



# OPTIMUM DESIGN GUIDELINES FOR PLYWOOD SANDWICH PANELS

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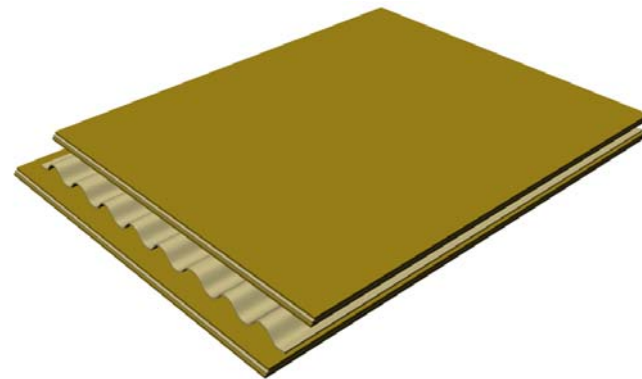
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2011

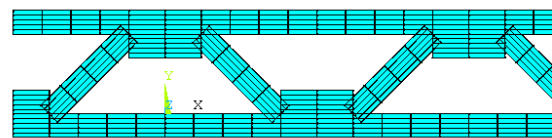
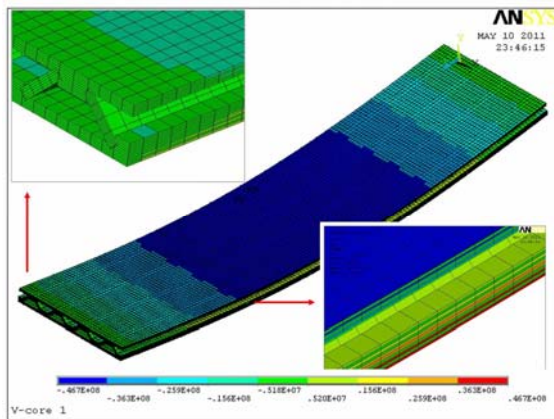
## Introduction

Advantages of using numerical simulations in development of new structural sandwich materials

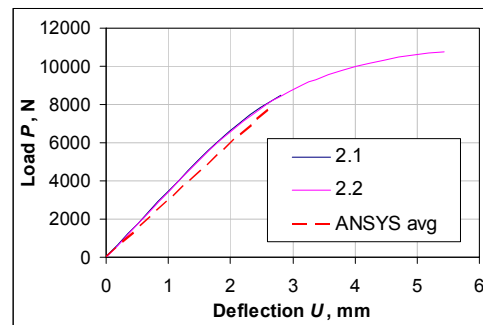
Description of all-plywood sandwich panels with corrugated core



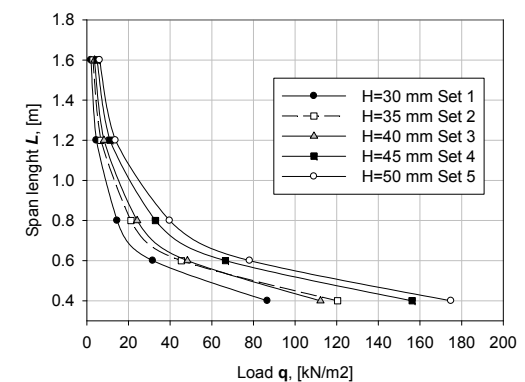
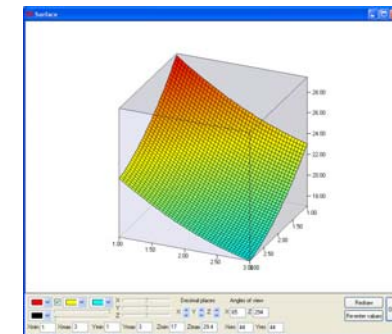
## Research methodology



FEM numerical analysis



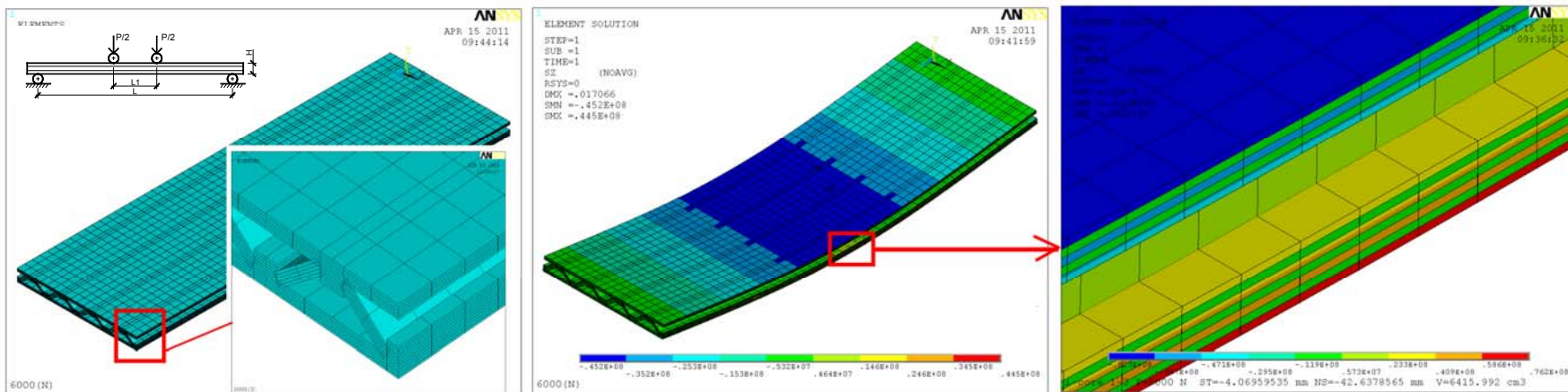
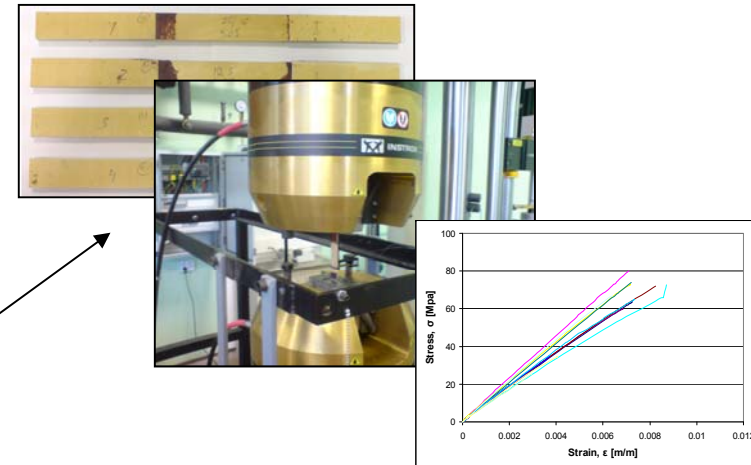
Experimental bending tests/ Model validation



Optimisation/ design guidelines

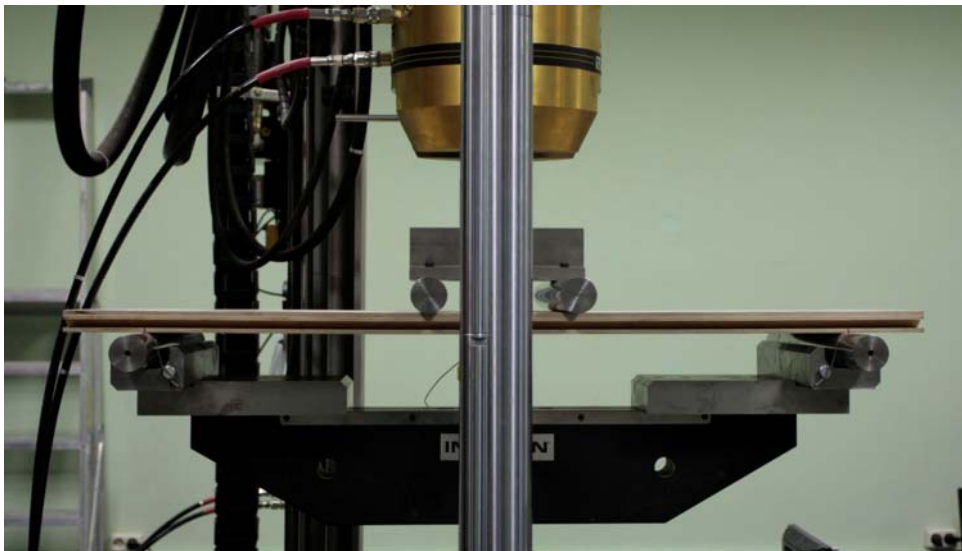
## Numerical modeling of sandwich panels

- ANSYS as FEM computer Software
- layered 3D structure using SHELL 181 elements
- experimentally obtained material mechanical properties

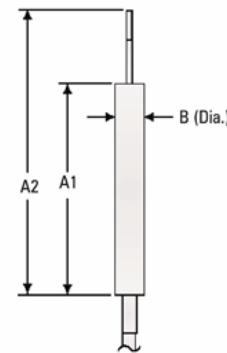
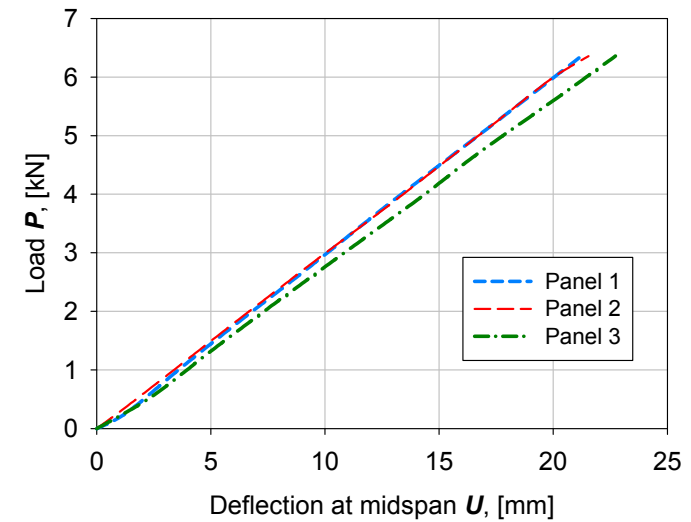


## Experimental investigation

- 4-point bending on INSTRON 8802
- strain and deflection measurements

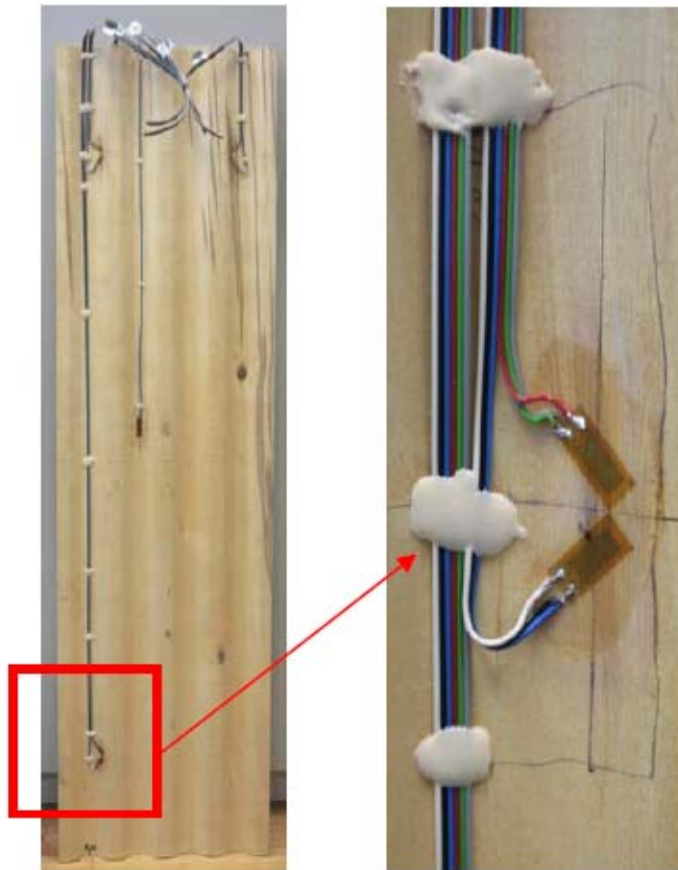


EN 789 standard used



## Experimental investigation

- strain and deflection validation with experimental results



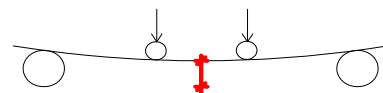
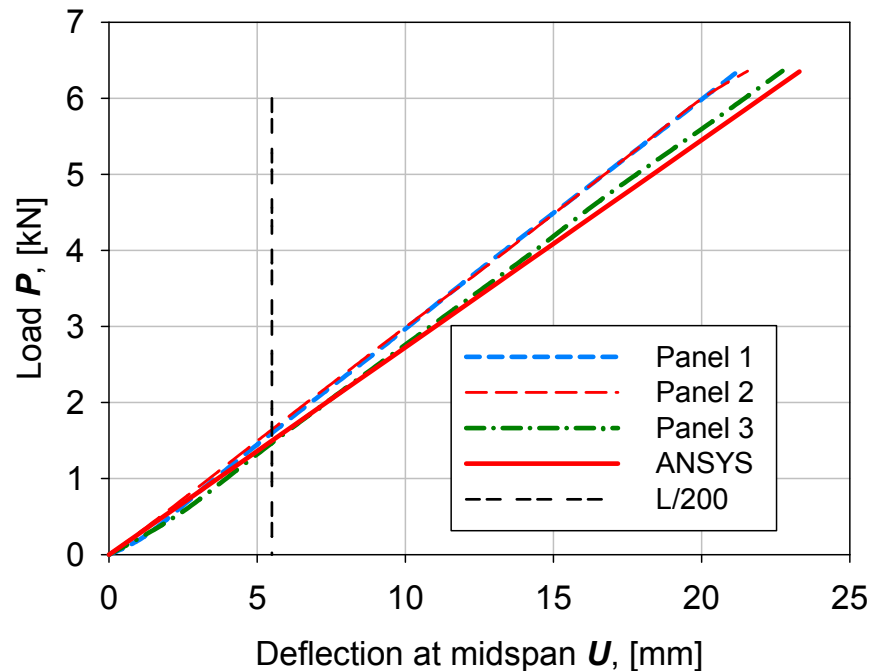
Inside on the core



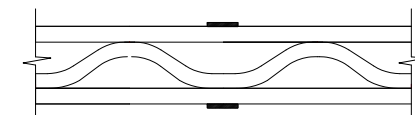
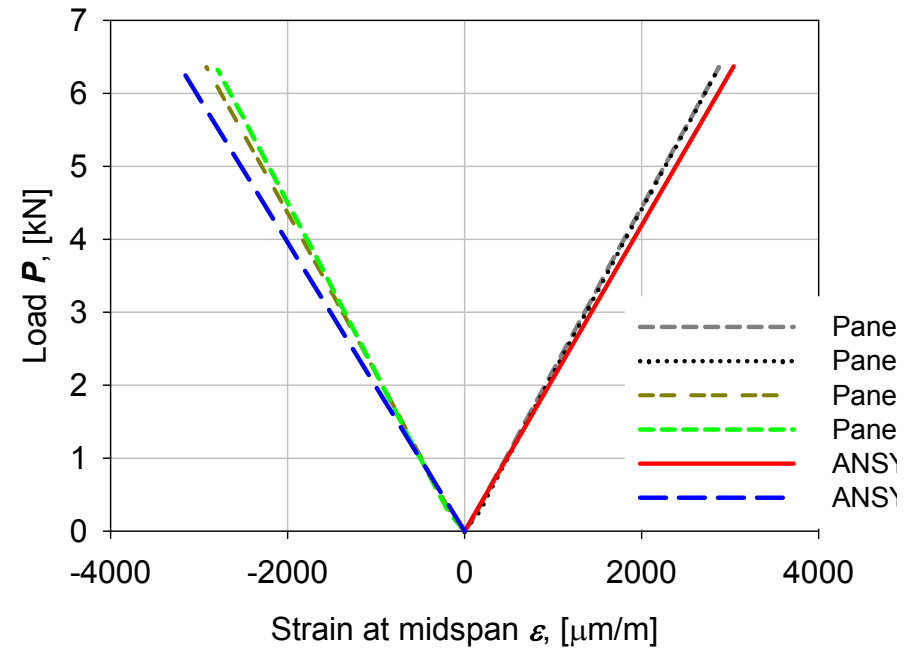
Outside on the surface

## Results validation for sandwich panels with corrugated core

Load/ deflection curves

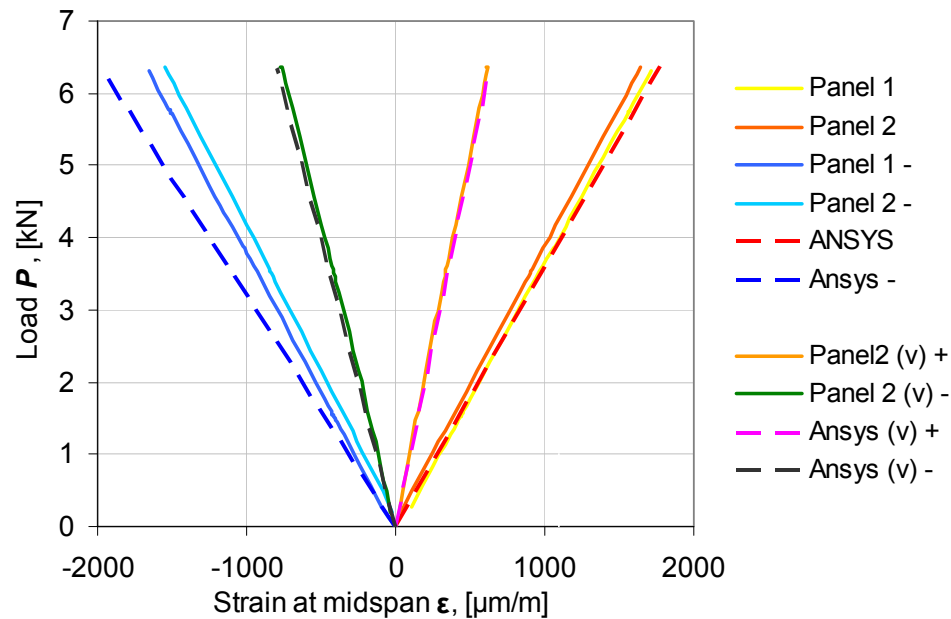


Load/ strain curves  
(on outer surfaces)

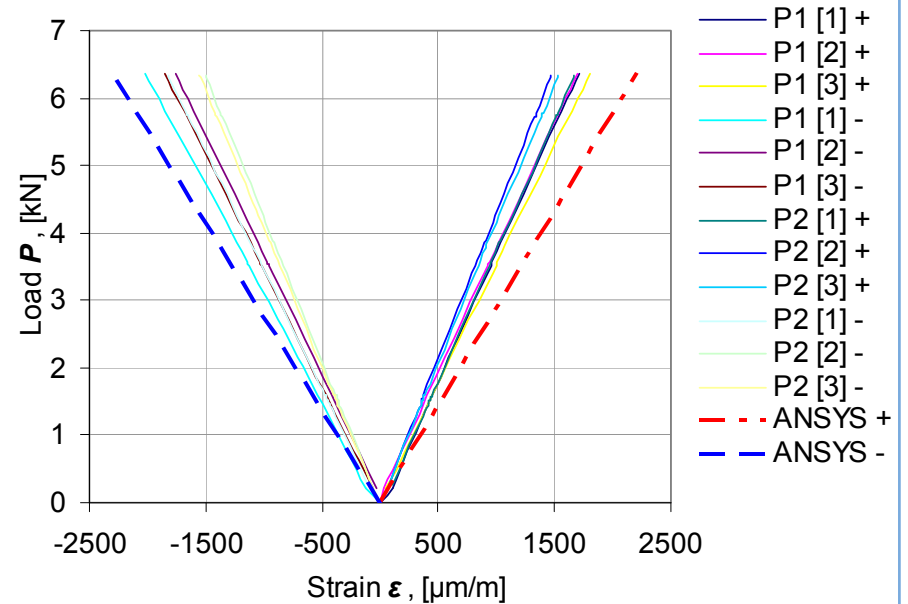


## Results validation for sandwich panels with corrugated core

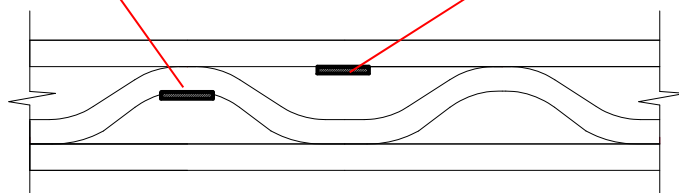
Load/ strain curves  
(on inner surfaces)



Load/ strain curves  
(on corrugated ply)

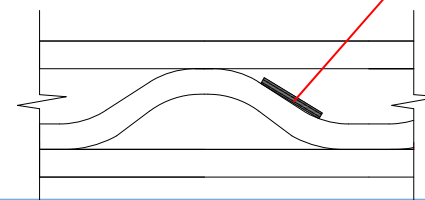


SG2 ( Panel 2 (v) - )

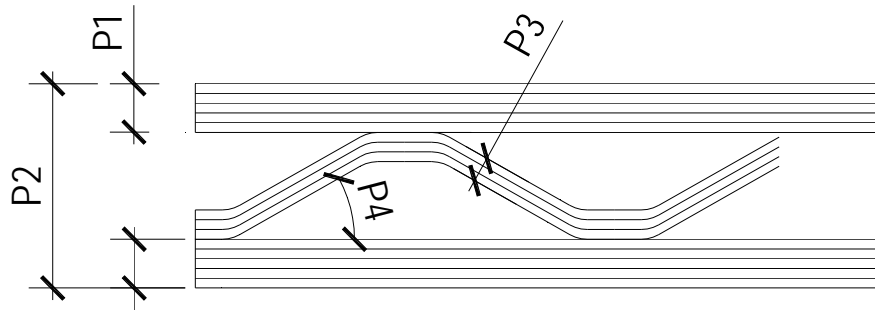


SG1 ( Panel 2 - )

SG3 ( P1 [1] - )

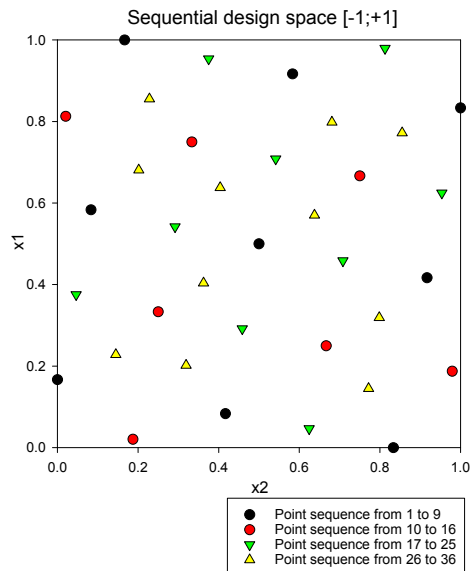


## Optimisation for sandwich panels with corrugated core



Parameter	Nomenclature	Lower bound	Upper bound	Increment step	Units
Number of cover plate plies	<b>P1</b>	3	7	2	-
Total section height	<b>P2</b>	30	50	5	mm
Number of plies in corrugate section	<b>P3</b>	3	5	1	-
Corrugated ply angle	<b>P4</b>	30	60	-	deg

## Design of numerical experiments



Applying MSE sequential space filling criteria

## Design of physical experiments

## Metamodel building:

Adaptive Base Function Construction (ABFC) method  
*VariReg software*

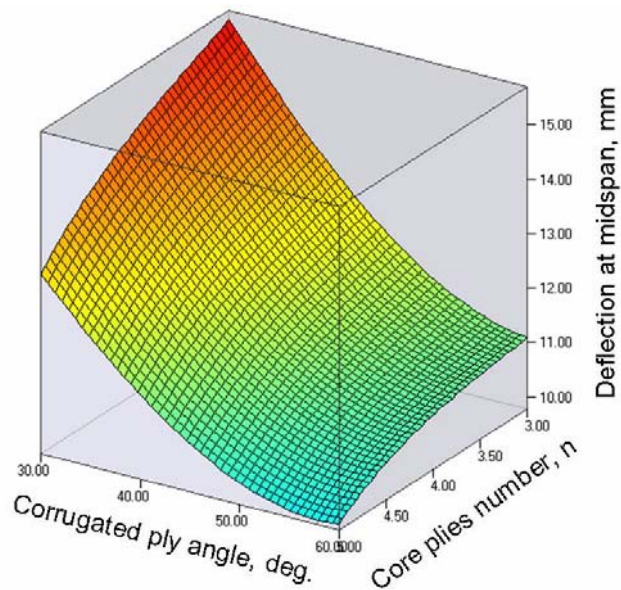
## Optimization:

Reducing weight versus stiffness balance for different panel configuration  
*Ms Excel Solver*

## Optimum design guidelines

## Optimisation results for sandwich panels with corrugated core

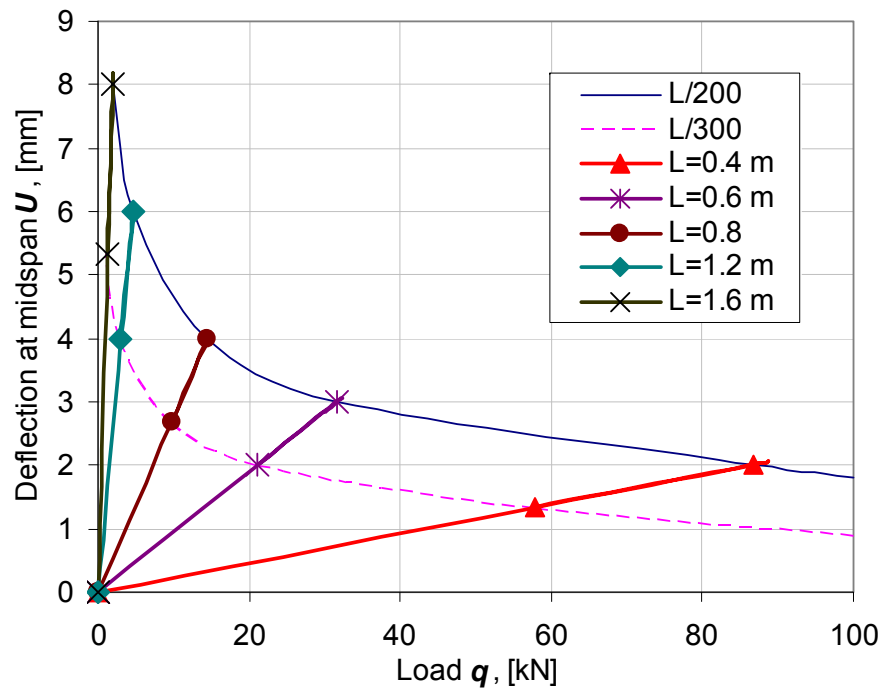
- influence of variables on response values
- optimal cross-section parameters
- general trends



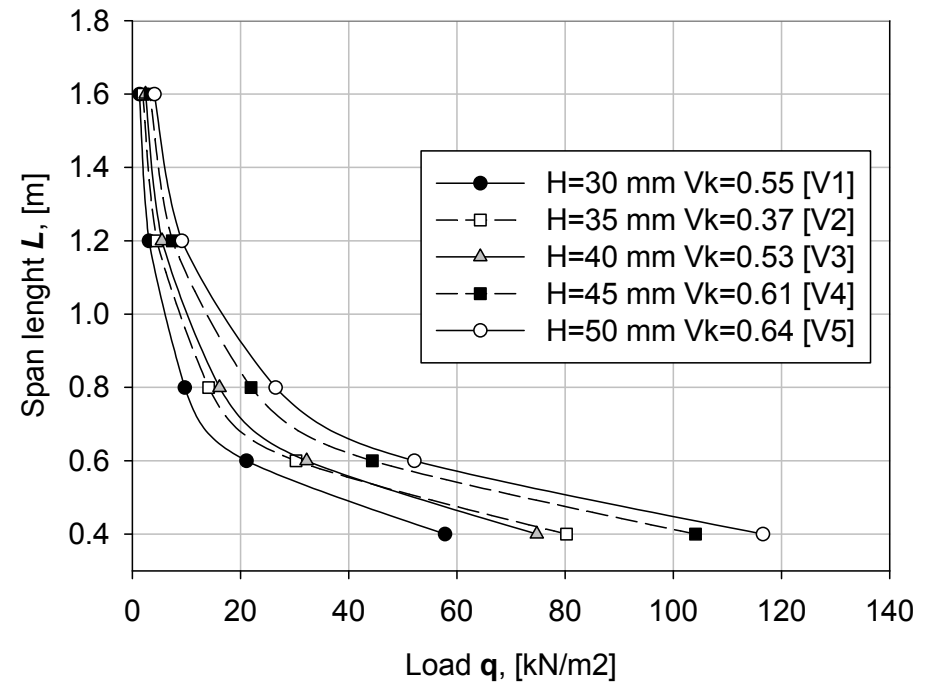
Variables	V1	V2	V3	V4	V5
<b><i>P1</i></b>	3	5	5	3	3
<b><i>P2</i></b>	0.03	0.035	0.04	0.045	0.05
<b><i>P3</i></b>	5	5	3	5	5
<b><i>P4</i></b>	60	60	60	60	60
<b><i>Vs</i>, cm<sup>3</sup></b>	3966	6600	5580	5300	5360
<b><i>Vs-Vp</i>, %</b>	55	37	53	61	64
<b><i>Us-Up</i>, %</b>	22	14	30	35	42
<b>Total, %</b>	33	23	23	26	22

## Design guidelines for sandwich panels with corrugated core

Panel with 3 layer surfaces and 60deg. corrugated ply angle



Design guidelines until deflection limit  $1/300 L$



## Conclusions

Numerical model with multilayer plywood structure is suitable for performing virtual bending tests for plywood sandwich panels – results difference from experimental values 10-15 %.

In some combinations of variables sandwich structure could be up to 40 % weight effective comparing with full section plywood board, losing only 10-20 % of load carrying capacity.

Design guidelines have been elaborated to assess allowable load values for certain span length.



Thank you for your attention !

