where it is most effective, the mechanically weaker and less durable core material between the FRP skins is particularly vulnerable for concentrated loads. As the whole cross section of the sandwich structure is susceptible to highly localized mechanical stresses, it is important to utilize a solution capable of distributing the mechanical load on the composite part into the sandwich structure, avoiding local damage to the material. Most often inserting is the solution.

1. Technical literature

Two components, at least one of which is a fibre-reinforced composite sandwich structure, can be connected in a number of ways using detachable fasteners. Fastening elements of various designs,

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usually threaded, can be placed on the surface or inside the sandwich structure using three approaches. Solutions include surface-bonded attachments – most often referred to as studs –, embedments requiring local machining and changing the basic structure of the sandwich structure, or fastener incorporated into the sandwich structure during the manufacturing process. There are significant, even orders of magnitude differences between the individual methods and fastening technology solutions in terms of their mechanical properties, but their dimensioning is far from trivial depending on the material combinations and geometries. There is only limited number of authoritative calculations in the literature (Abbott, 2017; ECSS, 2011), and most of the research that can be found typically focuses on a specific question, addressing the problem in the form of design and dimensioning challenges.

There are many different ways to fabricate an insert in composite sandwich structures, depending on the materials used for the skins, core, and insert, as well as dimensions, geometry, and type (Abbott, 2017; ECSS, 2011; Schwennen et al., 2016). It is difficult to predict how different inserts will behave under different loads, therefore, properties such as strength, ultimate failure load, and fatigue behavior are all properties that can be approximated using finite element simulations or determined experimentally. The latter is always necessary when introducing a new composite component in a safety-relevant product (e.g. in aerospace, railway or automotive), as only this can provide accurate and reliable data, free from idealizations and assumptions inevitably used in modelling. Consequently, there is great potential in determining the key characteristics of insert types for mechanical development of FRP structures (Schwennen et al., 2016).

The available technical literature frequently references the same couple of books and articles through time. With due diligence it can be stated, the topic specific scientific background – on FRP sandwich structure inserting – lacks comprehensive detail in terms of presenting the variety of insert designs and their characteristics, mechanical properties or describing positive or negative application cases. This may result from the application-specific design procedure of single attachment points of composite panels and industry confidentiality. Although the number and detailedness of previously published literature may be not sufficient to confidently address the field of FRP sandwich inserting and provides inadequate answers for some questions, some very important findings are documented. Schwennen et al. (Schwennen et al., 2016) studied different integrations of the same kind of inserts into the foam-core sandwich structure empirically. Inserting became part of the manufacturing process of the panel, which they made three pieces for each type of insert to make static pull-out tests. In their FEM simulations, R. W. Thompson et al. (Thompson et al., 1995) made suggestions on the stress distribution and first failing areas of inserts in monocoques, while developing the meshing strategies of inserts in numerical analysis adapted by subsequent authors. Heimbs and Pein (Heimbs & Pein, 2009) studied not just different insert shapes, but also the location of the insert in the potted region, supporting the importance of

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misalignment and manufacturing precision of potted inserts. Lim and Lee (Lim & Lee, 2011), just as Heimbs and Pein (Heimbs & Pein, 2009), made both empirical and numerical analyses on their subject. The prior developed and simulated metal inserts for satellite applications, while the latter examined various inserting solutions with additional effort in the potting direction. Kim and Lee (Kim & Lee, 2008) concentrated their empirical work on potted inserts, however, their tests covered not just static pull-out scenario, but the fatigue behavior of those. With novel solutions on the field, Block et al. (Block et al., 2005) tested carbon-tube inserts for space applications, while Bozhevolnaya and Lyckegaard (Bozhevolnaya & Lyckegaard, 2005) examined the substitution of the core material with differently shaped substitute material, better suited for supporting through-hole bolted connection.

I.2 Scope of study

The method and specific subjects of the investigation this paper covers were determined based on the literature research and solutions used in the composite industry, supplemented by the Author's personal experiences. This yielded in a six-piece set of bolted connections in composite sandwich structure made from carbon fiber-epoxy skins and aluminum honeycomb core material, visible on Figure 1. When determining the materials and dimensions of the test specimens, particular attention was paid to industrial applicability and the load-bearing nature of the joints. In this sense, the chosen inserts serve as imitation of structural connection points in composite structures, providing a safety-relevant, strong attachment between parts of a load bearing assembly. For determining the load-capabilities of such bolted connections out-of-plane tensile tests are standard for the empirical tests in both industry and scientific work (Block et al., 2005; Demelio et al., 2001; Heimbs & Pein, 2009; Kim & Lee, 2008; Lim & Lee, 2011; Schwennen et al., 2016; Thompson et al., 1995).

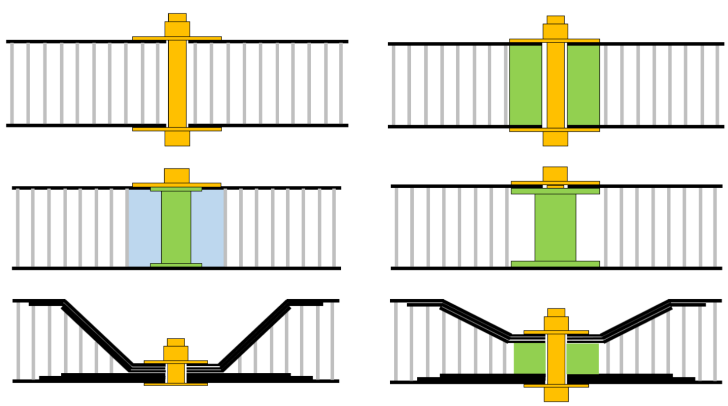

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Figure 1. Types of bolted connections in the current study; left column top to bottom: through-panel, fully potted insert, monolithic insert; right column top to bottom: strengthened core insert, in laminated insert, hybrid-monolithic insert.

II. METHODS

As mentioned, and illustrated in the previous section, six types of bolted connections were selected for the empirical test. The selected joint types are as follows: bolted joint with washers (drilled panel), bolted joint with washers and reinforced core material (panel with wood insert), fully potted inserts (through the thickness type), in laminated insert, monolithic insert, hybrid insert (a mixture of reinforced core material and monolithic type). Washers served as backing plates on the drilled panel as the location of the fastener was prepared as a 10 mm diameter hole in the sandwich structure; this type is used solely as a basis for comparison in the analysis, known that the weakest core material in this case can collapse during fastening the bolt, thus causing permanent damage to the sandwich structure even due to the required tightening torque. In the case of reinforced core material insert, the honeycomb core around the fastener was replaced with MDF wood in a diameter of 40 mm. In the case of potted insert, the core material was removed to a depth of 6 mm in radial direction around the insert so that the embedding adhesive could fill this cavity during injection. The adhesive can be pressed into the cavity through a hole in the top plate of the 20 mm high, 40 mm base diameter, 20 mm diameter 6062 aluminum insert. The same machined aluminum insert was used for the in laminated insert, but without potting material. The essence of the monolithic insert concept is that the fiber FRP skins are in direct contact and bonding with each other at the joint, thus eliminating the risk of crushing the core material. In the case of the test specimens, this was achieved by uniform 45° chamfer on the core material. In addition, local reinforcement layers were laminated into the monolithic structure, a 100 mm circular patch after each layer of the skins. The hybrid insert is completely identical to the monolithic insert, except that a 40 mm diameter, 10 mm thick MDF disk was laminated into the structure substituting the aluminum honeycomb locally. The four types of inserts where the core material was substituted with embedment can be seen on Figure 2. and some during the manufacturing process on Figure 3.

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Figure 2. Core substituting embedments for the hybrid, wood, potted and in laminated inserts from left to right.

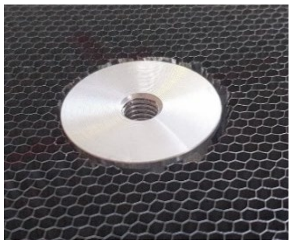
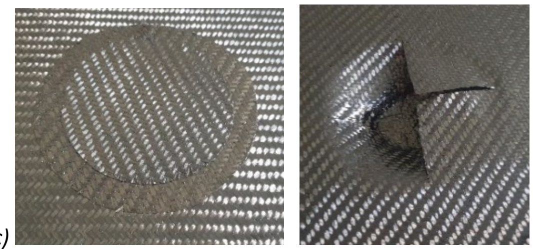
a)  *b)*  *c)* 

Figure 3.: Inserted panels during the manufacturing process, a) in laminated b) wood c) monolithic bottom and top side.

Prepreg carbon fiber and aluminum honeycomb are often used in structures of diverse applications from space- to racing industry. As prepreg material 200 gsm 2x2 twill woven carbon fiber fabric was chosen from Sigrapreg, impregnated with E323 epoxy resin. The chosen aluminum honeycomb was 20 mm thickness 4.5-1/8-001N specification 5052 aluminium alloy honeycomb manufactured by I.MA.TEC. These were used in the form of test specimens with identical, quasi-isotropic layer sequences. The test specimens measured 300x300 mm. The layer order is only minimally modified in the case of monolithic and hybrid inserts, apart from which it is as follows: 0°- 45°- 0°- 45° - HC - 45°- 0°- 45°- 0°, where HC denotes the aluminum honeycomb. Another change is that, in the case of monolithic and hybrid inserts, due to the significant change in thickness in the direction of the sandwich panel thickness, the fabric cannot fit into the recess, so on these test specimens, transverse cuts had to be made in the diameter of the insert in the same direction as the grain, then these were patched as mentioned before.

Both the connection types and the testing methodology were defined based on prior literature. In line with common practice, a perpendicular (out-of-plane) load was applied to the panel. A dedicated clamping fixture was designed in accordance with the 2023 Formula Student regulations for composite sandwich structures with fasteners (T4.5.5; Formula Student Germany GmbH, 2022). In this configuration, tensile loading is applied along the fastener axis, while the panel is supported by the fixture over the remaining surface at a radius of 125 mm from the insert axis (Figure 4).

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Figure 4. Test specimen in the clamping tool during empirical test.

III. RESULTS

The tensile tests on the test specimens were performed as shown in Figure 4. The measuring device was an Instron 5900R 4482 machine, which was set to a static tensile program at a speed of 2 mm/min. During the measurement, the tests of each test specimen were monitored on a tensile force-displacement graph.

The test specimens with the 10 mm hole and washers on the loaded side started to fail at 3 kN tensile force. The failure is gradual after that, mostly characterized by the starting collapse of the honeycomb core material at around 3 kN force. The cracking of the bottom carbon composite skin between 4,5-8,1 kN accompanies the collapse of the core material as the skin takes more load every time the core deforms and collapses a bit more.

The wooden insert prevents core collapse due to its high compressive strength, resulting in a distinctly different failure mode. At a slightly higher but comparable tensile load, progressive failure initiates, indicated by a serrated force–displacement response, audible cracking, and circular buckling, all associated with debonding between the lower skin and core. Consequently, the critical failure mechanism shifts from core compression to skin–core bond strength. This can be improved by using foam cores with increased bonding area or by enhancing honeycomb–skin adhesion through higher cell density, increased interfacial resin, additional adhesive layers, or plasma surface treatment. Two specimens exhibited similar behavior and were tested to ultimate panel failure,

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suggesting manufacturing inconsistency in the third specimen based on its different force-displacement curve to the other two.

Potted insert typically gains the most weight around the attachment point compared to the general structure of the sandwich structure. On the other hand, the amount of potting material has high influence on the strength of the bolted connection too (Bunyawanichakul et al., 2005; ECSS, 2011; Heimbs & Pein, 2009). The stiffness behavior of this insert is quasi constant from the start of loading to ultimate failure – as can be seen on Figure 3. The smaller drops on the curve did not have visible result on the test panel, therefore the exact initial failure method of the structure could not be determined from the tensile test. The test ended when the composite structure around the insert failed.

The in laminated insert had even higher stiffness value in the beginning and showed very similar behavior until the bottom of the insert delaminated from the bottom skin. This resulted in the end of the test. This is again an indication of the role of proper bonding of the skin to the core/insert material. The same strategies for improving the wood insert applies to the in laminated insert too with a likely serious improvement in strength of the bolted connection, similar to the potted insert.

The monolithic insert eliminates core crushing by removing the core material locally between the skins without introducing additional materials. Test results confirm consistently high ultimate failure loads comparable to those of potted inserts, albeit with reduced stiffness and increased compliance. Although the deformation at ultimate failure is nearly twice that of potted insert, no premature cracking or damage occurs prior to ultimate load. Thus, the monolithic insert represents a viable compromise among compliance, manufacturing complexity, and weight for specific applications.

The hybrid insert combines features of the monolithic and wood inserts, effectively functioning as a reinforced monolithic configuration. Experimental results confirm this behavior, as it exhibits greater stiffness than the monolithic insert and initial stiffness comparable to the wood insert. At deformation levels comparable to those of the monolithic insert, the hybrid configuration achieves approximately 40% higher ultimate strength. Notably, in one test, the panel fractured prior to insert failure, indicating that the mechanical performance and integration quality of the attachment point approach that of the base panel.

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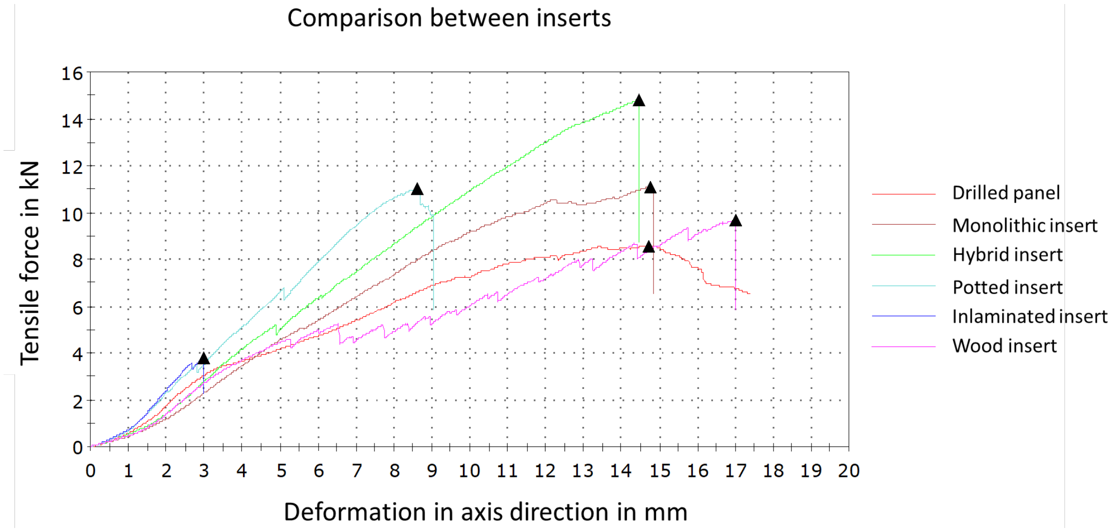

Figure 5. Comparison plot of most typical force-displacement curves of the different inserts.

There are significant differences between the characteristics of the six different types of detachable joints under tensile load, with respect to both failure modes and maximum load capacity. Figure 5. indicates that the specimen with an in-laminated insert exhibits the highest rigidity, followed by the potted insert, drilled panel, hybrid and wood inserts, and finally the monolithic insert. Insert configurations that reduce core thickness show lower rigidity, as they diminish the primary advantage of sandwich structures: stiffness proportional to thickness. Aluminum-based inserts demonstrate markedly superior rigidity due to retained sandwich thickness, high local core strength, and strong adhesion to carbon-fiber layers. Consequently, stiffness is best enhanced by using high-strength insert materials with favorable adhesive characteristics, while fastener load capacity can be improved through appropriate surface preparation of the adhesive layer. (Sedonja et al., 2022). In terms of ultimate failure, the in laminated insert showed the least force results. However, this is attributed to the unsatisfactorily prepared bonding surfaces of the insert during production and these results shall be treated with caution. Repeating those measurements is desired. By improving the quality of adhesion between the insert and the carbon fiber layers, the load-bearing capacity of this type should be significantly higher, and delamination failure between the insert and the carbon fiber layers should only occur at significantly higher loads. Table 1. summarizes the most important numerical metrics of the tensile test results.

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Table 1. Force and displacement values of the different inserts based on measurements in Figure 3.

	Highest force in kN	*Displacement at highest force in mm*	*Force at failure in kN*	*Displacement at failure in mm*
Drilled panel	8,561	14,70	6,553	17,40
Monolithic insert	11,108	14,74	10,743	14,83
Hybrid insert	14,821	14,46	14,460	14,46
Potted insert	11,021	8,60	9,839	9,05
Inlaminated insert	3,801	2,99	3,801	2,99
Wood insert	9,676	17,01	9,676	17,01

IV. CONCLUSIONS

This study examines six methods for implementing detachable fasteners in composite sandwich structures. Representative specimens were manufactured and tested to failure under quasi-static out-of-plane tensile loading using calibrated equipment. The results highlight key performance differences among insert types and demonstrate that insert selection strongly influences compliance, ultimate strength, and manufacturing complexity. The findings are consistent with published literature; however, they also indicate that inadequate process control can lead to significant manufacturing defects. Consequently, the establishment of a reliable and repeatable manufacturing process is essential prior to mass production. The presented findings also contribute to the general knowledge and capability to comparing different bolted connections in CFRP sandwich structures, serving as a benchmarking input for engineering design of road, marine and aerial vehicles or stable structures. As FRP materials offer exceptional material properties that are important for sustainable and energy efficient operation of vehicles and infrastructure, these experiments shall contribute to the faster and more reliable design of those FRP structures.

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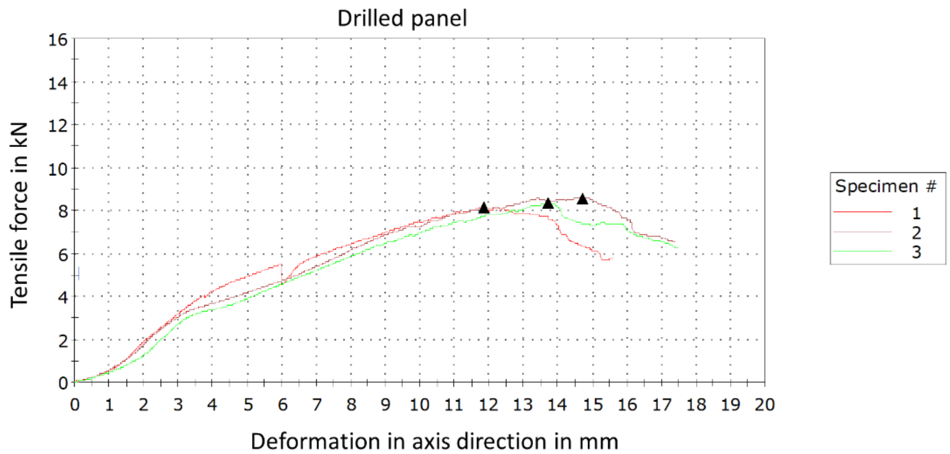
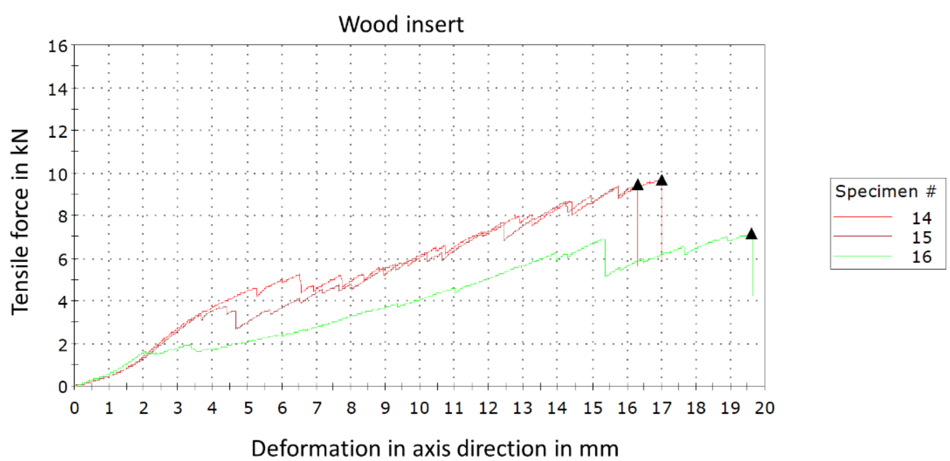
APPENDIX

Appendix 1. Force displacement curves of the drilled panel specimens.



Appendix 2. Force displacement curves of the wood insert specimens.



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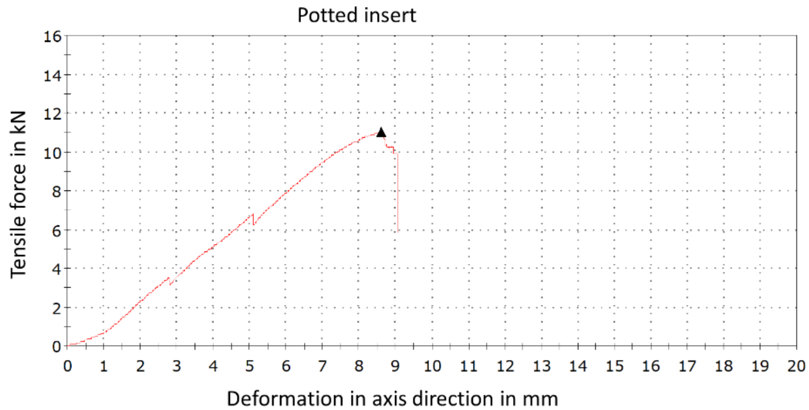
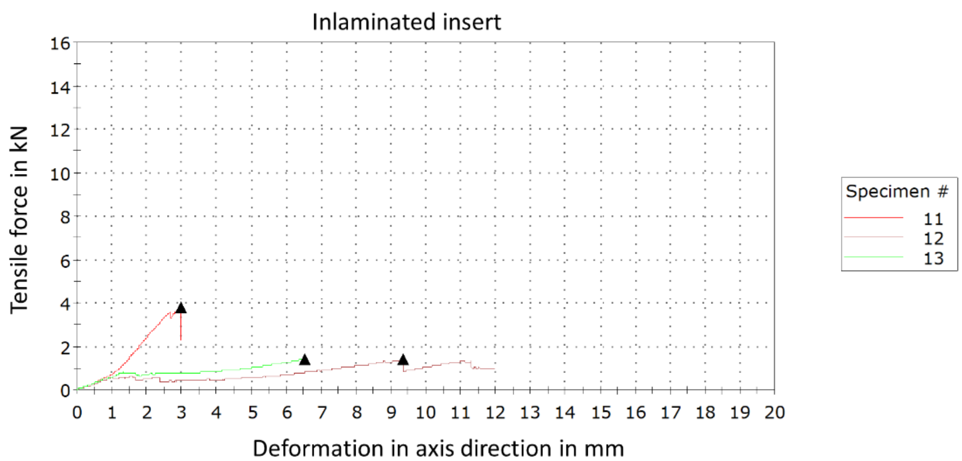
Appendix 3. Force displacement curves of the potted insert specimens.



Appendix 4. Force displacement curves of the inlaminated insert specimens.



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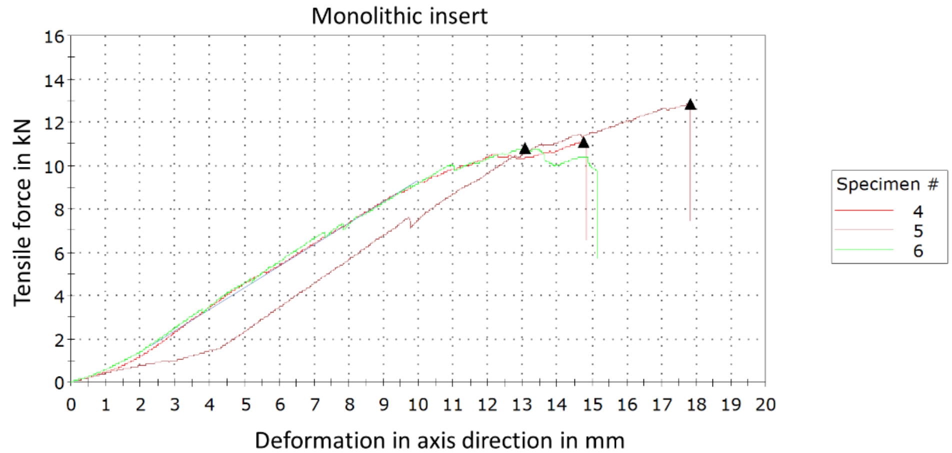
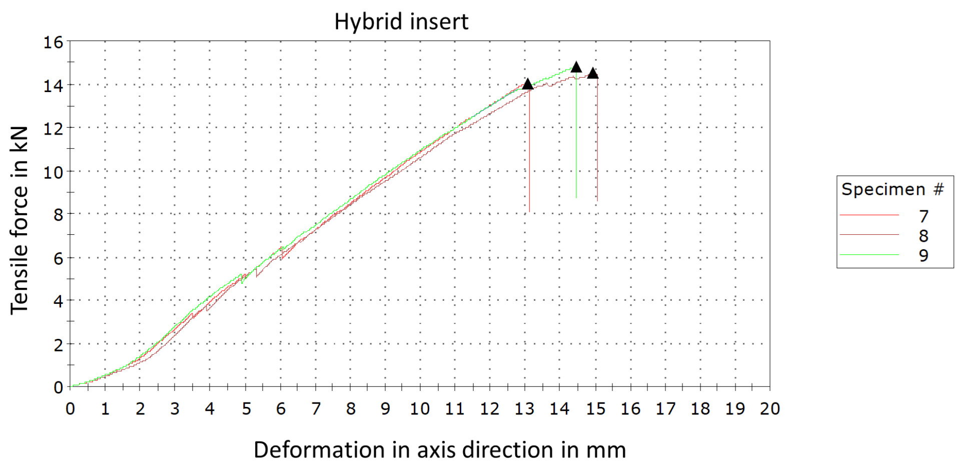
Appendix 5. Force displacement curves of the monolithic insert specimens.



Appendix 6. Force displacement curves of the hybrid insert specimens.



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Co-funded by the Erasmus+ Programme of the European Union

Co-funded by the European Union

International conference on sustainable mobility

Agenda

Project title: International Engineering Competence Centres to push Sustainable Mobility Development in Albania and Montenegro
Acronym: INTEC

Work package	
WP11	**International conference**
TASK	
11.4	Coummunity Building Events

Dates	05.03.-06.03.2026
City	Tirana
Meeting venue	POLIS University Entrance Hall
Address	Rr. Bylis 12, Kodi Postar 1051, Kutia Postare 2995, Tirana, Albania

05.03.2026	
Entrance Hall, POLIS University	
8:30 – 9:00	**Registration**
9:00 – 9:30	**Opening Performance**
Welcome session – Auditorium A5 (Ground floor)	
9:30 – 10:00	**Opening Remarks** **Dr. Elona Karafili** (Vice Rector, POLIS University) **Dr. Flora Krasniqi** (Head of Office of Projects and Internationalization, POLIS University) **DI Daniela Wenzl** (INTEC Project Coordinator)
Auditorium A5 (Ground floor)	
10:00 –11:00	**Keynote speakers** **DI Horst Pflügl AVL** Collaborative Research for sustainable Mobility **DPSHTRR Representative** – (General Directorate of Road Transport Services in Albania)
11:15 – 11:30	**Coffee break (Moving into parallel sessions)**

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11:30	SESSION 1: POLITICAL AND REGULATORY FRAMEWORK AULA B1	SESSION 2: TECHNOLOGICAL INNOVATION AULA B4
11:30 – 11:45	**Opening Session:** Prof. Emeritus dr Nataša Gospić (FSKL)	**Opening Session:** Associate Prof. Ivan Tolj (US)
11:45 – 12:00	**Integrating Event Data Recorder (EDR) Technology into Sustainable Road Safety Frameworks within the European Green Deal** Eriselda Alimeti, Parid Milo, Mentor Çejku, Anis Sulejmani, Odhisea Koça	**Empirical Comparative Study of Structural CFRP Sandwich Structure Inserts for Out-of-Plane loads** Imre Kovács
12:00 – 12:15	**Infrastructure Readiness for Sustainable Mobility: EU Frameworks and the Case of Albania** Ervin Kalemaj, Parid Milo, Mentor Çejku, Anis Sulejmani, Odhisea Koça	**The Role of Intermodal Transportation for the Sustainable Mobility** Márton Kovács
12:15 – 12:30	**Review of the Evolution of International Ship Energy Efficiency Regulations and the Albanian context** Dr. Blenard Xhaferaj, Doklejda Hodaj	**Impact of Heat Pump Systems on Winter Energy Use and Driving Range in Battery Electric Vehicles** Luis Henrique Pereira Martins
12:30 – 12:45	**Renewable Energy Procurement (CPPA) and Transport Electrification: European Perspectives and Albanian Challenge** Antonio Ndoci, Anis Sulejmani, Odhisea Koça, Mentor Çejku, Parid Milo	**Liquid Cooling Systems for Electric Vehicle Batteries: Improving Safety, Performance and Sustainability** João Miguel de Almeida Ribeiro Silva
12:45 – 13:00	**The Current Status of Autonomous Vehicle**	**Analysis of Battery Charging and Discharging Behavior for Electric Vehicle Applications** Leona Markic, Luka Filipović

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	Technology Adoption in the Balkan Region Darjana Lopičić, Oliver Popović, Miloš Ilić, Bojan Kocić	
13:00 – 14:00	**Lunch**	
14:00 – 14:15	**Reviewing the European Green Deal in Energy, Mobility and Industry** Veselinka Calasan, Ivana Ognjanovic	**Automotive Cooling Systems Sustainability: A Focus on the Expansion Tank** Ana Inês Barbeiro Casimiro
14:15 – 14:30	**The European Green Deal and its National Implementation: From Strategy to Practice** Blerina Bektashi, Andi Bektashi	**Design and Development of a Constant-Volume Combustion Chamber for Optical Investigation of Hydrogen and Water Injection Under Engine-like Conditions** Julius Hollerith, Prof. Dr. Bhavin Kapadia
14:30 – 14:45	**From Prediction to Regulation: Evidence Production Approaches in Autonomous Mobility Research and Their Policy Implications** Sadmira Malaj	**Emission Reduction of Marine Propulsion Systems in SECA Zones Through the Integration of Hydrogen Technologies** Motalleb Miri, Ivan Radaš, Marija Mandić, Ivan Tolj
14:45 – 15:00	**Questions and Discussion**	**A Comprehensive Analysis of Ventilation System for Enhanced Energy Efficiency in Marine Propulsion Applications** Sara Blašković, Gojmir Radica, Jakov Šimunović

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15:00 - 15:15		**Design and Topology Optimization of a Lightweight Chain Sprocket for Electric Motorcycle Applications** Teo Čolović, Ivo Marinić-Kragić
15:15 - 15:30	**SESSION 3: ECONOMIC AND BUSINESS PRESPECTIVES + CASE STUDIES AND GOOD PRACTICES** Aula B1	**Questions and Discussion**
	Opening Session: Dr. Anis Sulejmani (PUT)	
15:30 - 15:45	**Managing Renewable Energy Resources as a Foundation for Sustainable Mobility Transitions** Deivi Sinanaliaj, Martin Bektashi	
15:45 - 16:00	**Feasibility of Electric Bus deployment in Montenegro: A Case Study of Budva (Erasmus+ INTEC / IECC Context)** Anastasija Mrkajic, Vinko Nikic.	
16:00 -16:15	**Children Paths as an Urban Regeneration Strategy: Naim Frasheri Study Case** Dejvi Dauti	
16:15 - 16:45	**Questions and Discussion**	

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International conference on sustainable mobility

Agenda

Project title: International Engineering Competence Centres to push Sustainable Mobility Development in Albania and Montenegro
Acronym: INTEC

Work package	
WP11	International conference
TASK	
11.4	Coummunity Building Events

Dates	05.03.-06.03.2026
City	Tirana
Meeting venue	POLIS University Entrance Hall
Address	Rr. Bylis 12, Kodi Postar 1051, Kutia Postare 2995, Tirana, Albania

06.03.2026		
First Floor Hall, POLIS University		
8:30 – 9:00	Registration	
9:00- 9:15	SESSION 4: SOCIAL AND ENVIRONMENTAL IMPACT AULA B1	SESSION 5: FUTURE SCENARIOS AULA B4
9:00 – 9:15	Opening Session: Prof. Dr. Bhavin Kapadia (FHF)	Opening Session: MA Adrian Millward-Sadler (FHJ)
9:15 – 9:30	**Comparison of Lifecycle Emissions of a SUV with Fuel Cell and Battery Electric Powertrains** - Bhavin Kapadia, Alper Sayin, Sandra Eisenträger	**GENAI Literacy as a Transversal Skill for Emerging Professionals: Implications for Sustainability-Critical Knowledge Work** – Adrian Millward-Sadler
9:30 – 9:45	**Smart Mobility Technologies and their Impact on Urban Sustainability: Insights from**	**Effects of Technical Traffic Calming Measures** – Filip Perović

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	European and Western Balkan Cities – Alma Gjonaj, Vjola Ziu	
9:45 – 10:00	**The Disappearing Squares: Social and Environmental Impacts of Urban Mobility Planning in Durres –** Arjola Sava	**Cybersecurity Vulnerabilities in Electric Vehicle Operating Systems: A Global Awareness Analysis -** Aleksa Radević
10:00 – 10:15	**The City that Demands Continuous Movement: The Disappearance of the Right not to Move within the Framework of Sustainable Mobility –** Avrili Meshi	**Development of a risk assessment model for the transport of hazardous materials using ALOHA and GIS software tools –** Marko Radetić
10:15 – 10:30	**Between Rhetoric and Reality: Discursive Framings, Greenwashing and Outcomes in Sustainable Mobility –** Kejsi Veselagu	**Mapping Distance and Time Leveraging Isochrone Intelligence in Emerging Cities -** Andia Vllamasi, Erjon Cobani
10:30 – 10:45	**Reimagining the City Through Green Mobility Strategies: The Case of Tirana -** Vjola Ziu, Alma Gjonaj	**Can AI develop its Own "Taste" Automotive Design? -** Gregor Andoni, Kristjana Meço
	Coffee Break	
11:00 – 11:15	**Linking Morphology, Perceived Safety, and Sustainable Mobility in Post-Socialist Urban Contexts-** Sindi Doce	**Optimizing Public Transport Corridors Using AI-Based Scenario Modelling: A case Study on Tirana's Ring Road -** Erjon Çobani, Julian Beqiri, Merita Guri
11:15 – 11:30	**Towards Sustainable Transport: A Comparative Analysis of Electric Vehicle Adoption in Montenegro and Albania -** Radmila Milić	**Threat Landscape and Multi-Layered Protection Mechanisms for Autonomous and Electric Vehicle Systems -** Marko Asanovic, Oliver Popović, Zoran Avramović, Nataša Gospić

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11:30 – 11:45	Questions and Discussion	**Cybersecurity Challenges in Modern Vehicular Communication Networks** - Aleksandar Grgurević, Nataša Gospić, Oliver Popović
11:45 – 12:00		**Green Transition in Albania: Challenges and Future Actions** - Erik Kushta, Andi Hyka, Enea Nasto
12:00 – 12:15	SESSION 6: CONTROVERSIES AND CHALLENGES Aula B1 Opening Session: Prof. Kristofor Lapa (UV)	**Use of AI in the Process of Green Transformation and Impact on Public Health** - Esmeralda Hamiti, Federika Alliaj, Kristi Metushi
12:15-12:30	**The Adoption of Electric Vehicles in Albania: A Comparative Study with Other Western Balkan Countries** - Doklejda Hodaj, Andrea Lapa	**Development of an Automatic Traffic Sign Detection System Using YOLOv8** - Valentina Vojinović, Luka Filipović
12:30-12:45	**Application of Quality Tools in the Analysis of Factors Influencing the Development of Electromobility in Montenegro** - Jelena Šaković Jovanović, Draško Jovanović, Mirjana Grdinić Rakonjac, Marko Lučić, Miloš Perović, Aleksandar Vujović, Gordana Radulović	**The Historical Development of Artificial Intelligence and Its Influence on the job market in Automotive Engineering** - David Josef Pilgram
12:45 – 13:45	Questions and Discussion	Questions and Discussion
13:45	Lunch	

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