Pattern Kerfing for Responsive Wooden Surfaces

A formal approach to produce flexible panels with acoustic performance

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6 November 2018

PROBLEM STATEMENT

Producing building components with a freeform surface geometry is a challenging task.

OBJECTIVE

To determine a formal approach for the design and fabrication of responsive wooden surfaces
by using **pattern kerfing** techniques
towards better **acoustic performance**.

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>> To design a flexible acoustic panel.

RESEARCH QUESTION

How can we formalize the pattern kerfing techniques
in order to produce responsive wooden surfaces
for better acoustic performance?

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How can we formalize the pattern kerfing techniques
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for better acoustic performance?

SUB-QUESTIONS

PATTERN *on* FLEXIBILITY

How does pattern kerfing influence the attainable curvature of a panel?

PATTERN *on* ACOUSTICS

How does pattern kerfing influence the acoustic performance of a panel?

FLEXIBILITY *on* ACOUSTICS

What effect has a curved surface of a panel on its acoustic performance?

APPLICATION *of* SYSTEM

What are potential uses of responsive surfaces on acoustic performance?

PRESENTATION CONTENT

1.

FLEXIBILITY

Principles
Parameters
Observations
Simulation
Conclusion

2.

ACOUSTICS

Parameters
Measurements
Conclusions

3.

DESIGN

Concept
Prototype
Conclusion

4.

CONCLUSION

Responsive acoustic panel

BOUNDARY CONDITIONS

Focus on geometry and acoustics

No material, fire safety, structural analyis, production costs

Two-dimensional pattern

Meander pattern

Conceptual design

Prototype component

FLEXIBILITY

FLEXIBILITY
DEVELOPMENT

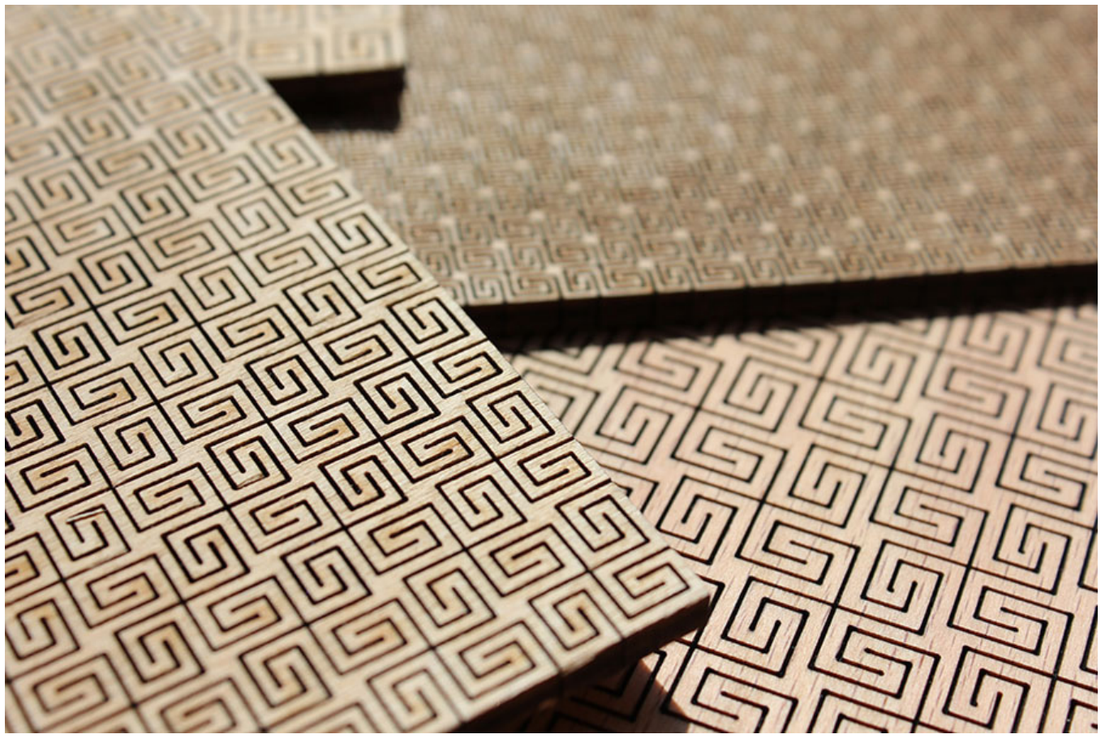
makezine.com (2018)

LINEAR PATTERN

FLEXIBILITY
DEVELOPMENT

makezine.com (2018)

LINEAR PATTERN

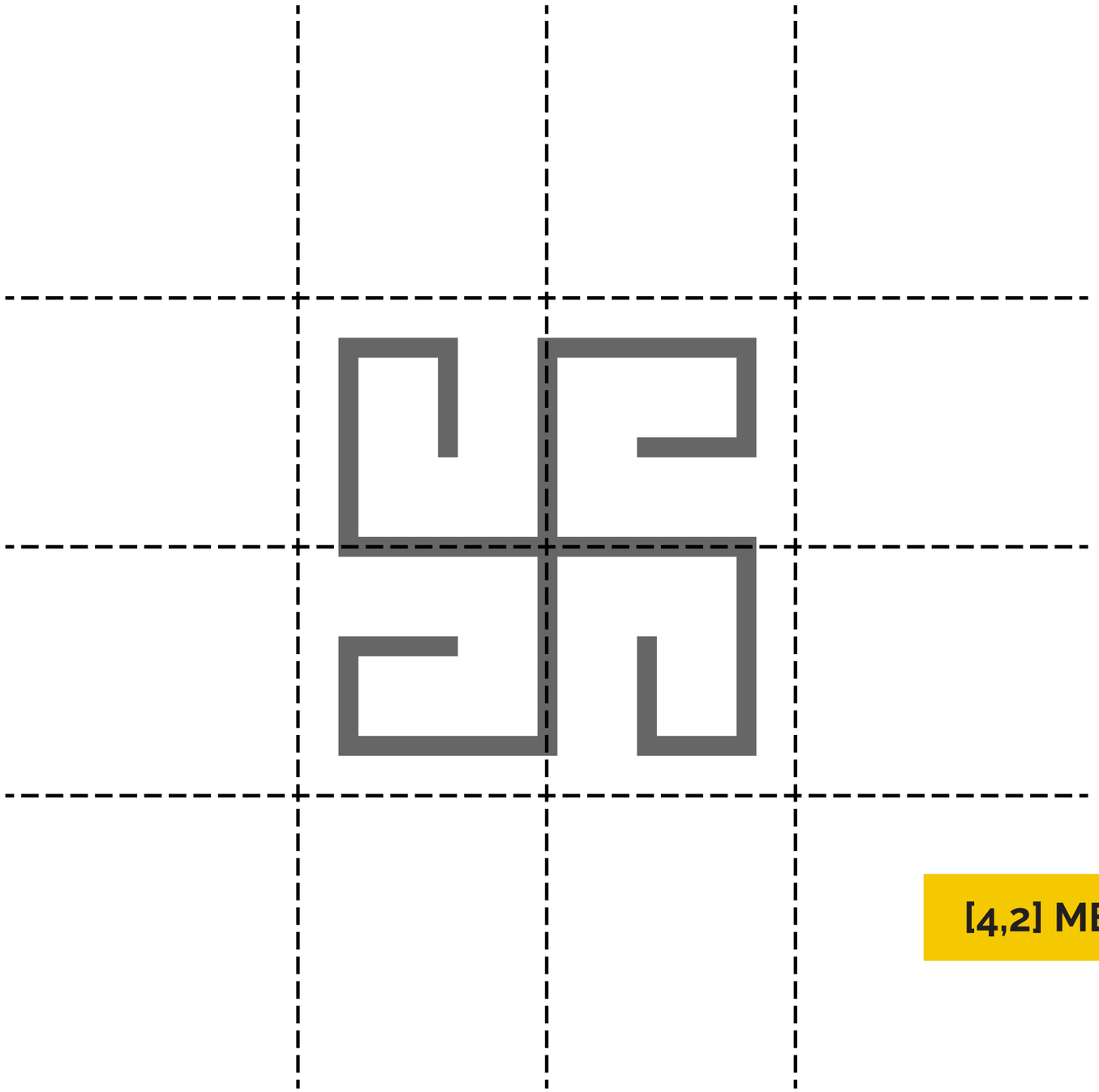


Ivanišević, D. (2014)

MEANDER PATTERN

FLEXIBILITY

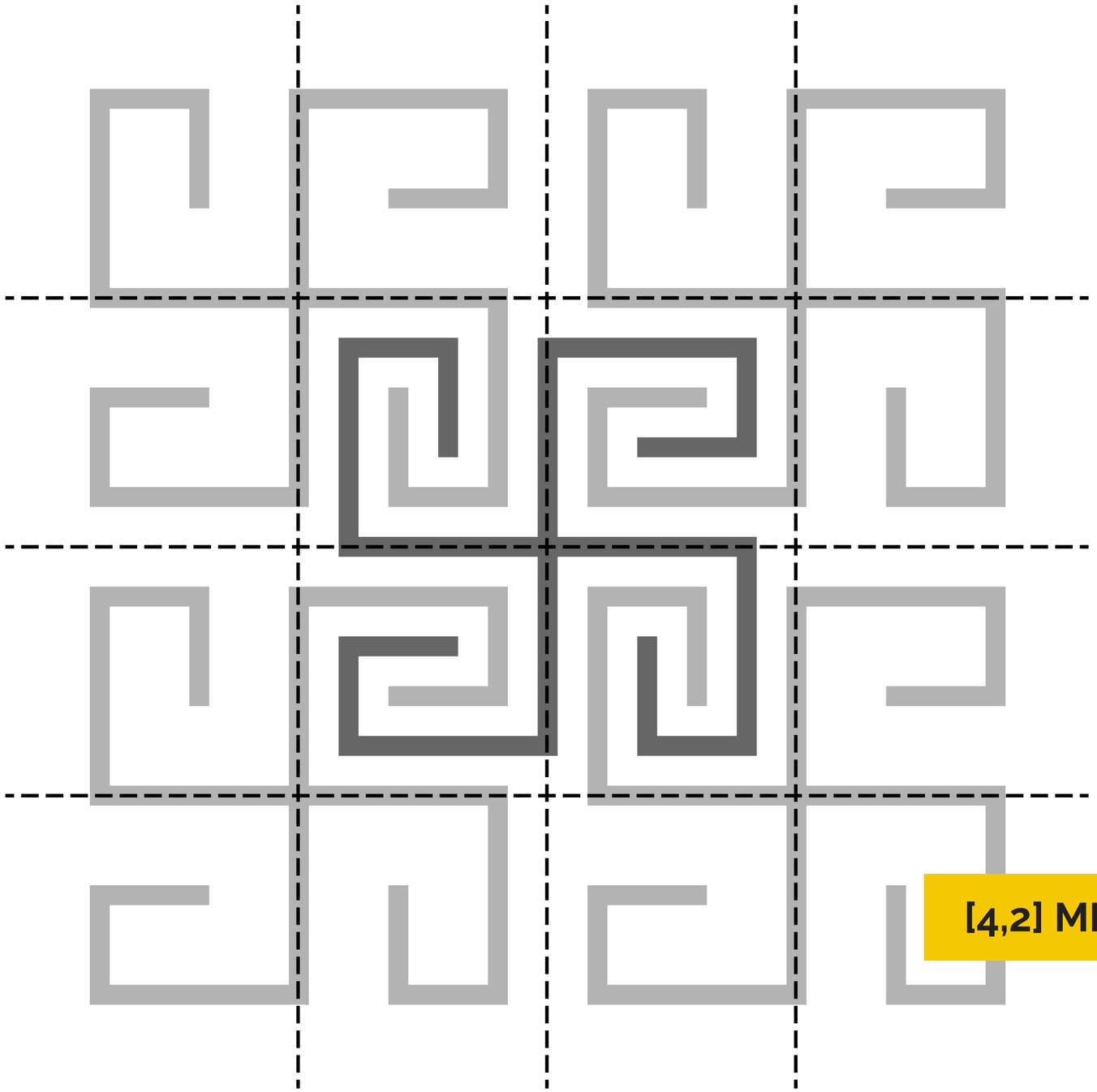
PATTERN PRINCIPLE



[4,2] MEANDER

FLEXIBILITY

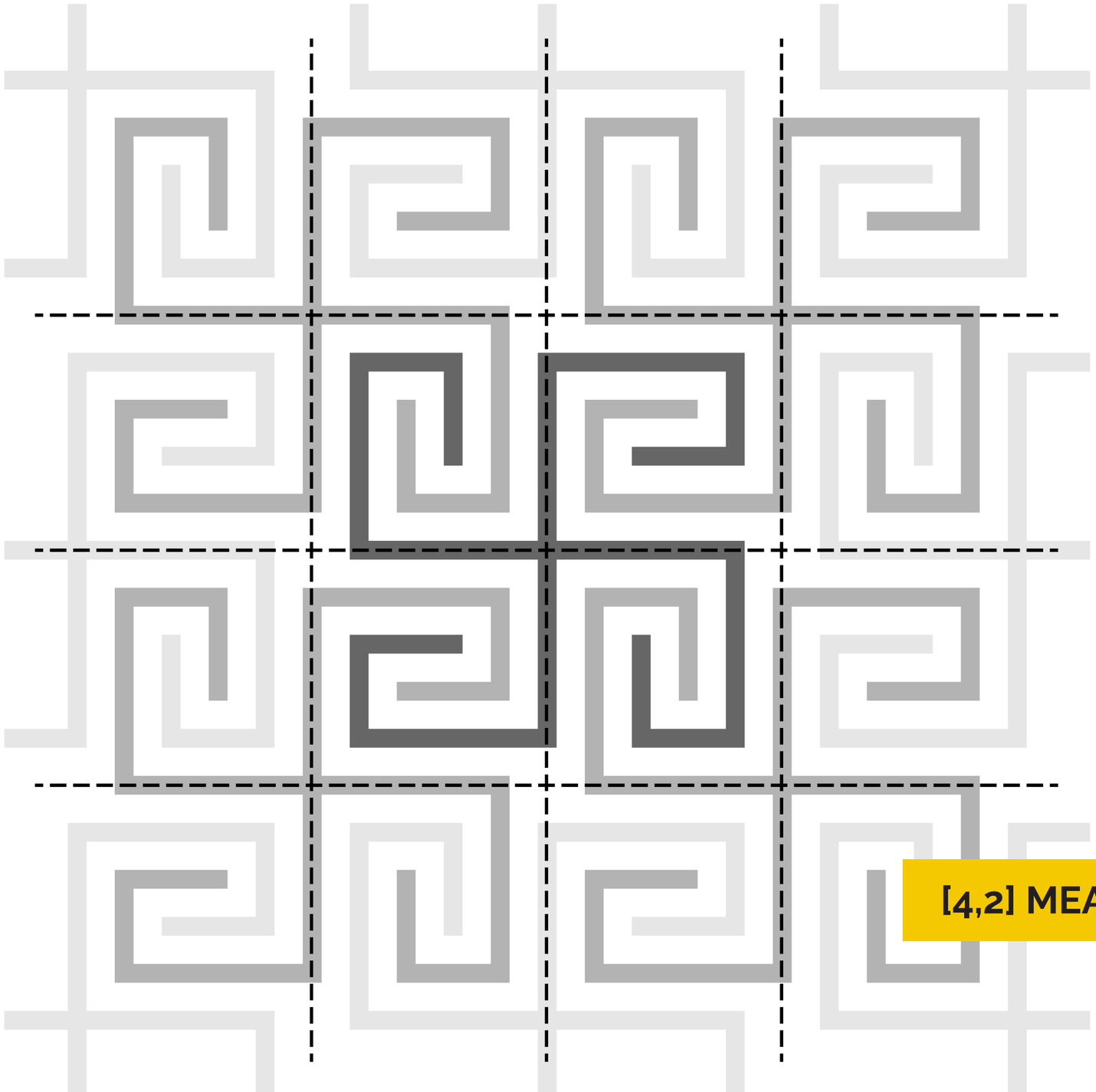
PATTERN PRINCIPLE



[4,2] MEANDER

FLEXIBILITY

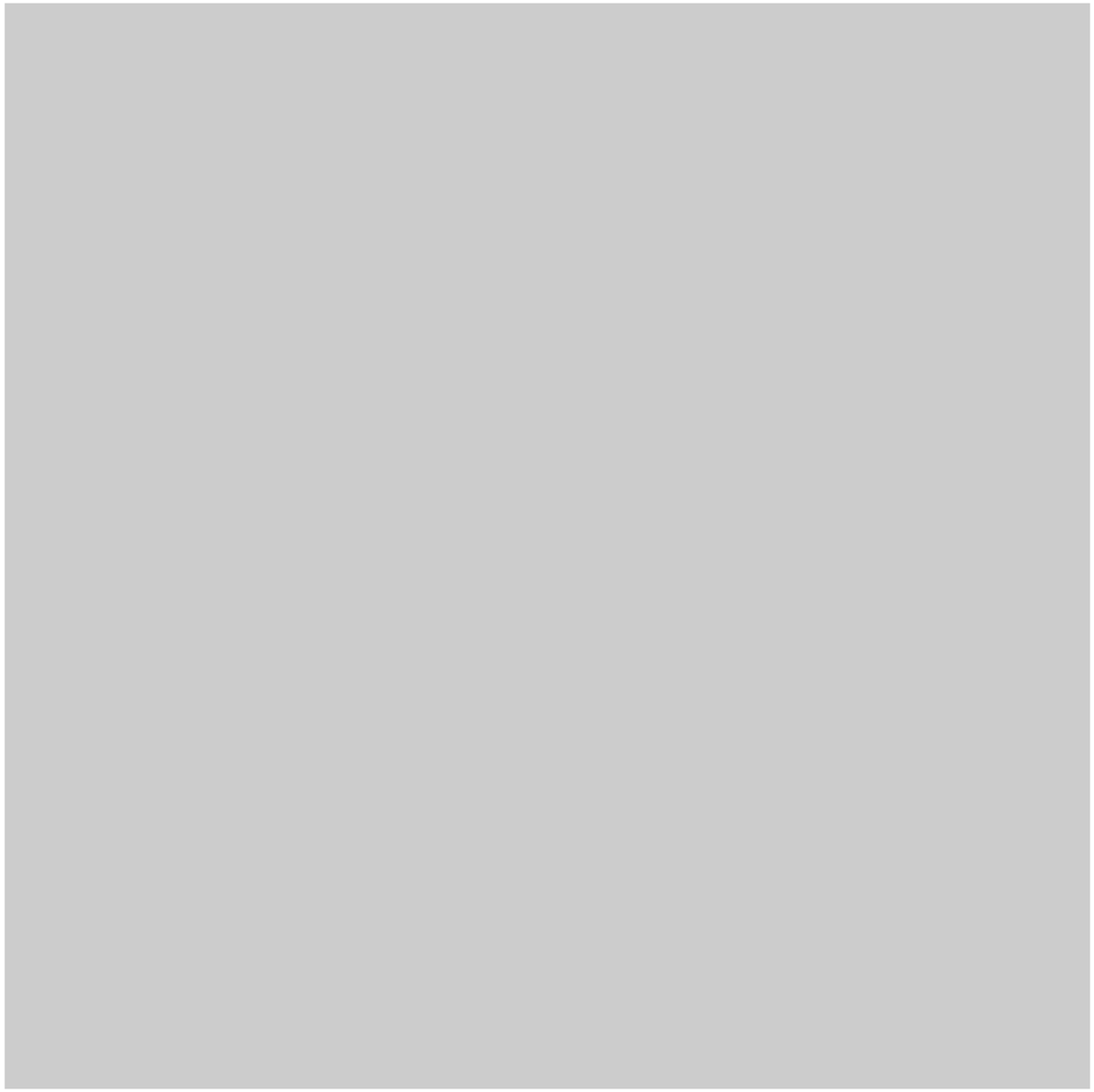
PATTERN PRINCIPLE



[4,2] MEANDER

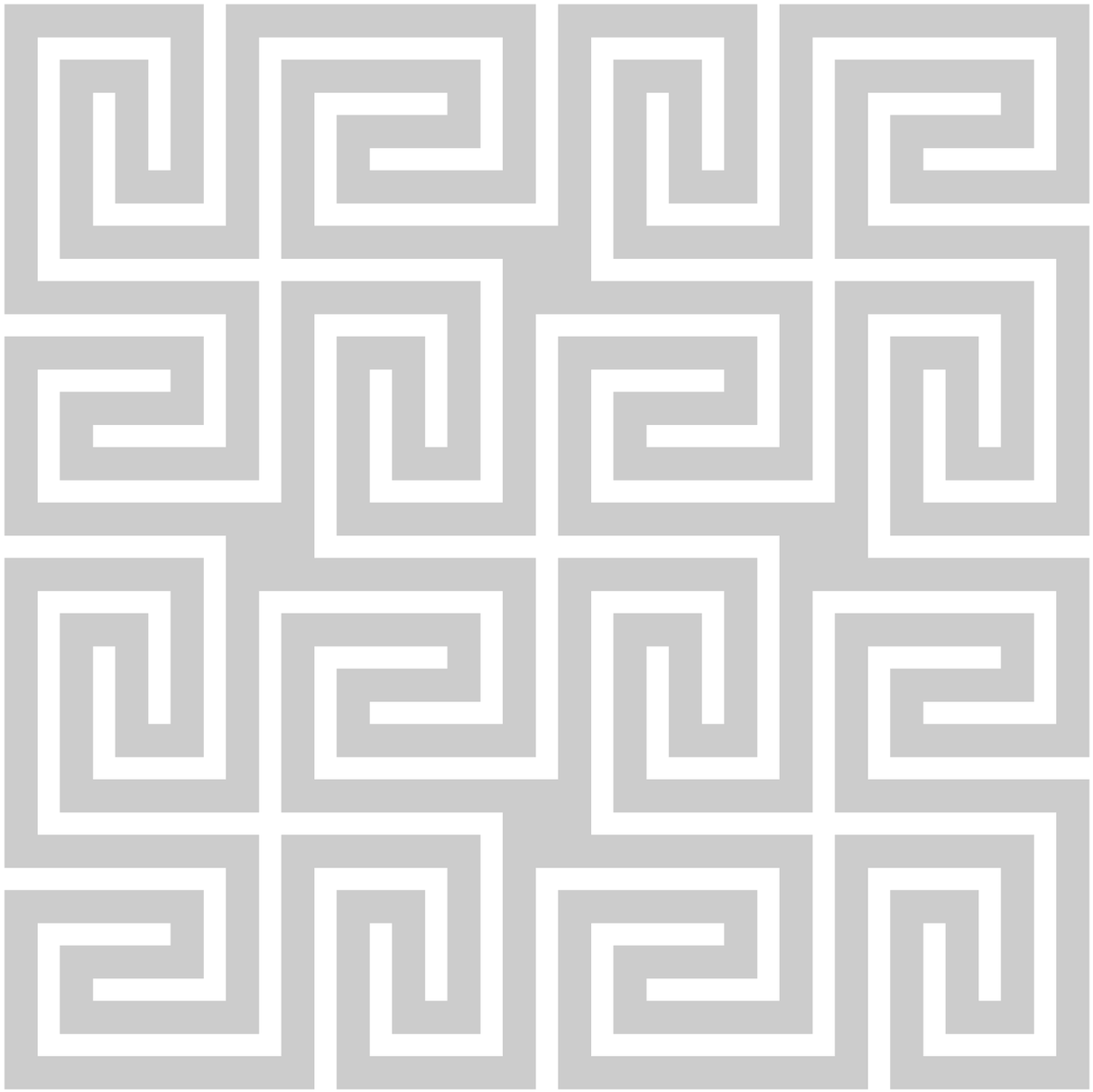
FLEXIBILITY

PATTERN PRINCIPLE



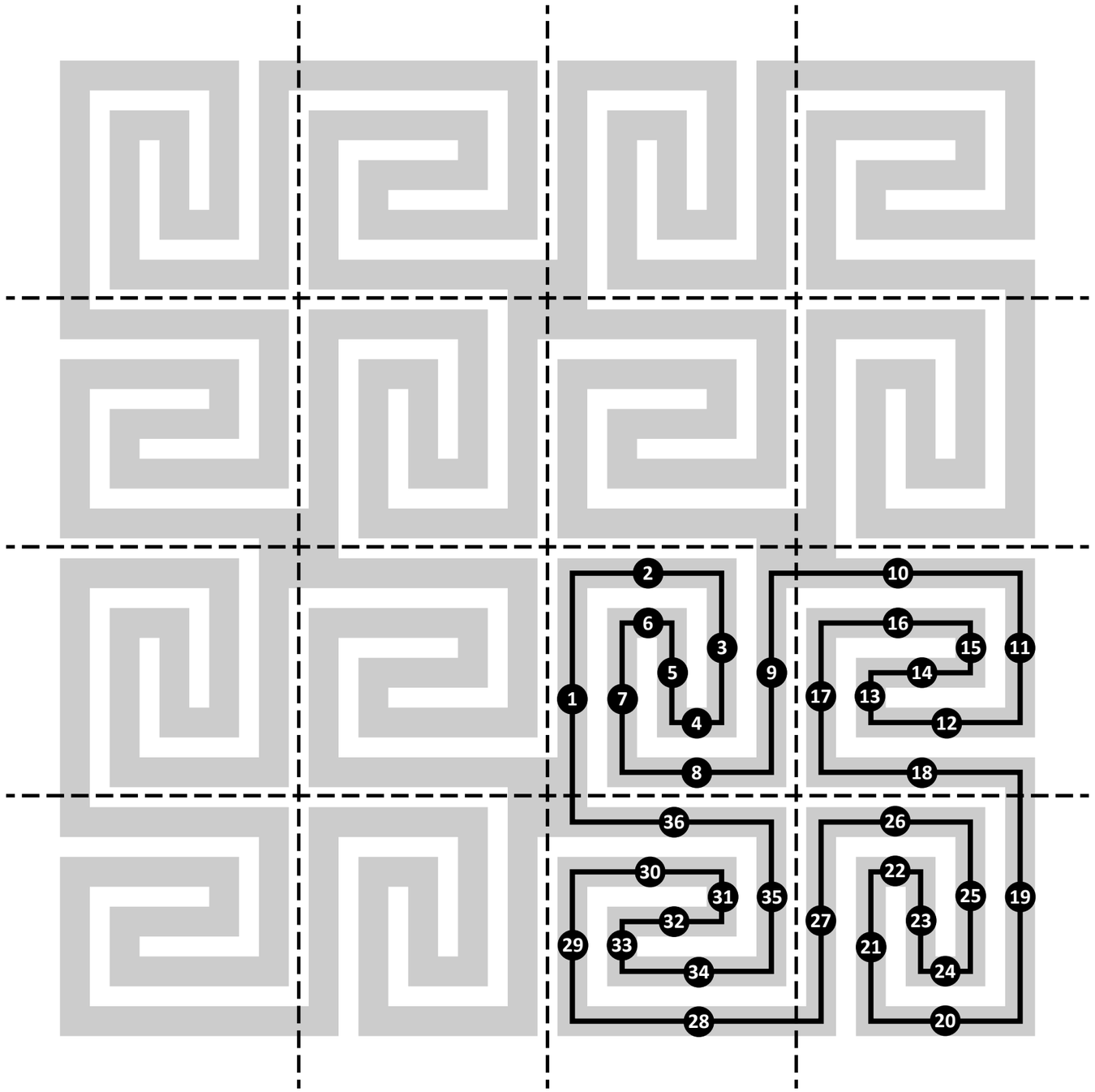
FLEXIBILITY

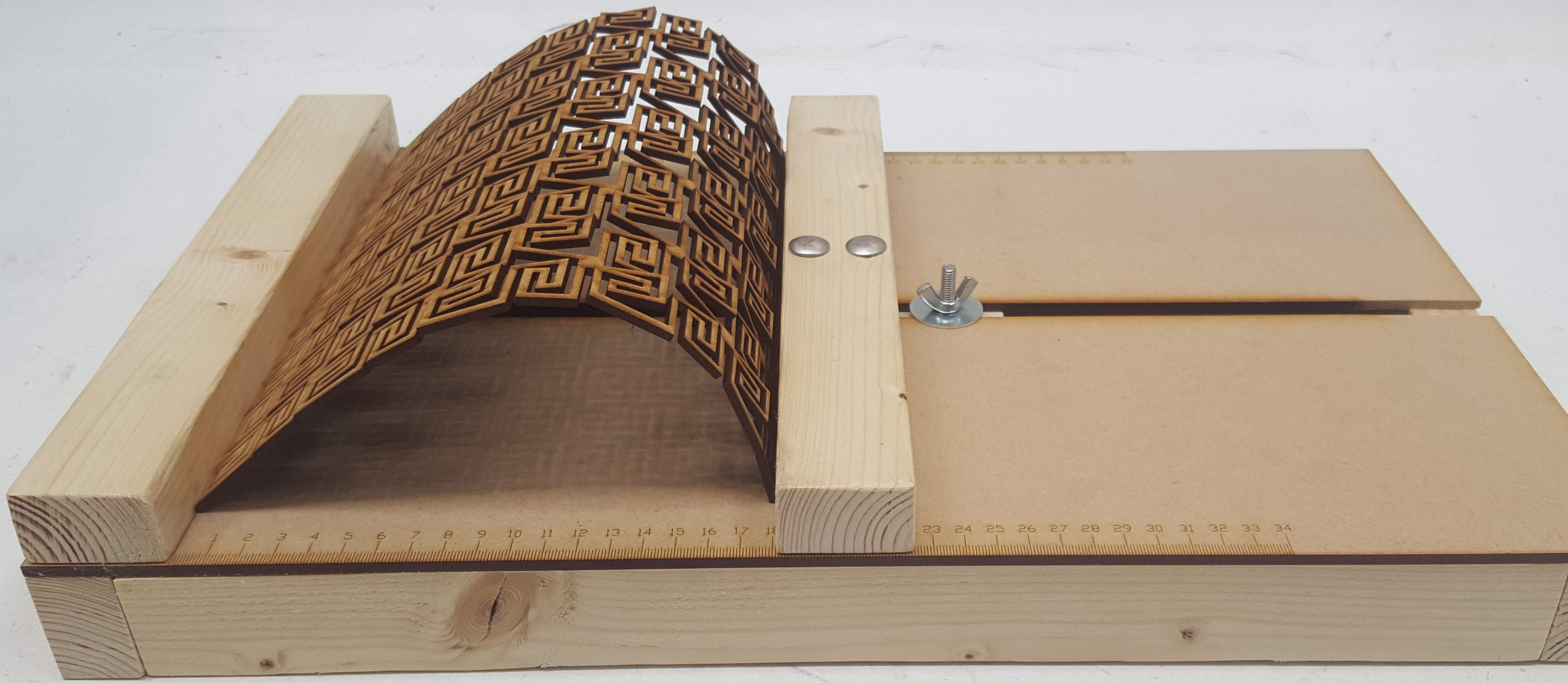
PATTERN PRINCIPLE

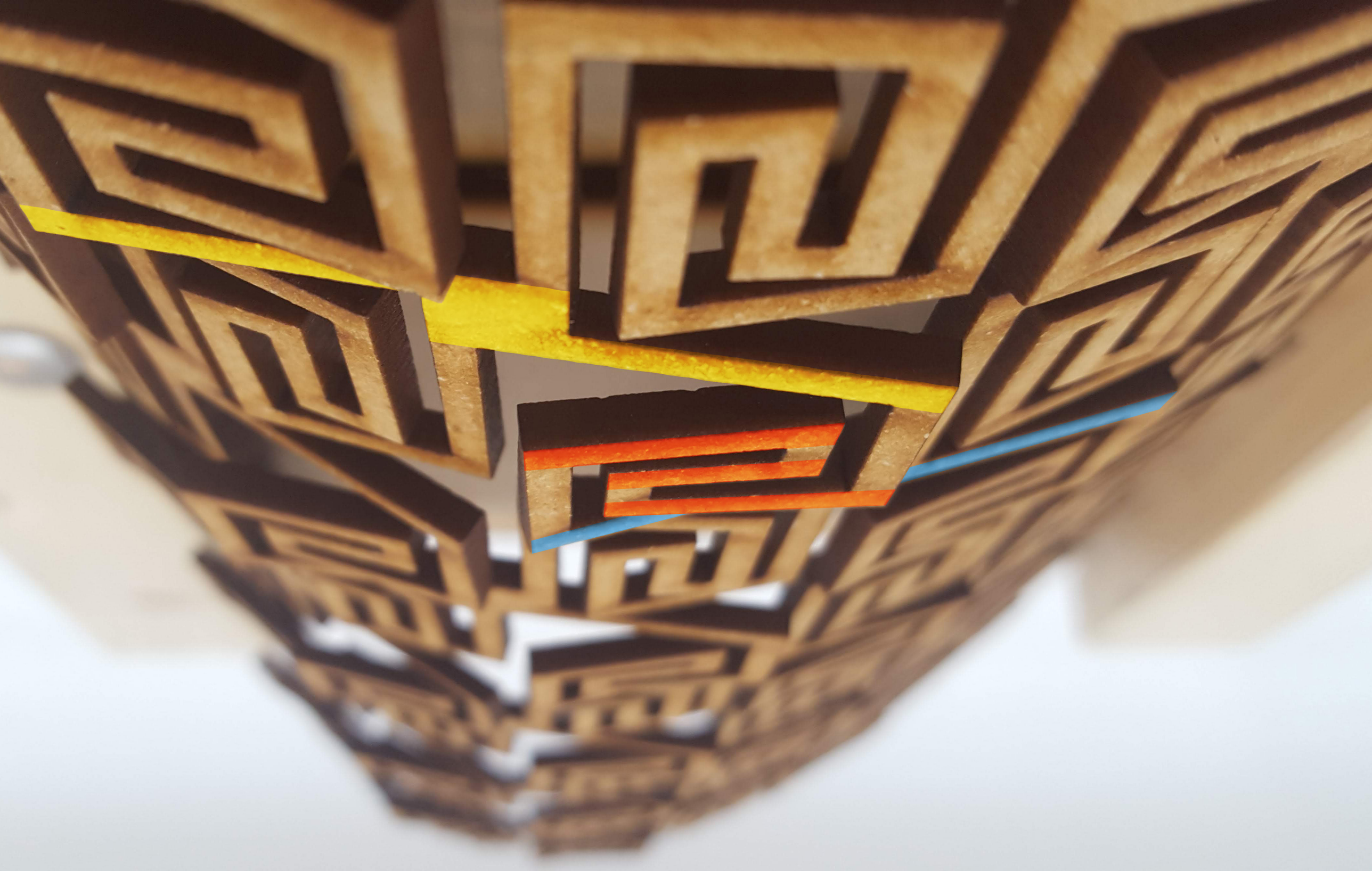


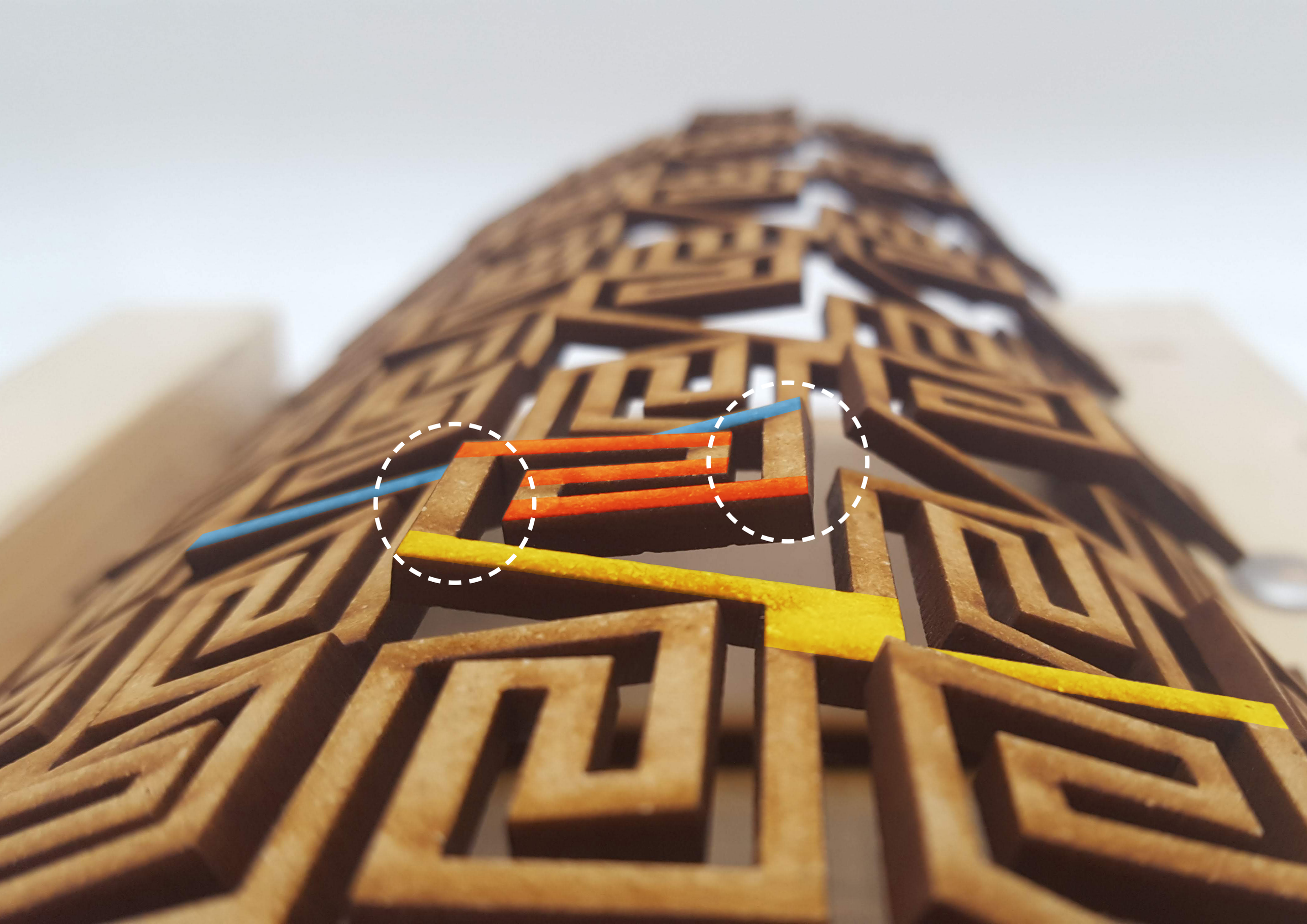
FLEXIBILITY

PATTERN PRINCIPLE







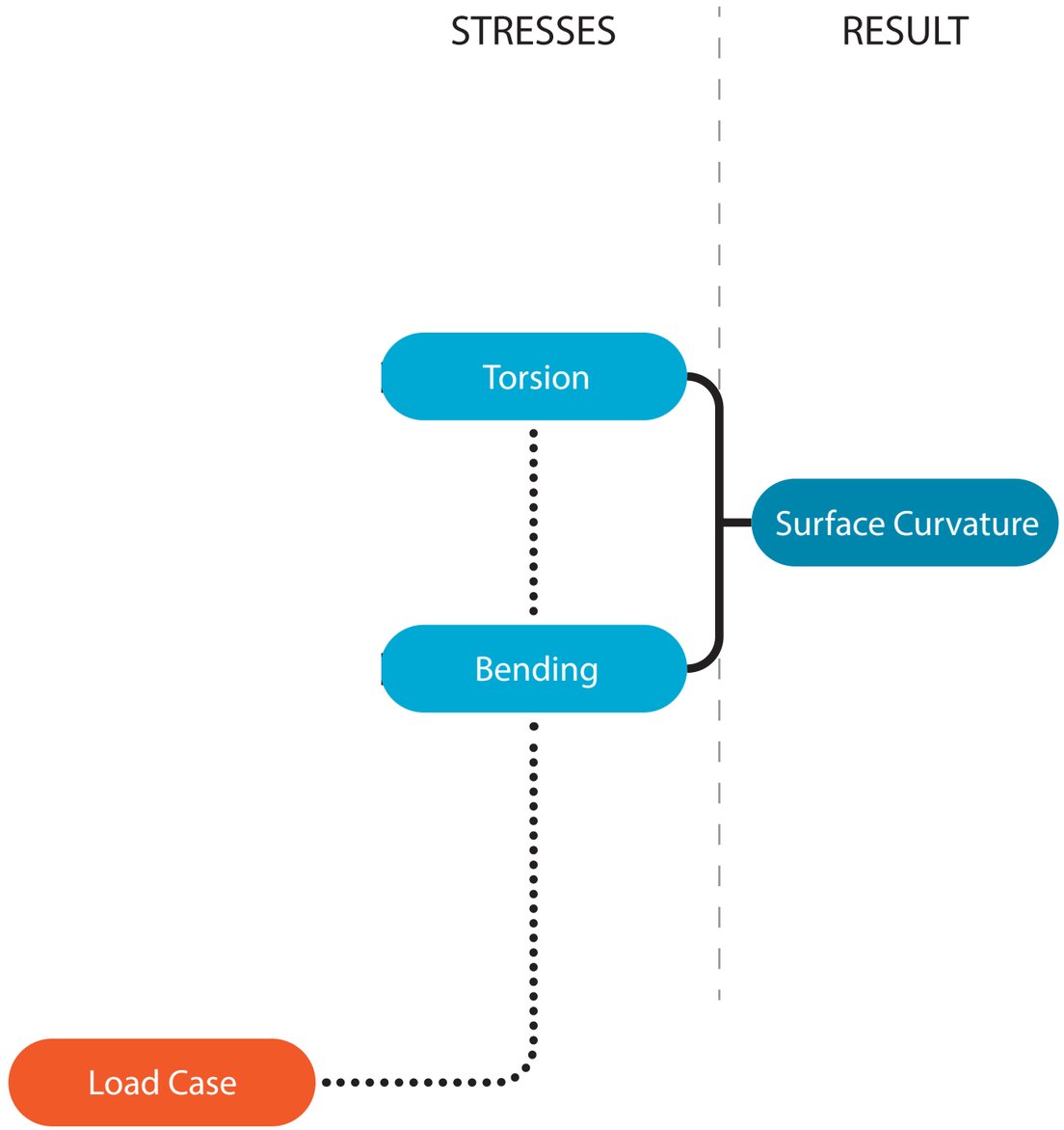


FLEXIBILITY
PARAMETERS

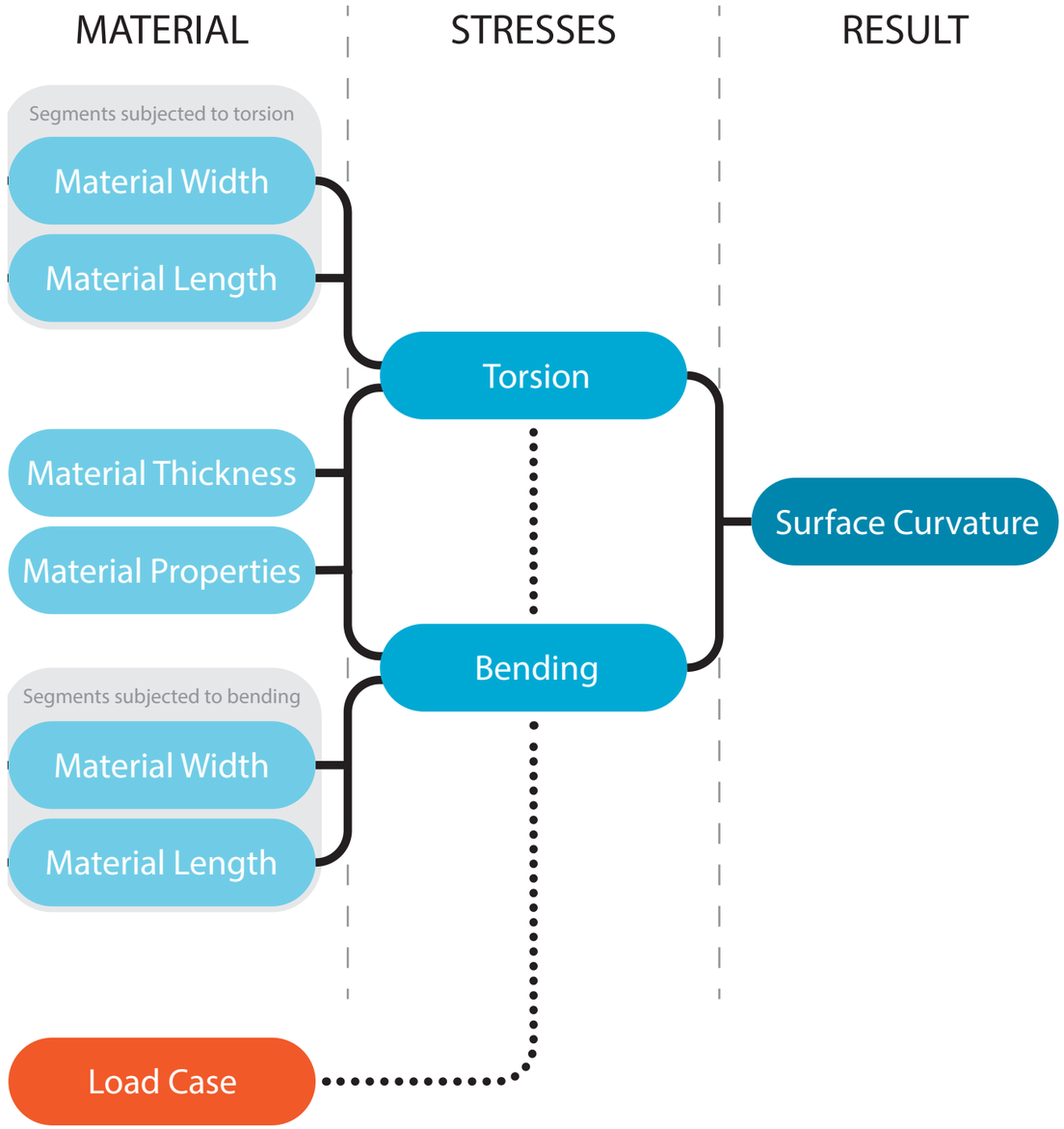
RESULT

Surface Curvature

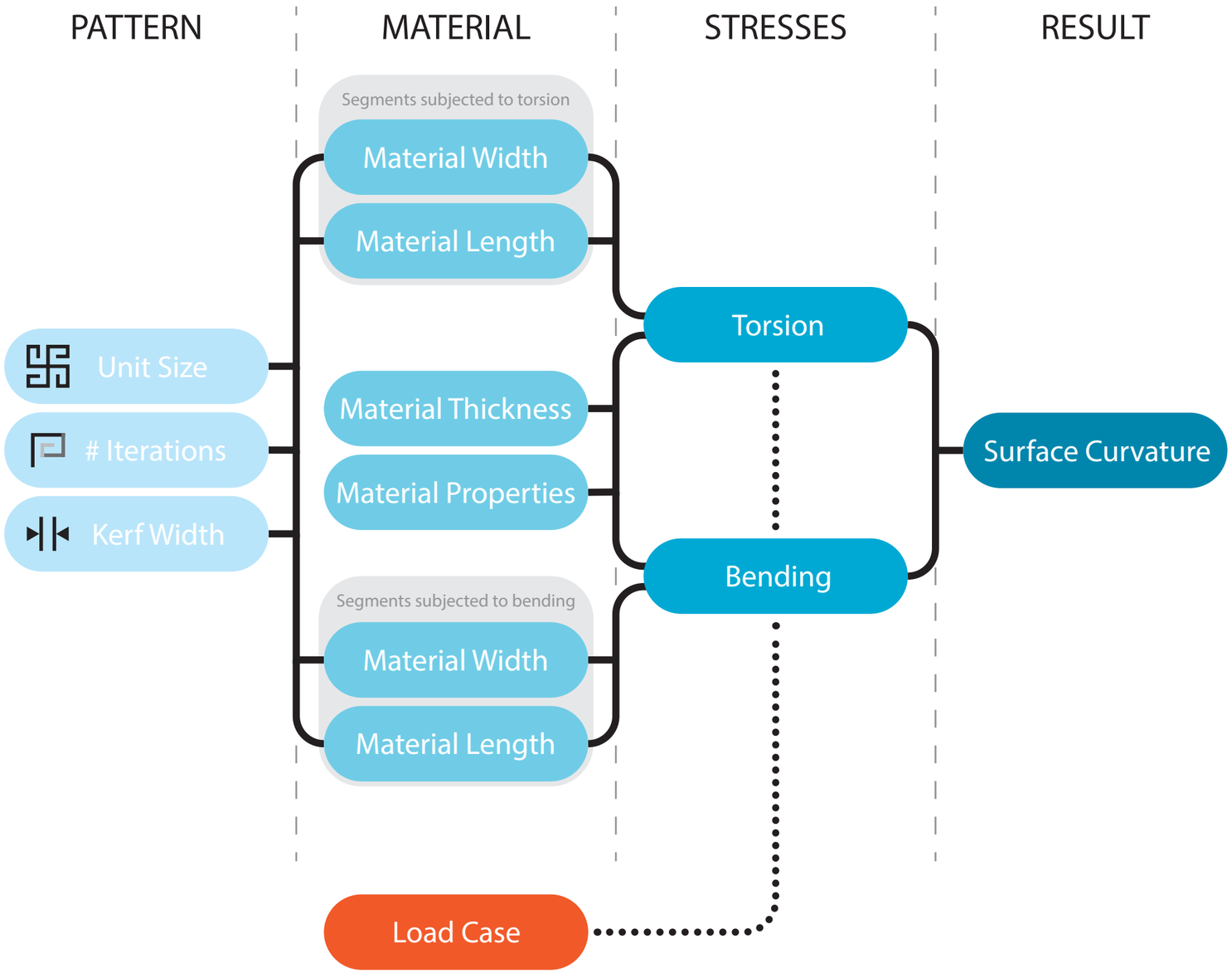
FLEXIBILITY
PARAMETERS



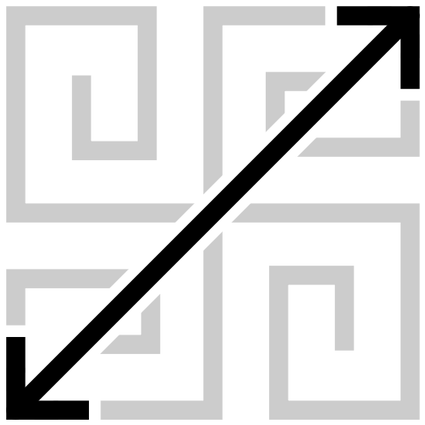
FLEXIBILITY
PARAMETERS



FLEXIBILITY
PARAMETERS

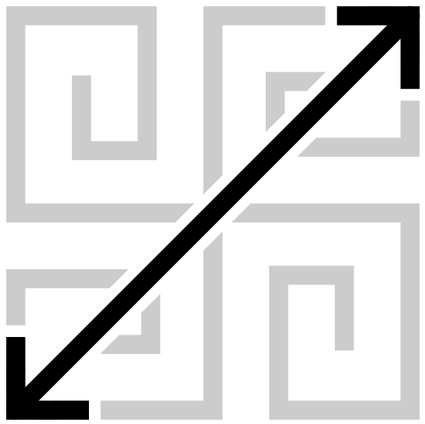


FLEXIBILITY
PARAMETERS

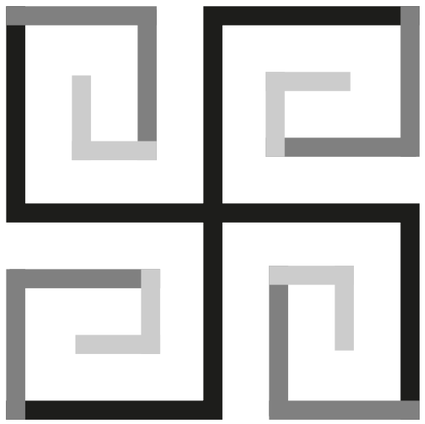


UNIT SIZE

FLEXIBILITY
PARAMETERS

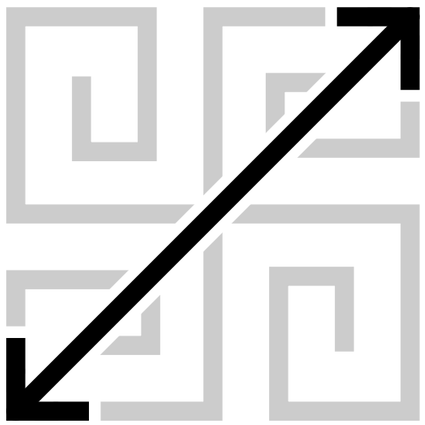


UNIT SIZE



NUMBER OF ITERATIONS

FLEXIBILITY
PARAMETERS



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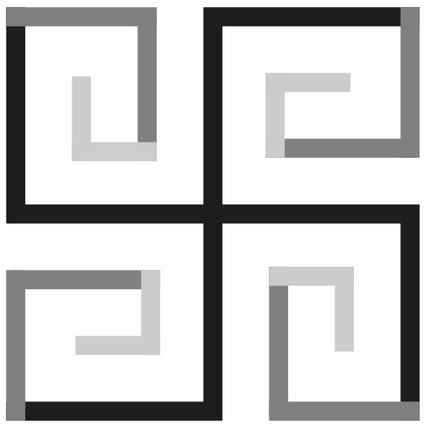

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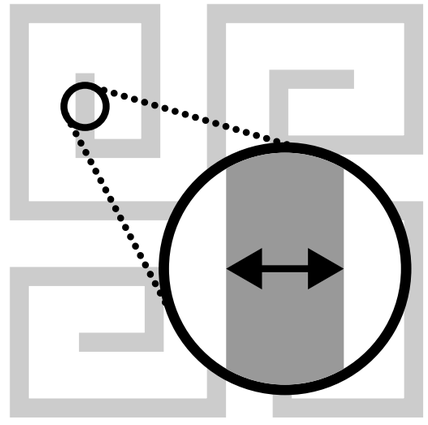


KERF WIDTH

FLEXIBILITY

BASIC MEANDER PATTERN

FLEXIBILITY

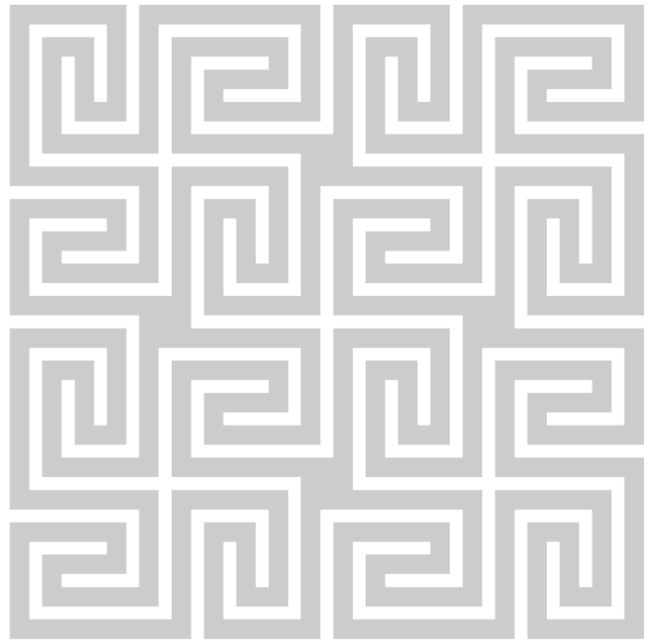
BASIC MEANDER PATTERN

INCREASED NUMBER OF ITERATIONS

FLEXIBILITY

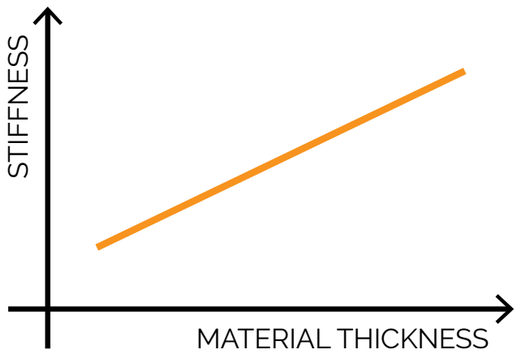
BASIC MEANDER PATTERN

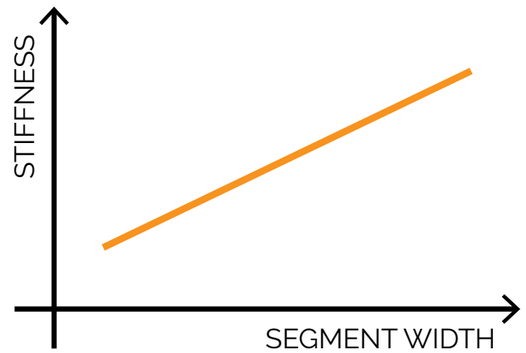
INCREASED NUMBER OF ITERATIONS

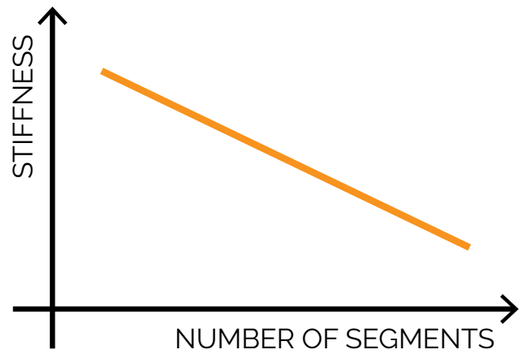


INCREASED KERF WIDTH

FLEXIBILITY
EXPECTATIONS





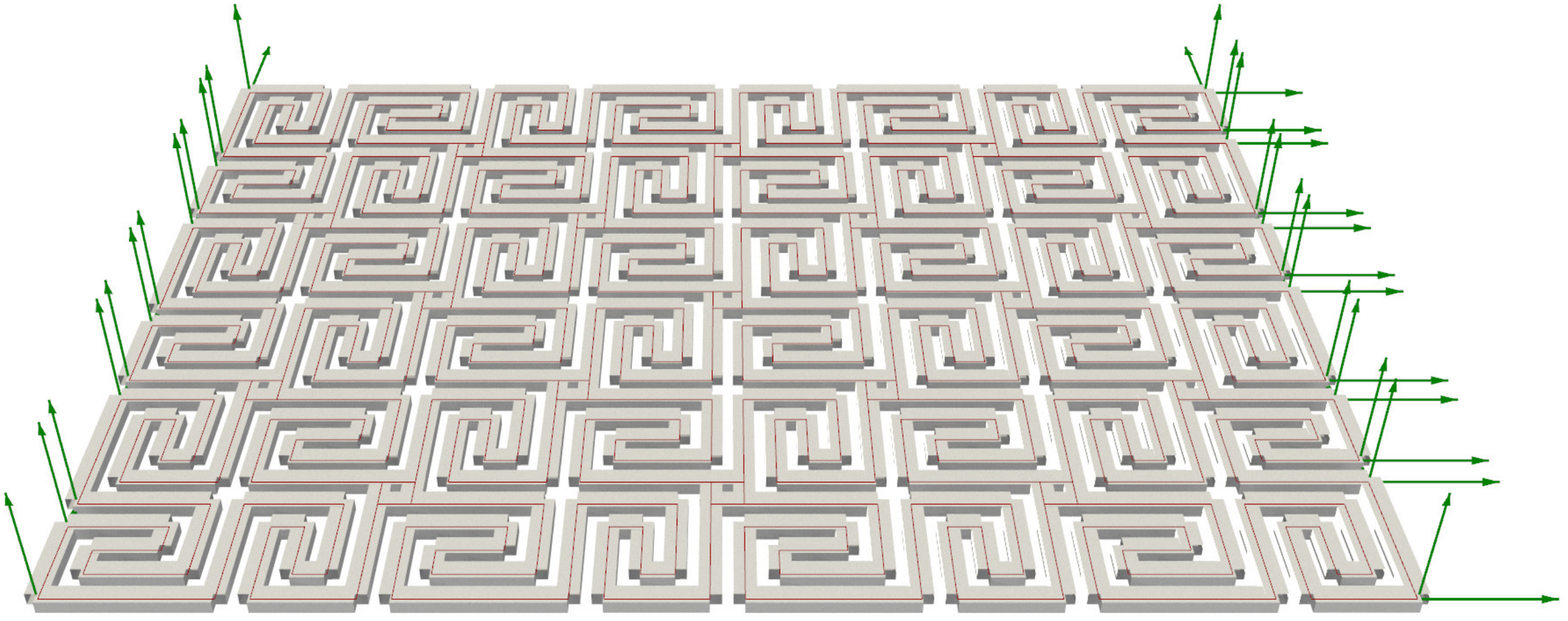


SIMULATION

Karamba

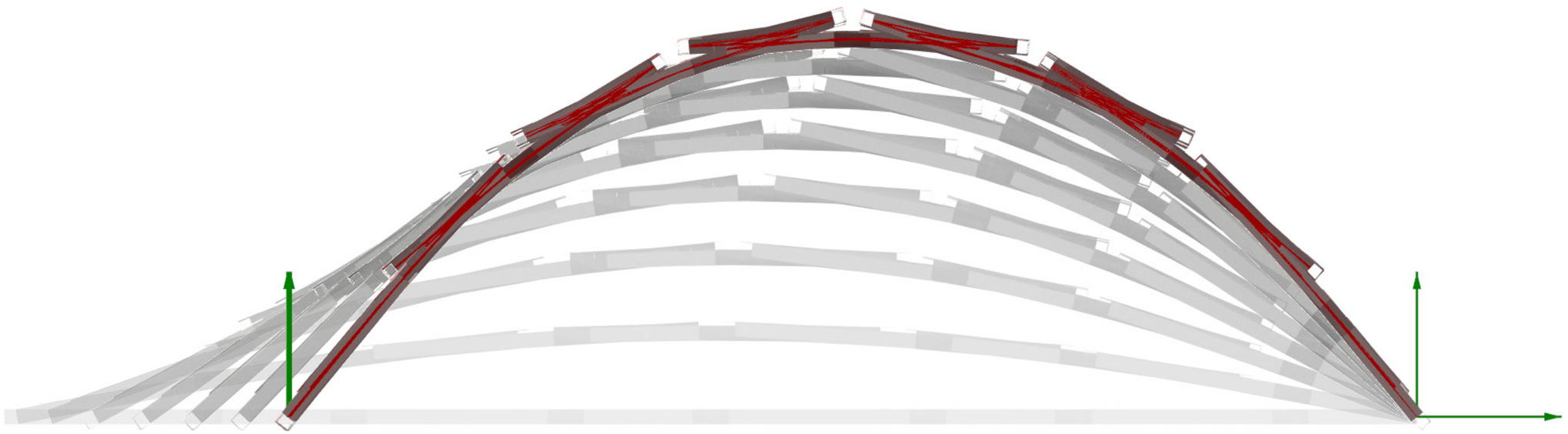
FLEXIBILITY

KARAMBA MODEL



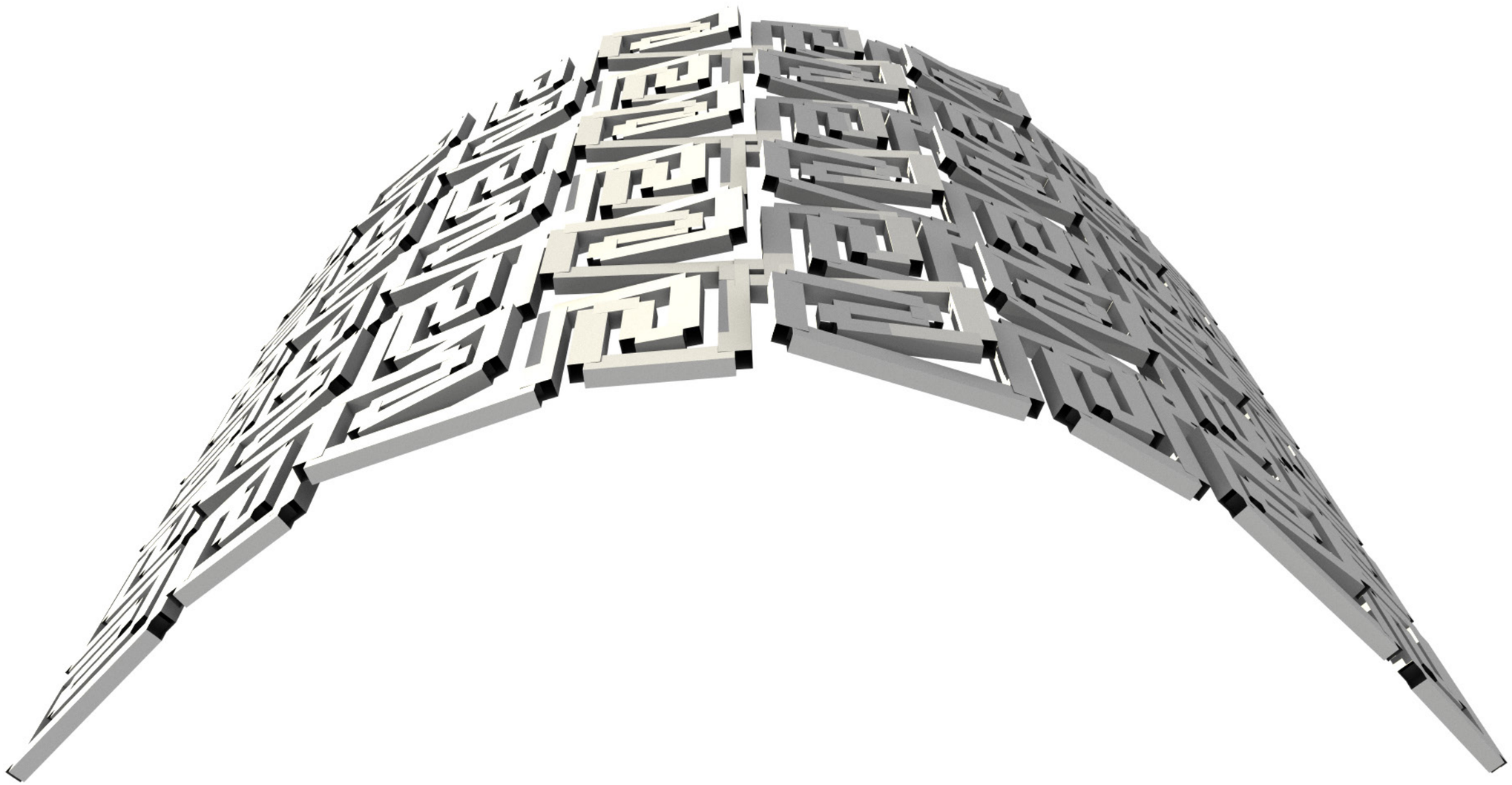
FLEXIBILITY

KARAMBA MODEL



FLEXIBILITY

KARAMBA MODEL



FLEXIBILITY
SIMULATIONS

Unit size
150 mm

Number of iterations
4

Kerf width
5 mm

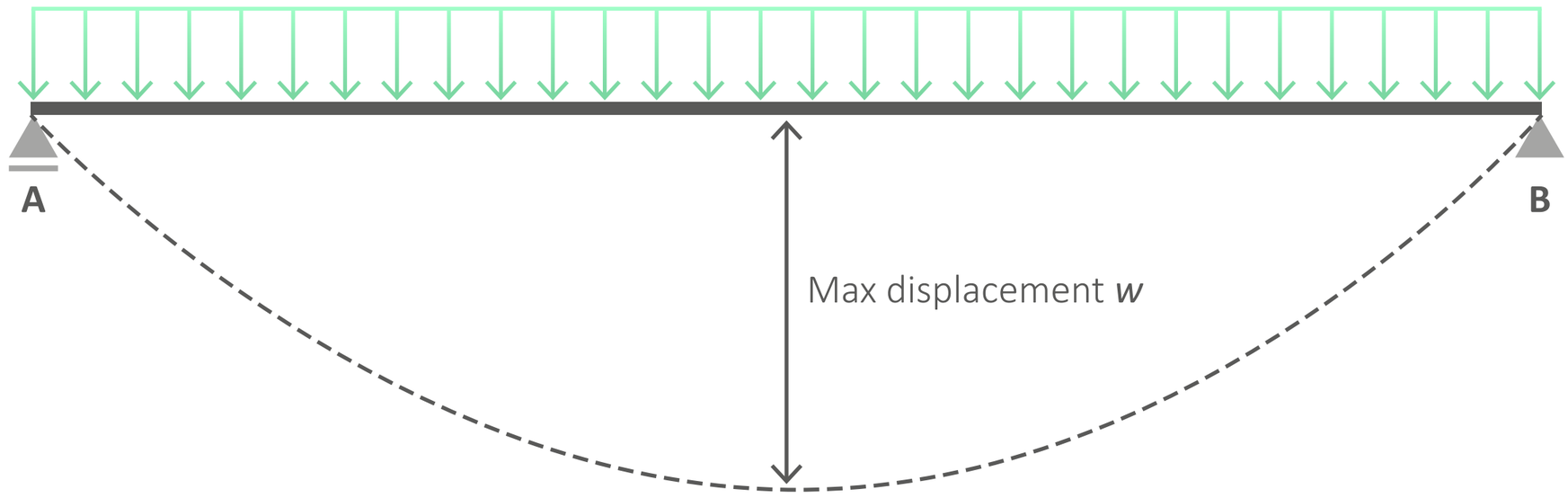
Segment width
10 mm

Segment height
6 mm

Open surface area
30%

FLEXIBILITY

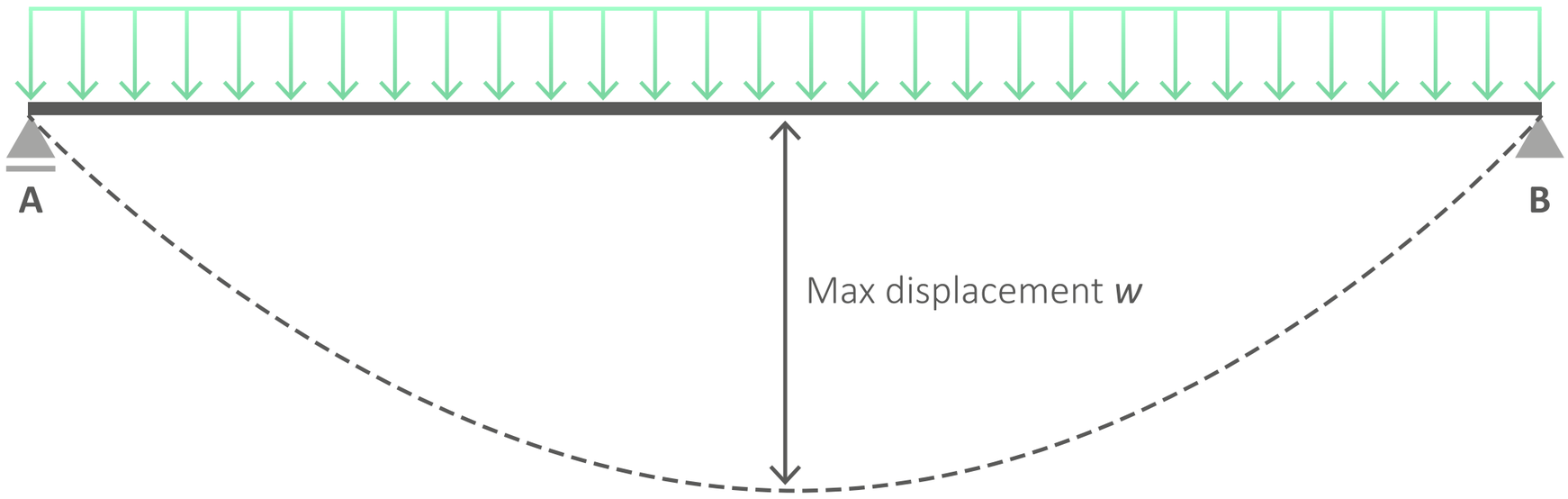
SIMULATIONS

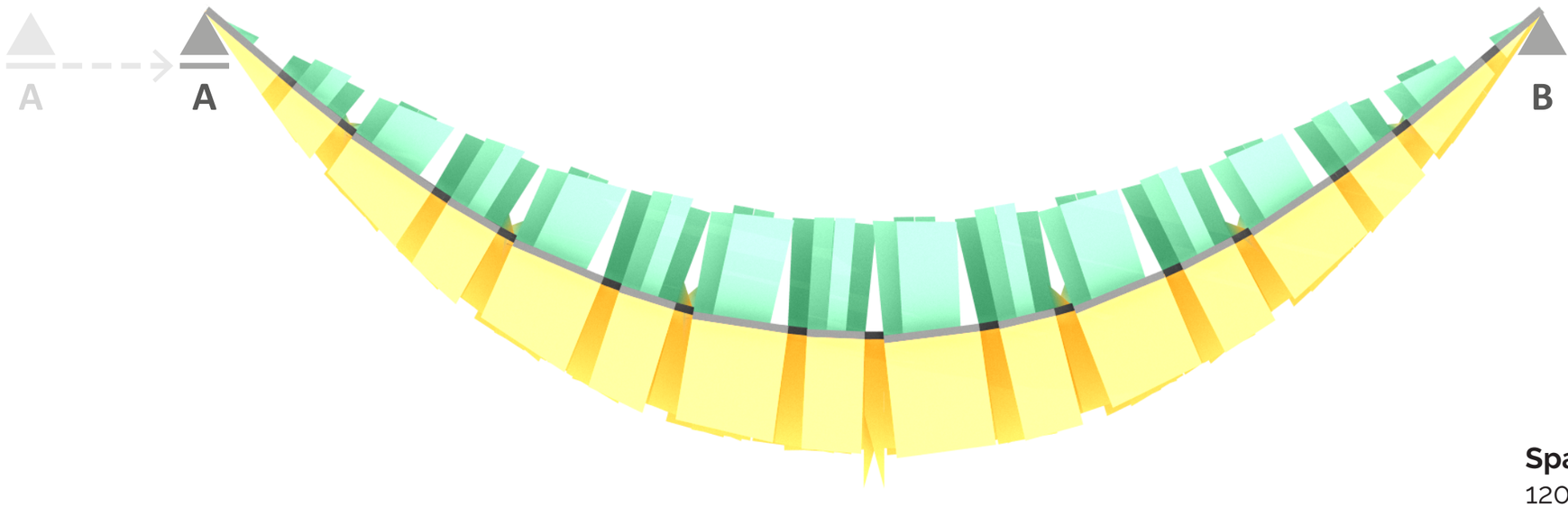


Span
1200 mm

FLEXIBILITY

SIMULATIONS

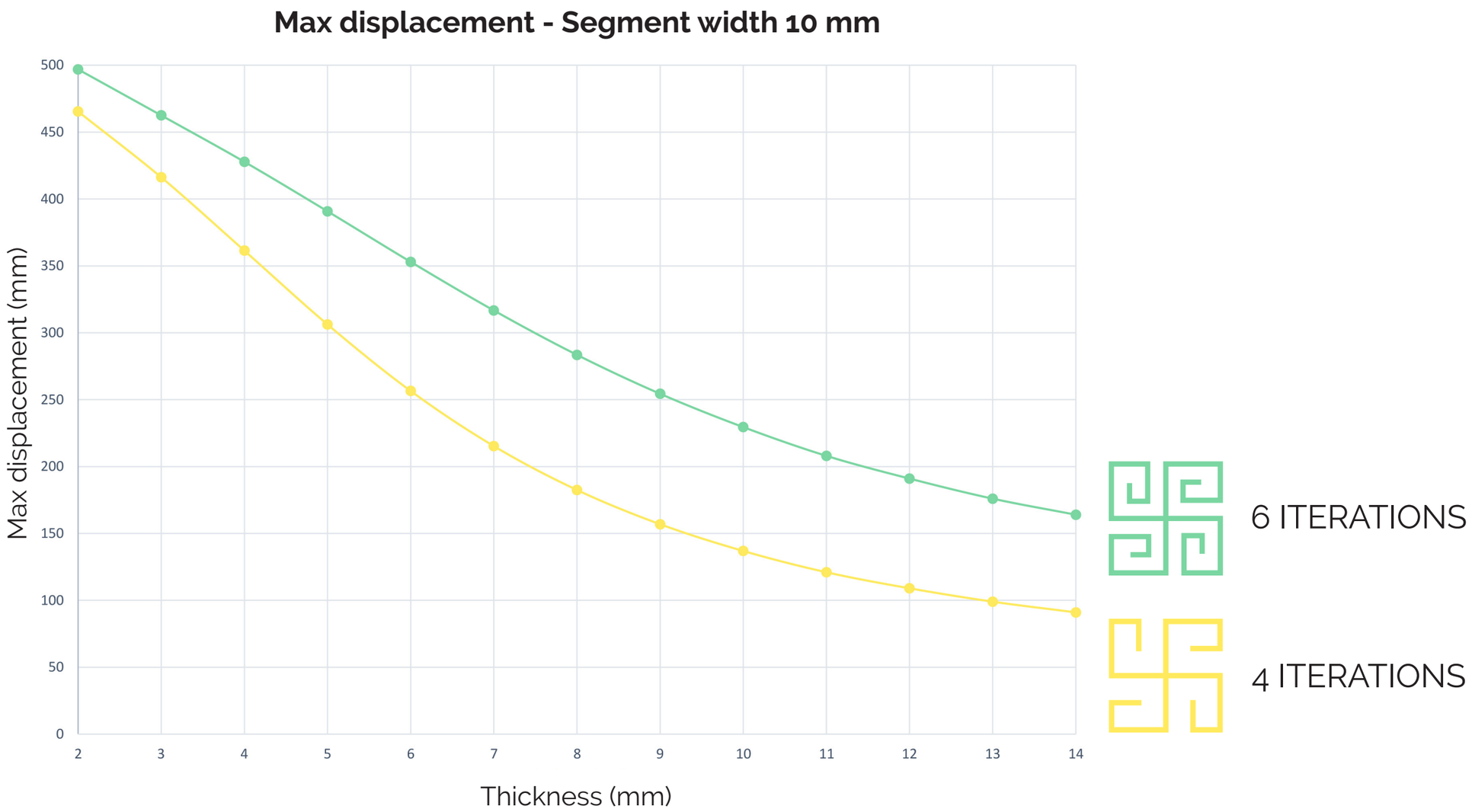




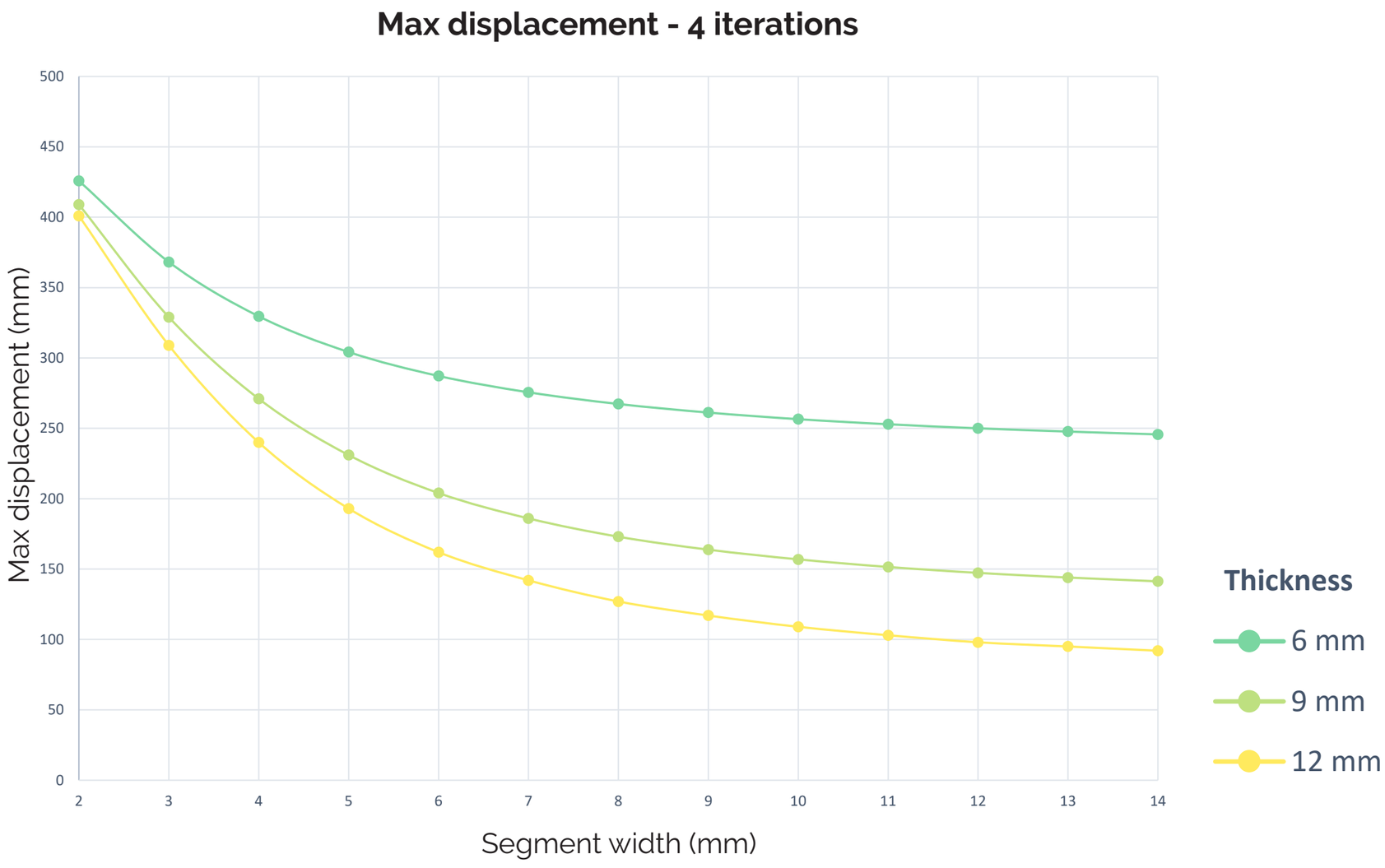
Span
1200 mm

Max displacement
257 mm

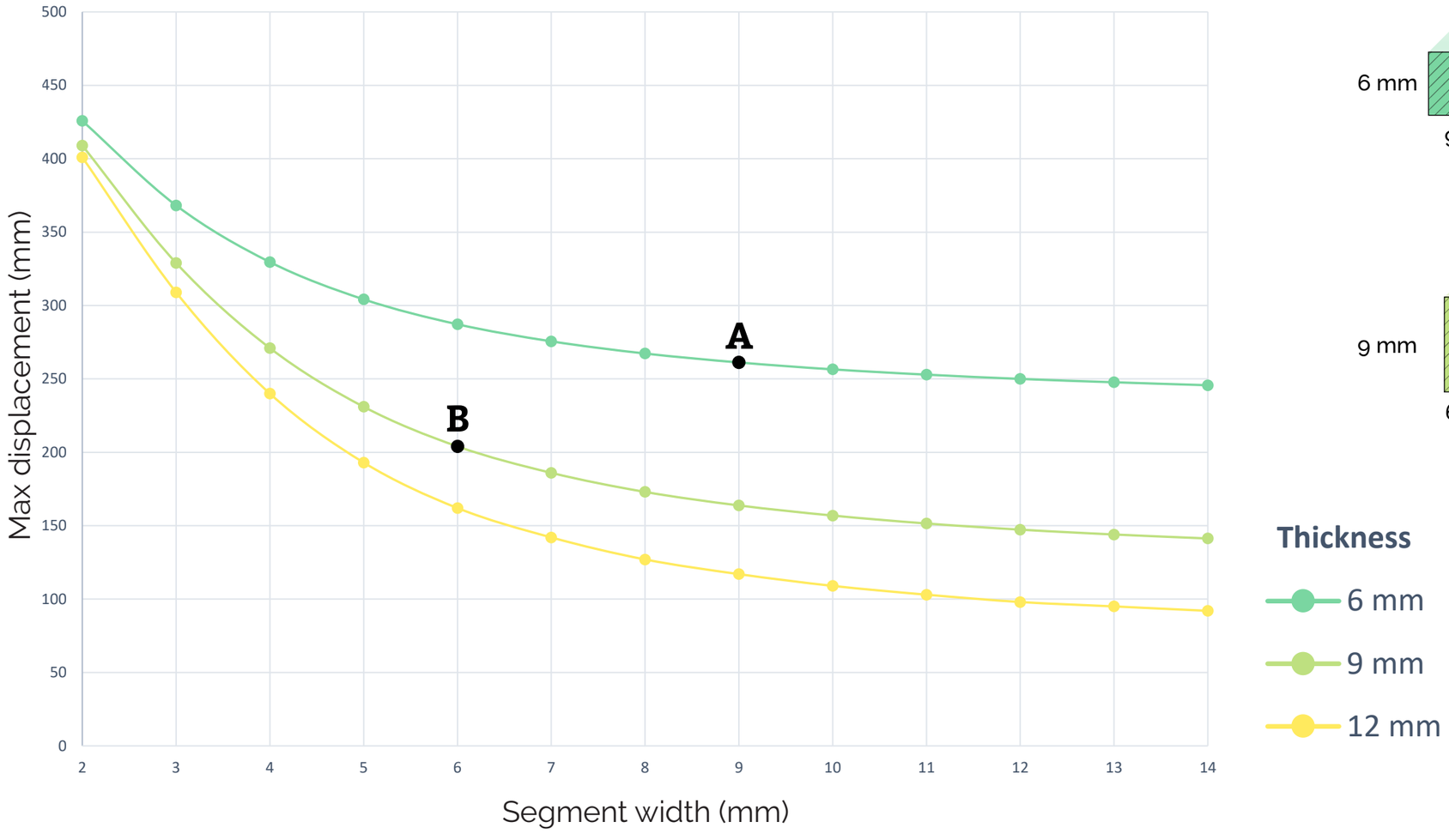
FLEXIBILITY
SIMULATIONS

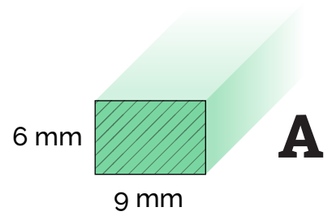


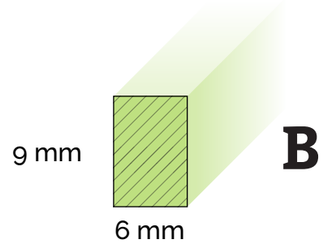
FLEXIBILITY
SIMULATIONS



FLEXIBILITY
SIMULATIONS







SUB-QUESTION

PATTERN
on
FLEXIBILITY

How does pattern kerfing influence the attainable curvature of a panel?

SUB-QUESTION

PATTERN
on
FLEXIBILITY

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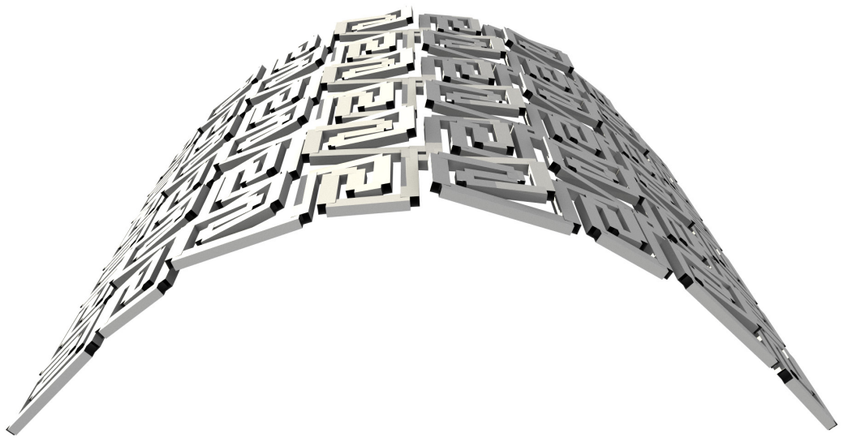


Interconnected segments enhance flexibility by means of torsion and bending, based on the chosen pattern parameters.

ACOUSTICS

TYPE OF PATTERN

ACOUSTICS
PARAMETERS

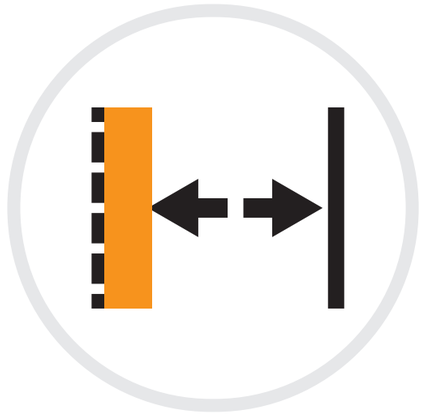
TYPE OF PATTERN

OPEN SURFACE AREA

ACOUSTICS
PARAMETERS

TYPE OF PATTERN

OPEN SURFACE AREA



AIR CAVITY

ACOUSTICS
PARAMETERS

TYPE OF PATTERN

OPEN SURFACE AREA

AIR CAVITY

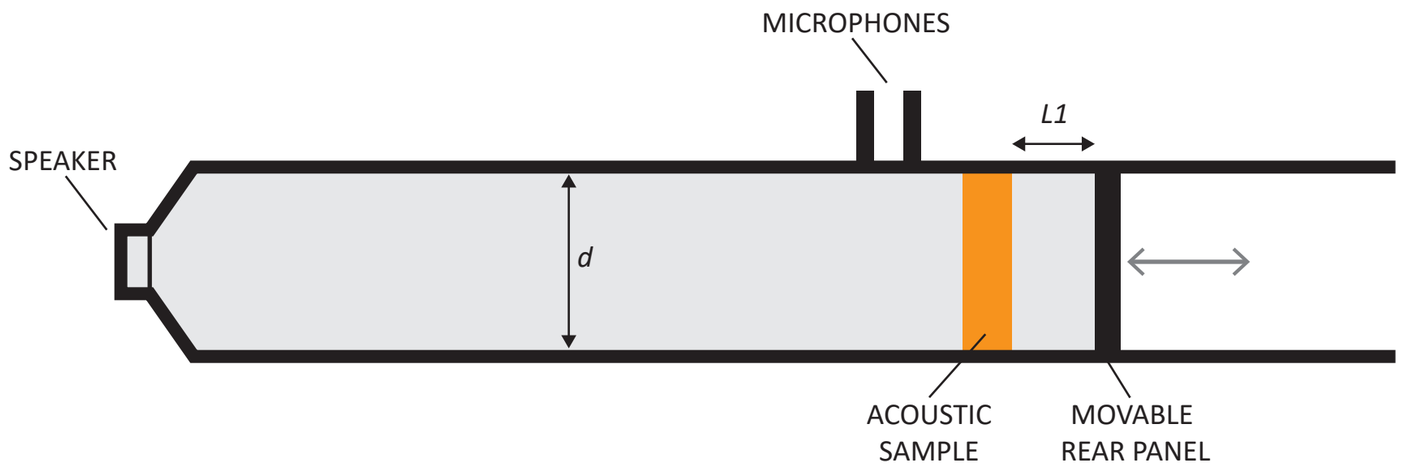
SURFACE CURVATURE

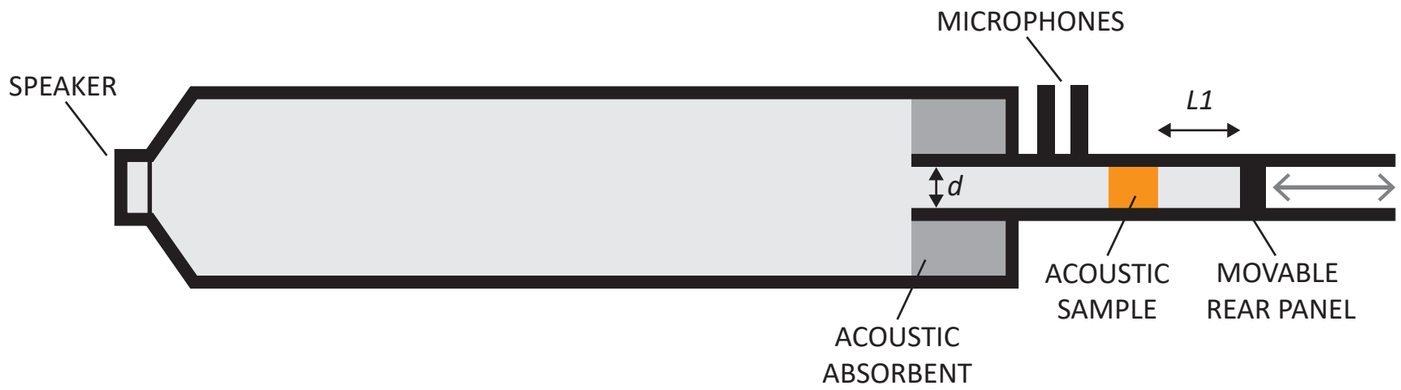
ACOUSTICS

MEASUREMENTS IMPEDANCE TUBE

ACOUSTICS

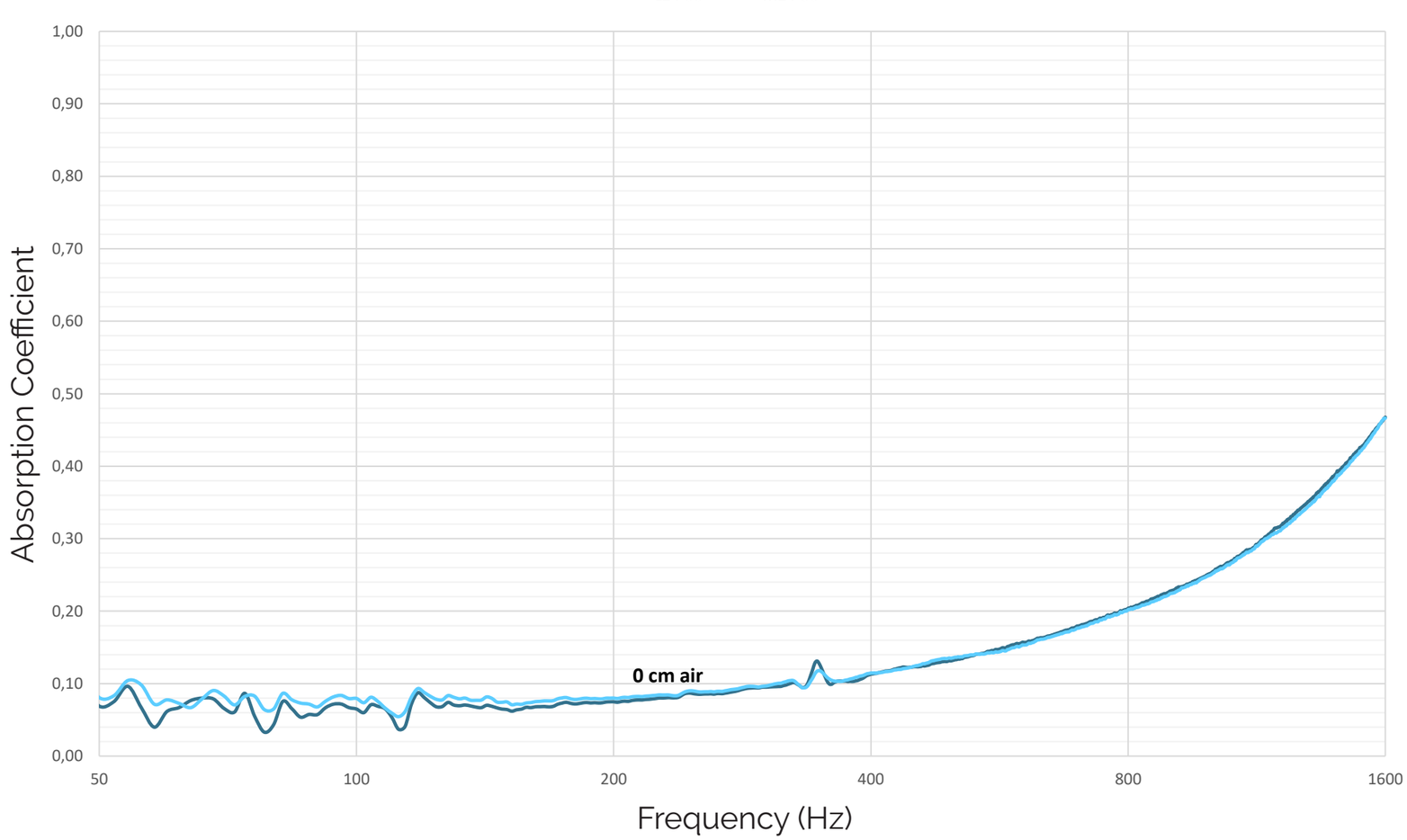
MEASUREMENTS IMPEDANCE TUBE





ACOUSTICS

MEASUREMENTS IMPEDANCE TUBE



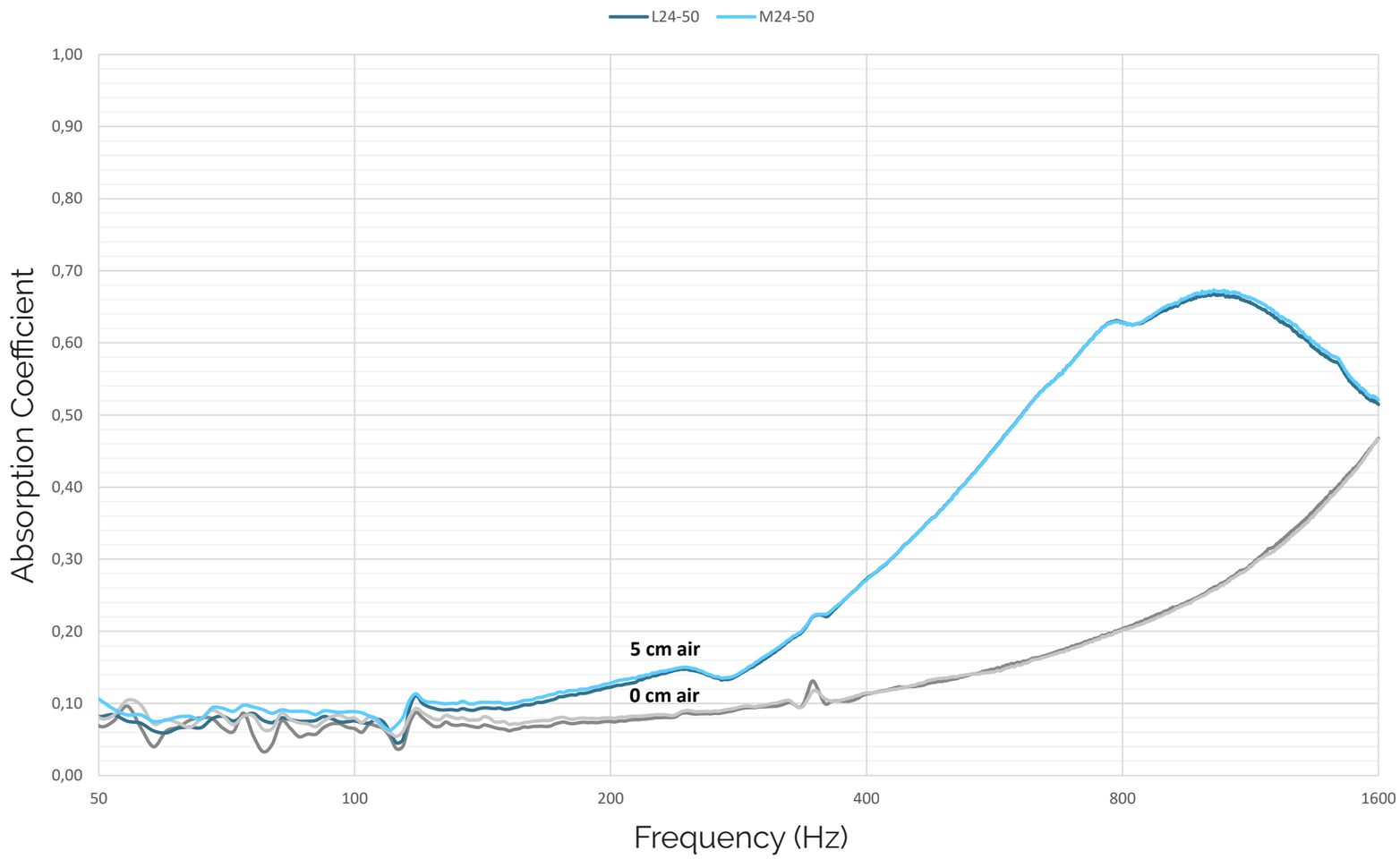
L24-50

M24-50

ACOUSTICS

MEASUREMENTS IMPEDANCE TUBE

ABSORPTION COEFFICIENT: L24-50 (31,1%) & M24-50 (30,5%)



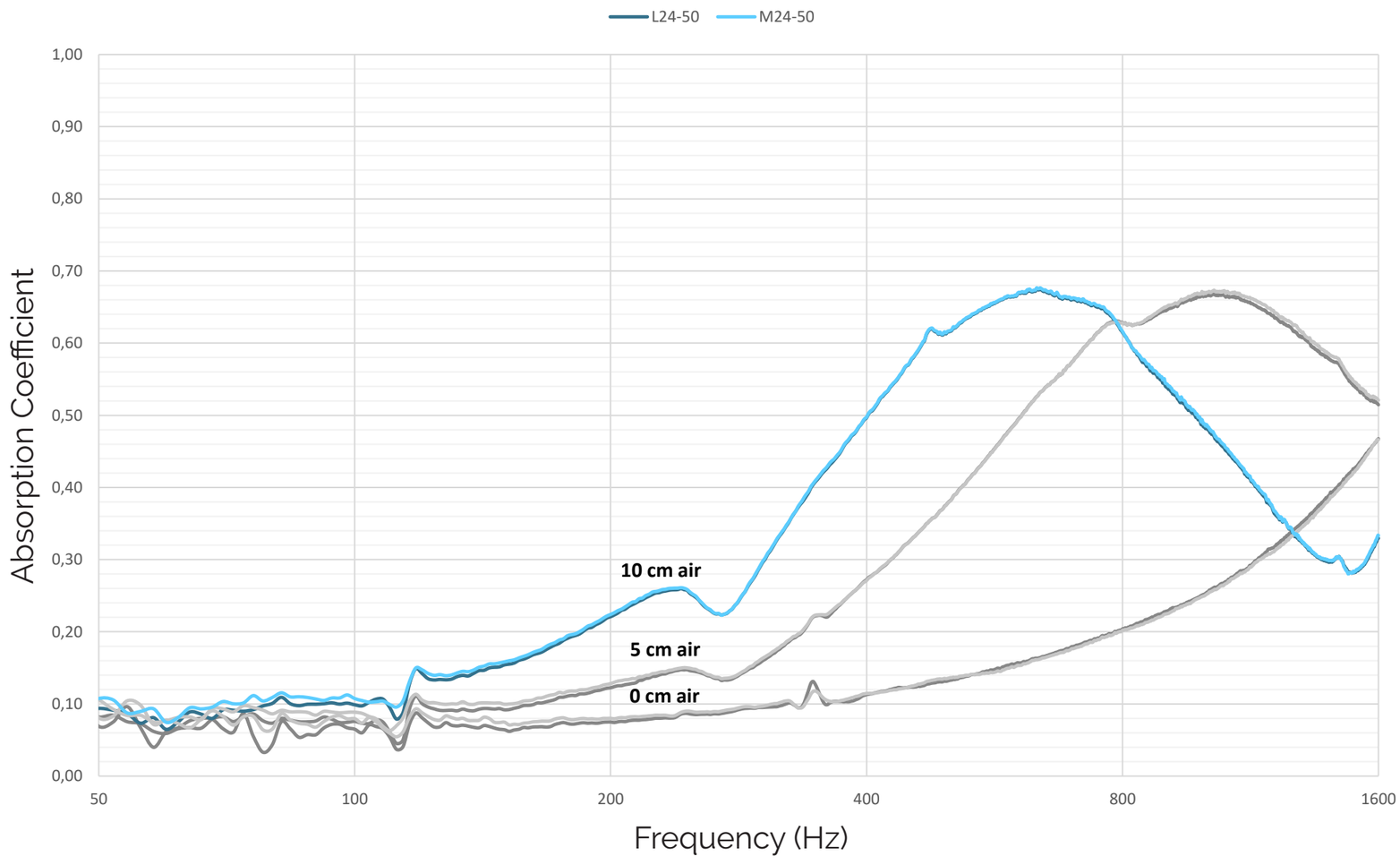
L24-50

M24-50

ACOUSTICS

MEASUREMENTS IMPEDANCE TUBE

ABSORPTION COEFFICIENT: L24-50 (31,1%) & M24-50 (30,5%)



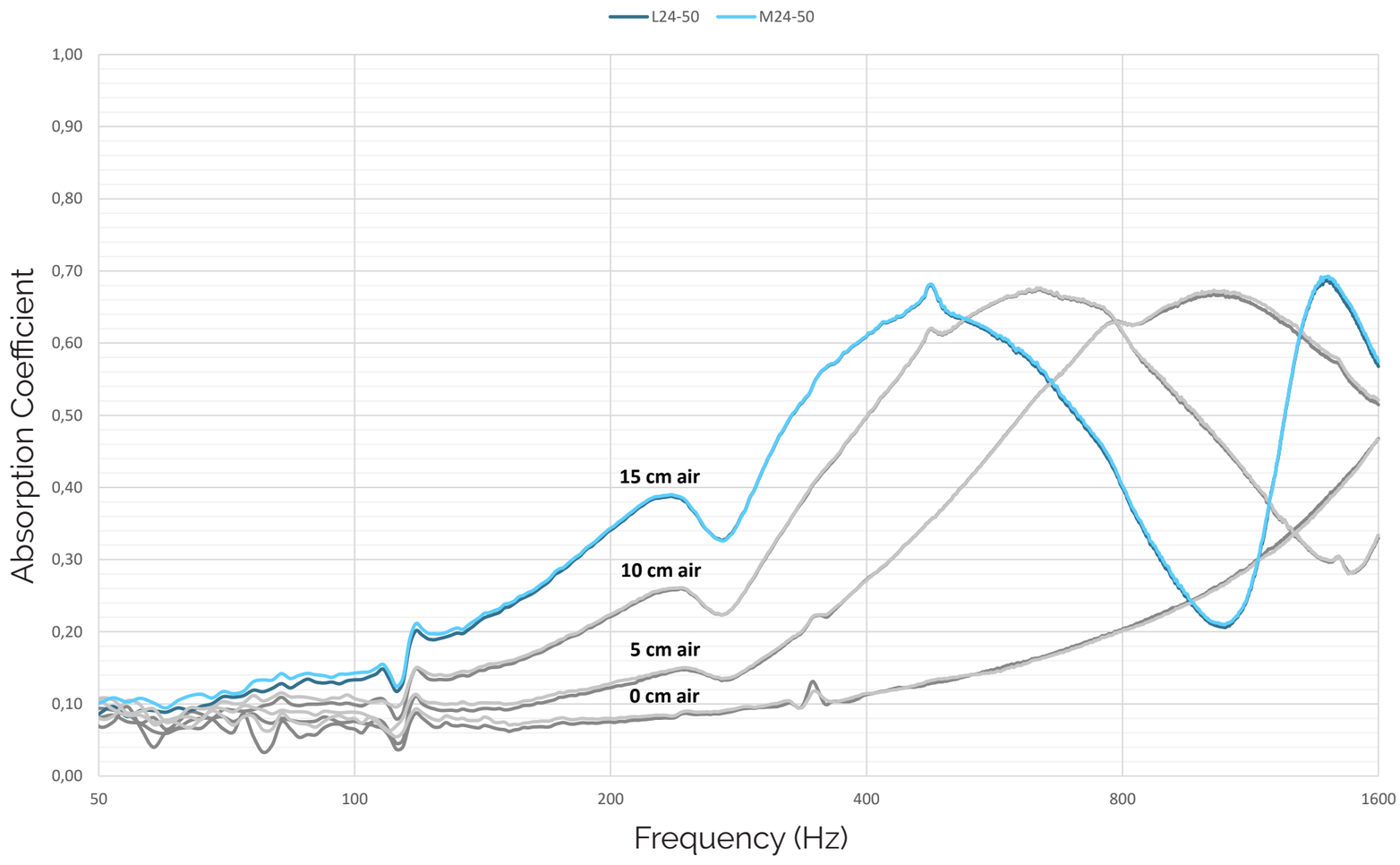
L24-50

M24-50

ACOUSTICS

MEASUREMENTS IMPEDANCE TUBE

ABSORPTION COEFFICIENT: L24-50 (31,1%) & M24-50 (30,5%)

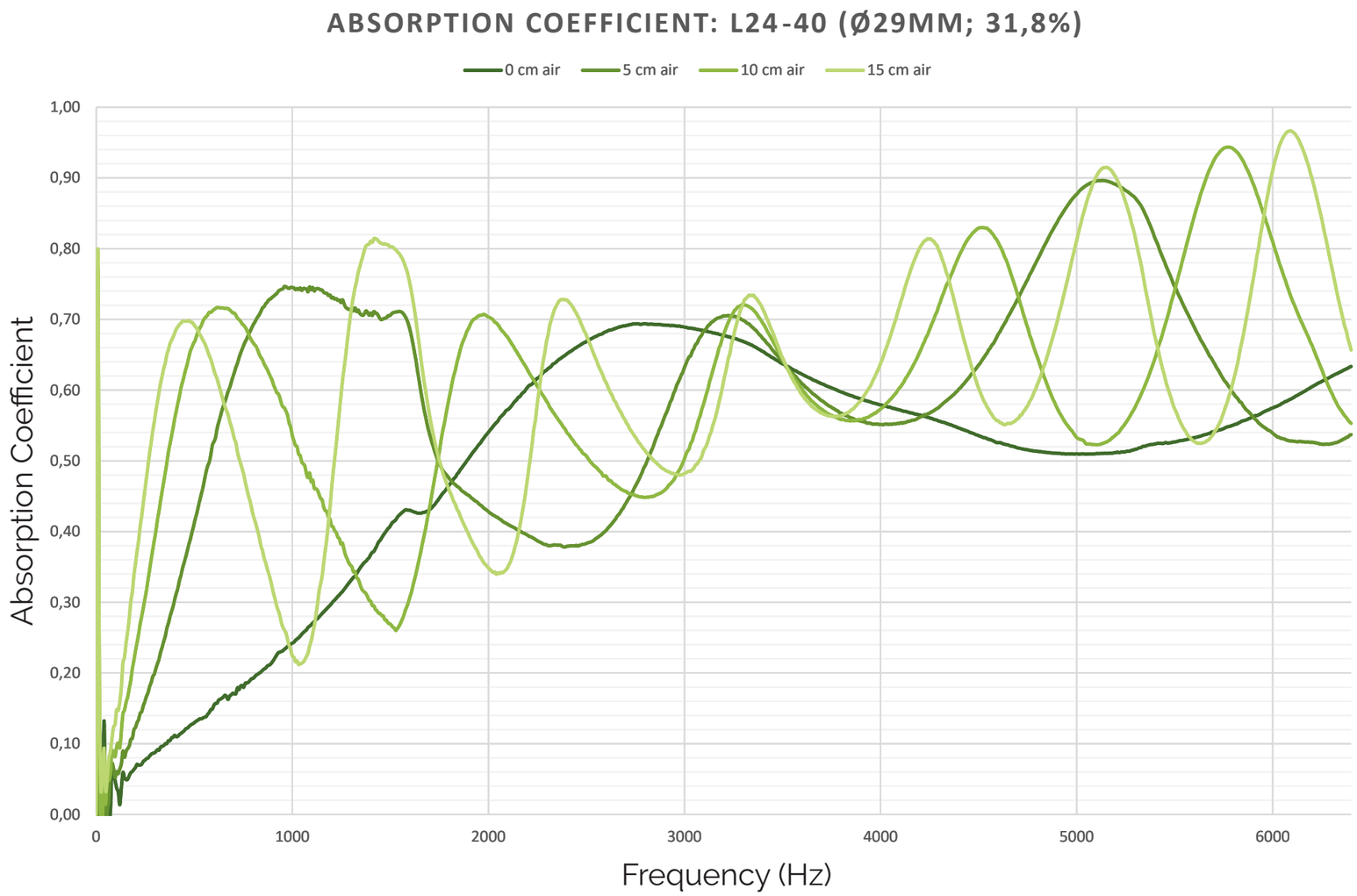


L24-50

M24-50

ACOUSTICS

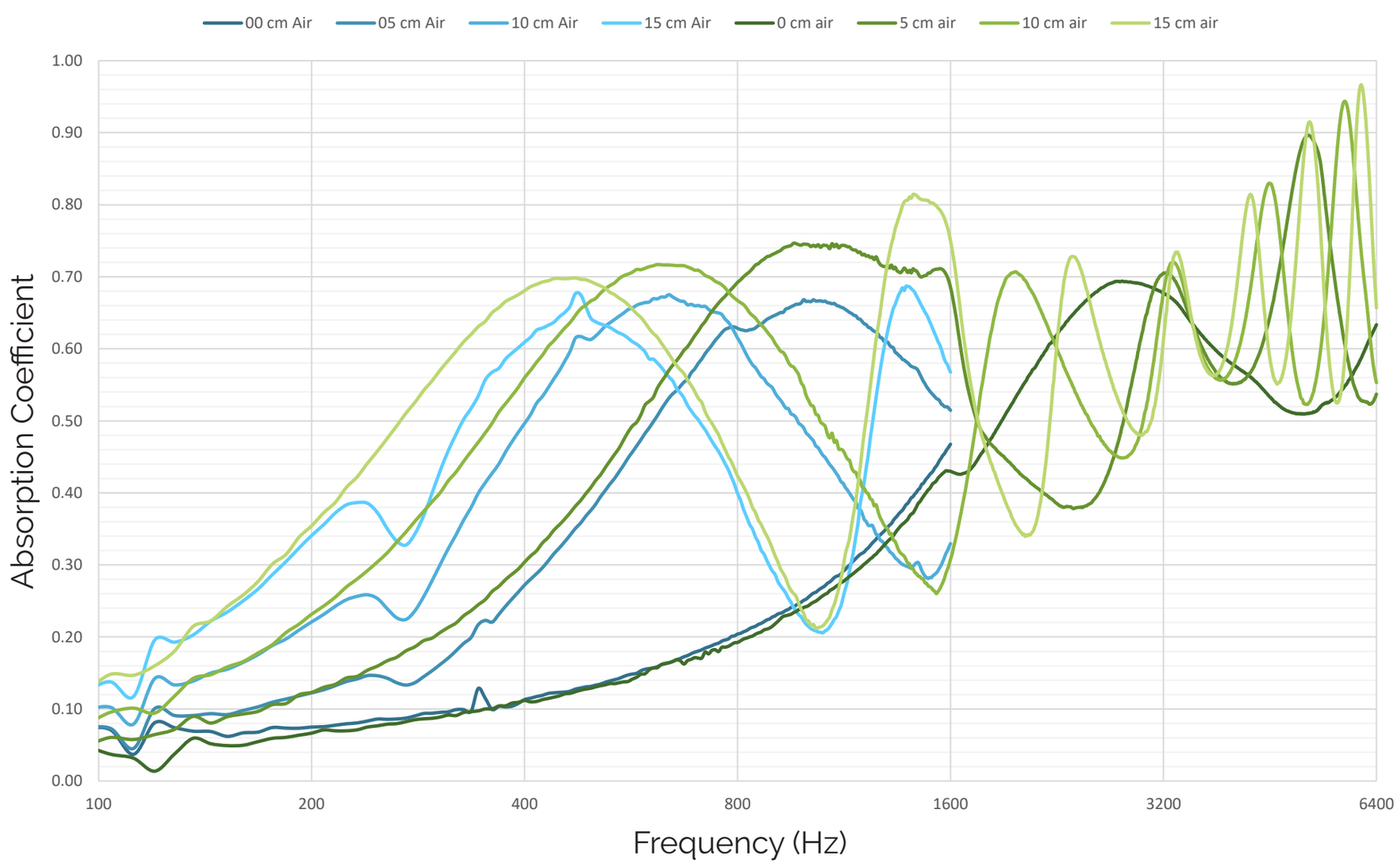
MEASUREMENTS IMPEDANCE TUBE



L24-40

ACOUSTICS

MEASUREMENTS IMPEDANCE TUBE

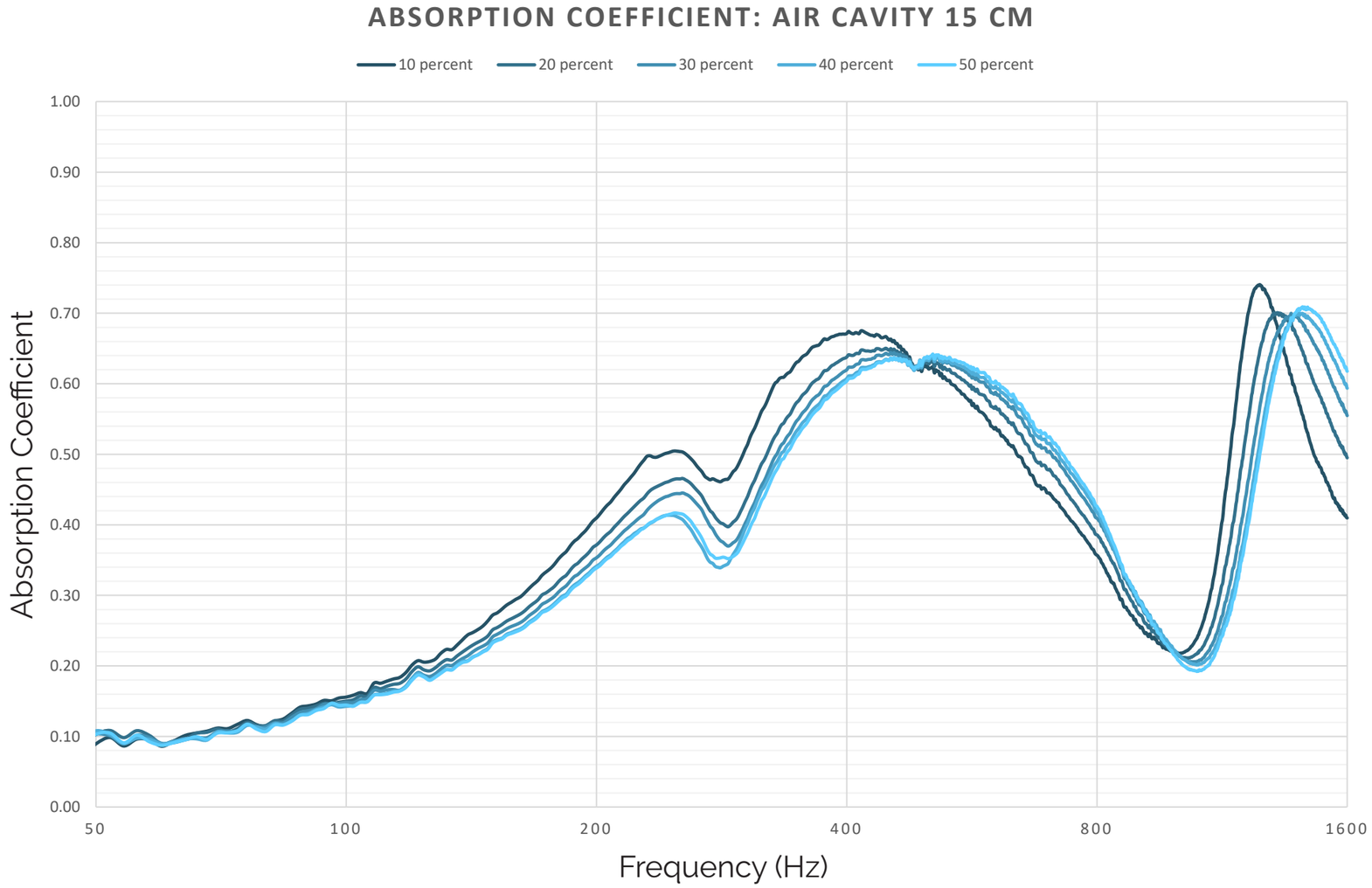


L24-40

L24-40

ACOUSTICS

MEASUREMENTS IMPEDANCE TUBE

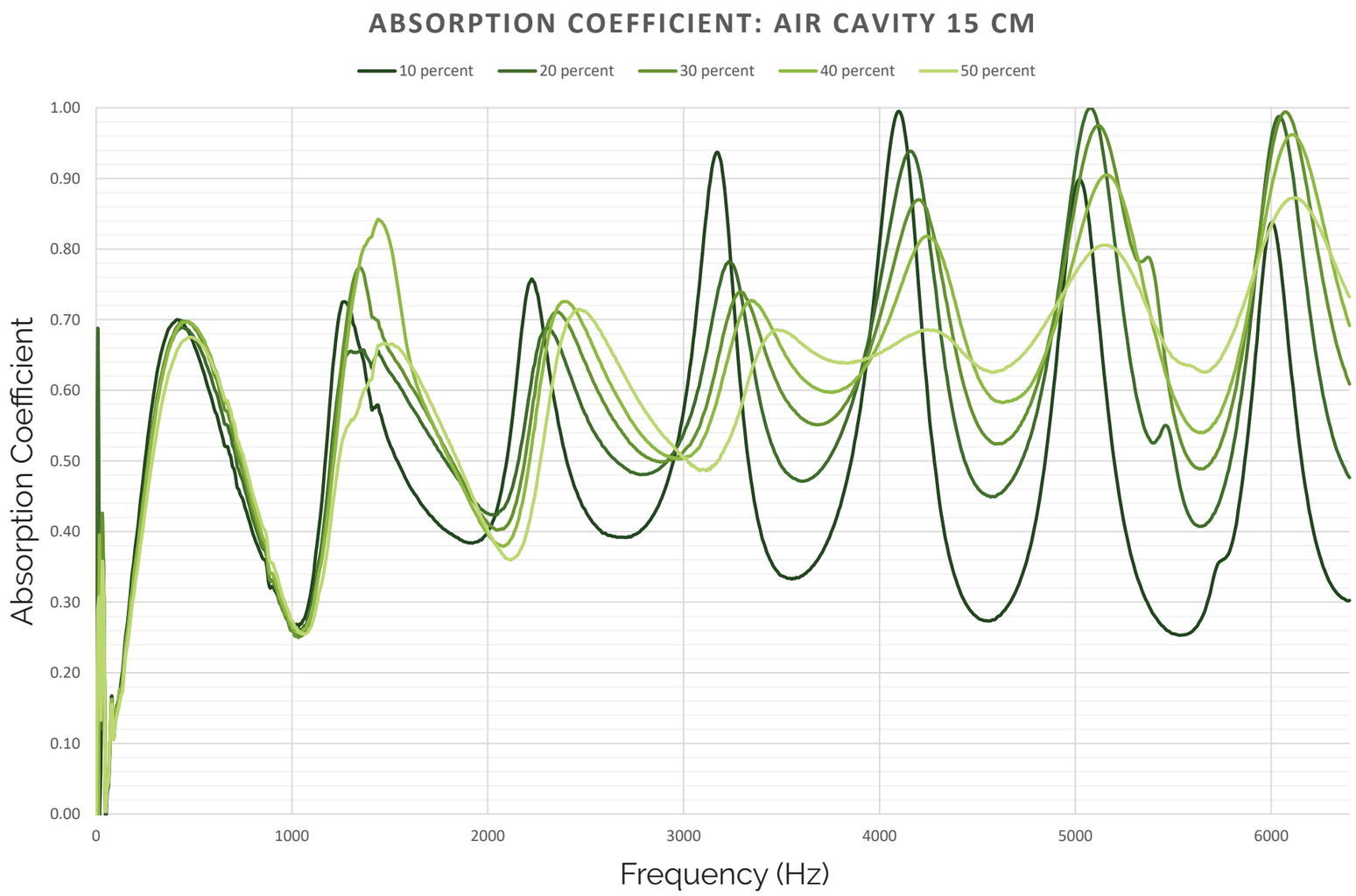


OSA: 10 %

OSA: 50 %

ACOUSTICS

MEASUREMENTS IMPEDANCE TUBE



OSA: 10 %

OSA: 20 %

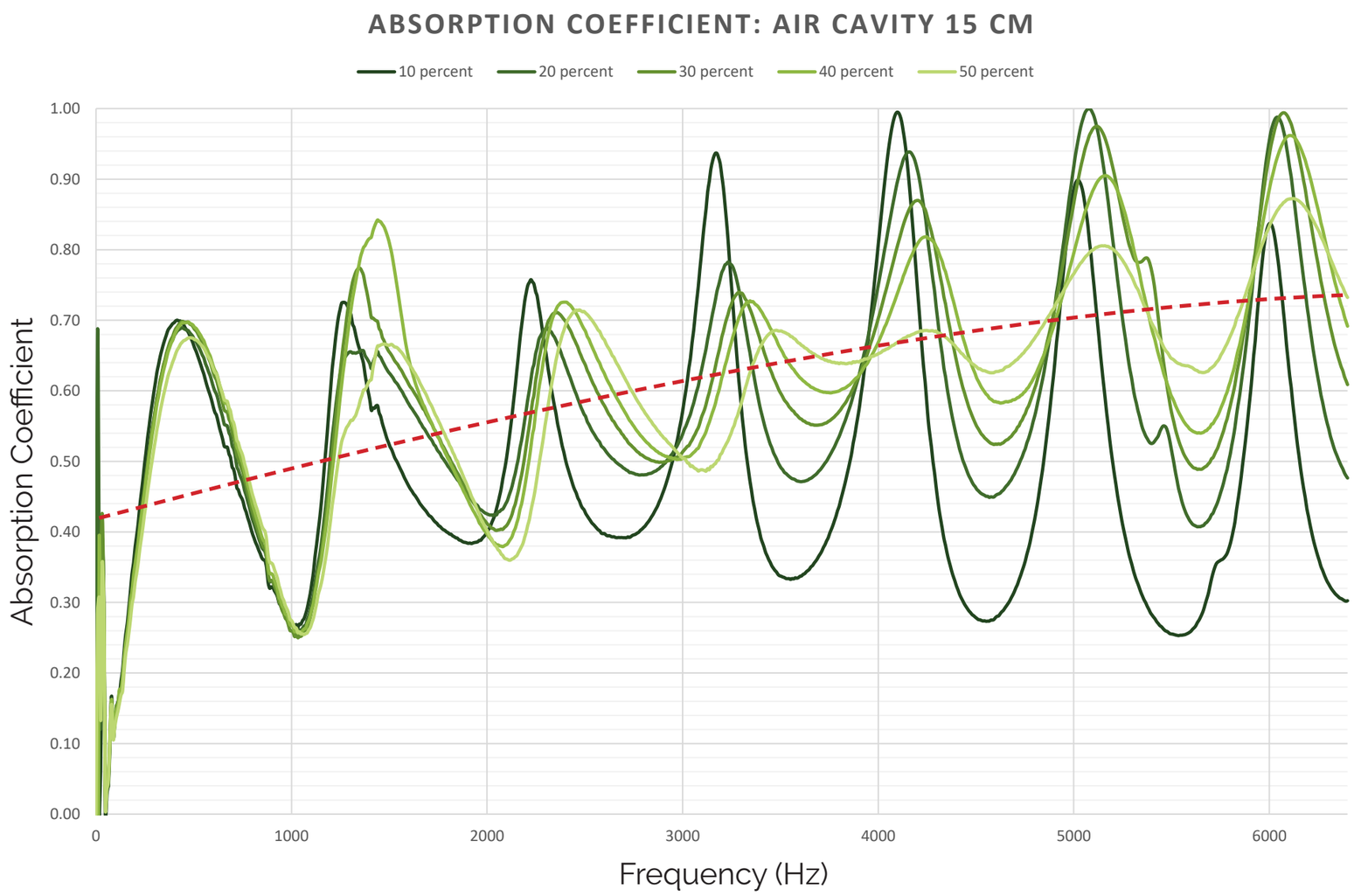
OSA: 30 %

OSA: 40 %

OSA: 50 %

ACOUSTICS

MEASUREMENTS IMPEDANCE TUBE



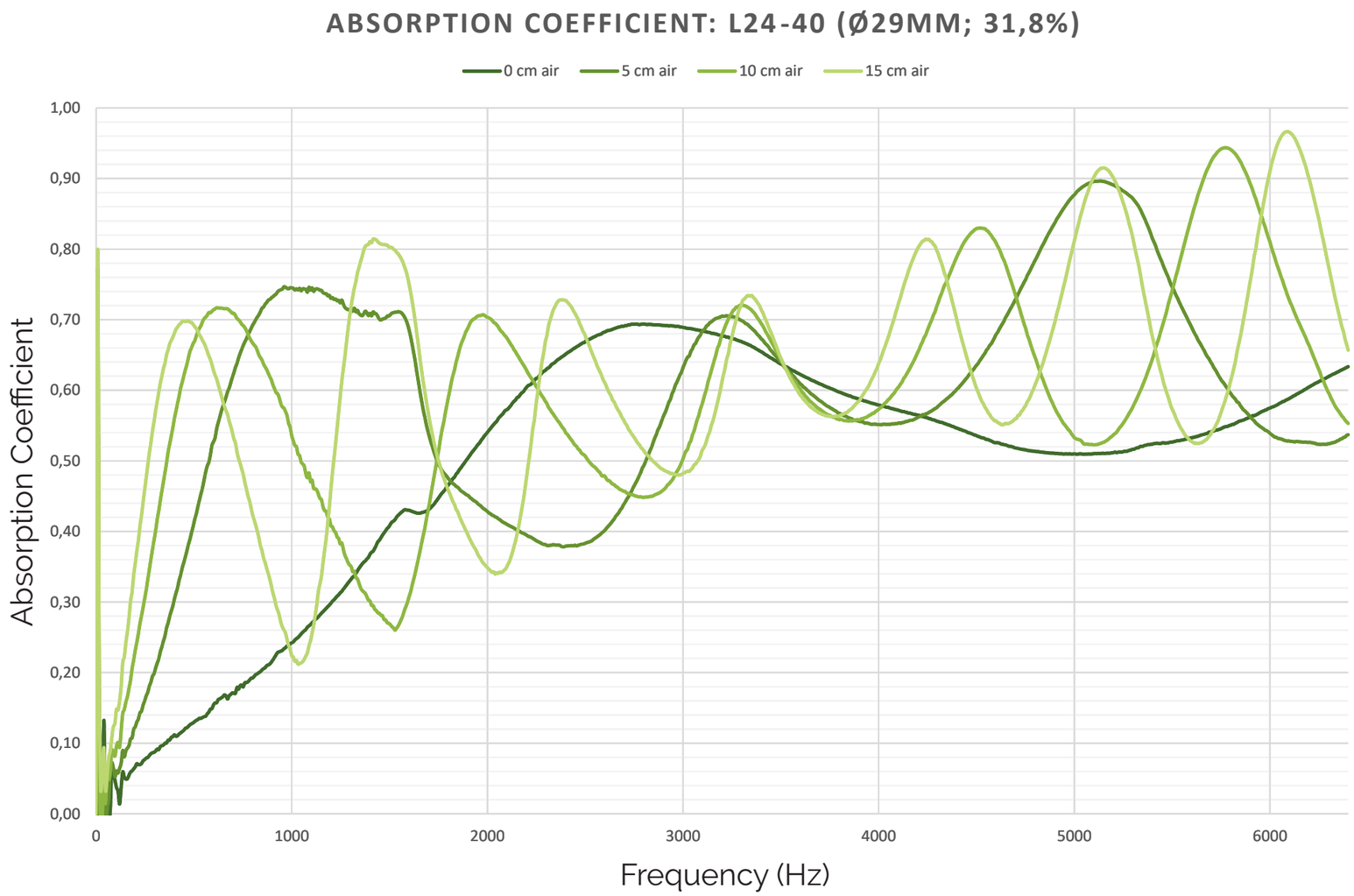
OSA: 10 %

OSA: 20 %

OSA: 30 %

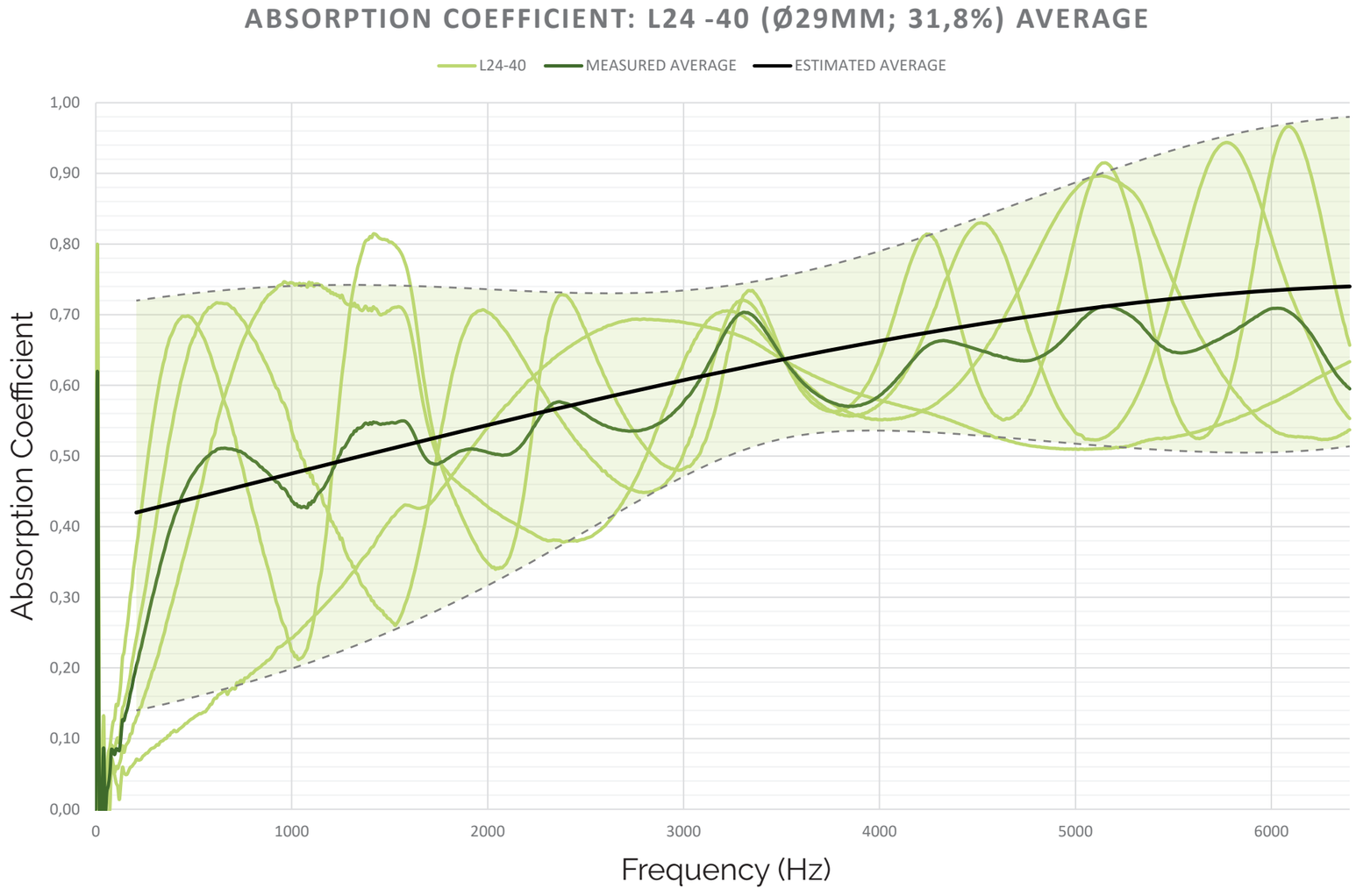
OSA: 40 %

OSA: 50 %


ABSORPTION COEFFICIENT: L24-40 (Ø29MM; 31,8%)
0 cm air
5 cm air
10 cm air
15 cm air
Absorption Coefficient
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
0
1000
2000
3000
4000
5000
6000
Frequency (Hz)

L24-40

ACOUSTICS
CONCLUSIONS



L24-40

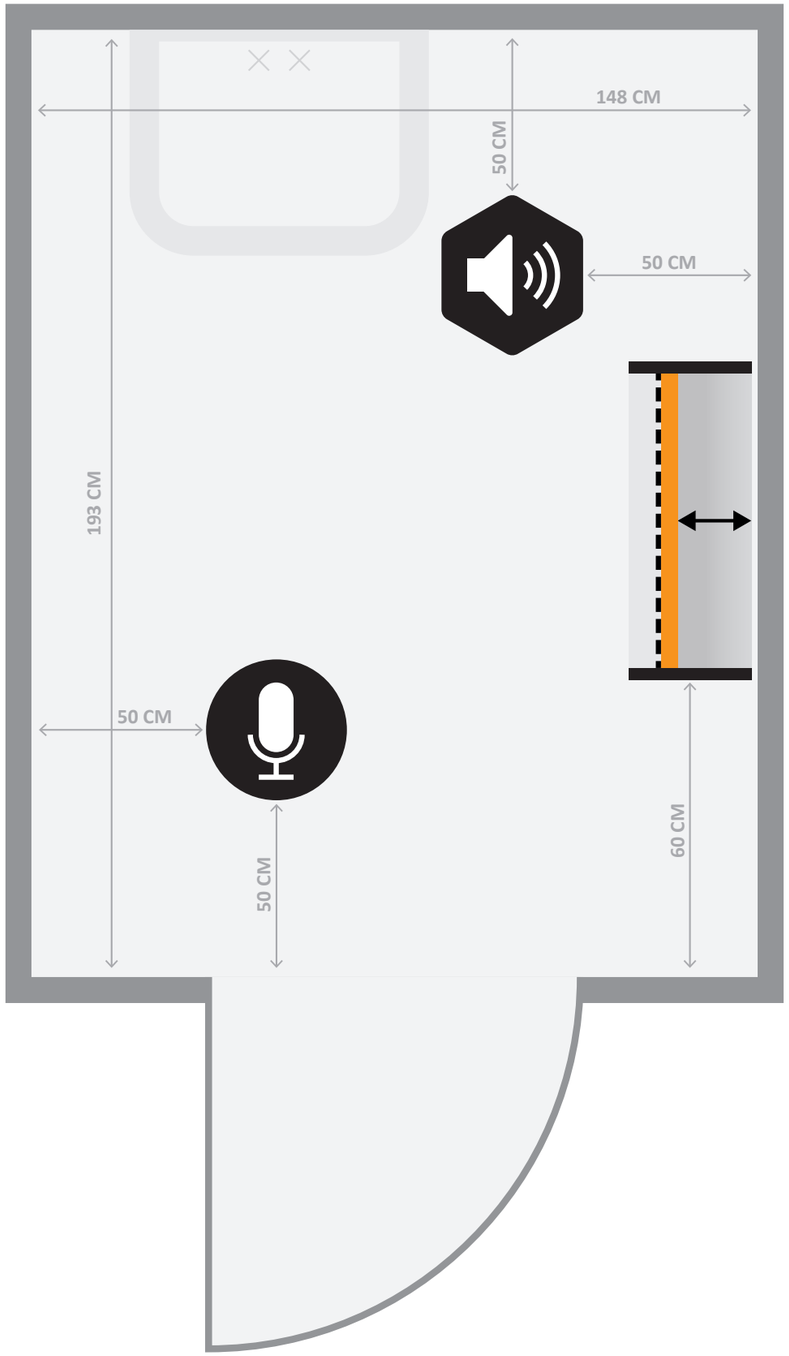
ACOUSTICS

MEASUREMENTS IMPULSE RESPONSE

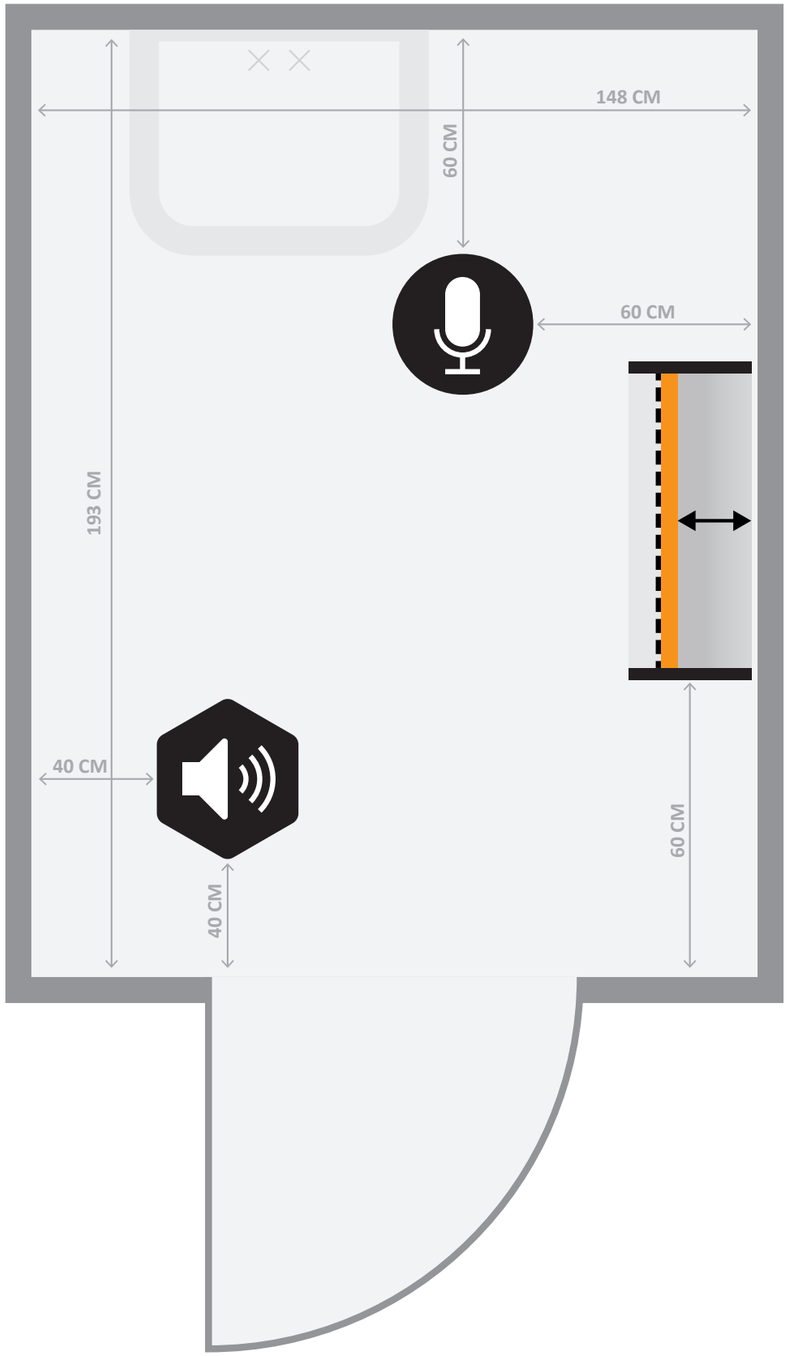
ACOUSTICS

MEASUREMENTS IMPULSE RESPONSE

SETUP **A**



SETUP **B**

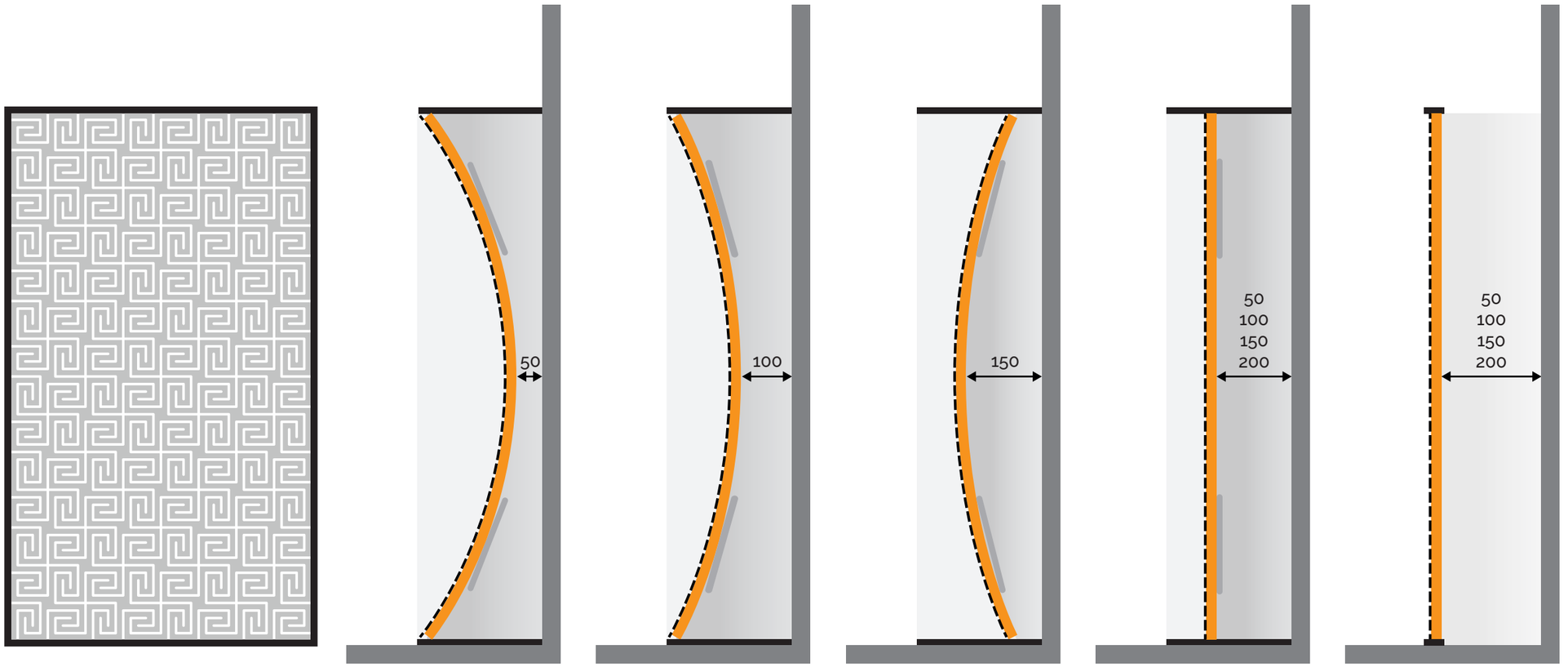


DESIGN

MEASUREMENTS IMPULSE RESPONSE

ACOUSTICS

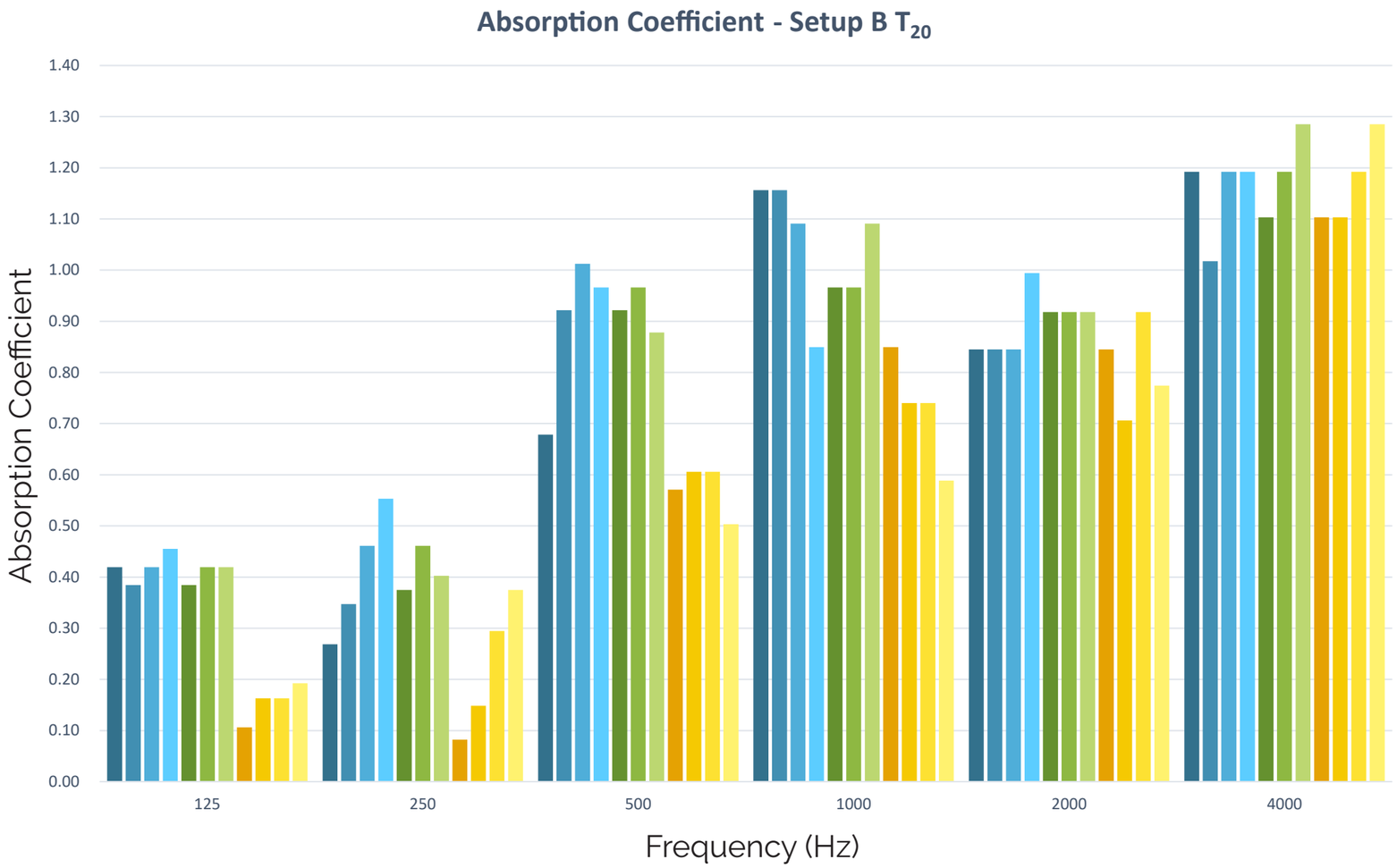
MEASUREMENTS IMPULSE RESPONSE



BOX_CONCAVE_05 BOX_CONCAVE_10 BOX_CONVEX_15 BOX_05, 10, 15, 20 FRAME_05, 10, 15, 20

ACOUSTICS

MEASUREMENTS IMPULSE RESPONSE



SUB-QUESTIONS

PATTERN *on* ACOUSTICS

How does pattern kerfing influence the acoustic performance of a panel?

FLEXIBILITY *on* ACOUSTICS

What effect has a curved surface of a panel on its acoustic performance?

SUB-QUESTIONS

PATTERN *on* ACOUSTICS

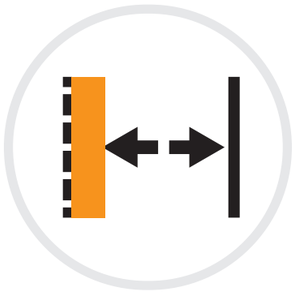
How does pattern kerfing influence the acoustic performance of a panel?

FLEXIBILITY *on* ACOUSTICS

What effect has a curved surface of a panel on its acoustic performance?

>> No effect

>> Amplitude

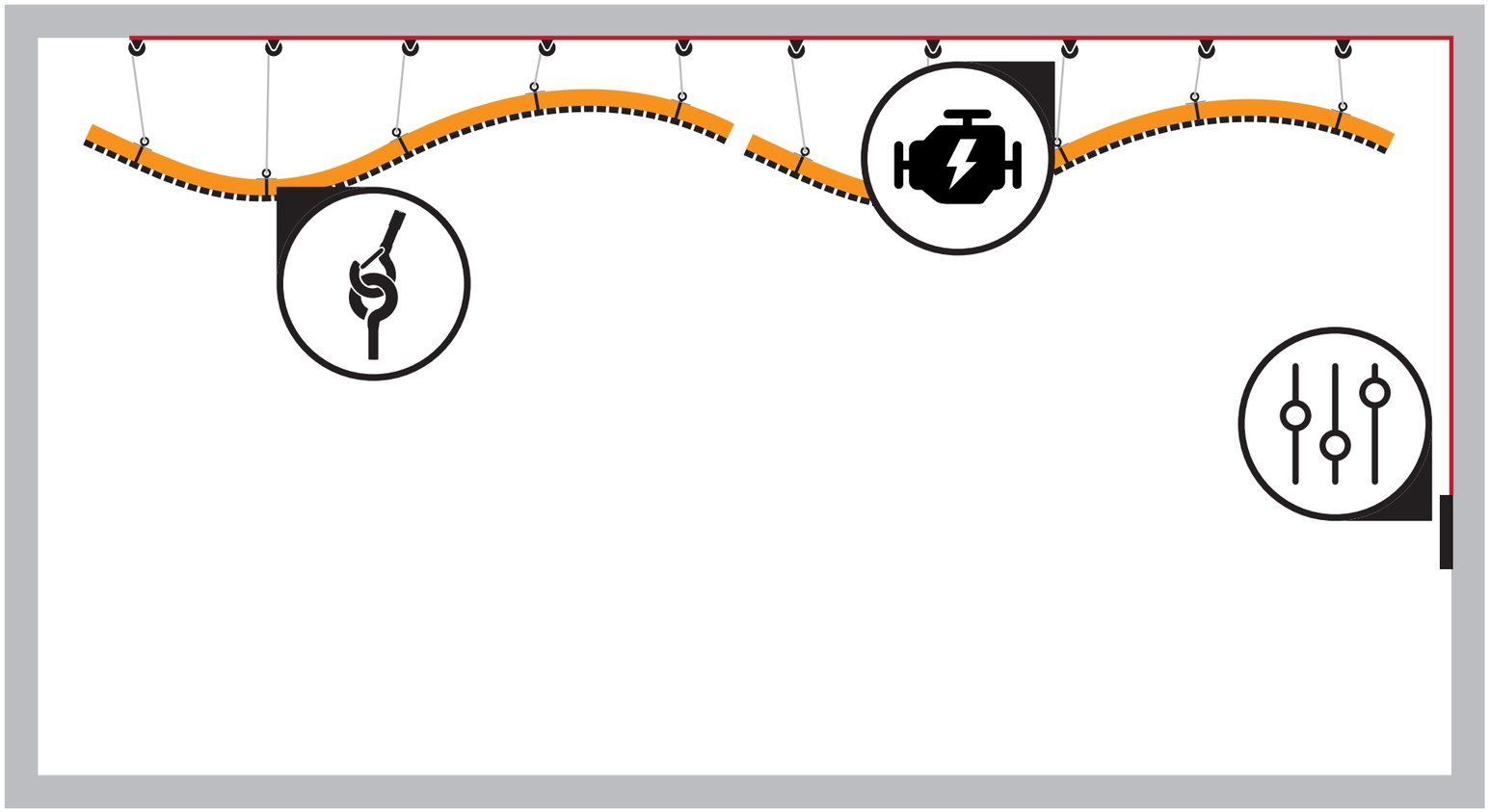


>> Peak position

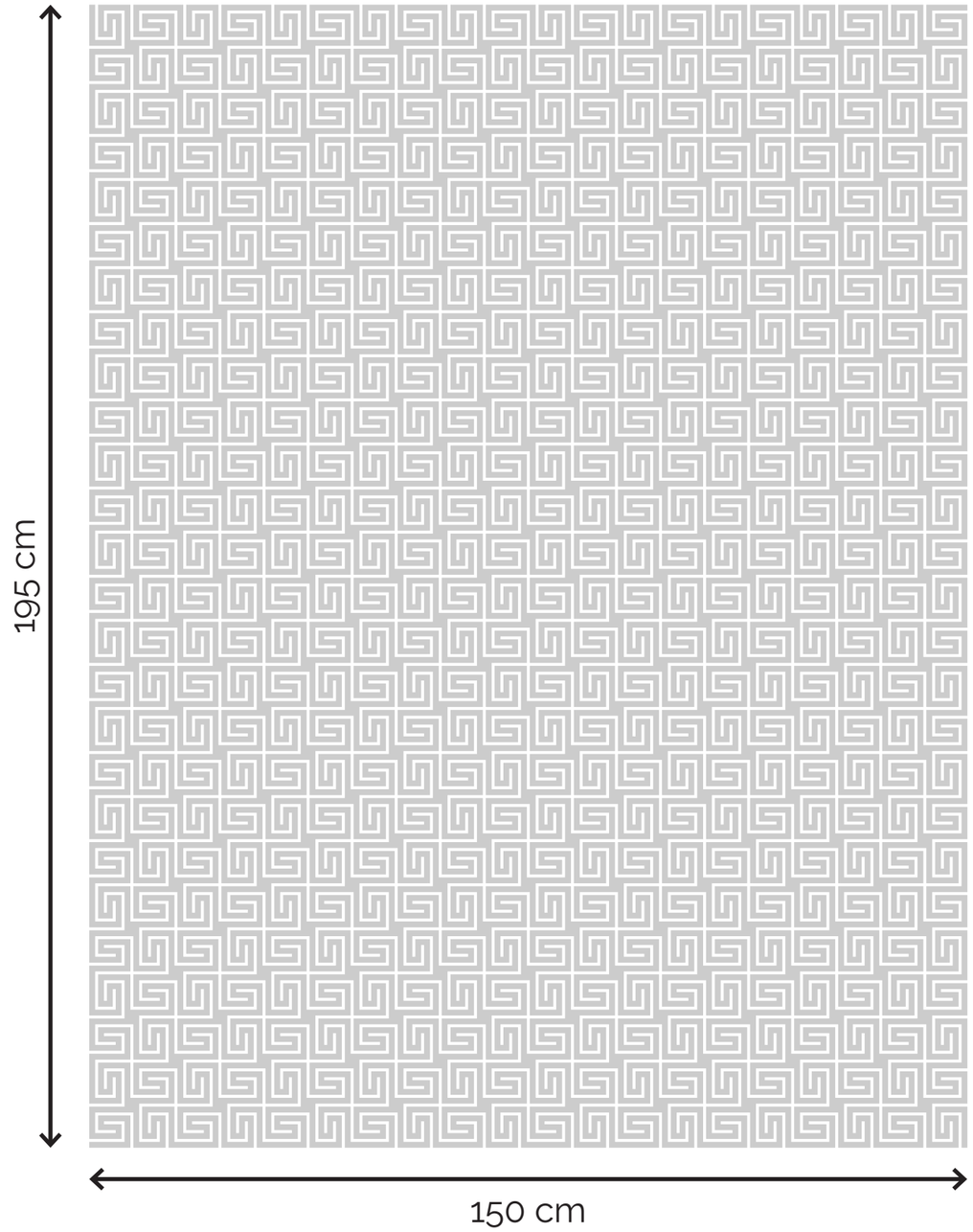
>> Air cavity (reflection)

DESIGN

DESIGN
CONCEPT



DESIGN
CONCEPT



Unit size
150 mm

Number of iterations
4

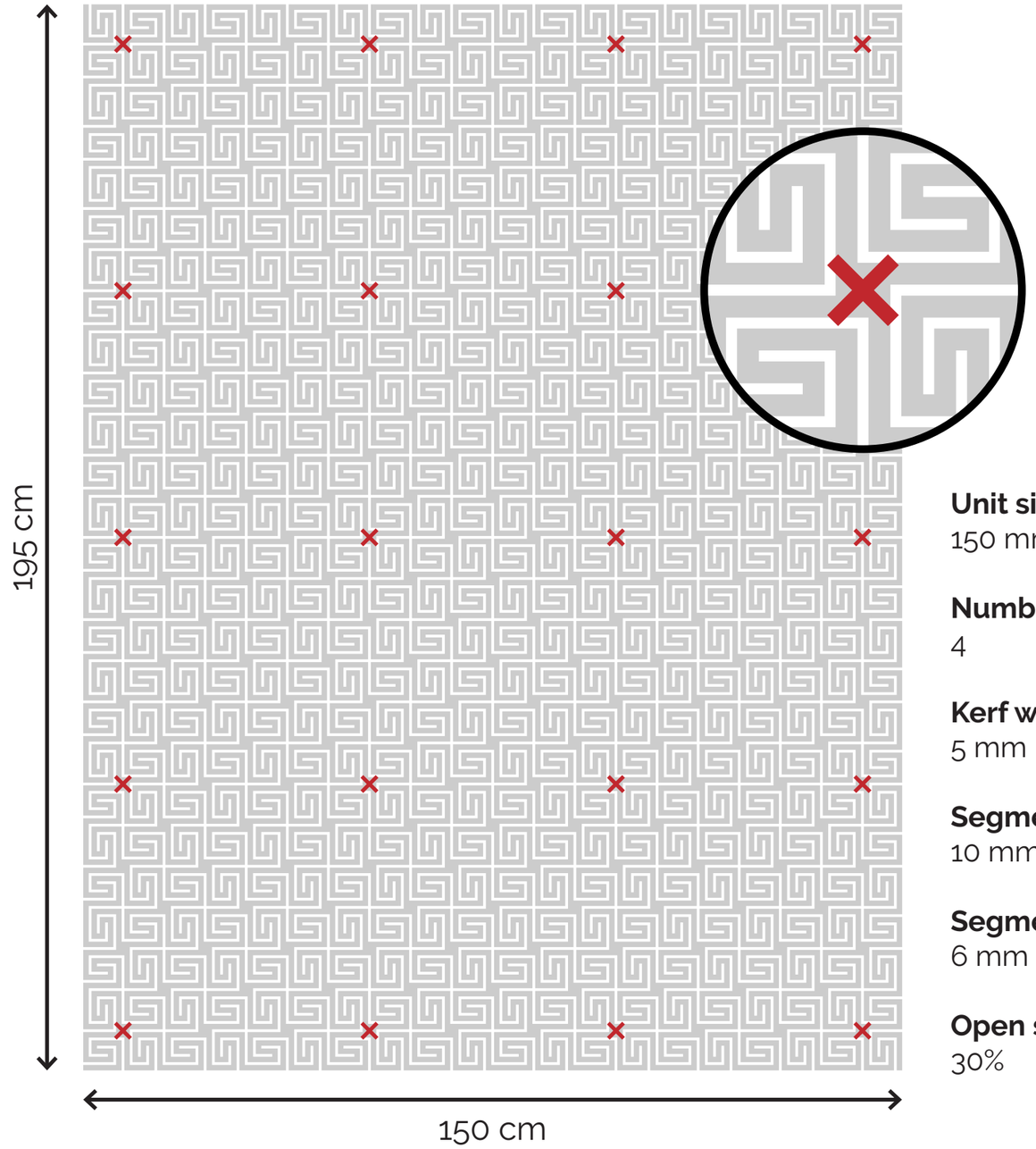
Kerf width
5 mm

Segment width
10 mm

Segment height
6 mm

Open surface area
30%

DESIGN
CONCEPT



Unit size
150 mm

Number of iterations
4

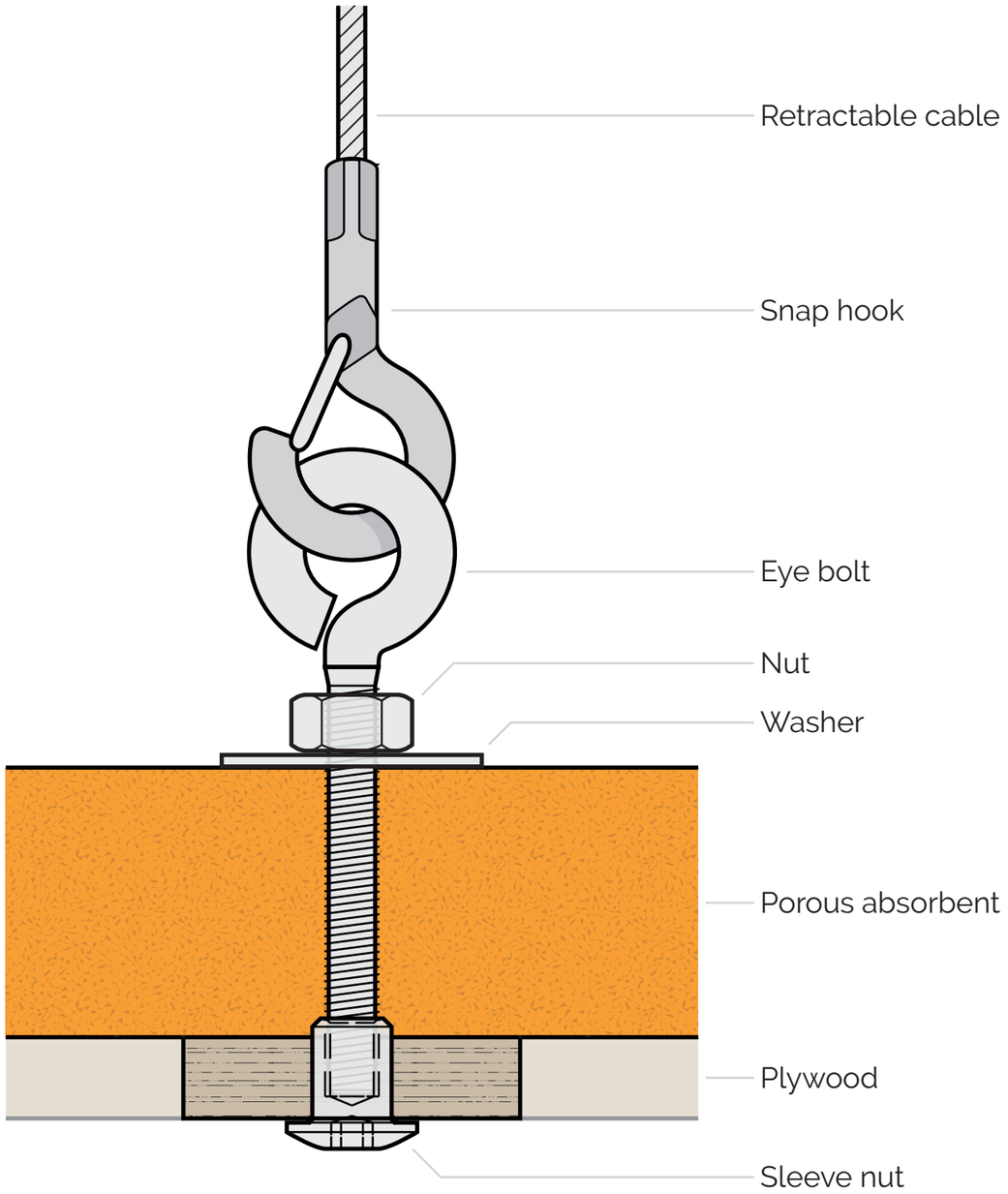
Kerf width
5 mm

Segment width
10 mm

Segment height
6 mm

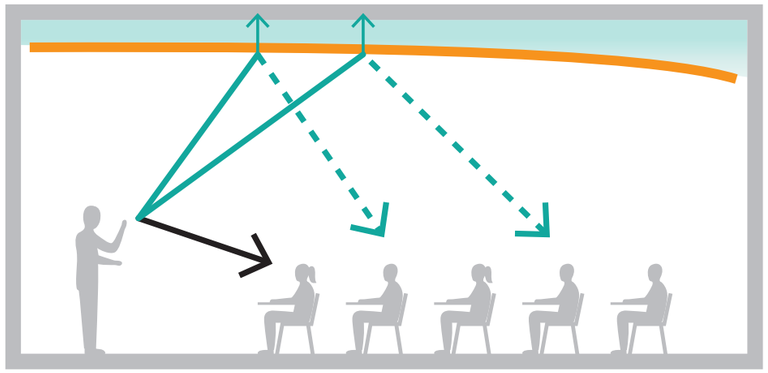
Open surface area
30%

DESIGN
DETAIL

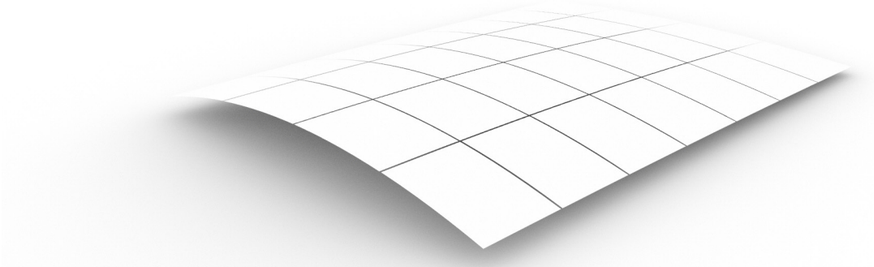


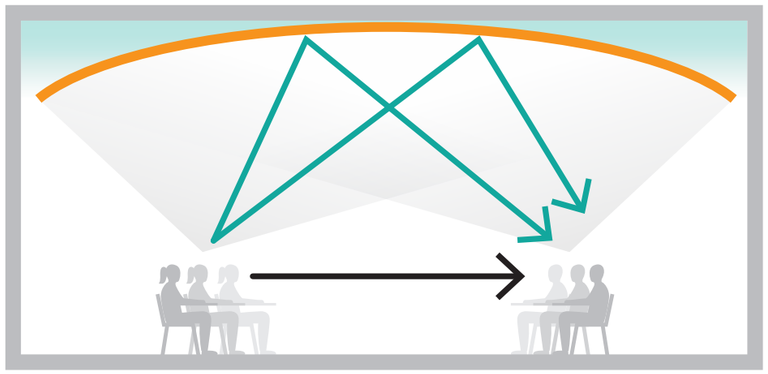
DESIGN

DIFFERENT COMPOSITIONS

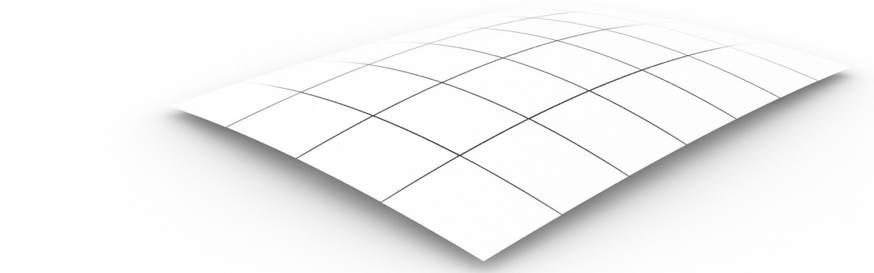


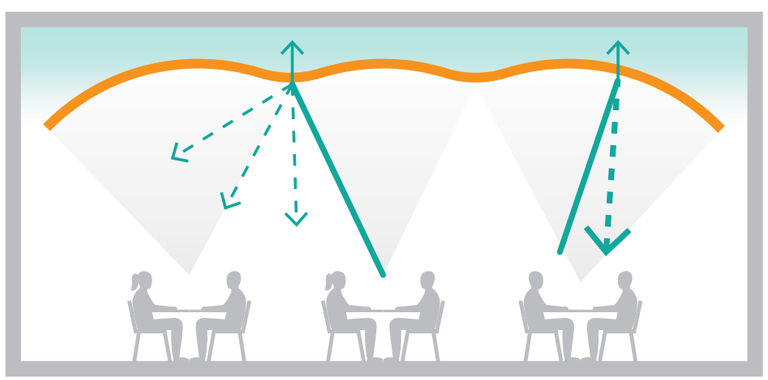
SINGLE SPEAKER



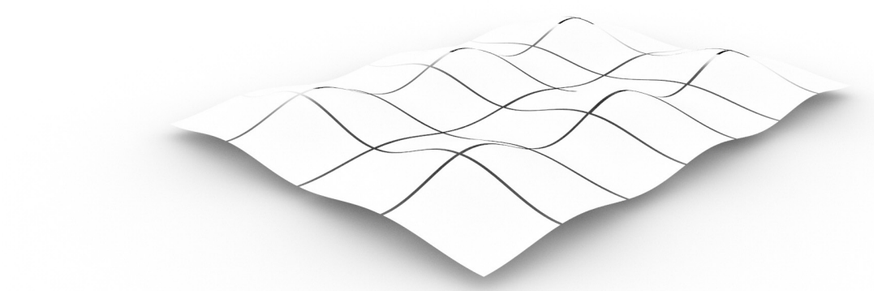


ROUND-TABLE DISCUSSION





SMALL GROUPS




Faculty of Architecture
and the Built Environment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and the Built Environment


Faculty of Architecture
and the Built Environment

SUB-QUESTION

APPLICATION *of* SYSTEM

What are potential uses of responsive surfaces on acoustic performance?

SUB-QUESTION

APPLICATION *of* SYSTEM

What are potential uses
of responsive surfaces on
acoustic performance?

>> Beneficial for changing acoustic needs in a lecture room,
but also applicable when this is not required.

CONCLUSION

RESEARCH QUESTION

How can we formalize the pattern kerfing techniques
in order to produce responsive wooden surfaces for better acoustic performance?

RESEARCH QUESTION

How can we formalize the pattern kerfing techniques
in order to produce responsive wooden surfaces for better acoustic performance?

>> Pattern kerfing techniques enhance the flexibility towards better acoustic performance,
but provides limited possibilities to respond to specific acoustic needs.

THANK YOU.