University of BRISTOL

Bristol Composites Institute

Wind Blade Design for Disassembly

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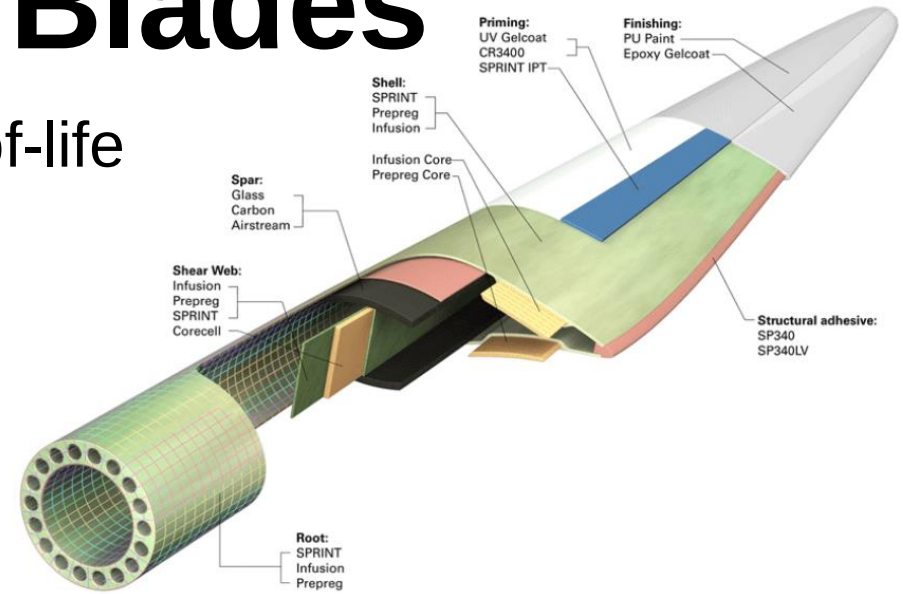
Overview

- Motivation
- Background
- Current Work – Joint Selection Taxonomy
  - Research Objective
  - Taxonomy Process Overview
  - Classification Hierarchy
  - Breakdown of Classification Parameters
- Future Work

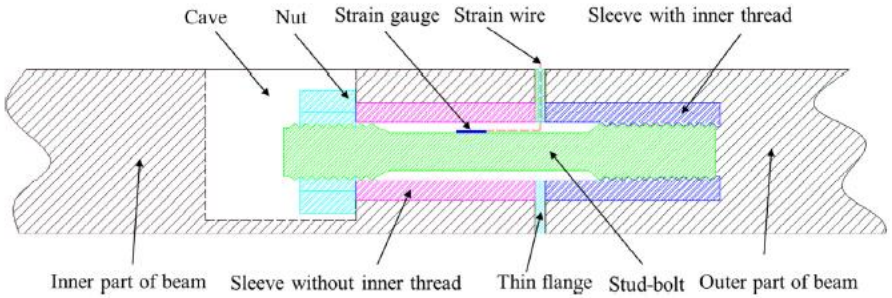
Motivation for Modular Blades

- Lack of cost-effective recycling options at end-of-life
- Most composite waste is disposed of in land-fill



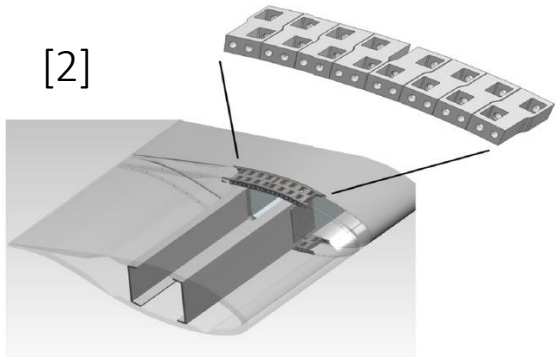
- In current designs, high value composite components cannot be easily separated for reuse
- Most cost-effective solution = **MODULAR BLADES FOR COMPONENT REUSE**

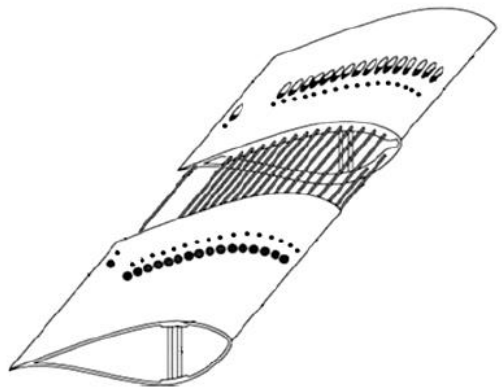
Background



[1]

[2]





[3]

Existing Concepts

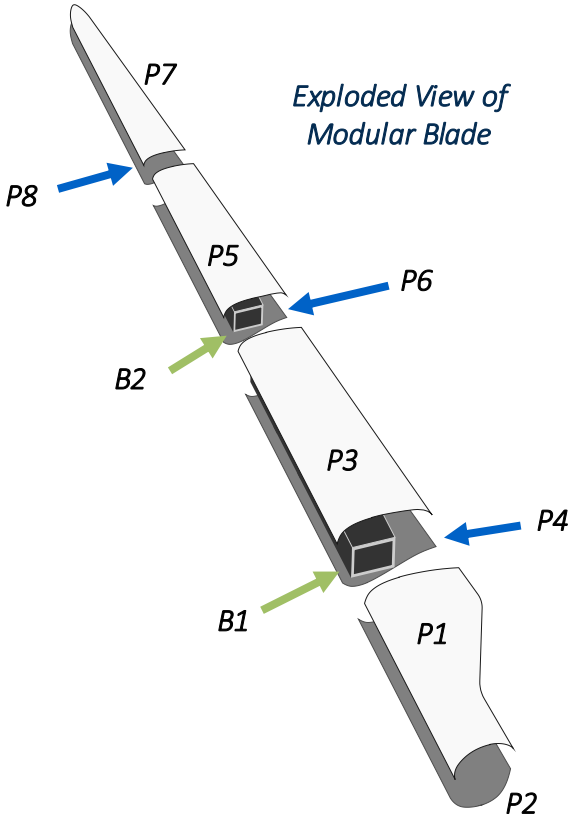
- Joint selection not scalable for larger blades
- Traditional joining techniques too heavy for blade dynamics
- Non-cost-effective disassembly process

[1] Qin et al. (2018); https://doi.org/10.1016/j.compstruct.2018.08.073
[2] Peeters et al. (2017); DOI: 10.3390/en10081112
[3] Xu et al. (2016); DOI: 10.6052/j.issn.1000-4750.2014.06.0548

Current Work: Research Objectives

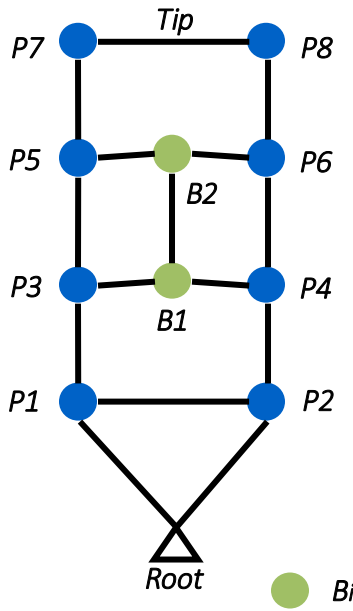
1. Define tolerances for joint mass/stiffness and determine dynamic effect of joint incorporation on blade performance
2. Functional characterisation and evaluation of joints for modular wind turbine blades
3. Design and test joint concept for use in modular wind turbine blade, evaluating its strength and disassembly potential

Current Work: Taxonomy of Joint Features

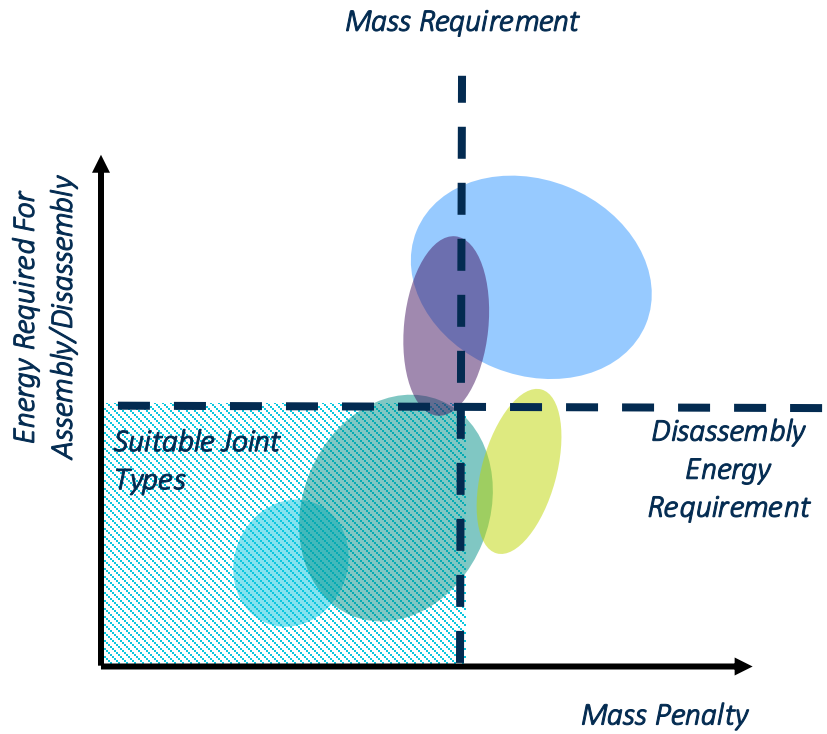


Exploded View of Modular Blade

Create Parts Graph From Assembly



Follow Taxonomy Process For Each Joint



Bi = Spar Box Component

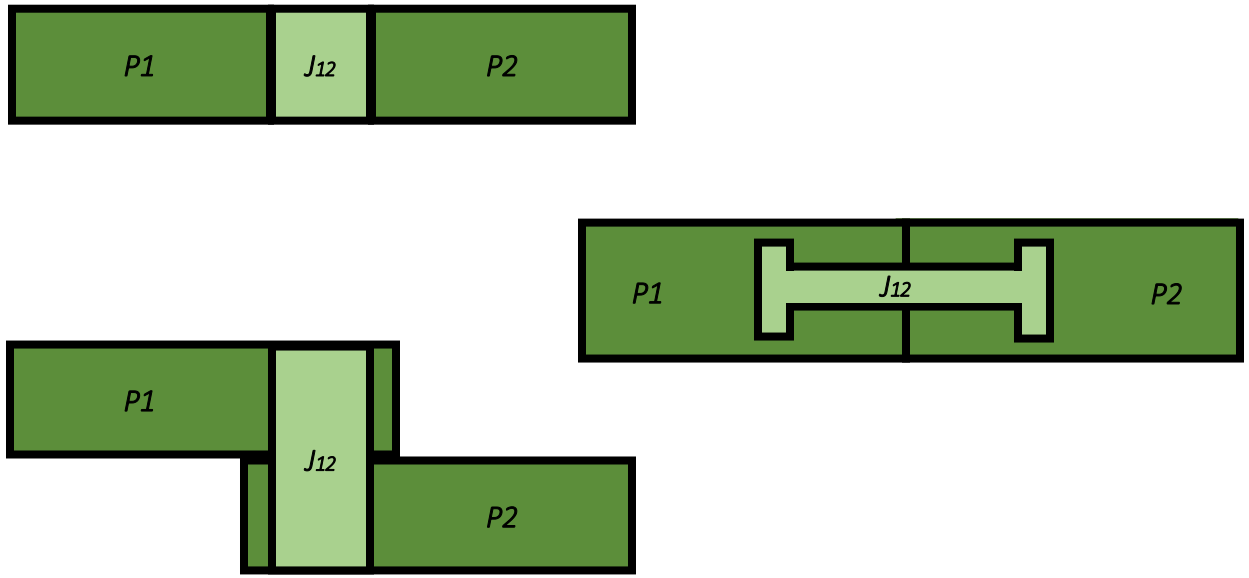
Pi = Skin Panel Component

= Joint

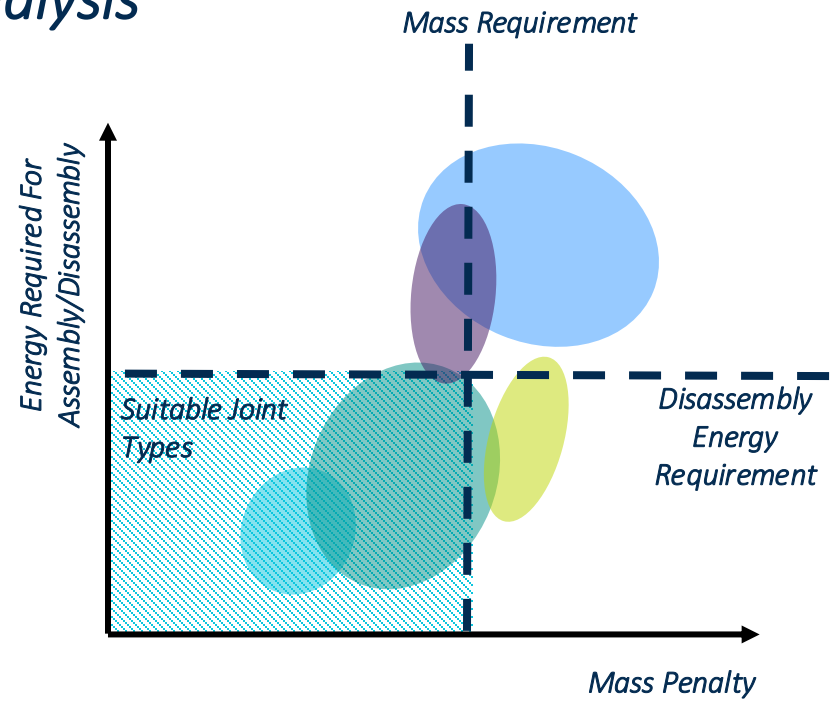
Current Work: Taxonomy Process Overview

The joint taxonomy methodology consists of two sub-projects:

1. Joint Concept Classification

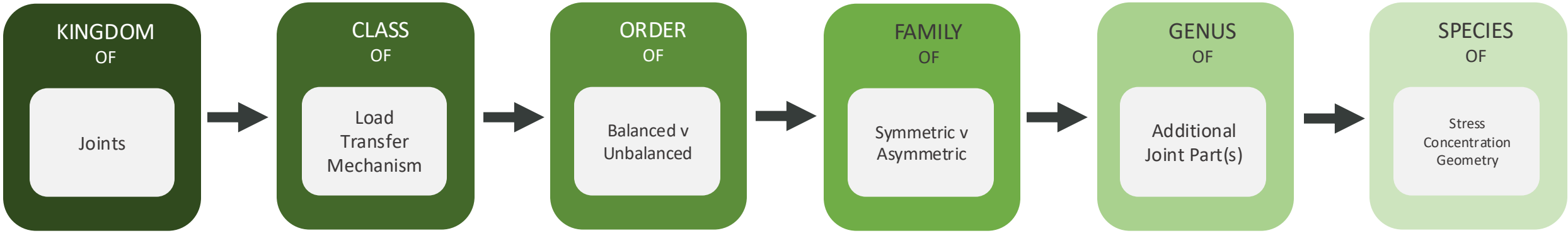


2. Analysis



Current Work: Joint Classification

Joint concepts are classified hierarchically based on relevant joining features:



- TENSILE
- SHEAR
- COMPRESSIVE

- SYMMETRIC DISTRIBUTION OF ADHERENDS EITHER SIDE OF DISCONTINUITY

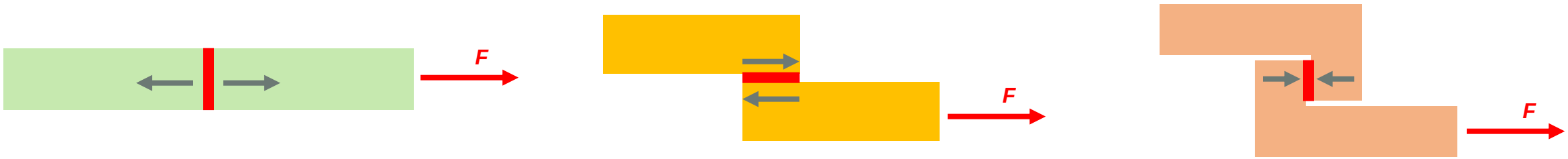
- SYMMETRIC DISTRIBUTION OF JOINT FEATURES EITHER SIDE OF LOAD VECTOR

- ARE ADDITIONAL PARTS USED TO ACHIEVE A SPECIFIC TYPE OF LOAD TRANSFER?

- TAPERING
- HOLE
- INLET
- WEDGE

Current Work: Load Transfer Mechanism

A ***joint*** is a structural feature to transfer load across a discontinuity using:



Tensile Surface ***Shear Surface*** ***Compressive Surface***

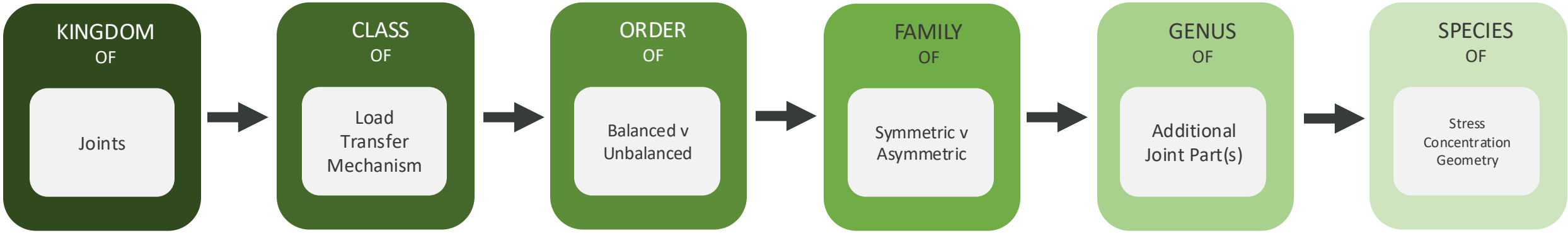
Tensile Joint Adherends

Shear Joint Adherends

Compressive Joint Adherends

Current Work: Joint Classification

Joint concepts are classified hierarchically based on relevant joining features:



- TENSILE
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- SYMMETRIC DISTRIBUTION OF ADHERENDS EITHER SIDE OF DISCONTINUITY

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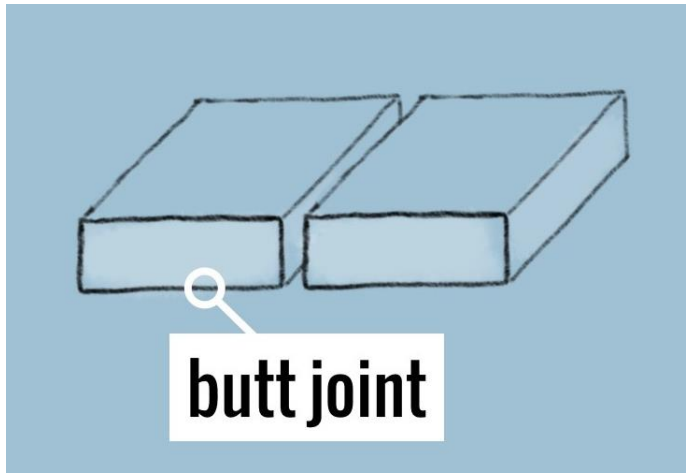
- ARE ADDITIONAL PARTS USED TO ACHIEVE A SPECIFIC TYPE OF LOAD TRANSFER?

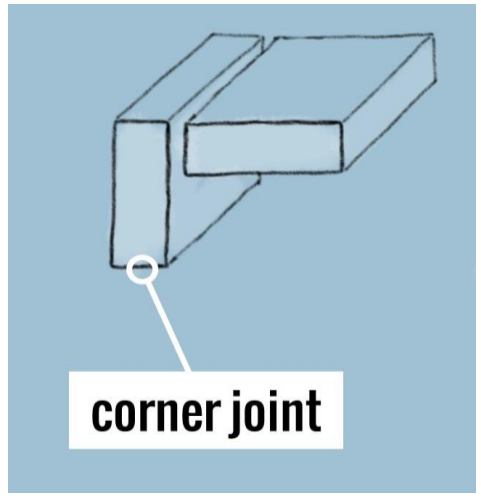
- TAPERING
- HOLE
- INLET
- WEDGE

Current Work: Balanced v Unbalanced

A joint is ***balanced*** if there is symmetric distribution of adherends either side of discontinuity



Example of balanced joint

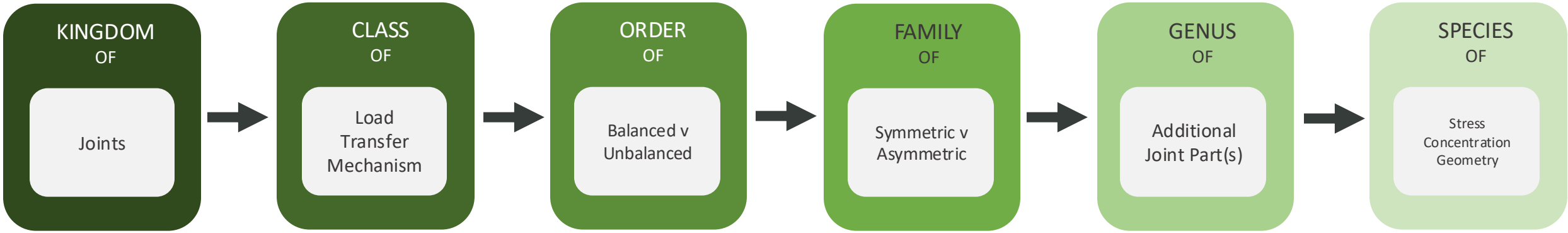


Example of unbalanced joint

Source: www.inchbyinch.de

Current Work: Joint Classification

Joint concepts are classified hierarchically based on relevant joining features:



- **TENSILE**
- **SHEAR**
- **COMPRESSIVE**

- **SYMMETRIC DISTRIBUTION OF ADHERENDS EITHER SIDE OF DISCONTINUITY**

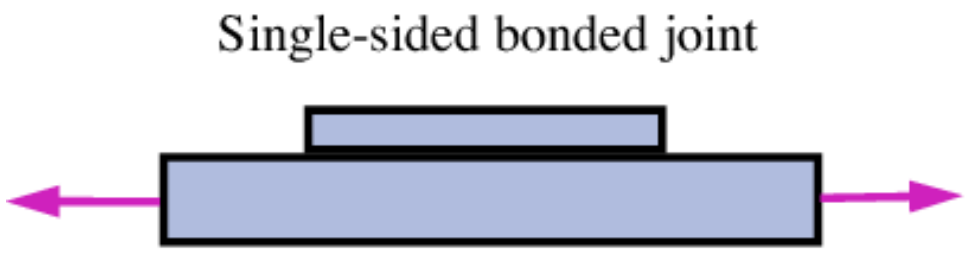
- **SYMMETRIC DISTRIBUTION OF JOINT FEATURES EITHER SIDE OF LOAD VECTOR**

- **ARE ADDITIONAL PARTS USED TO ACHIEVE A SPECIFIC TYPE OF LOAD TRANSFER?**

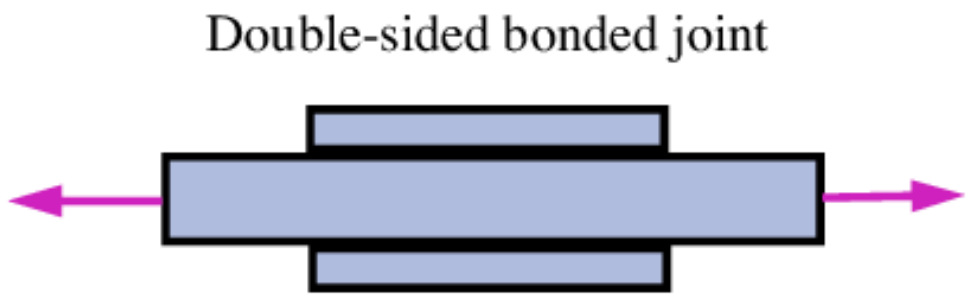
- **TAPERING**
- **HOLE**
- **INLET**
- **WEDGE**

Current Work: Symmetric v Asymmetric

A joint is ***symmetric*** if there is symmetric distribution of joint features either side of the load vector



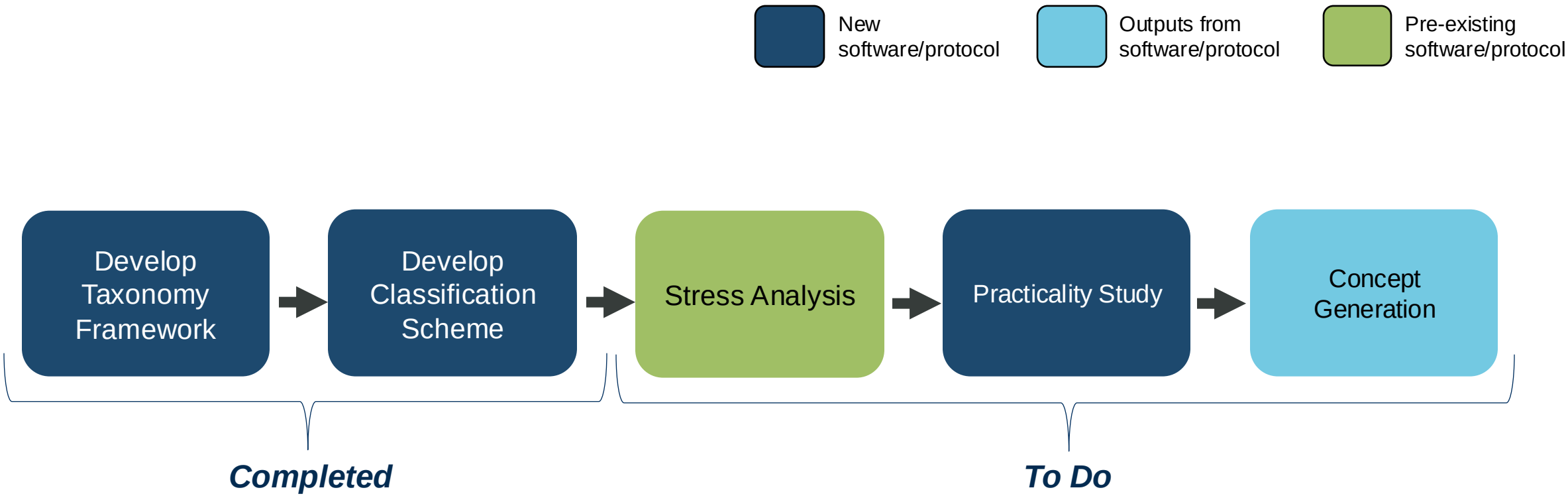
Example of asymmetric joint



Example of symmetric joint

Source: www.engineersblog.net

Future Work


New software/protocol
Outputs from software/protocol
Pre-existing software/protocol
Develop Taxonomy Framework
Develop Classification Scheme
Stress Analysis
Practicality Study
Concept Generation
Completed
To Do

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Thank you for listening.

Any questions?

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Vestas