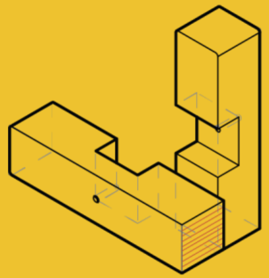
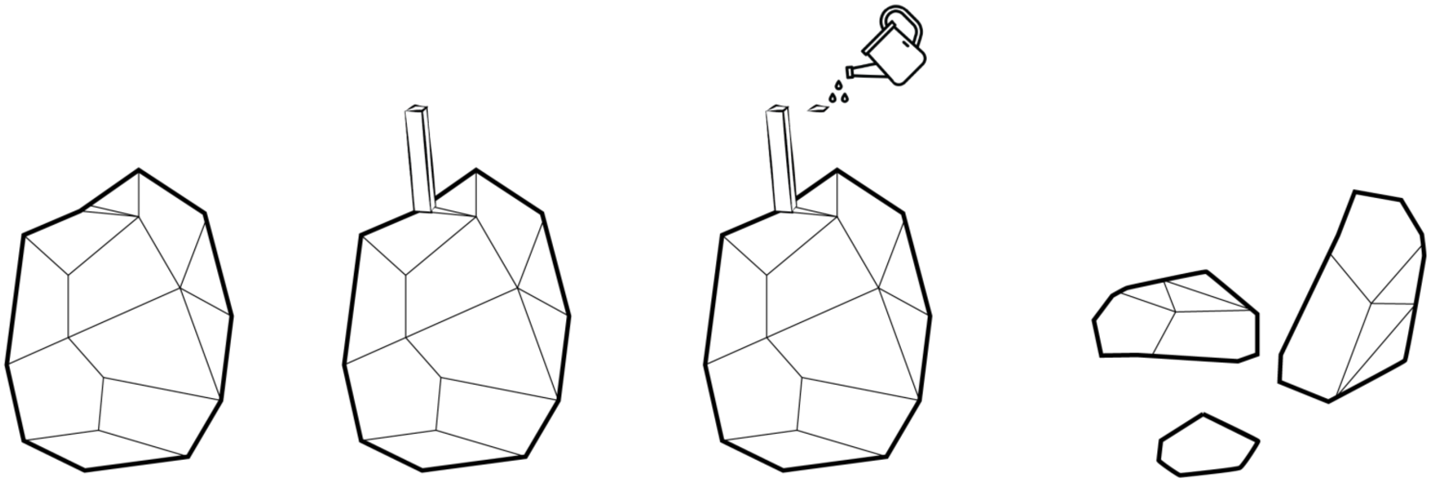
P5

INTERLOCKING WOOD-TO-WOOD JOINERY CONNECTIONS WITH MOISTURE INDUCE PROCESS

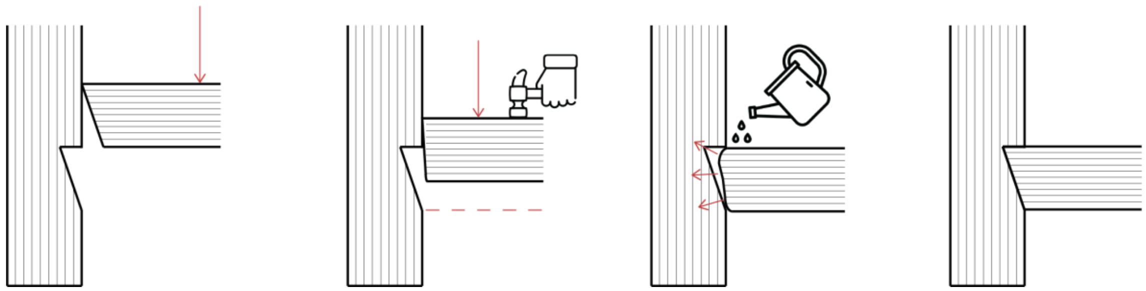


TU Delft

BREAKING BOULDERS

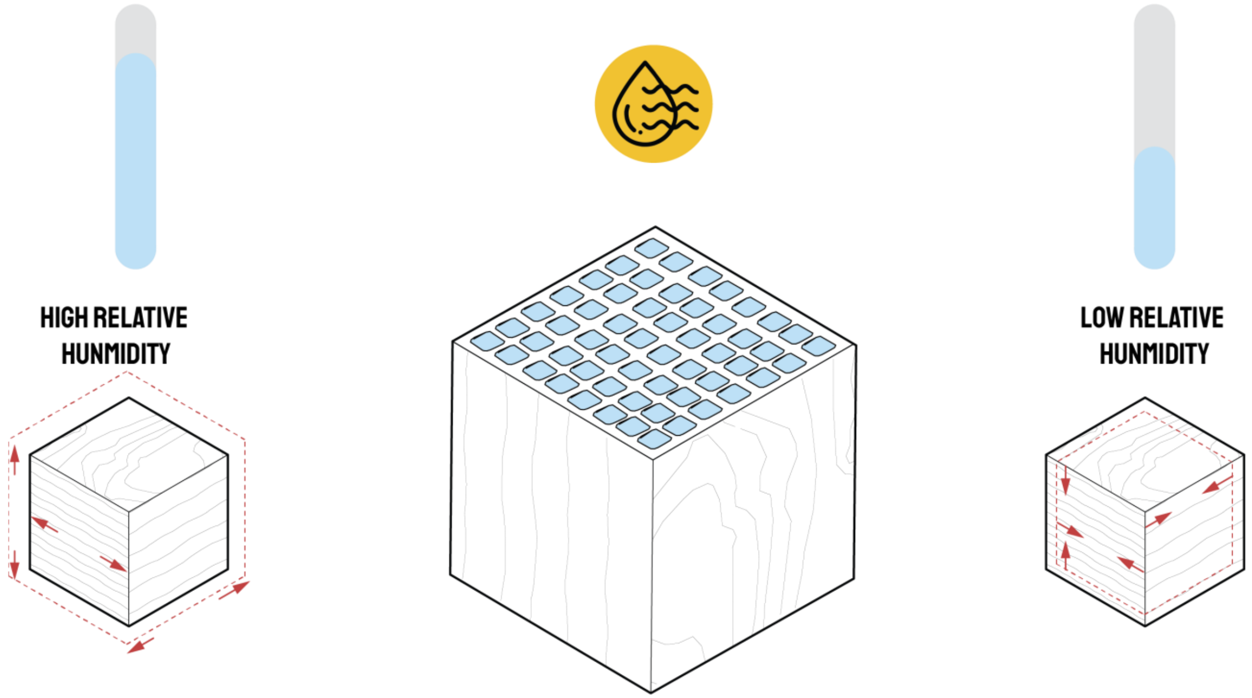


NAKAGAWA SHUJI



EMC

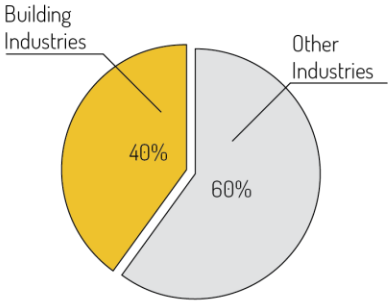
EQUILIBRIUM MOISTURE CONTENT



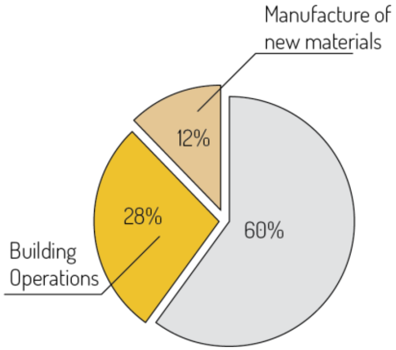
IS THIS THE SECRETE OF THE FUTURE BUILDING INDUSTRY ?

INDUSTRY IMPACT

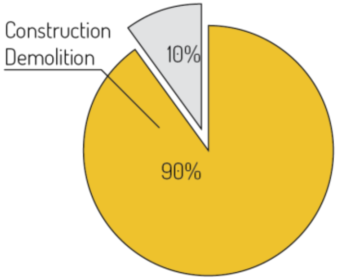
CARBONE EMMISIONS



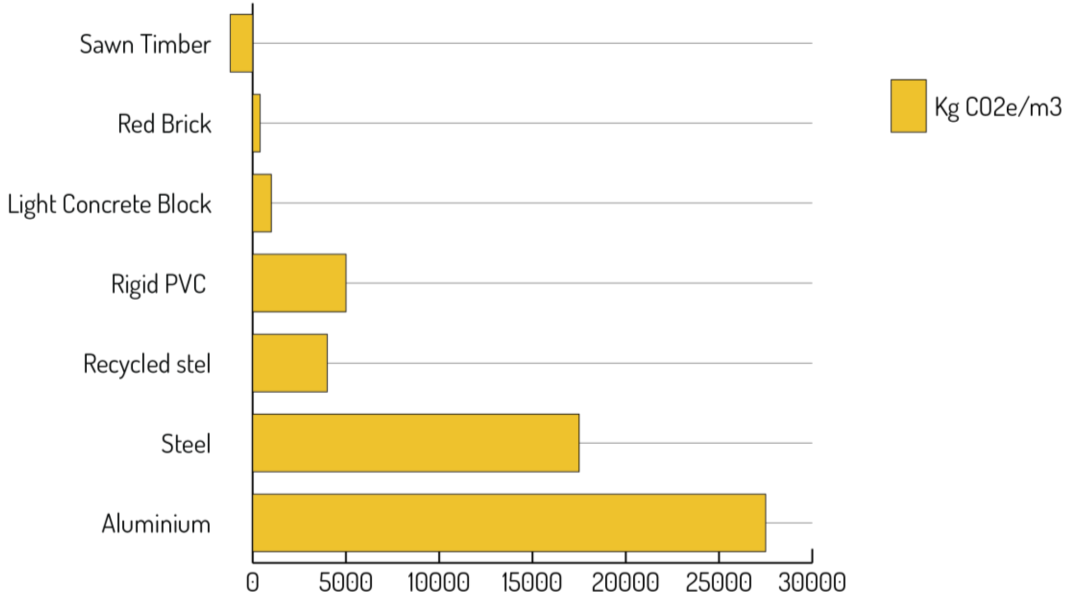
CARBONE EMMISIONS



BUILDING INDUSTRY WASTE

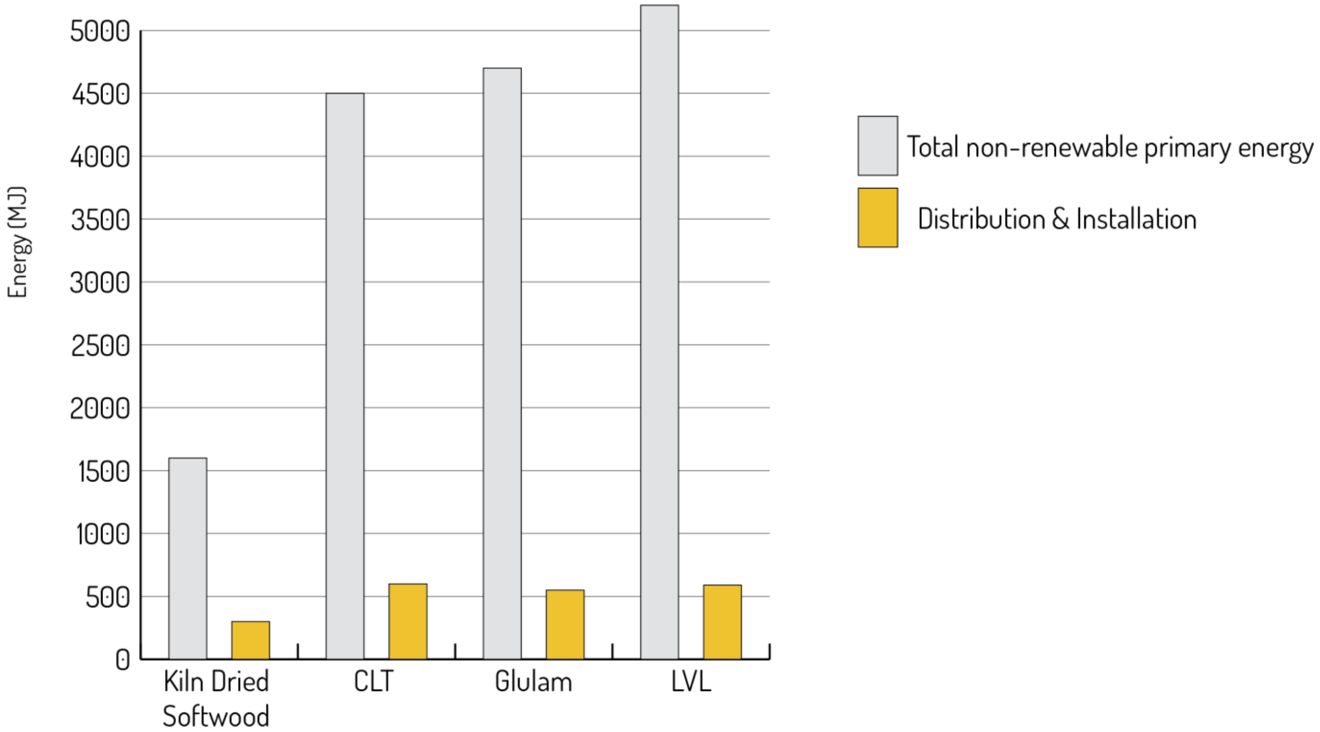


MATERIAL IMPACT



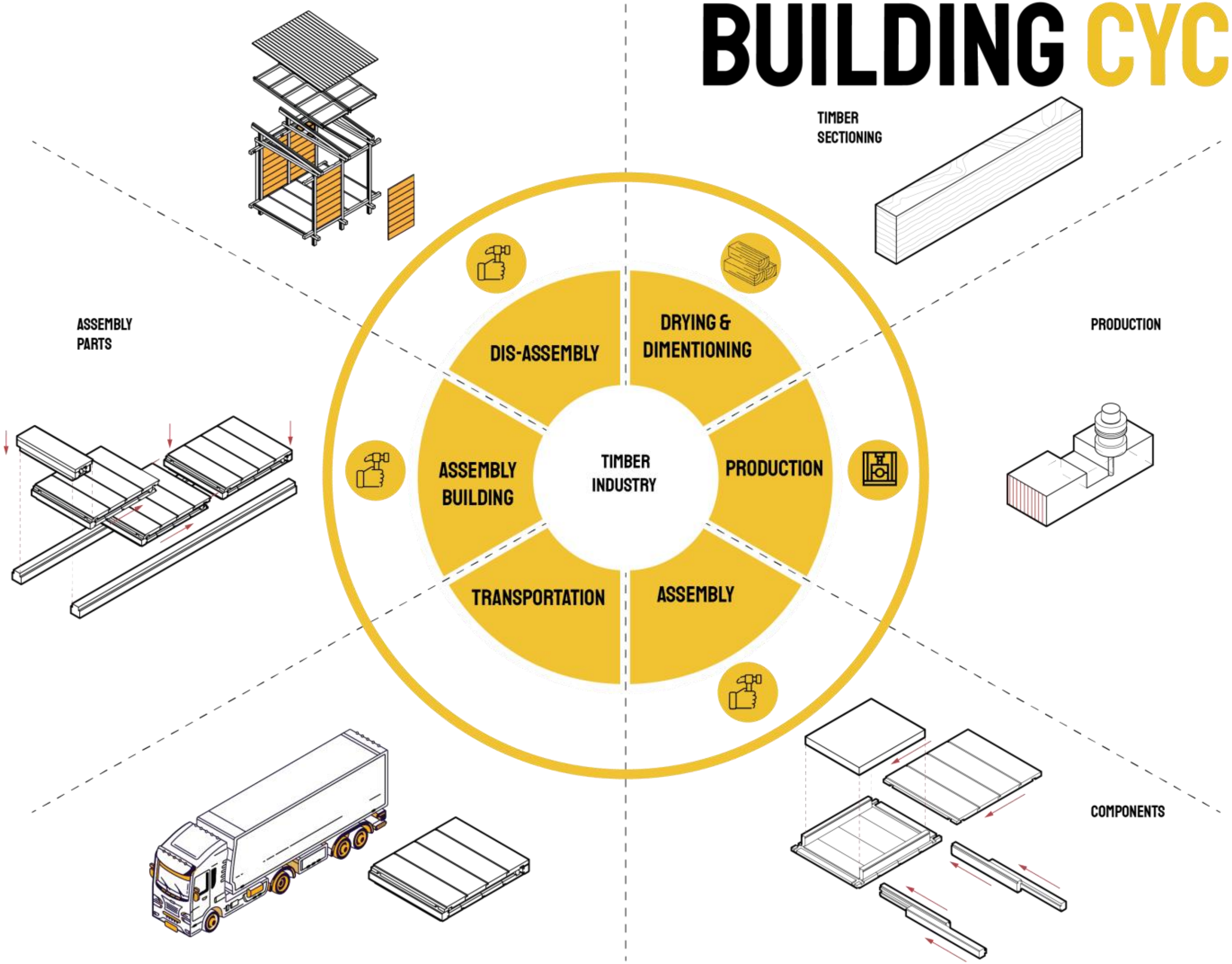
MATERIAL CO2 PRODUCTION COMPARISON OF DIFFERENT CONSTRUCTION MATERIALS

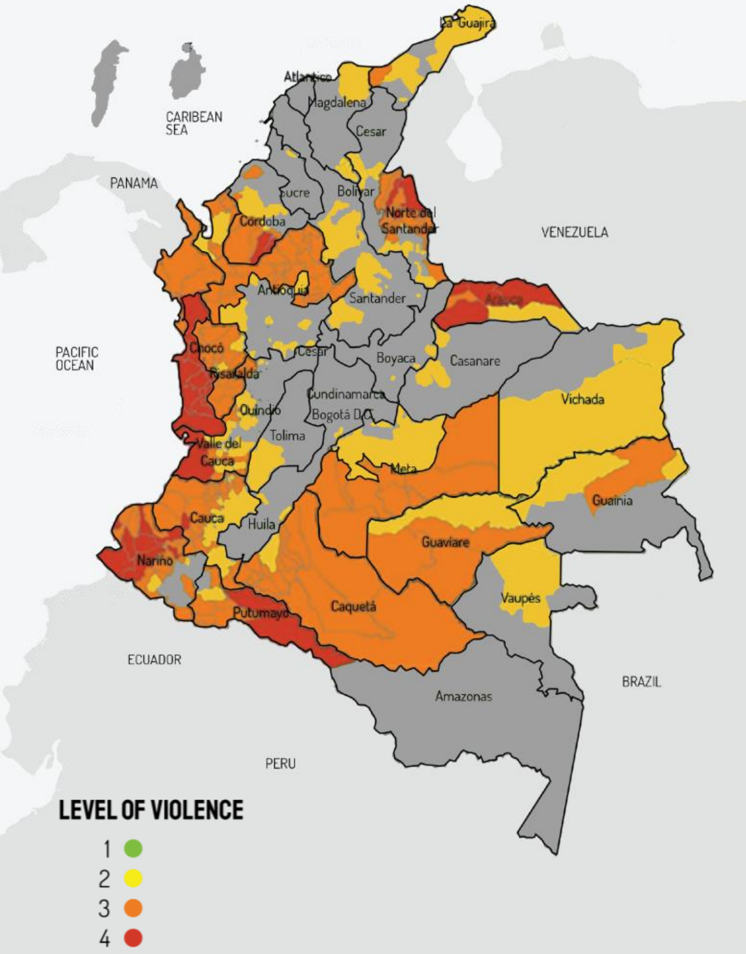
EWP IMPACT



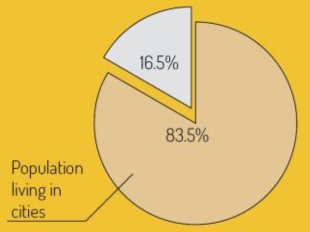
Total **non-renewable** primary energy consumption and distribution/installation energy associated with **adhesively bonded engineered timber products** manufactured in the EU.

BUILDING CYCLE





PEOPLE FORCE-DISPLACEMENT



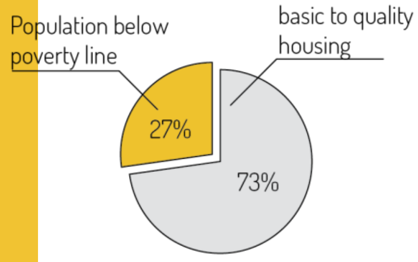
8.1 MILLION PEOPLE
49 million people
Country's population

FORCE-DISPLACEMENT
50 YEARS OF WAR

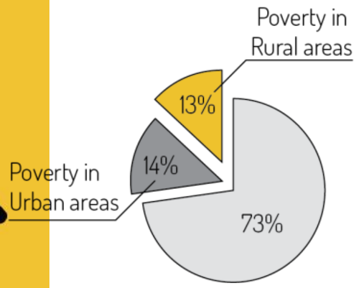
AFTER PEACE AGREEMENT
2016

BETWEEN JANUARY - MAY
2022

POPULATION BELOW POVERTY LINE



POVERTY IN RURAL AREAS

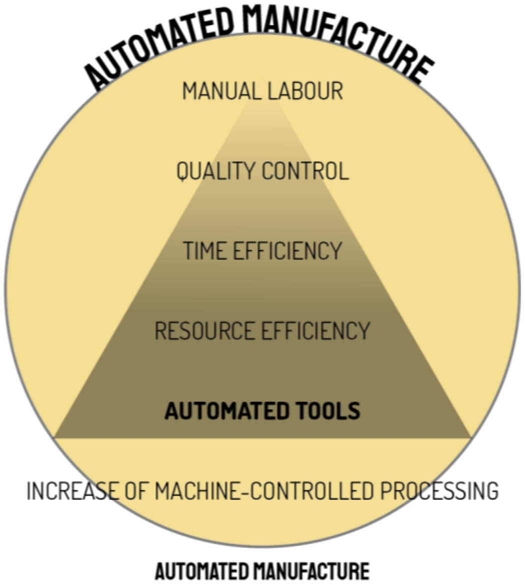


RE-CONSTRUCTION

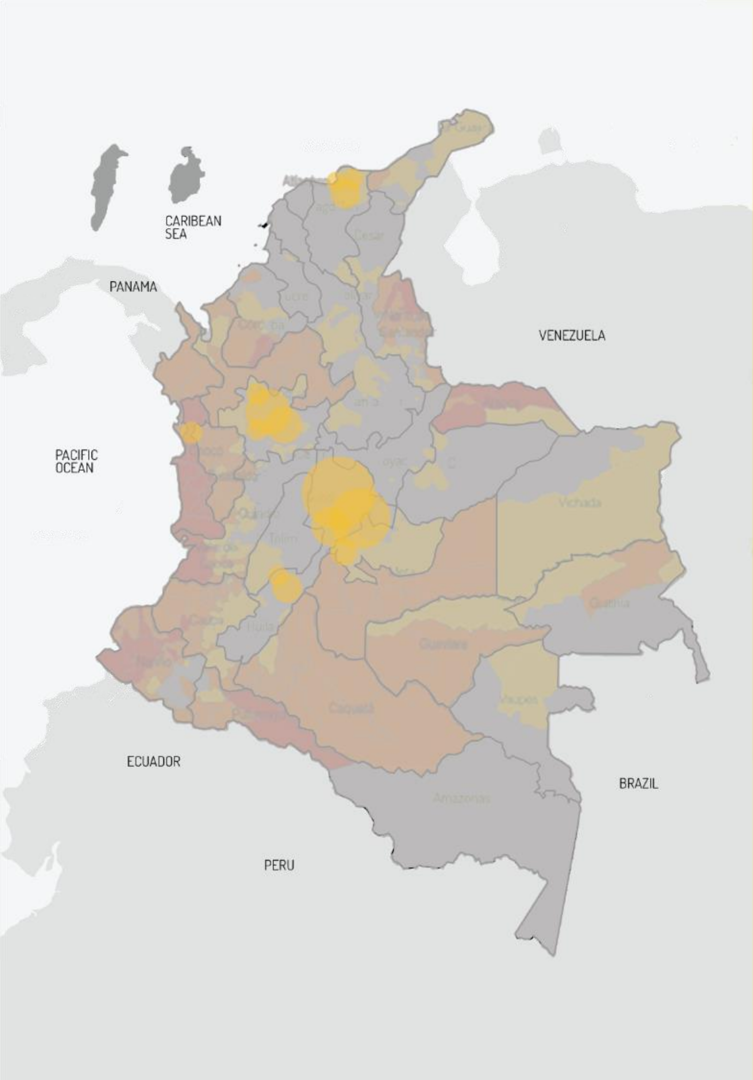
SOCIAL

QUALITY

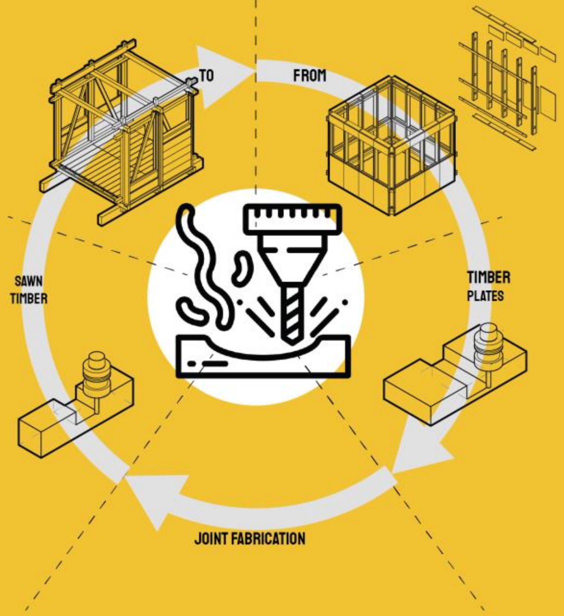
TIME

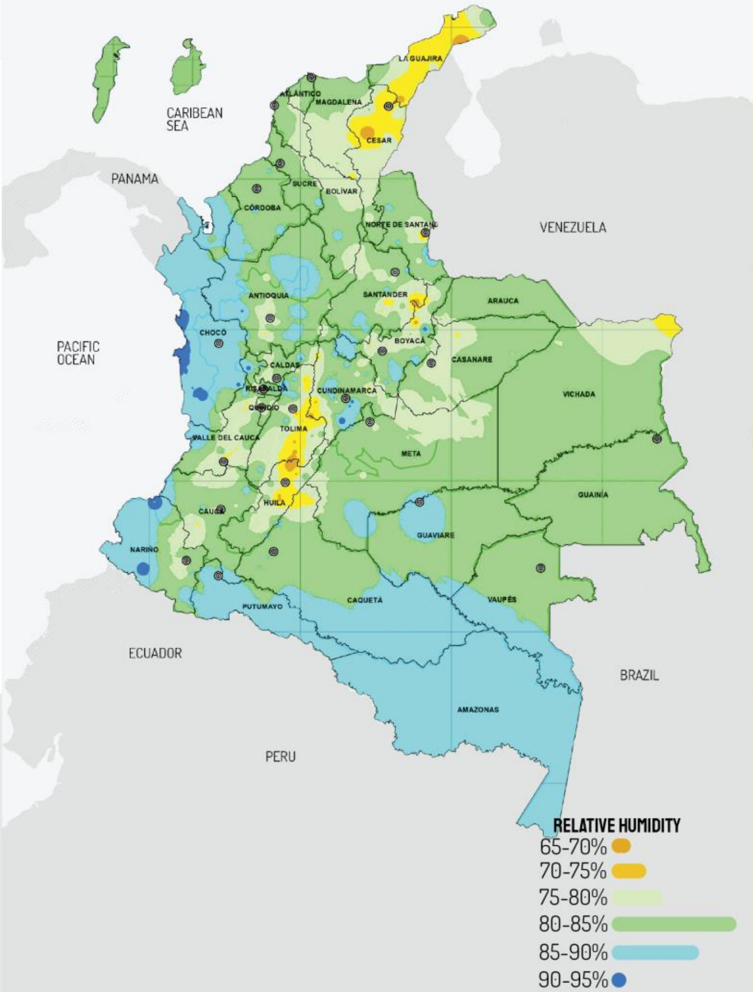


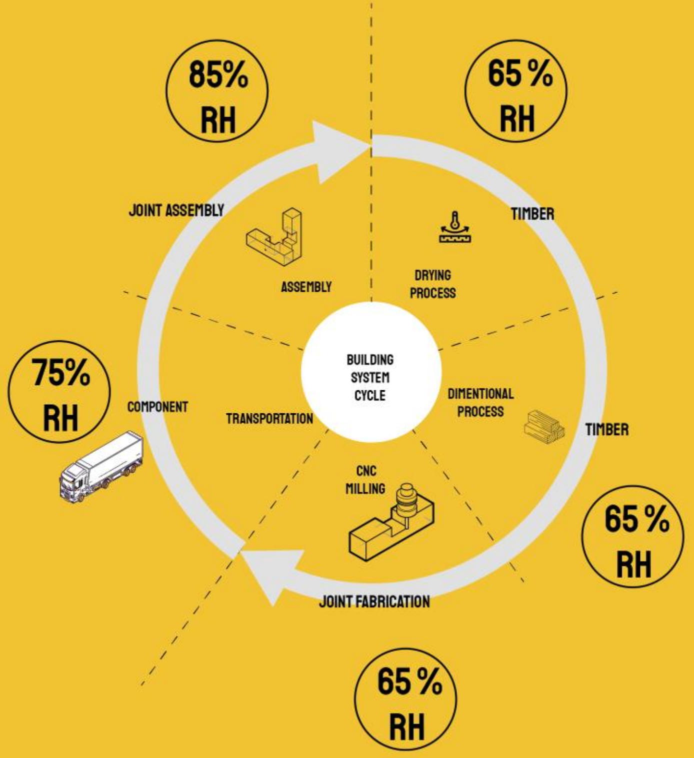
BUDGET


CARIBEAN
SEA
PANAMA
VENEZUELA
PACIFIC
OCEAN
ECUADOR
BRAZIL
PERU

CNC MILLING

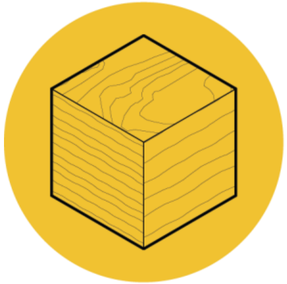

TO
FROM
SAWN
TIMBER
TIMBER
PLATES
JOINT FABRICATION



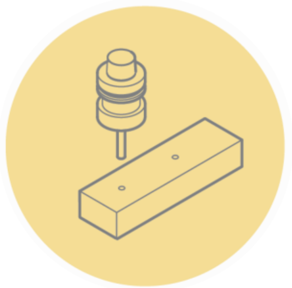


BUI LD- ING SYS TEM

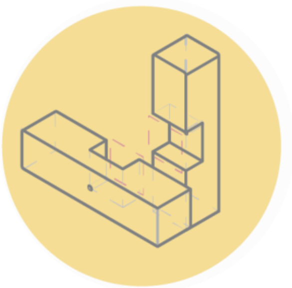
RESEARCH STRUCTURE



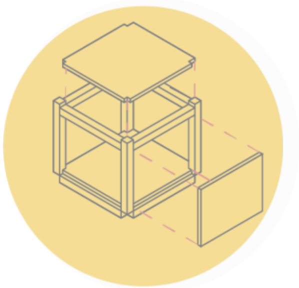
MATERIAL



CNC MILLING

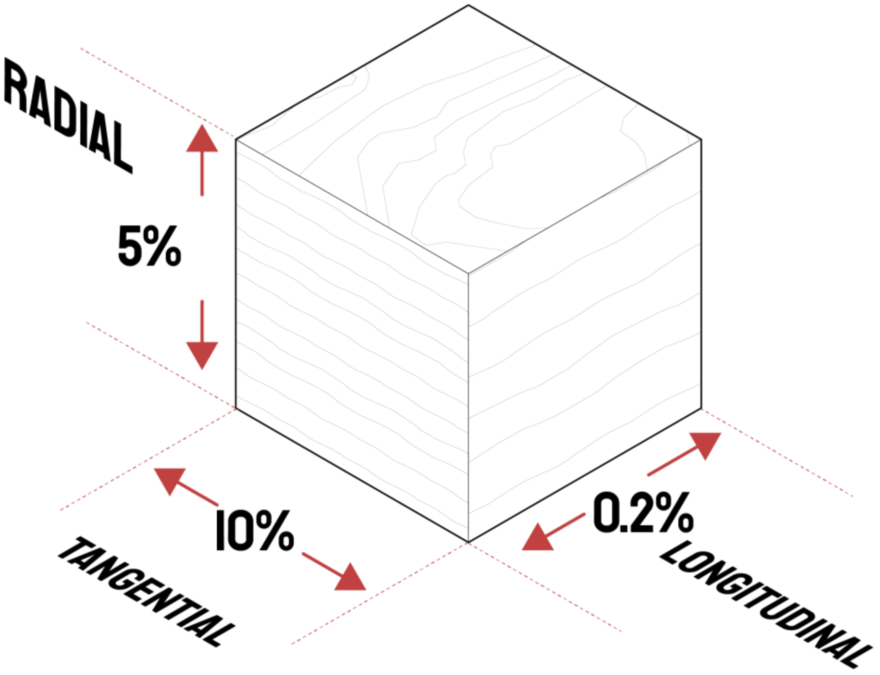


JOINT

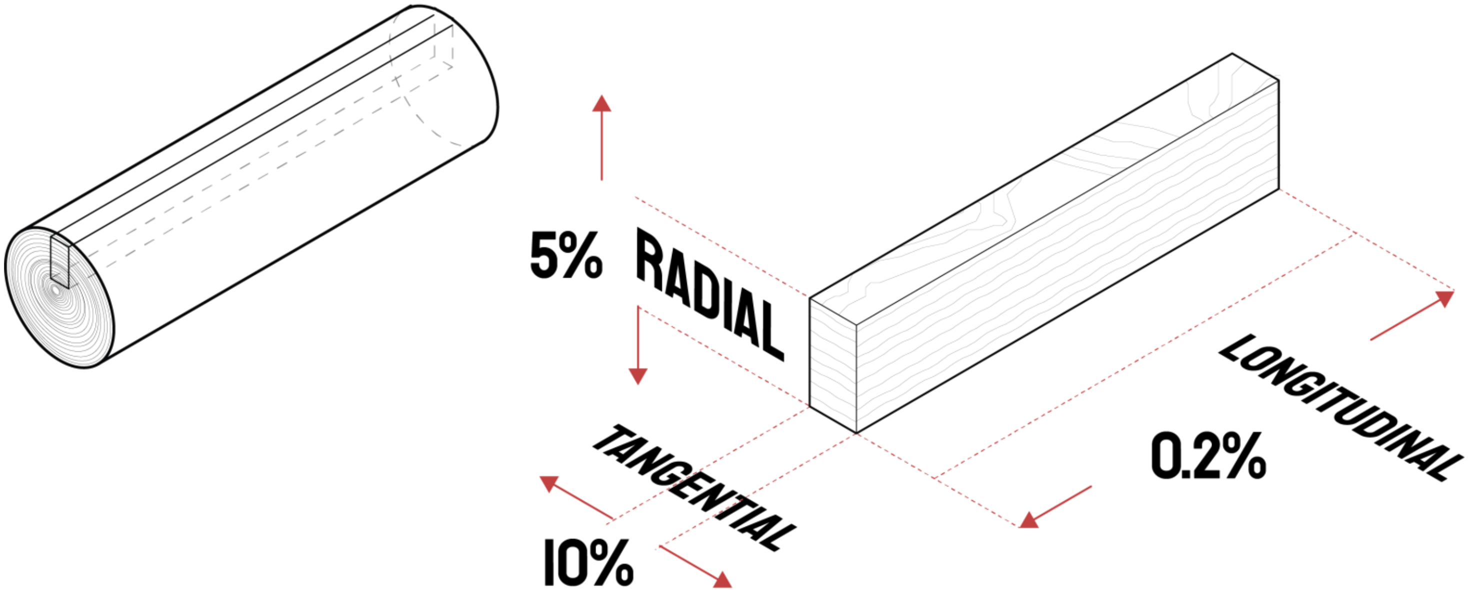


SYSTEM

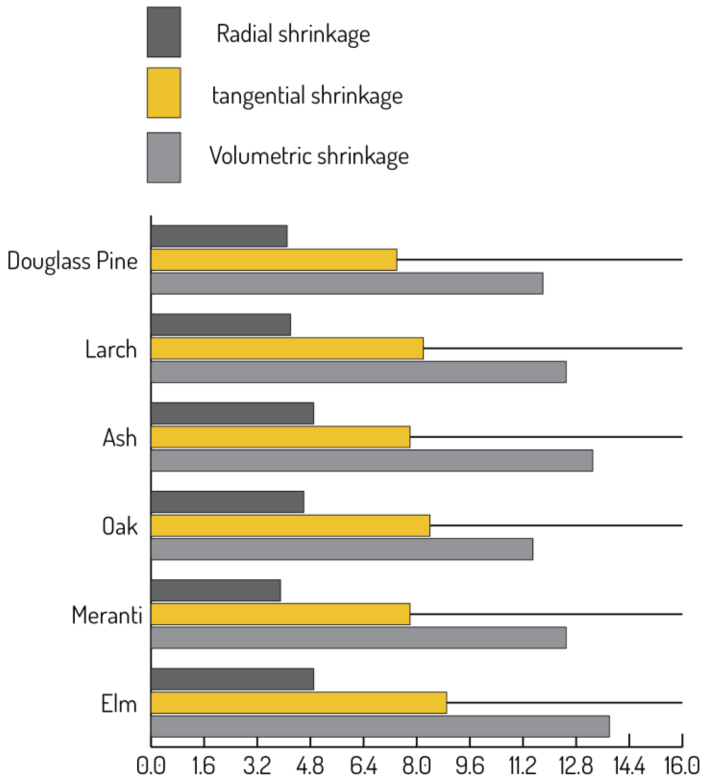
FIBER DIRECTION



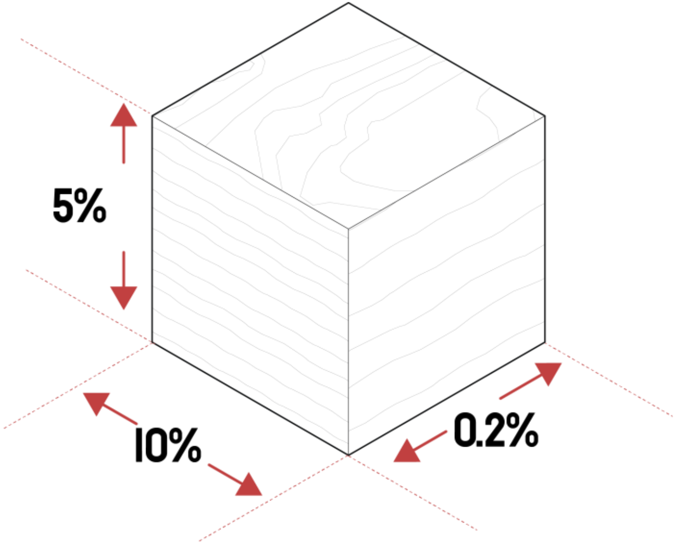
FIBER IN STRUCTURAL ELEMENT



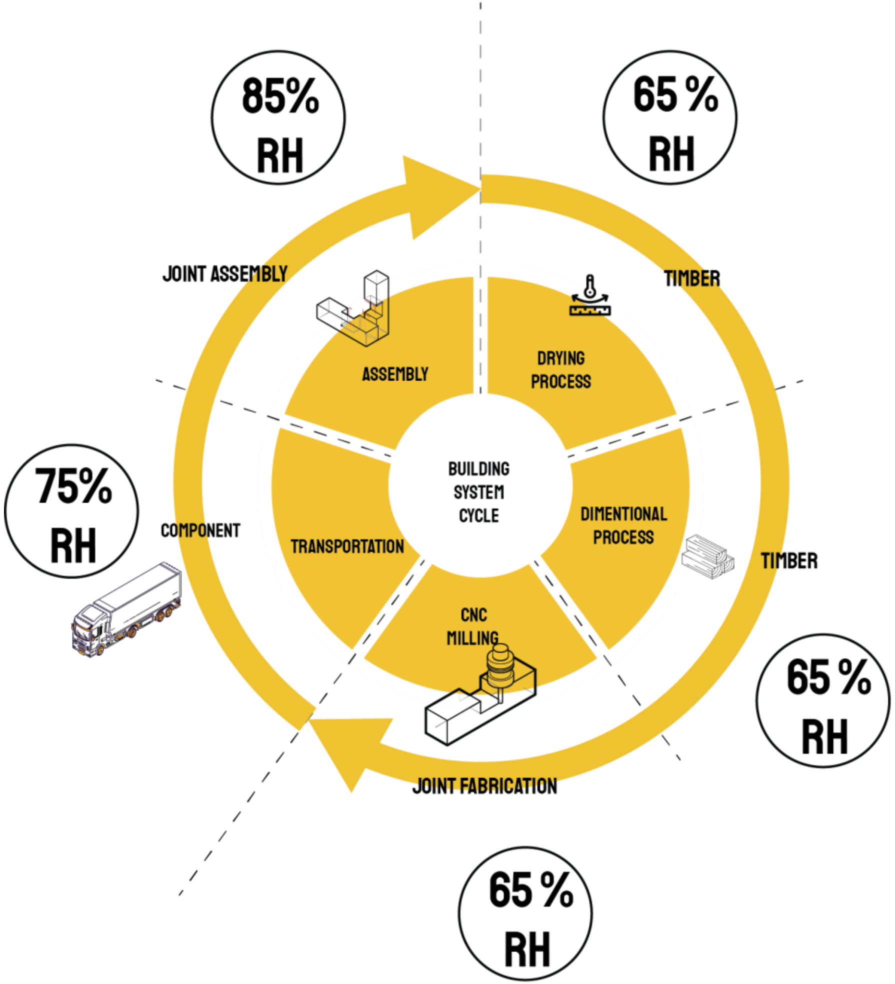
THEORICAL DIMENSIONAL CHANGE



VOLUMETRIC CHANGE

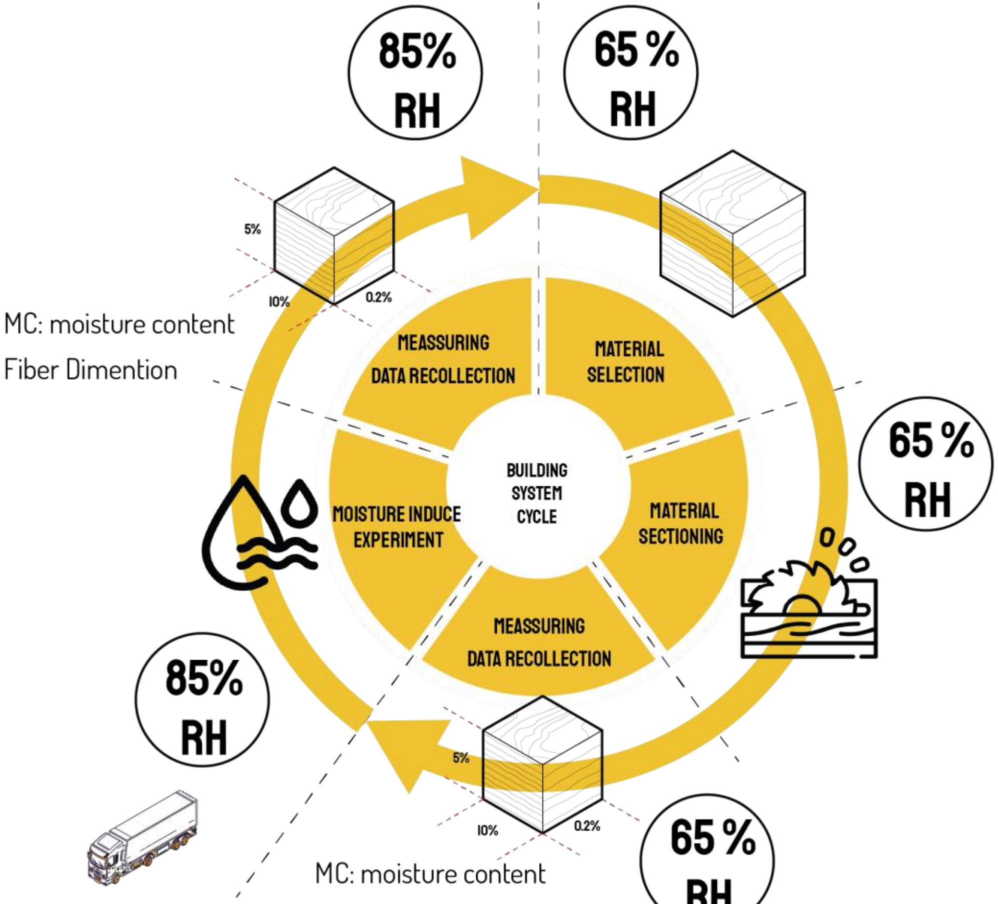


HERITAGE & TECHNOLOGY LAB



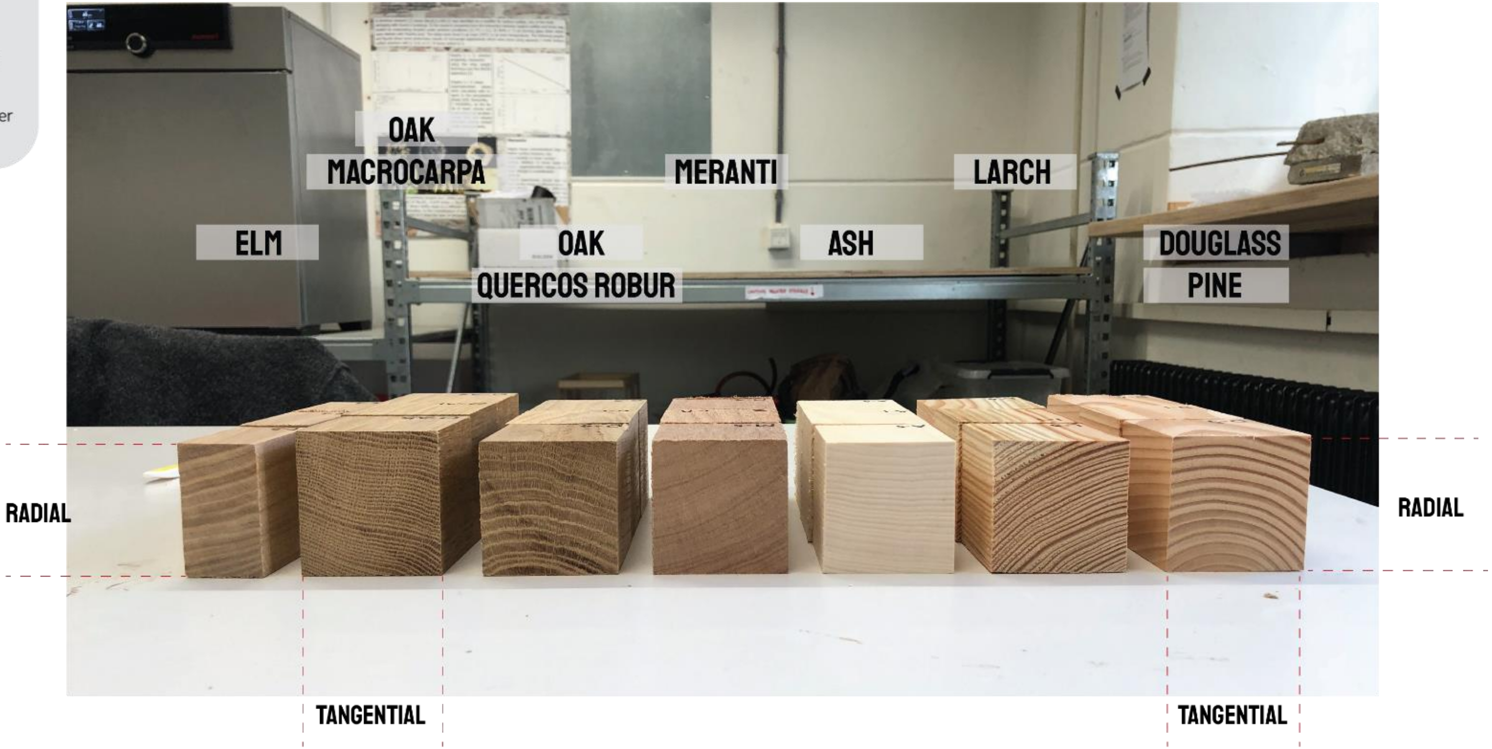
EXPERIEMNT

SET UP

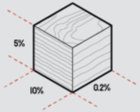


Tangential fiber
Radial fiber
Longitudinal fiber

MATERIAL SECTIONING



MEASSURING DATA RECOLLECTION



MC: moisture content

Fiber Dimention

Douglas Pine

11.5%

Day 1 - Experiment

Larch

10.9%

Day 1 - Experiment

Ash

25.4%

Day 1 - Experiment

Elm

10.5%

Day 1 - Experiment

Quercus Robur - Oak

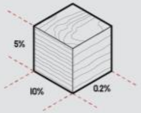
9.2%

Day 1 - Experiment

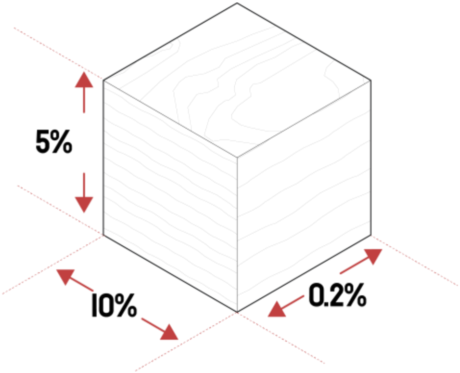
Moisture Sensor

Day 1 - Experiment

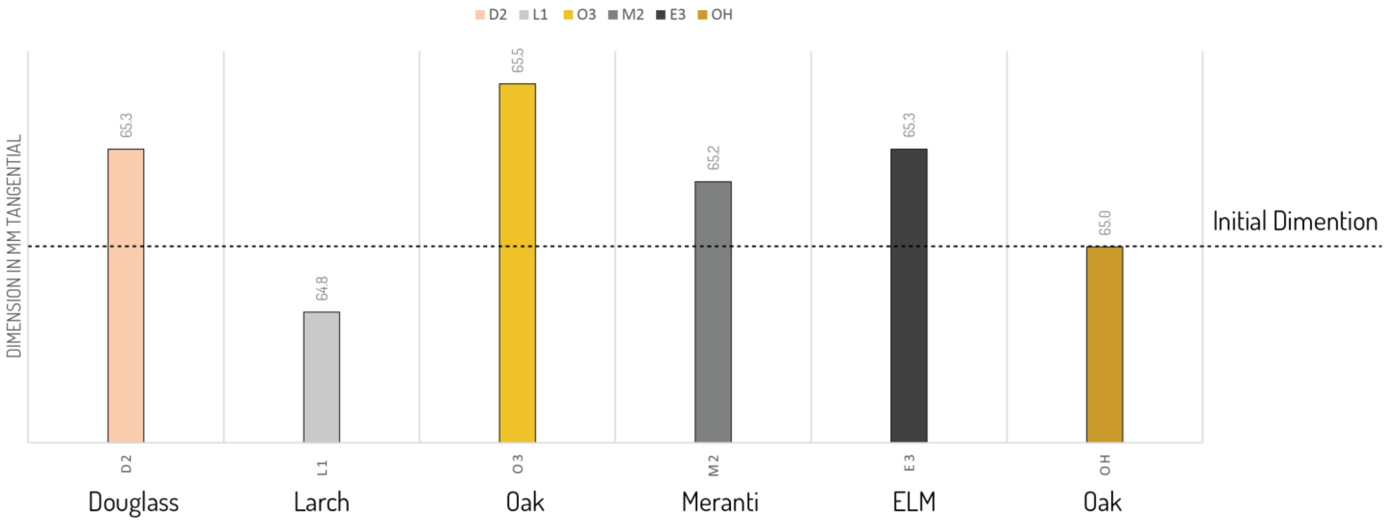
MEASSURING
DATA RECOLLECTION

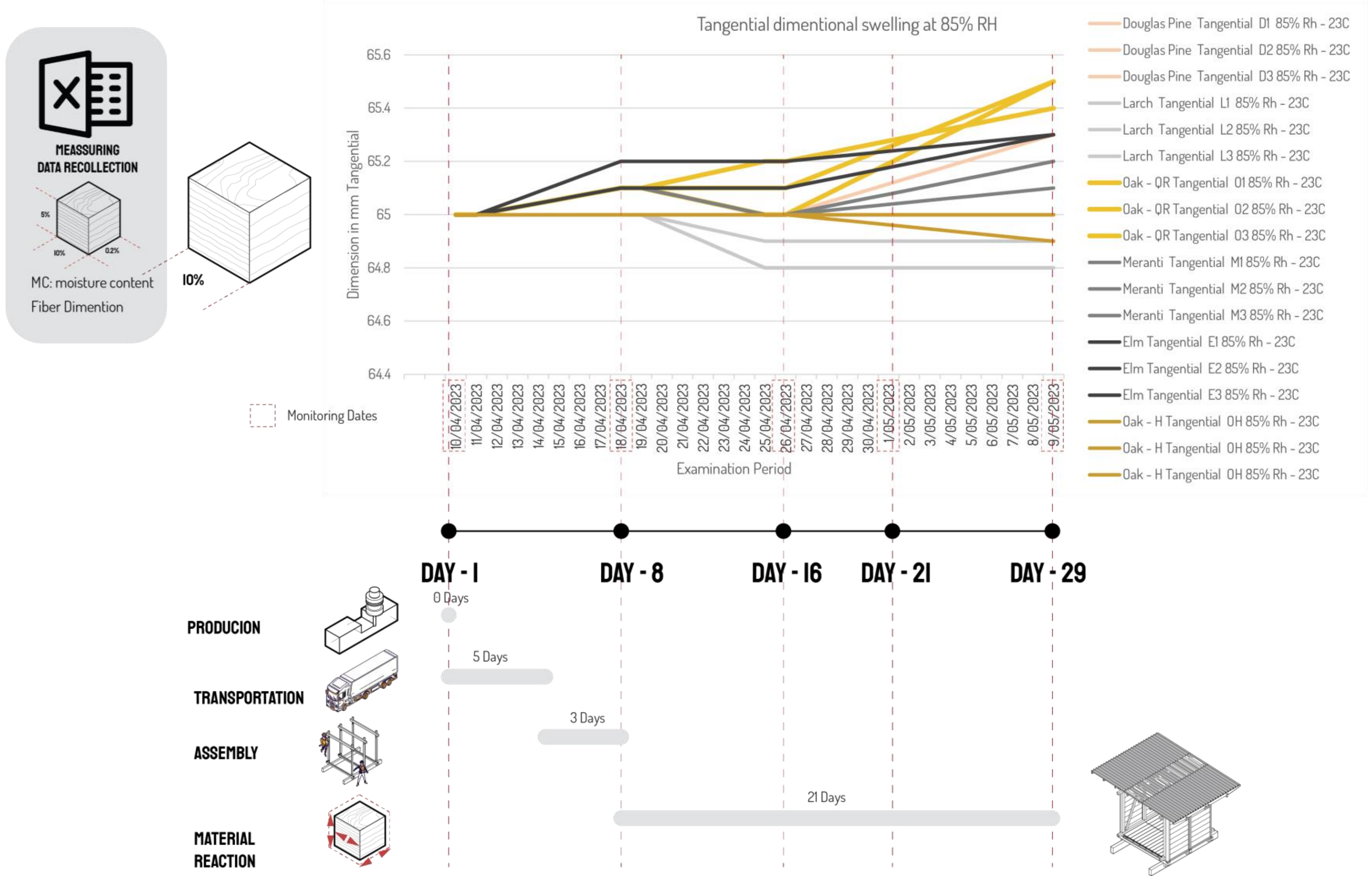


MC: moisture content
Fiber Dimention

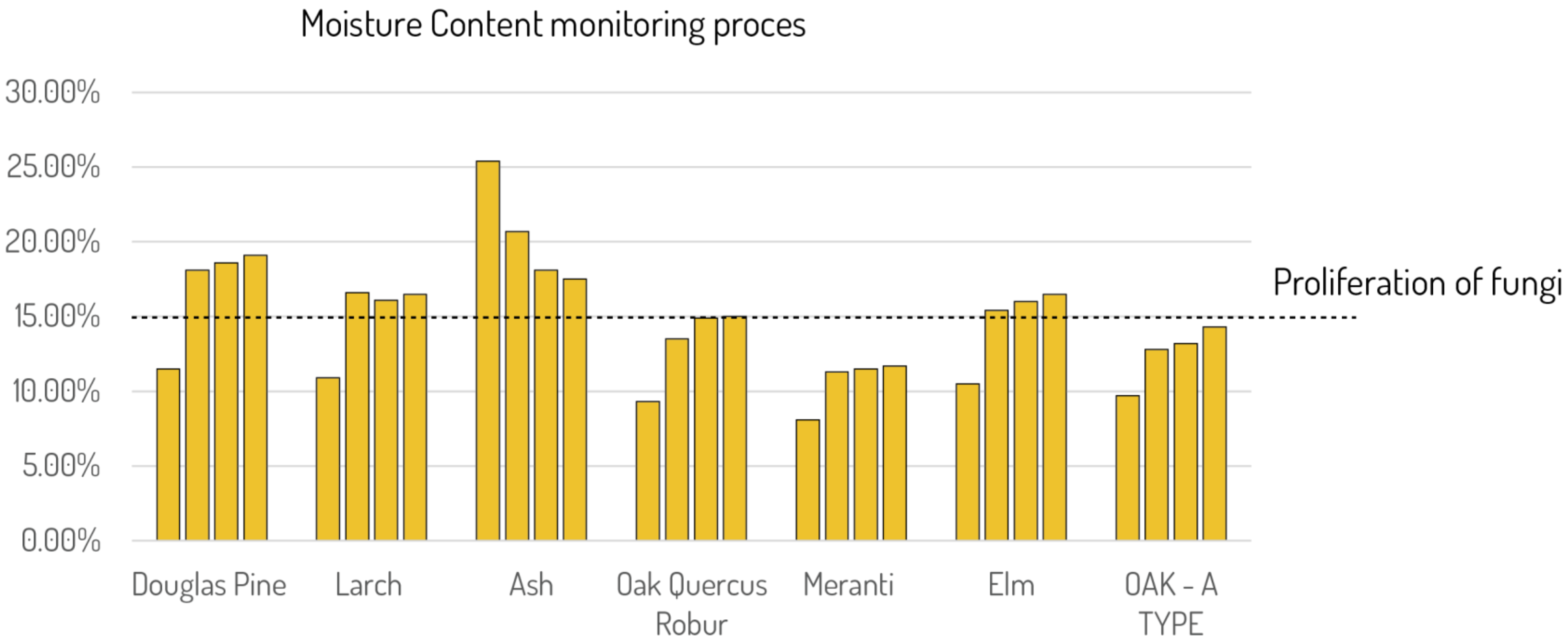


Tangential Dimentional swelling at 85% Relative Humidity

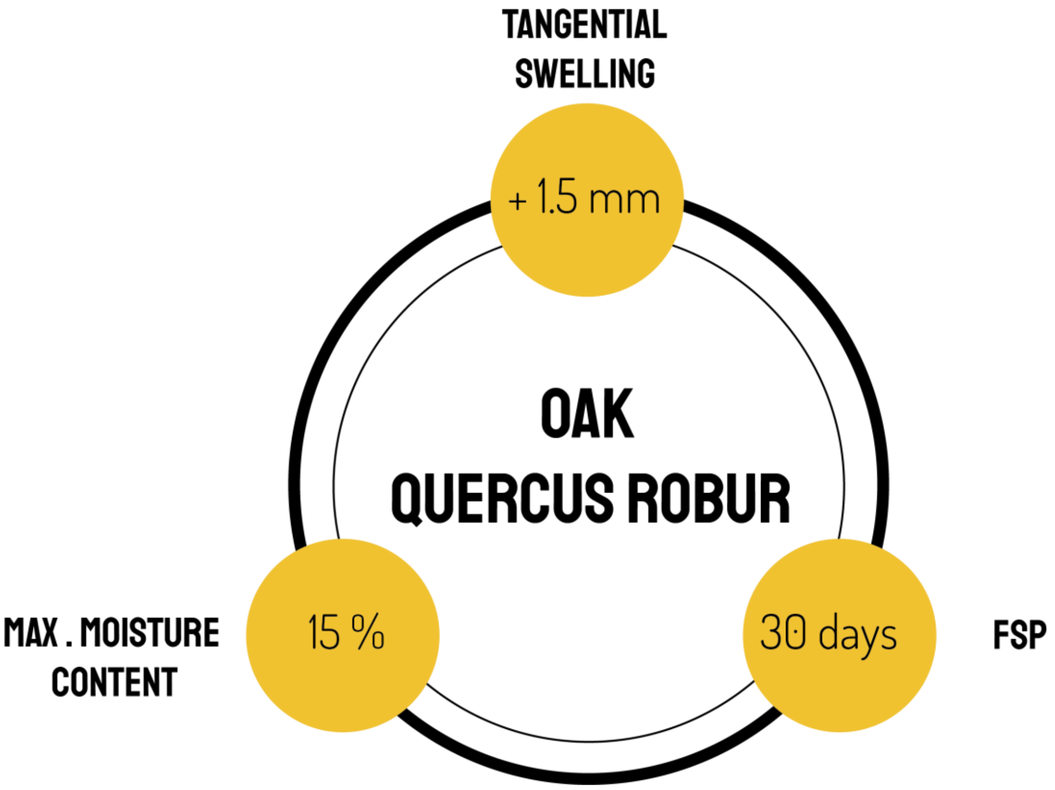



MEASSURING
DATA RECOLLECTION
5%
10%
0.2%
MC: moisture content
Fiber Dimention
10%
Tangential dimentional swelling at 85% RH
65.6
65.4
65.2
65
64.8
64.6
64.4
Dimension in mm Tangential
10/04/2023
11/04/2023
12/04/2023
13/04/2023
14/04/2023
15/04/2023
16/04/2023
17/04/2023
18/04/2023
19/04/2023
20/04/2023
21/04/2023
22/04/2023
23/04/2023
24/04/2023
25/04/2023
26/04/2023
27/04/2023
28/04/2023
29/04/2023
30/04/2023
1/05/2023
2/05/2023
3/05/2023
4/05/2023
5/05/2023
6/05/2023
7/05/2023
8/05/2023
9/05/2023
Examination Period
Monitoring Dates
Douglas Pine Tangential D1 85% Rh - 23C
Douglas Pine Tangential D2 85% Rh - 23C
Douglas Pine Tangential D3 85% Rh - 23C
Larch Tangential L1 85% Rh - 23C
Larch Tangential L2 85% Rh - 23C
Larch Tangential L3 85% Rh - 23C
Oak - QR Tangential O1 85% Rh - 23C
Oak - QR Tangential O2 85% Rh - 23C
Oak - QR Tangential O3 85% Rh - 23C
Meranti Tangential M1 85% Rh - 23C
Meranti Tangential M2 85% Rh - 23C
Meranti Tangential M3 85% Rh - 23C
Elm Tangential E1 85% Rh - 23C
Elm Tangential E2 85% Rh - 23C
Elm Tangential E3 85% Rh - 23C
Oak - H Tangential OH 85% Rh - 23C
Oak - H Tangential OH 85% Rh - 23C
Oak - H Tangential OH 85% Rh - 23C
DAY - 1
DAY - 8
DAY - 16
DAY - 21
DAY - 29
PRODUCION
0 Days
TRANSPORTATION
5 Days
ASSEMBLY
3 Days
MATERIAL
REACTION
21 Days

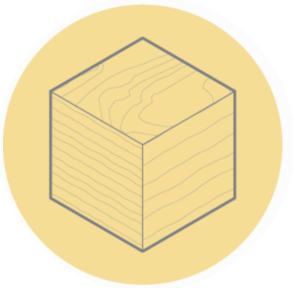

MEASSURING
DATA RECOLLECTION
5%
10%
0.2%
MC: moisture content
Fiber Dimention


Moisture Content monitoring proces
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Proliferation of fungi
Douglas Pine
Larch
Ash
Oak Quercus Robur
Meranti
Elm
OAK - A TYPE

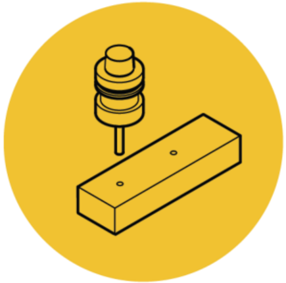
CONCLUSION


TANGENTIAL
SWELLING
+ 1.5 mm
OAK
QUERCUS ROBUR
MAX . MOISTURE
CONTENT
15 %
30 days
FSP

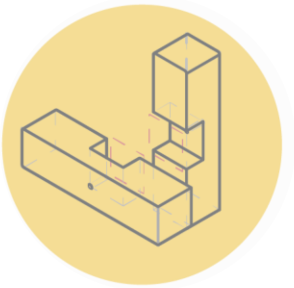
RESEARCH STRUCTURE



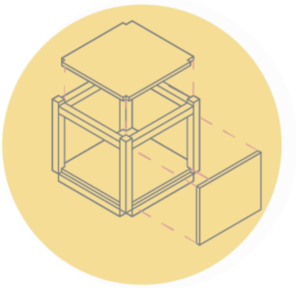
MATERIAL



CNC MILLING



JOINT



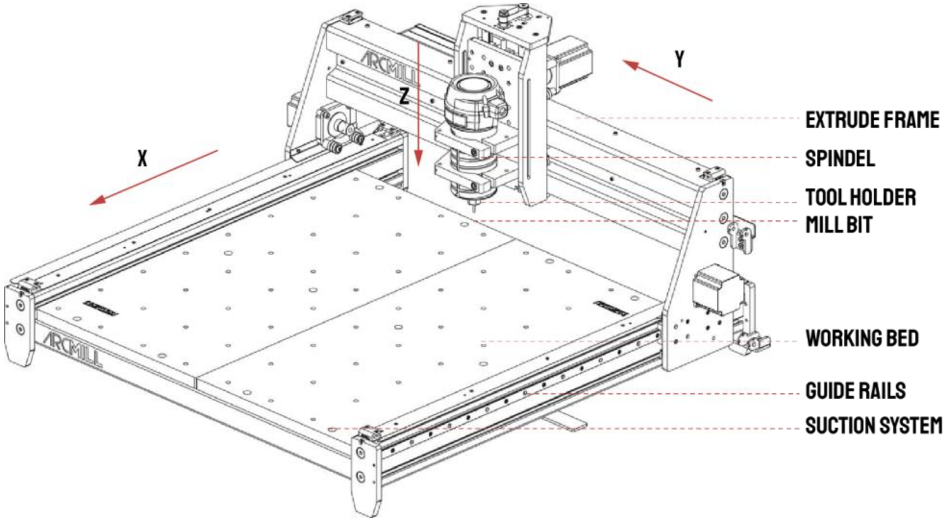
SYSTEM

TU DELFT

CAM LAB

BOB DE BOER – CNC OPERATOR

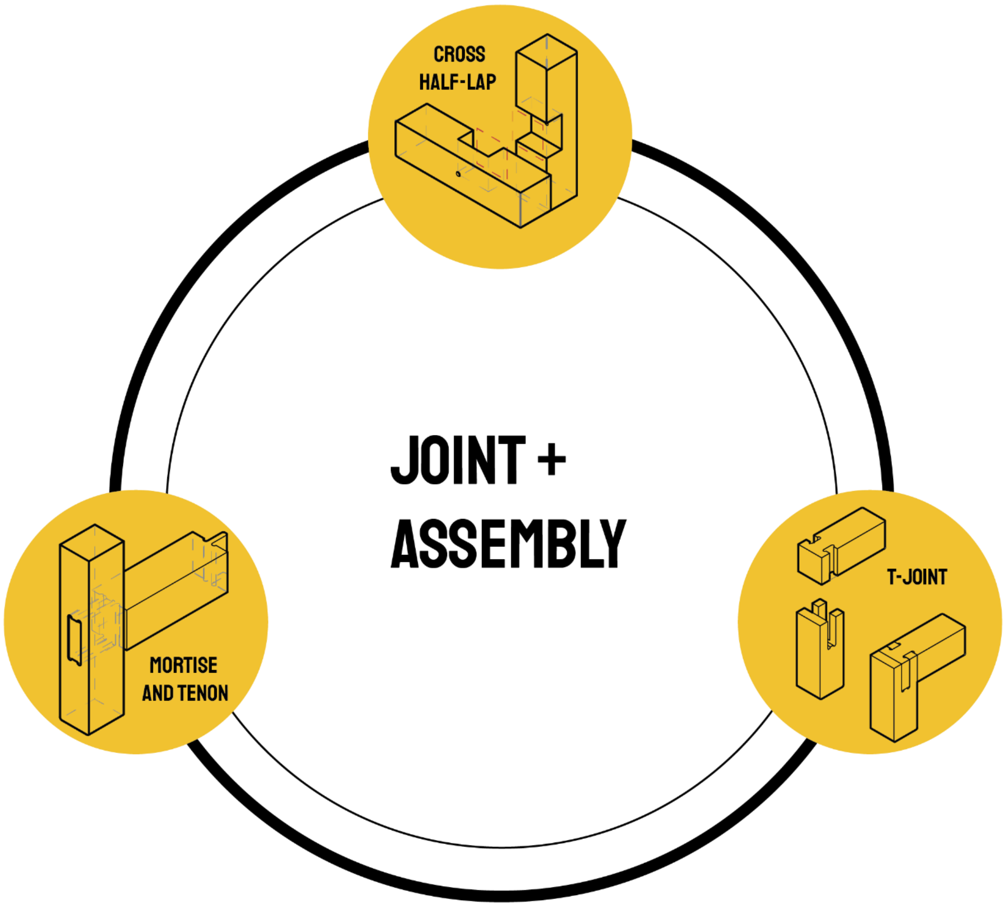
MILLING RESTRICTIONS



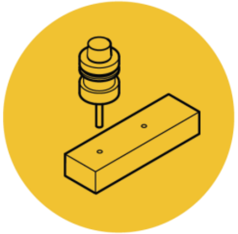
Z Maximum milling hight:100mm

X Maximum Lenght:3000mm

Y Maximum Lenght:1200mm


CROSS
HALF-LAP
JOINT +
ASSEMBLY
MORTISE
AND TENON
T-JOINT

CNC ASSESEMENT CRITERIA



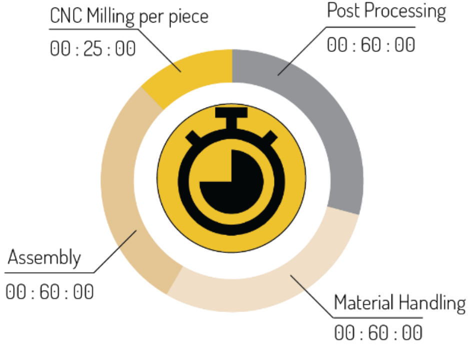
MILLING TIME

MATERIAL HANDLING

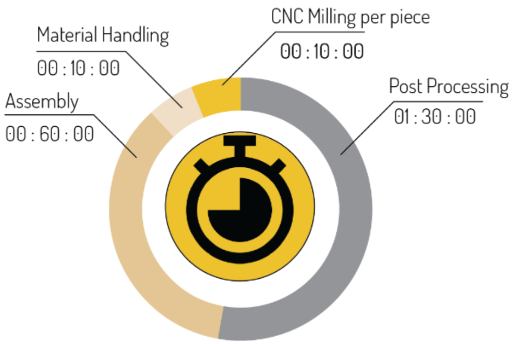
JOINT ASSEMBLY

POST PROCESSING

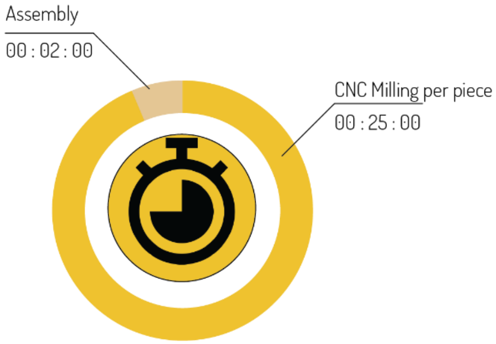
MORTISE AND TENON



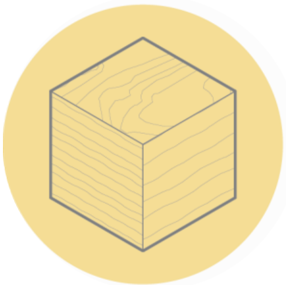
T-JOINT



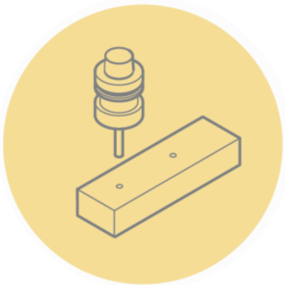
CROSS HALF LAP



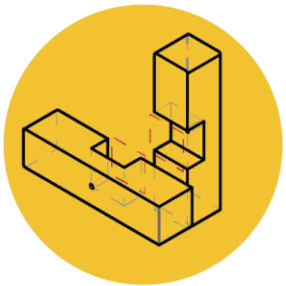
RESEARCH STRUCTURE



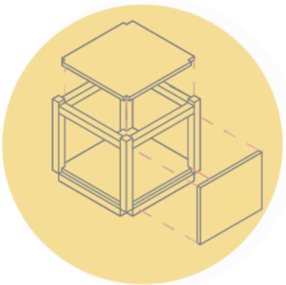
MATERIAL



CNC MILLING



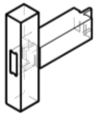
JOINT



SYSTEM

FIRST METHOD

$$M = \frac{\sigma \cdot (b \cdot d^2)}{6}$$



σ = modulus of rupture / Douglas Pine

b = Thickness

d = depth

ULTIMATE BENDING MOMENT

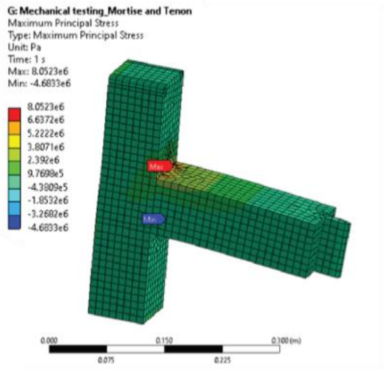
$$M = \frac{66,9N / mm^2 \cdot (27mm \cdot 76mm^2)}{6} =$$

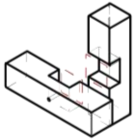
$$M = 1.74Kn / m$$

FORCE CAPACITY

$$= \frac{1.74Kn / m^2}{(60mm / 100)} = 2.9Kn / m$$

MORTISE AND TENON





ULTIMATE BENDING MOMENT

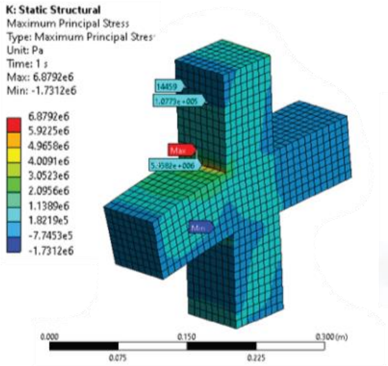
$$M = \frac{66,9N / mm^2 \cdot (38mm \cdot 76mm^2)}{6} =$$

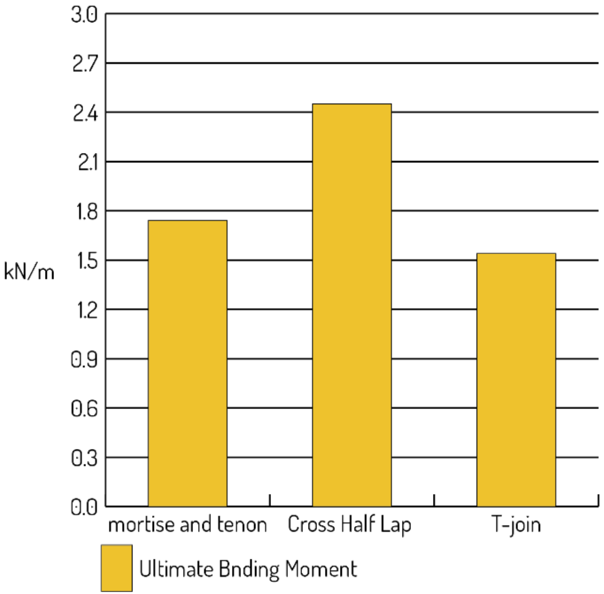
$$M = 2.45kNm$$

FORCE CAPACITY

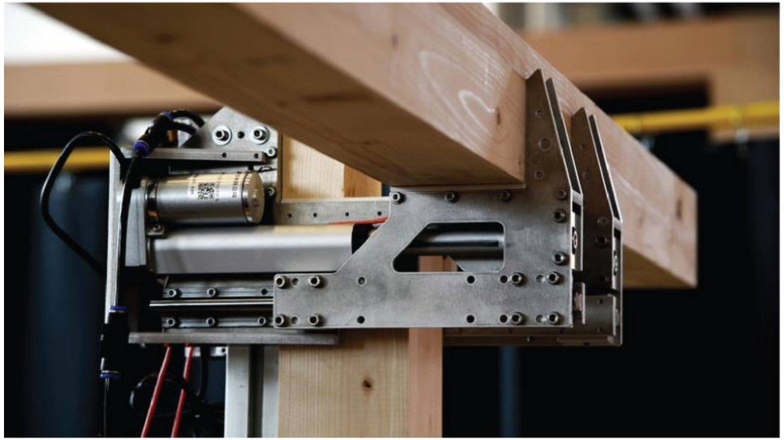
$$= \frac{2.45Kn / m^2}{(60mm / 100)} = 4.04Kn / m$$

CROSS-HALF LAP



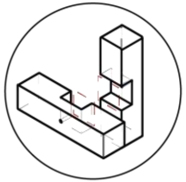


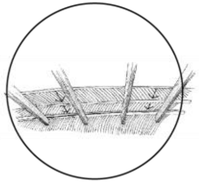
ASSEMBLY METHOD



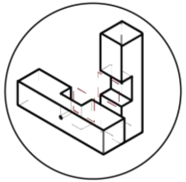
GRAMAZIO KHOLER – Timber assembly with distributed architectural robotics 2018 - 2022

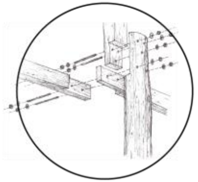
ROOF SYSTEM



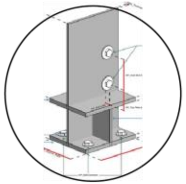


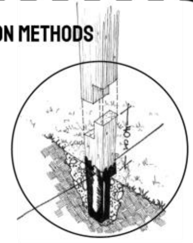
COLOMBIAN TRADITIONAL JOINERY





FOUNDATATION METHODS

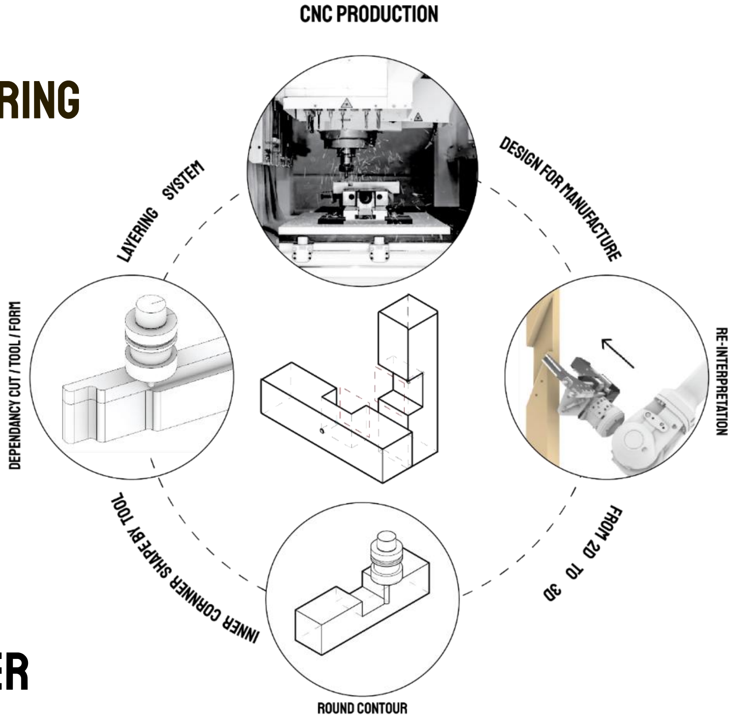




CONCLUSION

FLEXIBLE MANUFACTURING METHOD

TOLERANCES

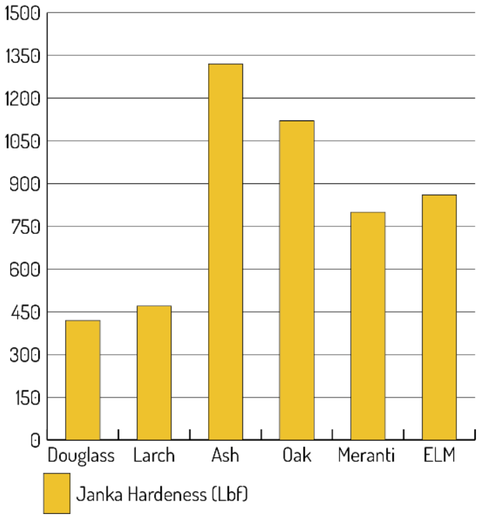


TIGHT FITTING CONTACT LOAD TRANSFER

MISALIGNMENT CORRECTIONS

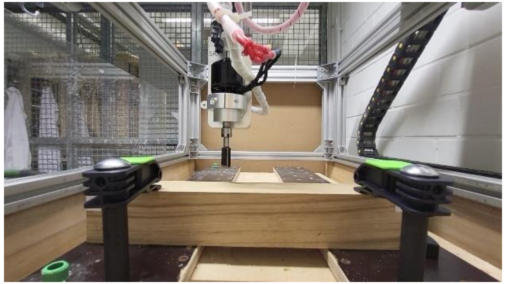
TH KÖLN CNC

MATERIAL HARDNESS



TH KOLN – 4 AXIS CNC SET UP

MATERIAL RESISTANCE

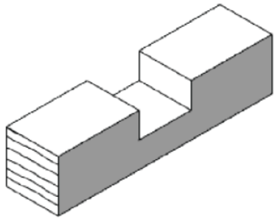


LIST OF MATERIALS AVAILABLE - CROSS HALF-LAP

PLANED BEAMS - GRAIN - 18%

#	CROSS - SECTION	LENGTH	MOISTURE CONTENT	GRAIN DIRECTION	CHECK LIST	ELEMENT	JOINT GRAIN DIRECTION	PRODUCITON	HUMIDITY
1	67 x 67 mm	400 mm	18%	Tangential		Column	II - Tangential	0:02:47	
2	67 x 67 mm	400 mm	18%	I - Radial		Beam	I - Radial	0:02:47	60%
3	67 x 67 mm	400 mm	18%	Tangential		Column	II - Tangential	0:02:47	
4	67 x 67 mm	400 mm	18%	I - Radial		Beam	I - Radial	0:02:47	85%
5	67 x 67 mm	400 mm	18%	Tangential		Column	II - Tangential	0:02:47	
6	67 x 67 mm	400 mm	18%	Tangential		Beam	II - Tangential	0:02:47	60%
7	67 x 67 mm	400 mm	18%	Tangential		Column	II - Tangential	0:02:47	
8	67 x 67 mm	400 mm	18%	Tangential		Beam	II - Tangential	0:02:47	85%
9	67 x 67 mm	400 mm	18%	I - Radial		Column	I - Radial	0:02:47	
10	67 x 67 mm	400 mm	18%	I - Radial		Beam	I - Radial	0:02:47	60%

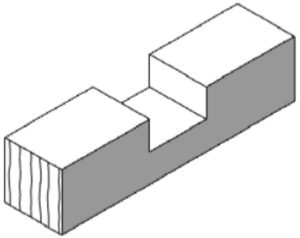
II - Tangential



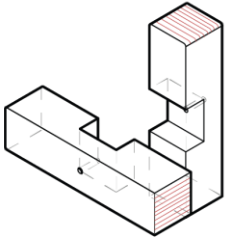
NO PLANED BEAMS - II GRAIN - 10.5%

#	CROSS - SECTION	LENGTH	MOISTURE CONTENT	GRAIN DIRECTION	CHECK LIST	ELEMENT	JOINT GRAIN DIRECTION	PRODUCITON	HUMIDITY
1	65 x 67 mm	400 mm	11%	Tangential		Column	II - Tangential	0:03:33	
2	65 x 67 mm	400 mm	11%	I - Radial		Beam	I - Radial	0:03:33	60%
3	65 x 67 mm	400 mm	11%	Tangential		Column	II - Tangential	0:03:33	
4	65 x 67 mm	400 mm	11%	I - Radial		Beam	I - Radial	0:03:33	85%
5	65 x 67 mm	400 mm	11%	Tangential		Column	II - Tangential	0:03:33	
6	65 x 67 mm	400 mm	11%	Tangential		Beam	II - Tangential	0:03:33	60%
7	65 x 67 mm	400 mm	11%	Tangential		Column	II - Tangential	0:03:33	
8	65 x 67 mm	400 mm	11%	Tangential		Beam	II - Tangential	0:03:33	85%
9	65 x 67 mm	400 mm	11%	I - Radial		Column	I - Radial	0:03:33	
10	65 x 67 mm	400 mm	11%	I - Radial		Beam	I - Radial	0:03:33	60%

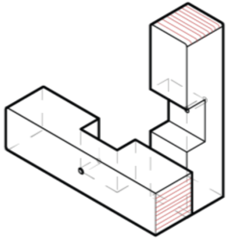
I - Radial



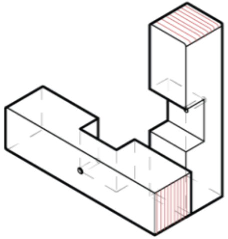
RED -3-4-65%



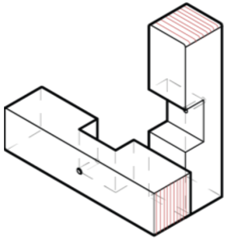
RED -1-2-85%



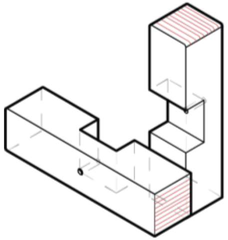
RED -7-8-85%



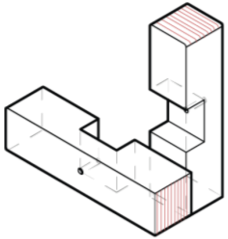
RED -5-6-65%



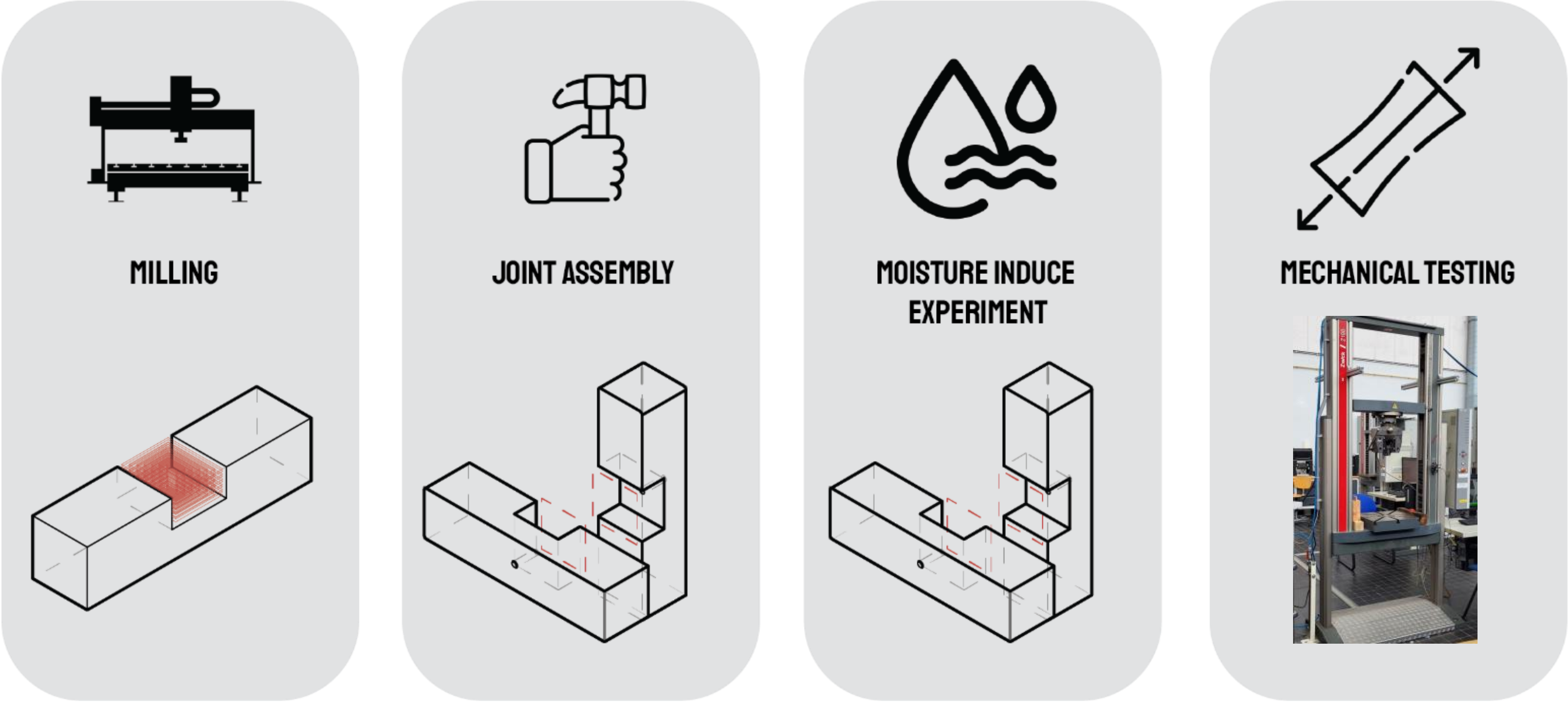
BLUE -3-4-65%



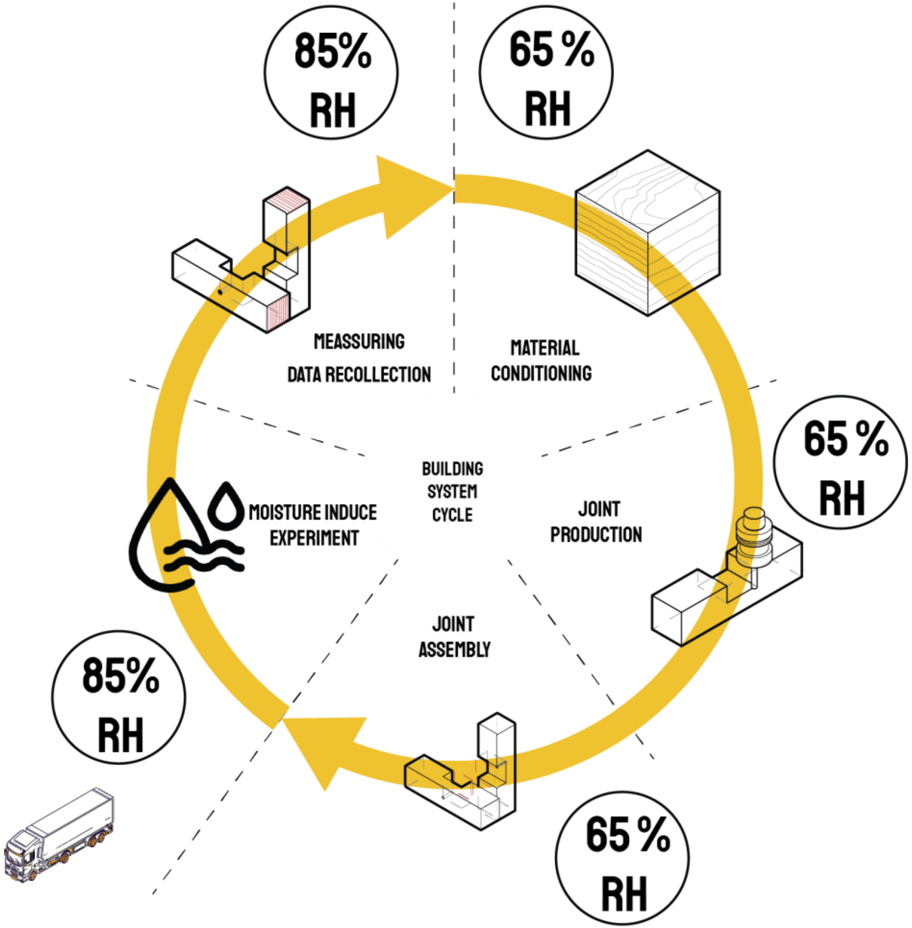
BLUE -7-8-85%



MOISTURE INDUCE


MILLING
JOINT ASSEMBLY
MOISTURE INDUCE EXPERIMENT
MECHANICAL TESTING

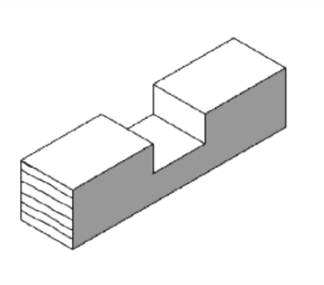

KNO3 ±95% RH
potassium nitrate


85% RH
65 % RH
MEASSURING DATA RECOLLECTION
MATERIAL CONDITIONING
65 % RH
BUILDING SYSTEM CYCLE
MOISTURE INDUCE EXPERIMENT
JOINT PRODUCTION
JOINT ASSEMBLY
85% RH
65 % RH

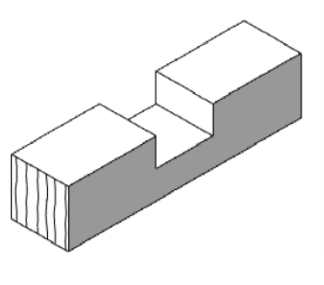
LIST OF MATERIALS AVAILABLE - CROSS HALF-LAP

#	CROSS - SECTION	LENGTH	MOISTURE CONTENT	GRAIN DIRECTION	CHECK LIST	ELEMENT	JOINT GRAIN DIRECTION	PRODUCITON	HUMIDITY
PLANED BEAMS - GRAIN - 18%									
1	67 x 67 mm	400 mm	18%	Tangential		Column	II - Tangential	0:02:47	
2	67 x 67 mm	400 mm	18%	I - Radial		Beam	I - Radial	0:02:47	60%
3	67 x 67 mm	400 mm	18%	Tangential		Column	II - Tangential	0:02:47	
4	67 x 67 mm	400 mm	18%	I - Radial		Beam	I - Radial	0:02:47	85%
5	67 x 67 mm	400 mm	18%	Tangential		Column	II - Tangential	0:02:47	
6	67 x 67 mm	400 mm	18%	Tangential		Beam	II - Tangential	0:02:47	60%
7	67 x 67 mm	400 mm	18%	Tangential		Column	II - Tangential	0:02:47	
8	67 x 67 mm	400 mm	18%	Tangential		Beam	II - Tangential	0:02:47	85%
9	67 x 67 mm	400 mm	18%	I - Radial		Column	I - Radial	0:02:47	
10	67 x 67 mm	400 mm	18%	I - Radial		Beam	I - Radial	0:02:47	60%
NO PLANED BEAMS - II GRAIN - 10.5%									
1	65 x 67 mm	400 mm	11%	Tangential		Column	II - Tangential	0:03:33	
2	65 x 67 mm	400 mm	11%	I - Radial		Beam	I - Radial	0:03:33	60%
3	65 x 67 mm	400 mm	11%	Tangential		Column	II - Tangential	0:03:33	
4	65 x 67 mm	400 mm	11%	I - Radial		Beam	I - Radial	0:03:33	85%
5	65 x 67 mm	400 mm	11%	Tangential		Column	II - Tangential	0:03:33	
6	65 x 67 mm	400 mm	11%	Tangential		Beam	II - Tangential	0:03:33	60%
7	65 x 67 mm	400 mm	11%	Tangential		Column	II - Tangential	0:03:33	
8	65 x 67 mm	400 mm	11%	Tangential		Beam	II - Tangential	0:03:33	85%
9	65 x 67 mm	400 mm	11%	I - Radial		Column	I - Radial	0:03:33	
10	65 x 67 mm	400 mm	11%	I - Radial		Beam	I - Radial	0:03:33	60%

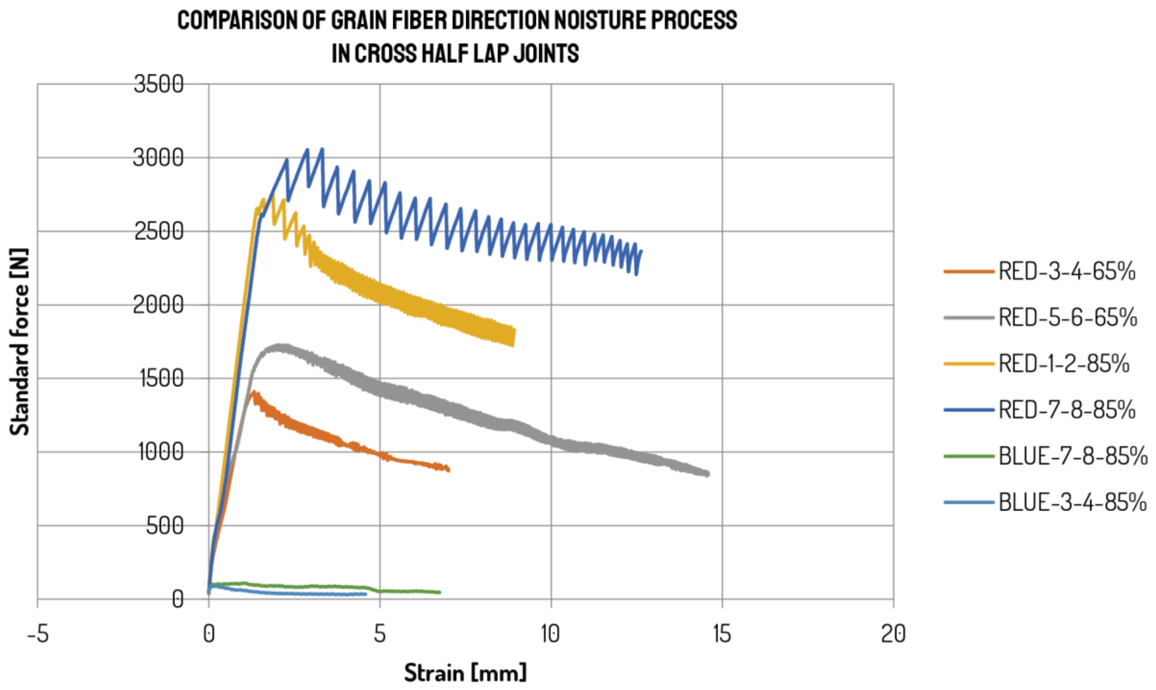
II - Tangential

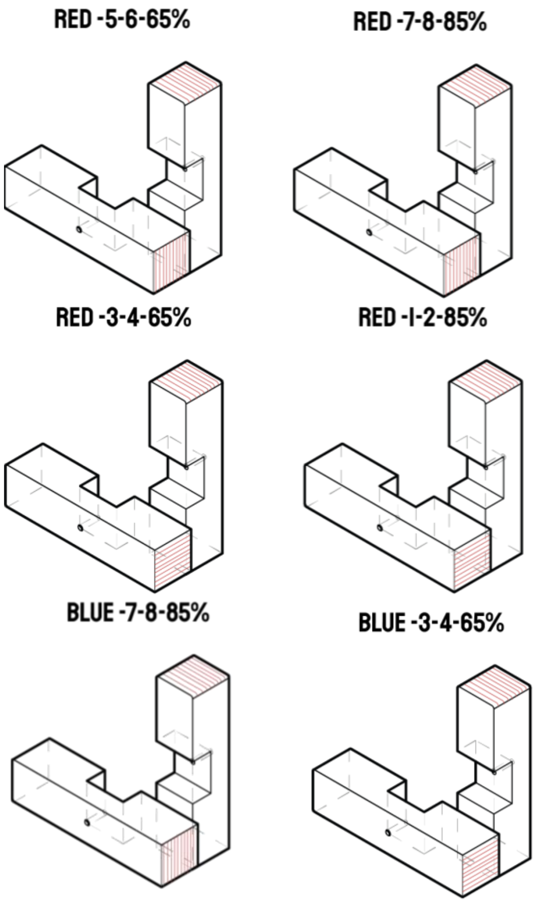


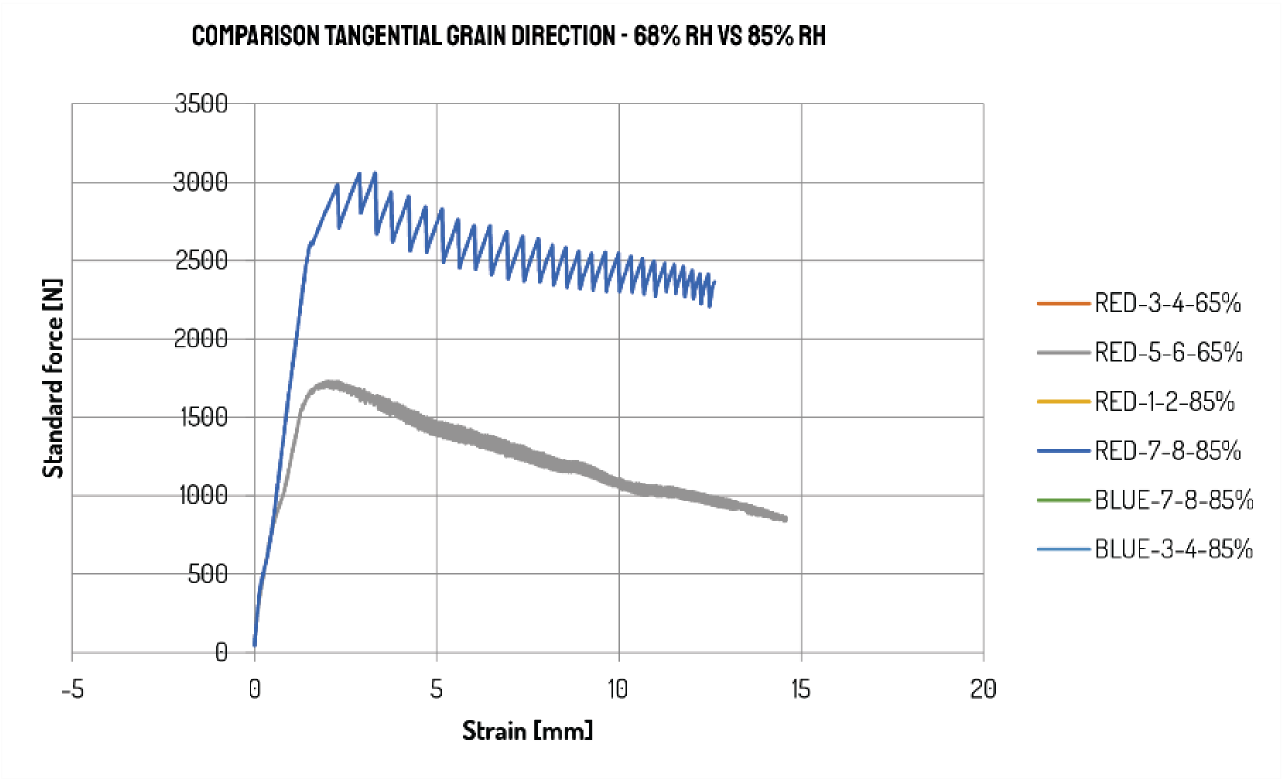
I - Radial



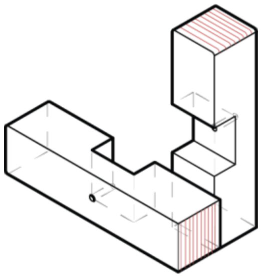
MECHANICAL TESTING OF MOISTURE IMPACT IN THE JOINERY


COMPARISON OF GRAIN FIBER DIRECTION NOISTURE PROCESS
IN CROSS HALF LAP JOINTS
Standard force [N]
Strain [mm]
3500
3000
2500
2000
1500
1000
500
0
-5
0
5
10
15
20
RED-3-4-65%
RED-5-6-65%
RED-1-2-85%
RED-7-8-85%
BLUE-7-8-85%
BLUE-3-4-85%

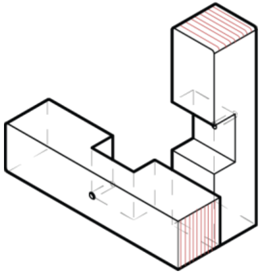

RED -5-6-65%
RED -7-8-85%
RED -3-4-65%
RED -1-2-85%
BLUE -7-8-85%
BLUE -3-4-65%



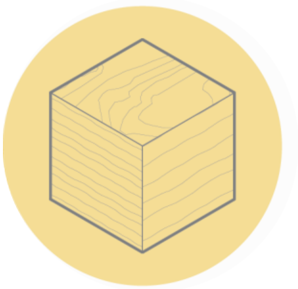
RED -5-6-65%



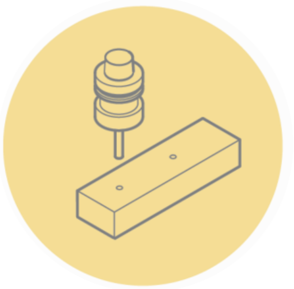
RED -7-8-85%



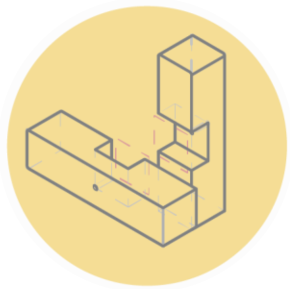
RESEARCH STRUCTURE



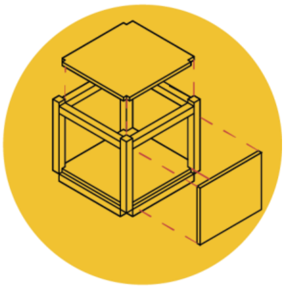
MATERIAL



CNC MILLING



JOINT

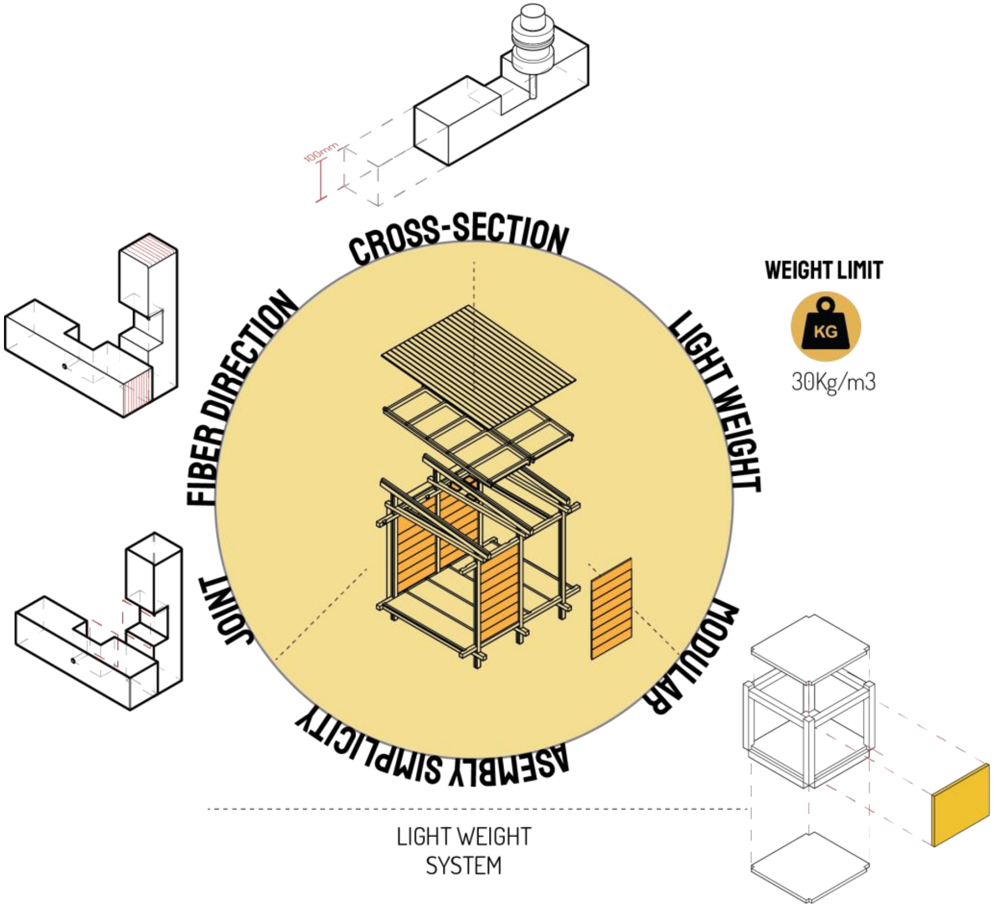


SYSTEM

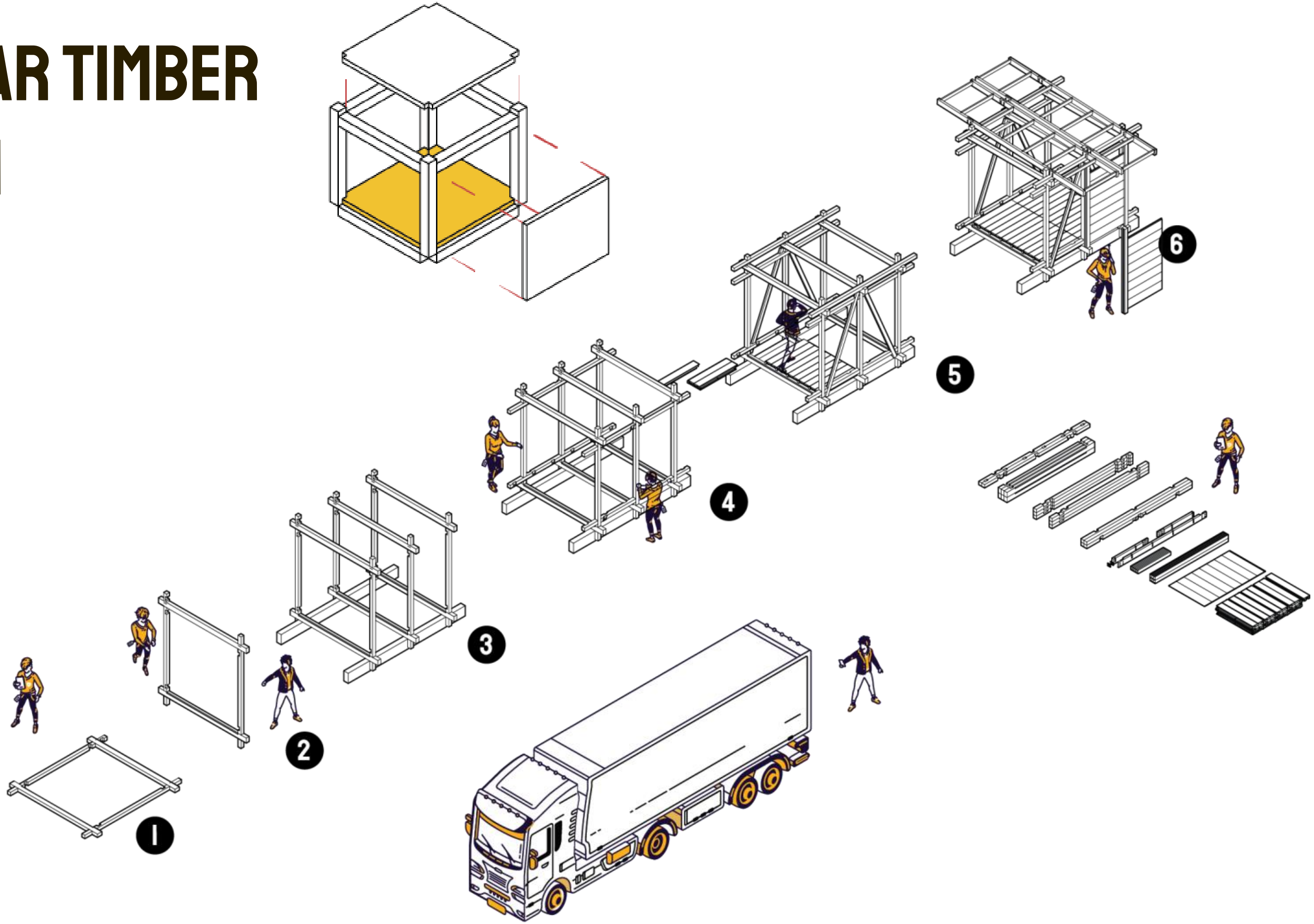
APPLICATION OF TECHNOLOGY IN A LATIN AMERICAN CONTEXT

DESIG

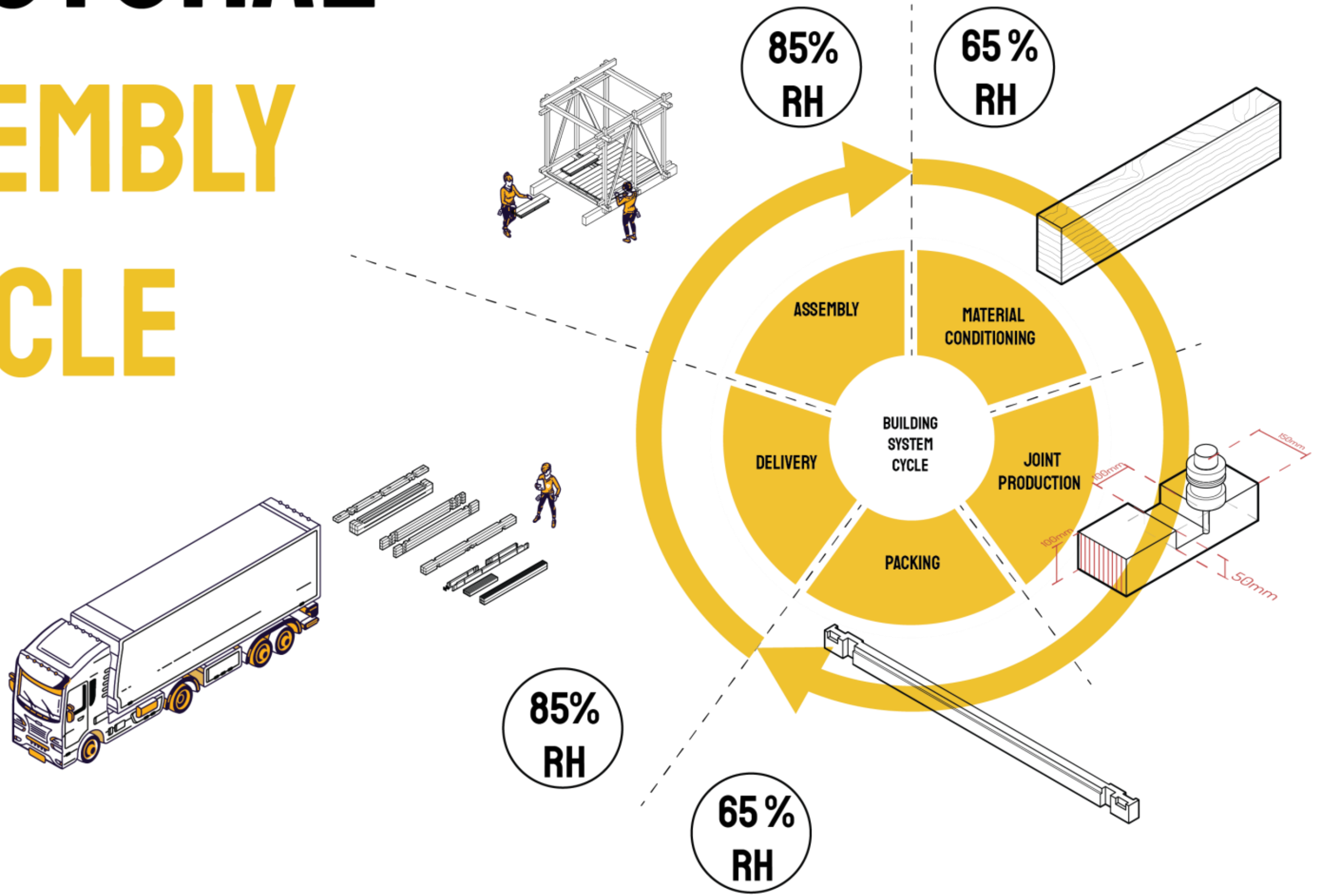
DESIGN GUIDELINES



MODULAR TIMBER SYSTEM

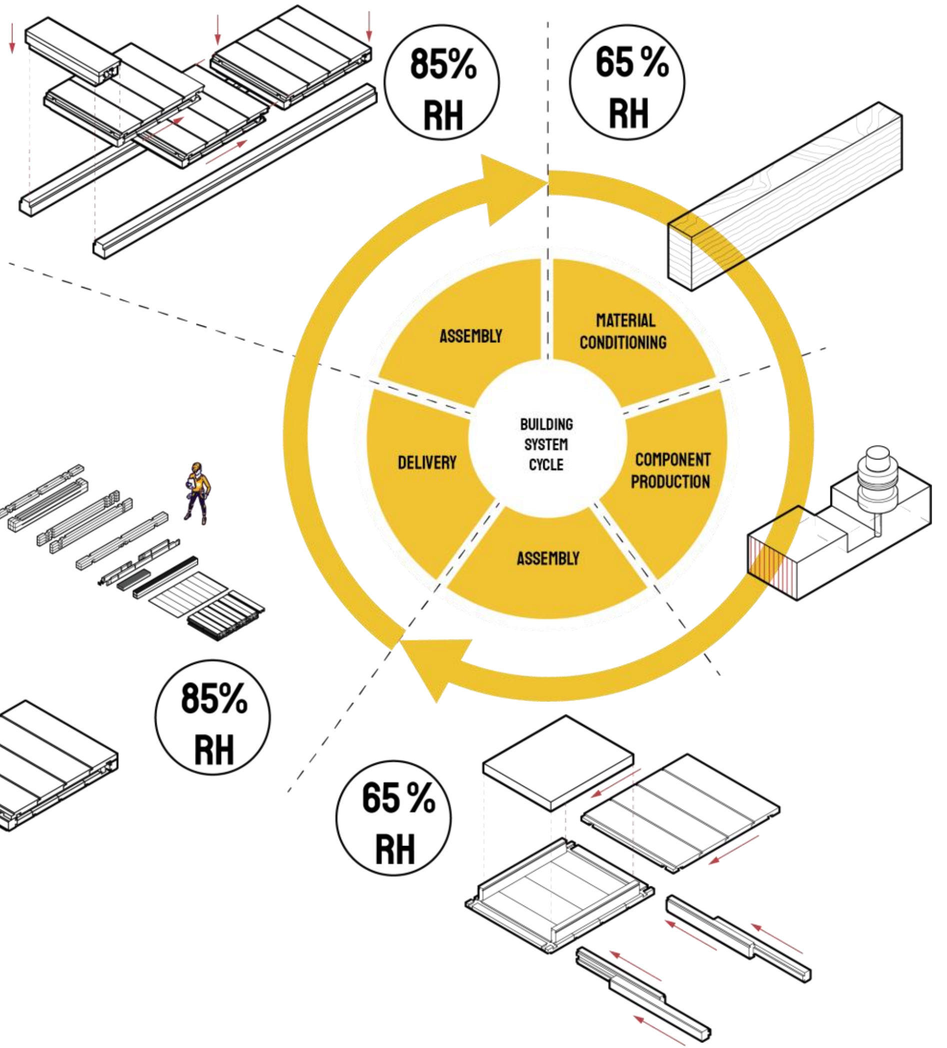


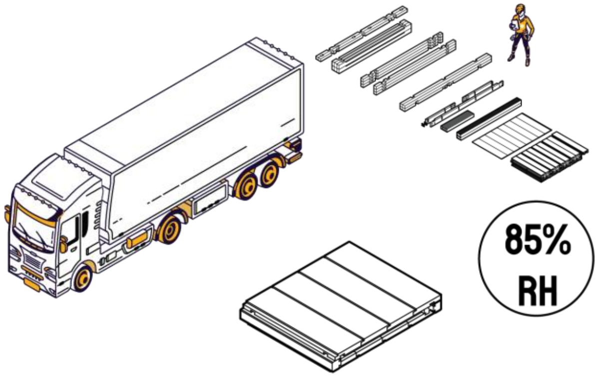
STRUCTURAL
ASSEMBLY
CYCLE

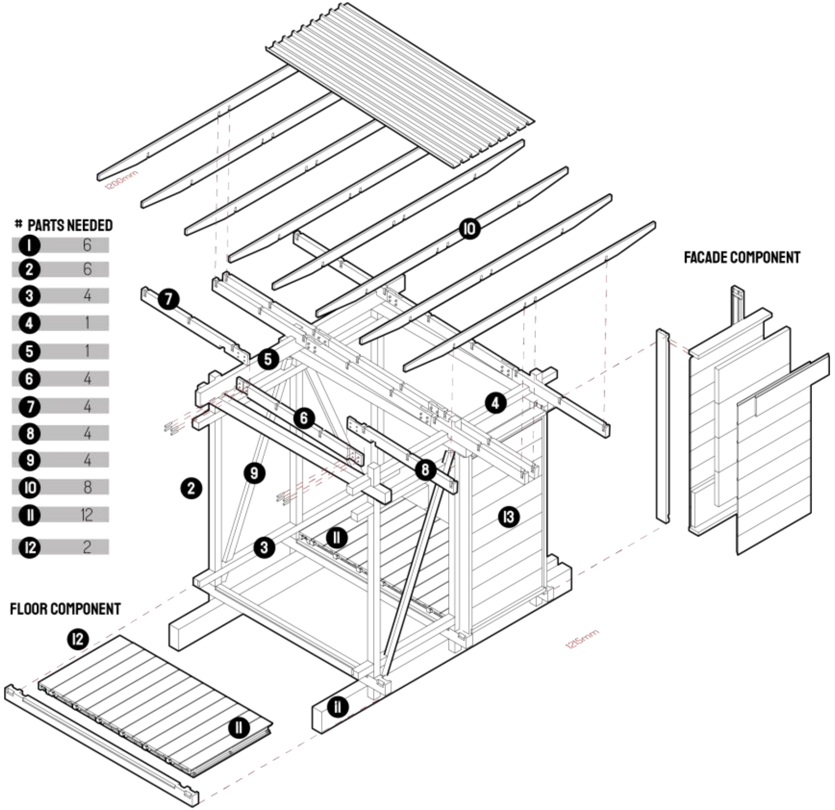


COMPONENT

CYCLE







PARTS NEEDED
1 6
2 6
3 4
4 1
5 1
6 4
7 4
8 4
9 4
10 8
11 12
12 2
FACADE COMPONENT
FLOOR COMPONENT
1200mm
1215mm