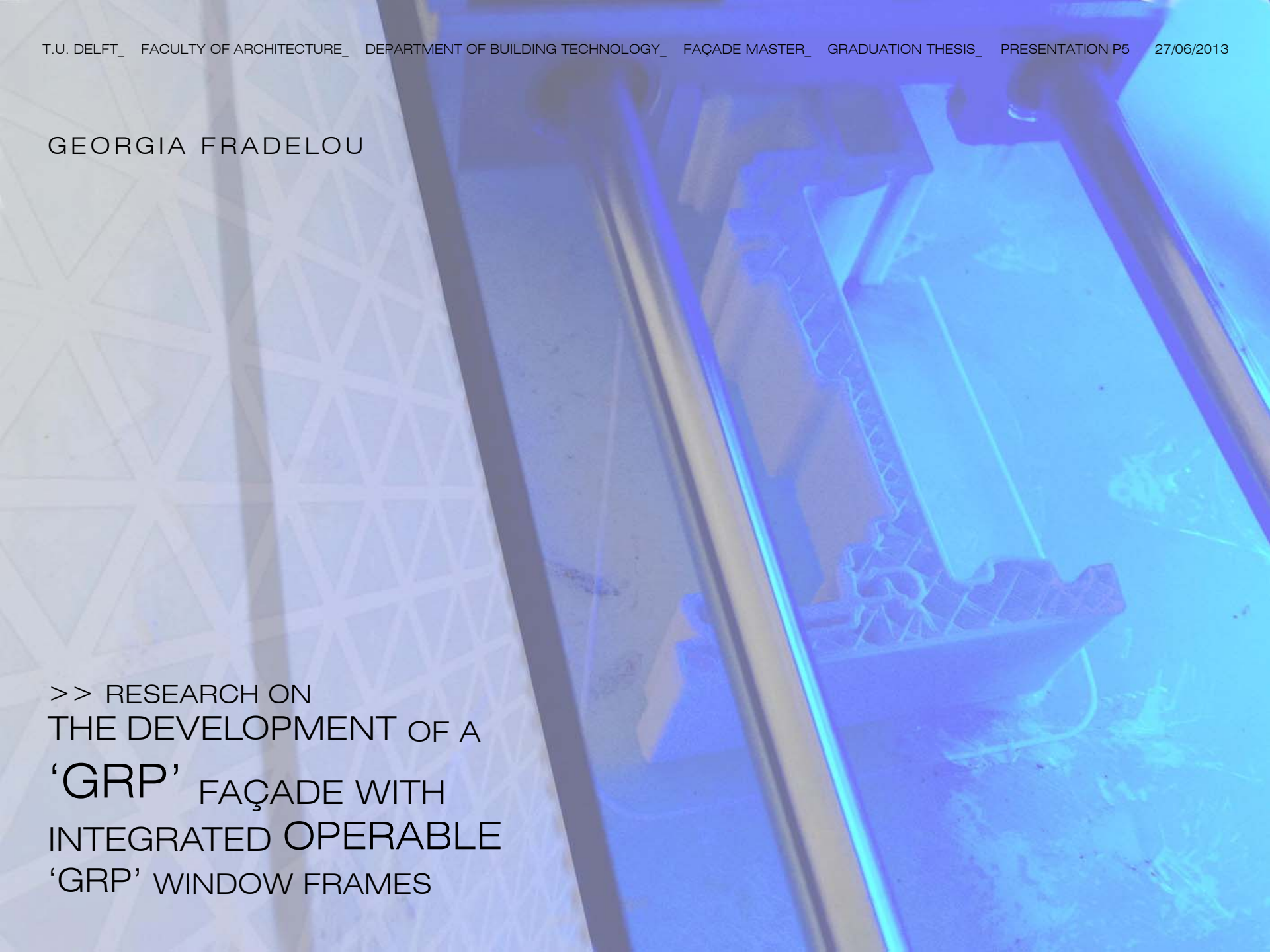


GEORGIA FRADELOU

>> RESEARCH ON
THE DEVELOPMENT OF A
'GRP' FAÇADE WITH
INTEGRATED OPERABLE
'GRP' WINDOW FRAMES



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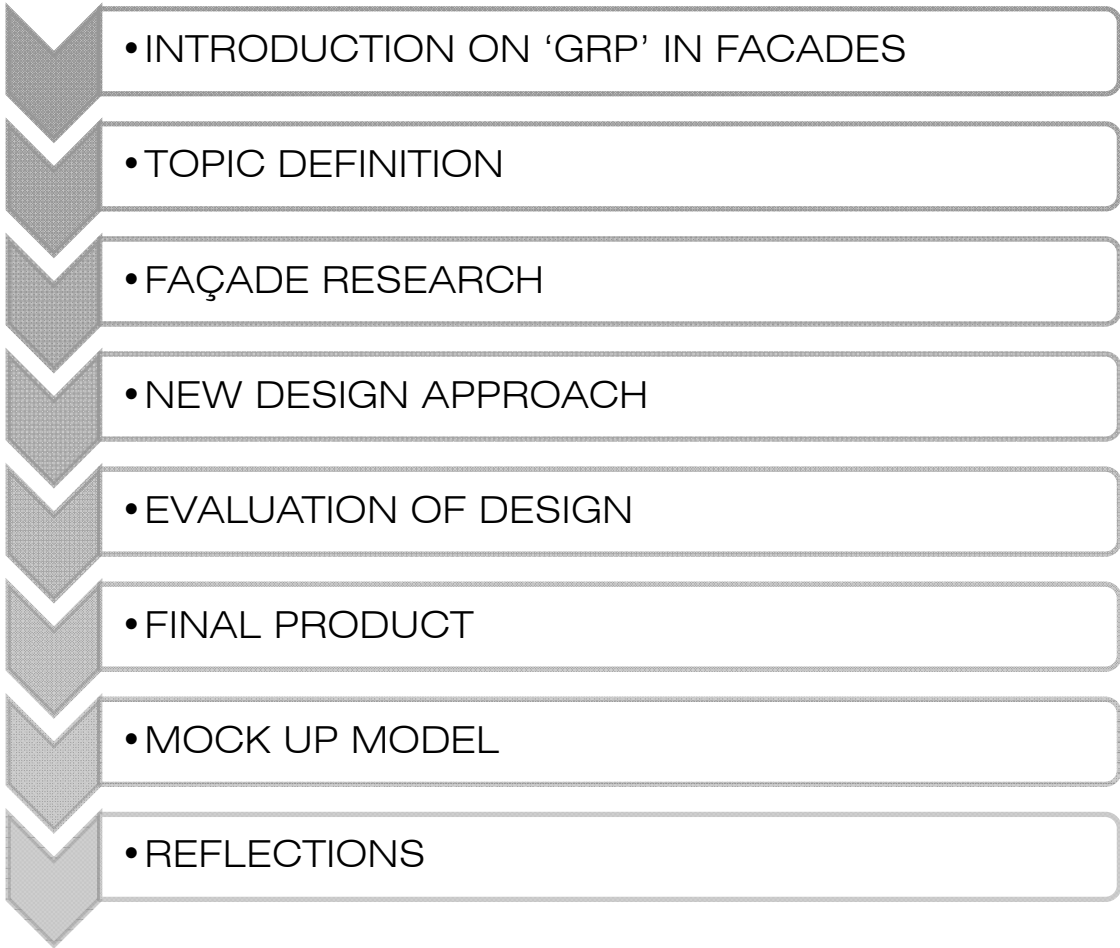
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THIRD MENTOR: JHON DE WILD

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- INTRODUCTION ON 'GRP' IN FACADES

- TOPIC DEFINITION

- FAÇADE RESEARCH

- NEW DESIGN APPROACH

- EVALUATION OF DESIGN

- FINAL PRODUCT

- MOCK UP MODEL

- REFLECTIONS

GRP IS

A REINFORCED POLYMER MADE OF A PLASTIC MATRIX
REINFORCED BY FINE FIBERS OF GLASS



PLASTIC (polymer) as matrix

STRESS TRANSFER AND PROTECTION
the matrix material surrounds and
supports the reinforcement materials by
maintaining their relative positions

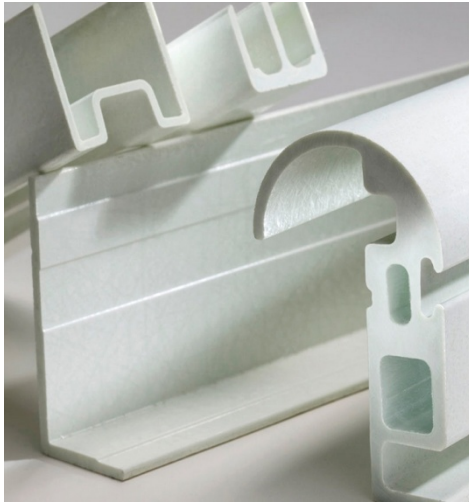


Long (continuous) FIBRES

REINFORCEMENT

the reinforcements impart
their special mechanical and
physical properties to
enhance the matrix properties

PROFILES



PULTRUSION

LAMINATES



HAND LAY-UP
 SPRAY LAY-UP
 CONTINUOUS LAMINATION
 AUTOMATED LAY-UP

SANDWICH PANELS



VACUUM ASSISTED RESIN
 TRANSFER MOLDING (VARTM)
 VACUUM BAG MOLDING
 INJECTION MOLDING
 RESIN TRANSFER MOLDING (RTM)

2 ANALYSIS GRP APPLICATIONS IN FACADES

WINDESCHEIM // ZWOLLE



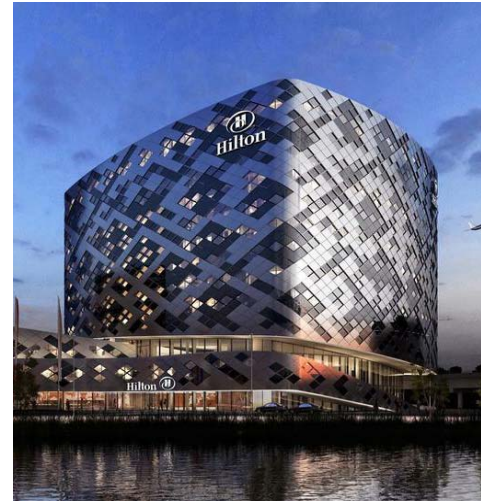
VACUUM INJECTION
ONLY TWO DIFFERENT MOLDS
12X3.6 METERS ELEMENT SIZE

STADSKANTOOR // UTRECHT



VACUUM ASSISTED RESIN
TRANSFER MOLDING
5.4X3.6 METERS ELEMENT SIZE

HILTON HOTEL //SCHIPHOL



VACUUM ASSISTED RESIN
TRANSFER MOLDING
DIAMOND SHAPE GRP ELEMENTS
DIAGONAL LINES
4.6X3.0 METERS ELEMENT SIZE

ANALYSIS_ GRP SANDWICH PANELS

TWO STIFF AND STRONG FACES / ONE THICK LIGHT AND WEAKER CORE

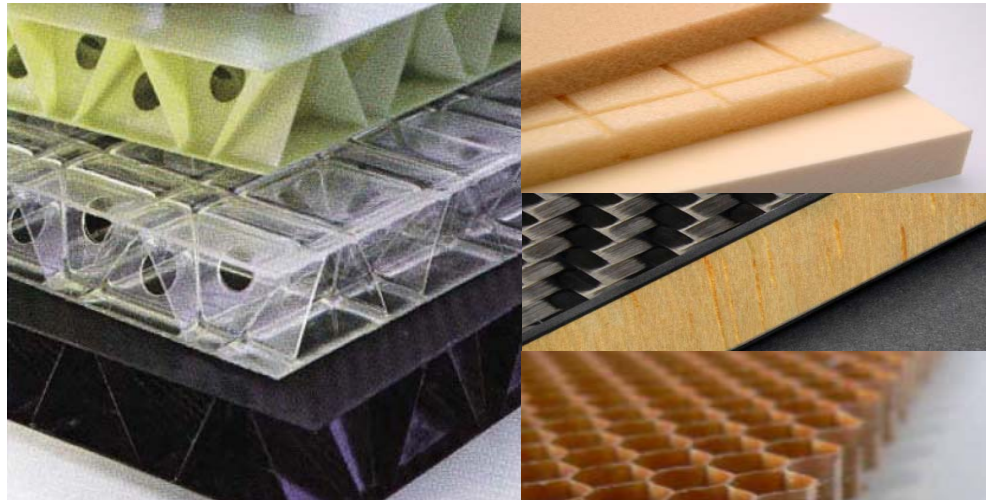
LAMINATE COMPOSITE



⋮ FACING MATERIAL

HIGH STIFFNESS
HIGH TENSILE
HIGH COMPRESSIVE STRENGTH
IMPACT RESISTANCE
WEAR RESISTANCE

CORRUGATED // HONEYCOMB // Balsa // FOAM



⋮ CORE MATERIAL

LOW DENSITY
SHEAR STRENGTH
STIFFNESS PERPENDICULAR TO THE FACES
THERMAL INSULATION
ACOUSTICAL INSULATION



GLASS FIBERS



CLOSED MOLD



FINAL PRODUCT

3 TOPIC DEFINITION_MOTIVATION



INCREASE OF GRP IN FAÇADE APPLICATIONS

MATERIAL ADVANTAGES OVER TRADITIONAL MATERIALS

- HIGH STRENGTH
- HIGH STIFFNESS
- LOW WEIGHT
- FREE FORM POSSIBILITIES

3

TOPIC DEFINITION

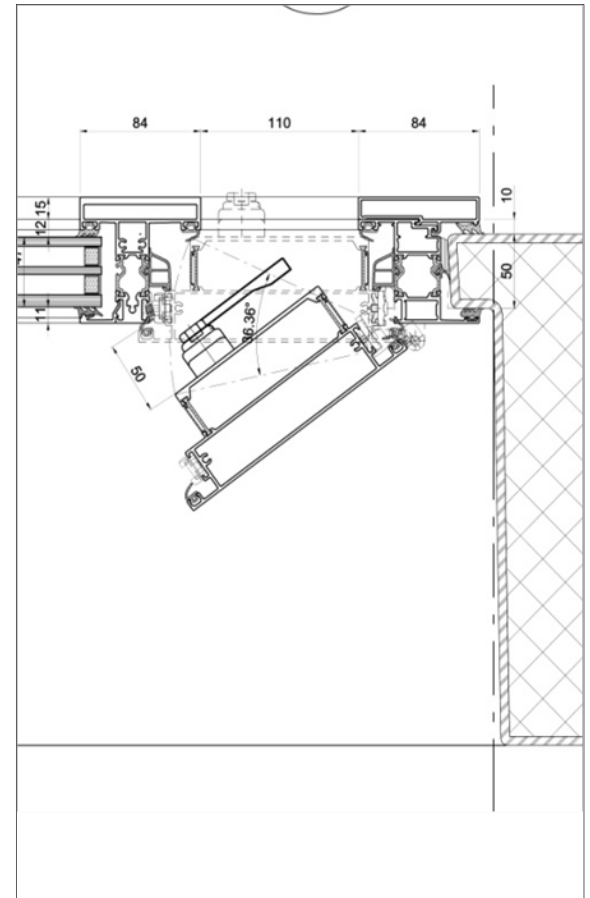
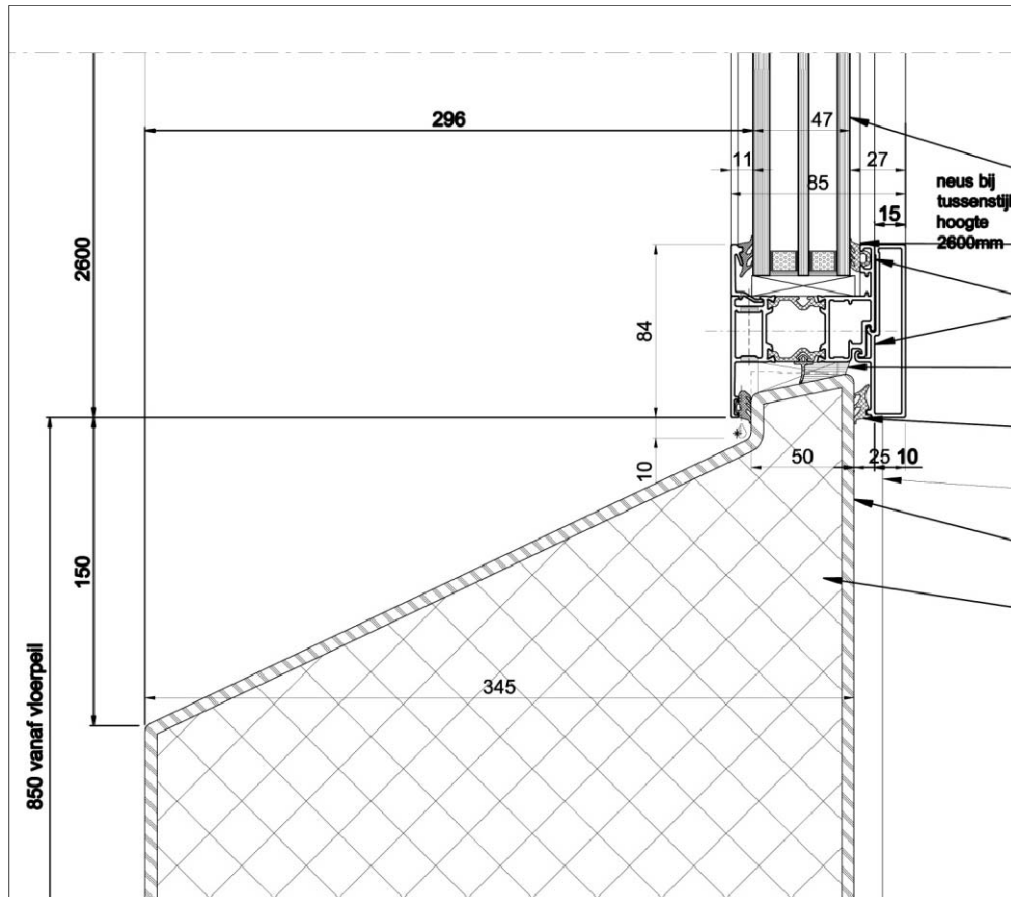
PROBLEM STATEMENT

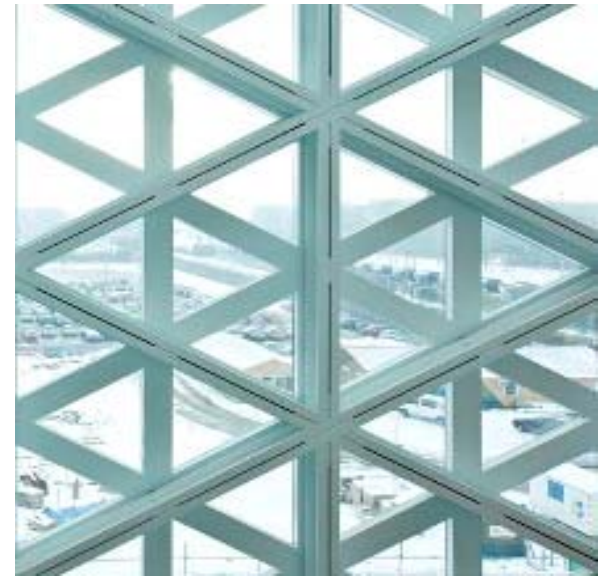
THERE IS NO **FAÇADE PRODUCT** DEVELOPED
THAT IS MADE ENTIRELY OUT OF GRP FAÇADE PANELS
AND OPERABLE GRP WINDOW FRAMES



ALUMINUM OPERABLE FRAMES







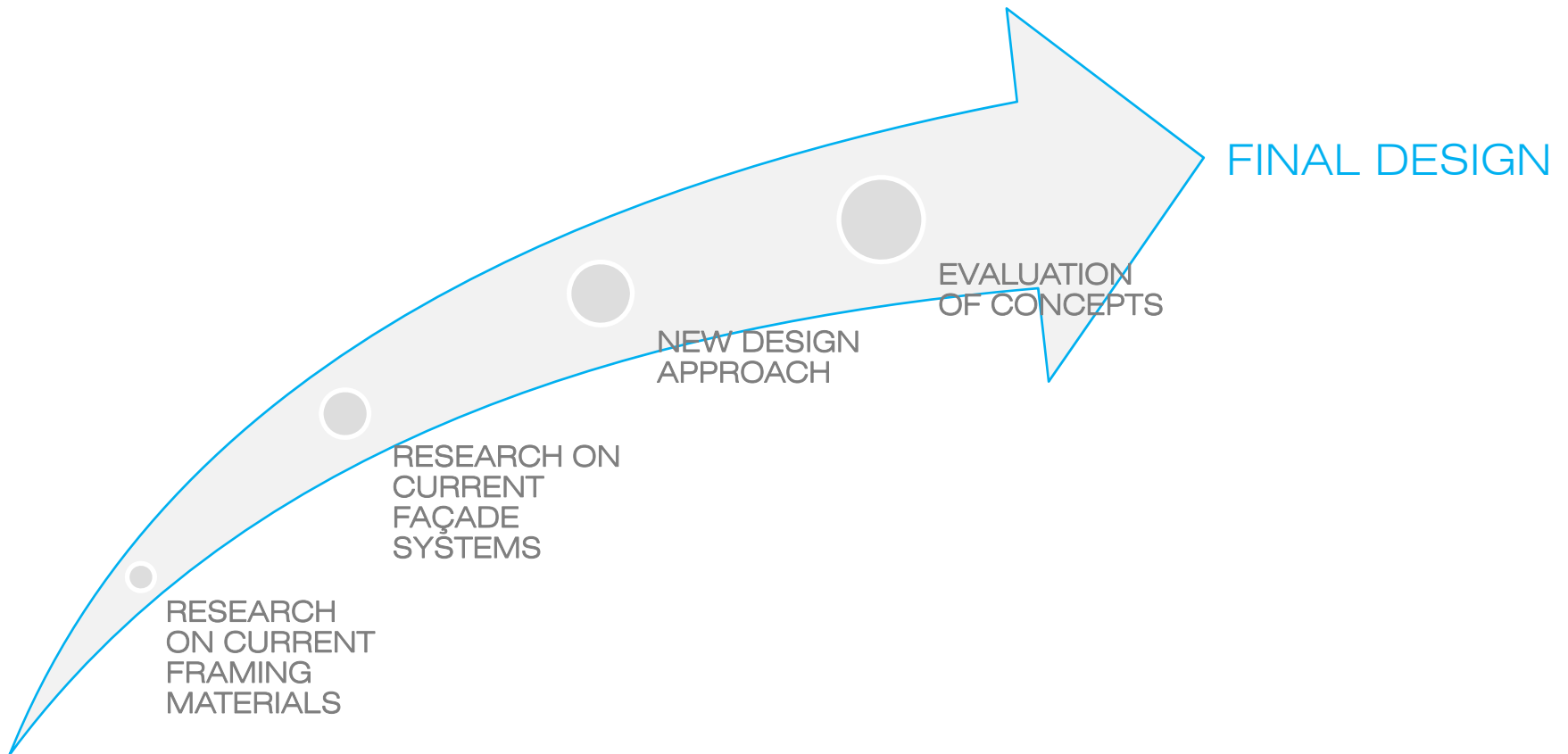
GRP GLUED WINDOW FRAMES

WHAT **PRINCIPLES** SHOULD A DESIGN OF A GRP FAÇADE WITH INTEGRATED OPERABLE GRP WINDOW FRAMES MEET IN ORDER TO ACHIEVE

HIGH DEGREE OF INTEGRATION AND A GREAT NUMBER OF **PERFORMANCE BENEFITS** OVER A CONVENTIONAL GRP-ALUMINUM FACADE?



3 TOPIC DEFINITION_METHODOLOGY

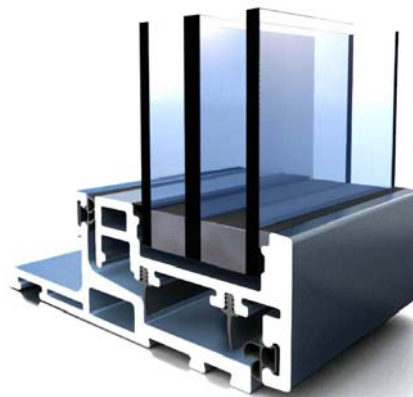


MATERIALS

ALUMINUM
STEEL
TIMBER
TIMBER/ALUMINUM
PVC
GRP/ALUMINUM
GRP

PROPERTIES

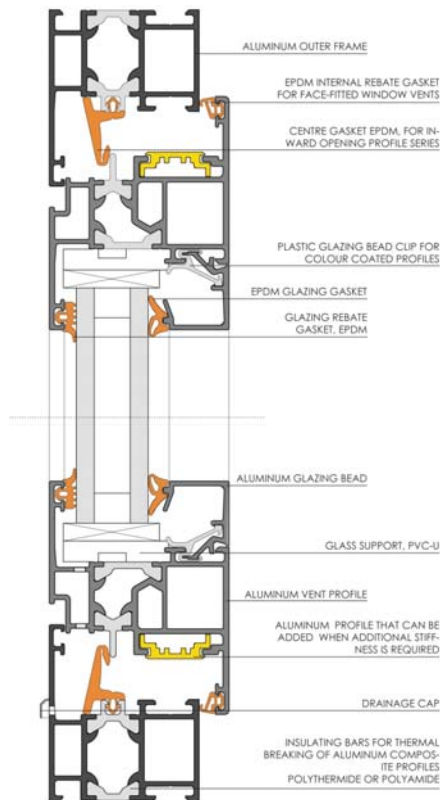
THERMAL
INSULATION
DURABILITY
FIRE RESISTANCE
WATER RESISTANCE
DIFFICULTY TO
REPAIR
LOW MAINTENANCE



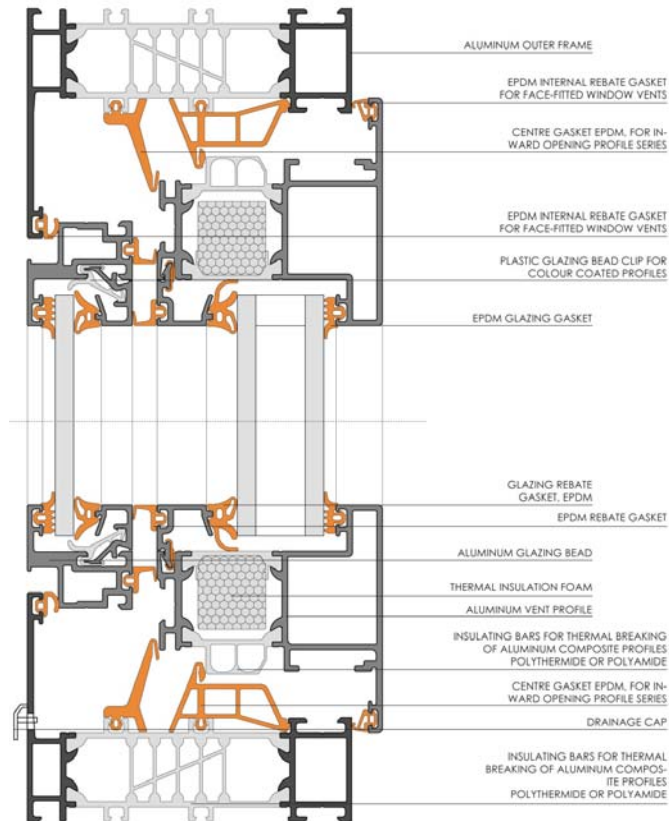
ADVANTAGES OF GRP

- + Superior thermal insulation
- + Light-weight
- + Durability
- + High stiffness
- + Low maintenance
- + Water resistance
- + Corrosion resistance
- + Availability of complex shapes
- + Smaller profiles if compared with other materials
- + Low thermal expansion

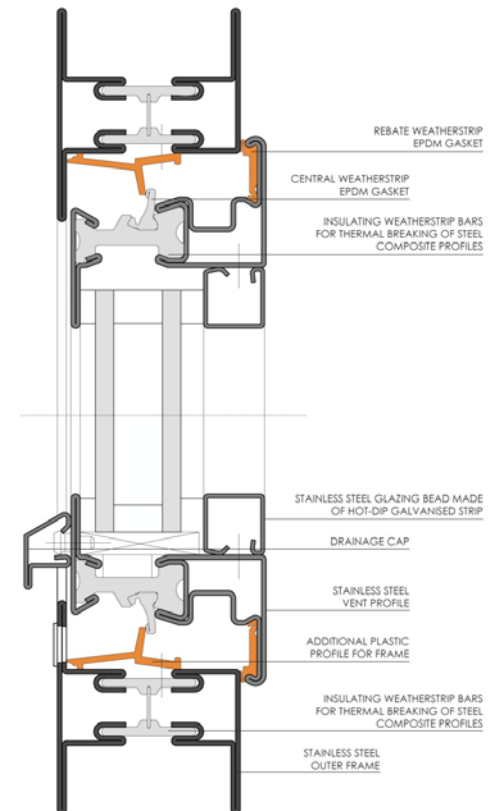
ALUMINUM DOUBLE
GLAZED FRAME (SCHUCO)



ALUMINUM TRIPLE GLAZED
FRAME (SCHUCO)



STEEL DOUBLE GLAZED
FRAME (SCHUCO)

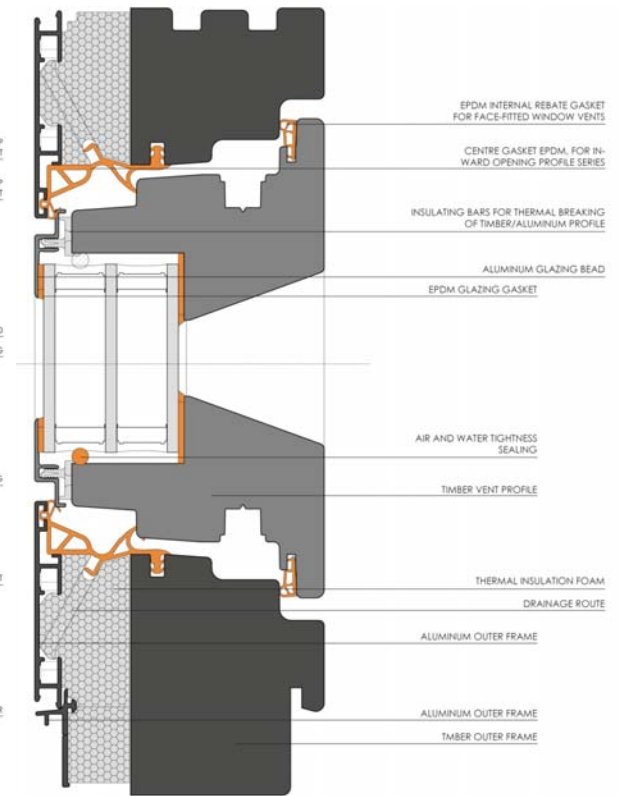
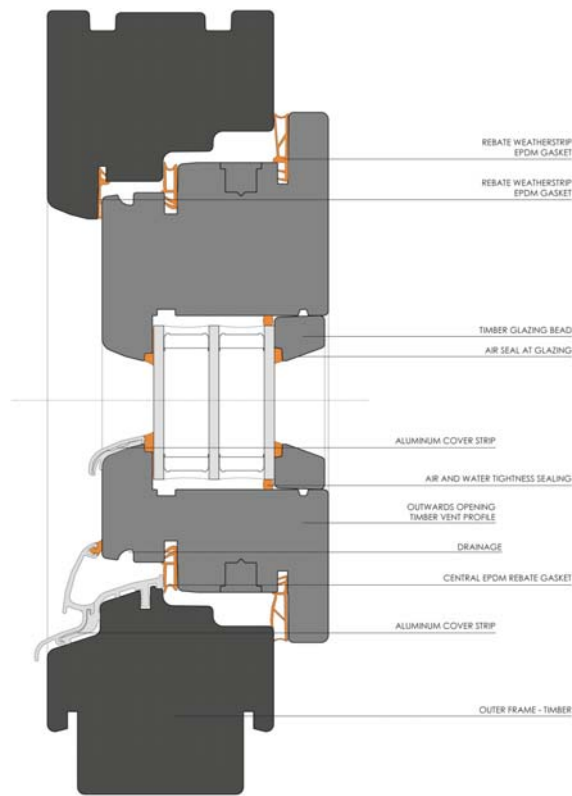
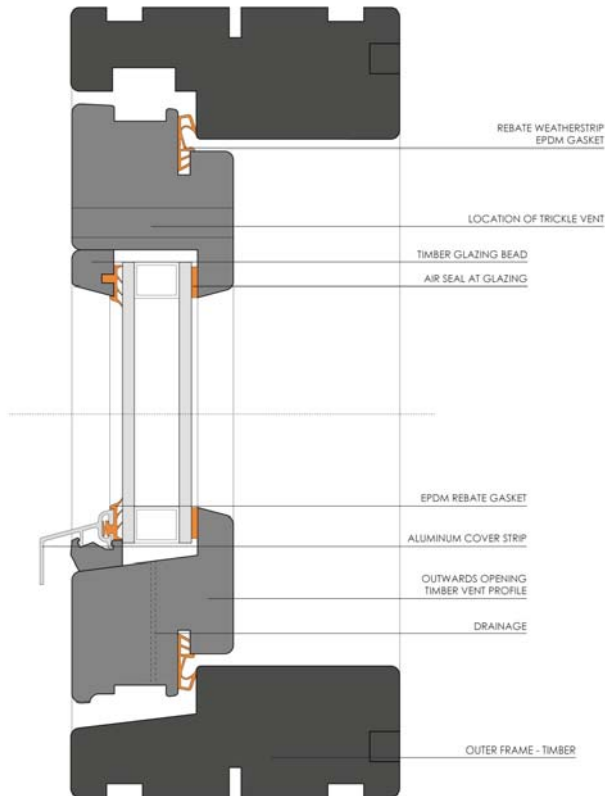


4 FAÇADE RESEARCH FRAMING MATERIALS

TIMBER DOUBLE GLAZED
FRAME (SCAND. TIMBER)

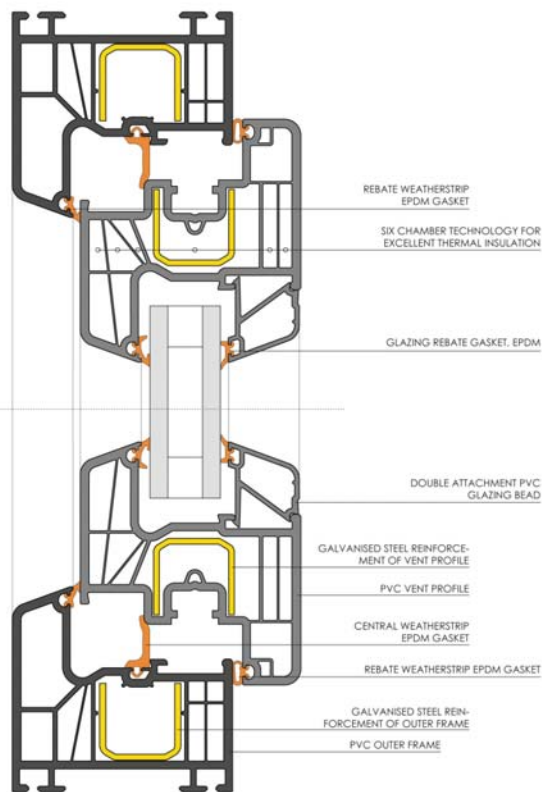
TIMBER TRIPLE GLAZED
FRAME (JOSKO)

TIMBER/ALUMINUM TRIPLE
GLAZED FRAME (JOSKO)

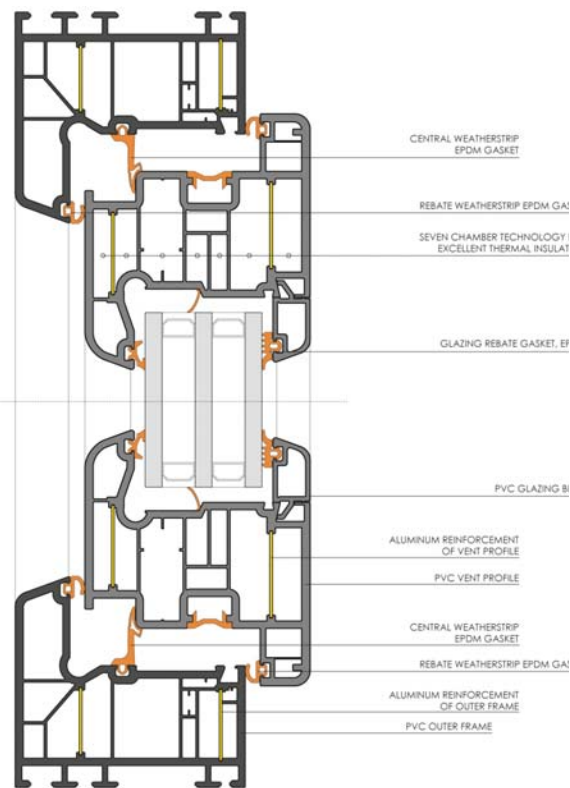


4 FAÇADE RESEARCH FRAMING MATERIALS

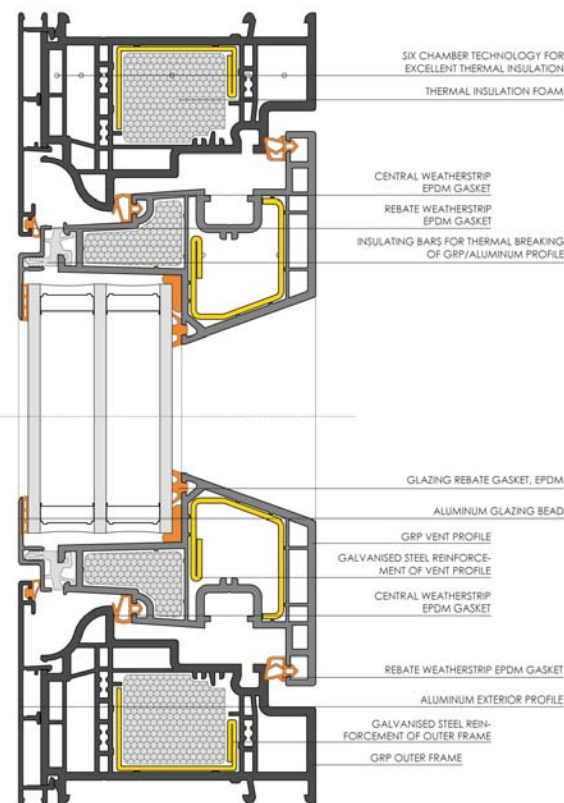
PVC DOUBLE GLAZED FRAME (INOUTIC)

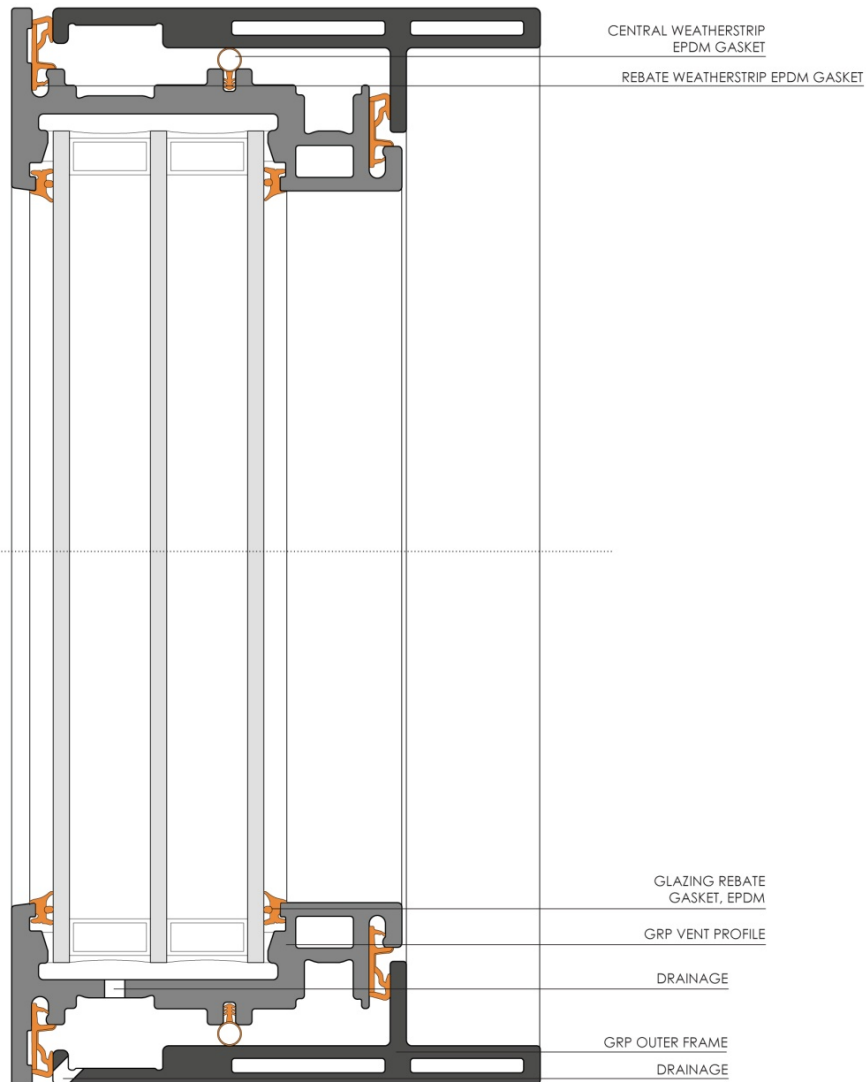


PVC TRIPLE GLAZED FRAME (SCHUCO)



GRP/ALUMINUM TRIPLE GLAZED FRAME (JOSKO)





GRP TRIPLE GLAZED FRAME (ECLIPTICA)

EXTERIOR GRP FRAME
OF MINIMUM
MAINTENANCE

TRIPLE GLAZING FOR
HIGH THERMAL
INSULATION

WOODEN FRAME



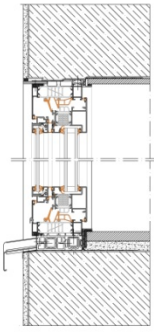
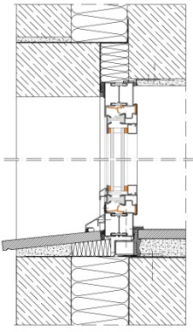
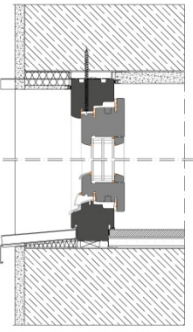
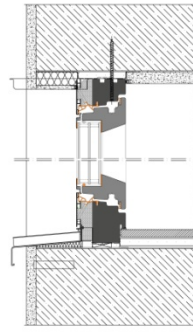
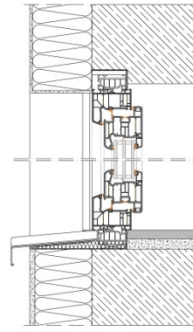
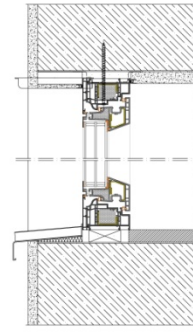
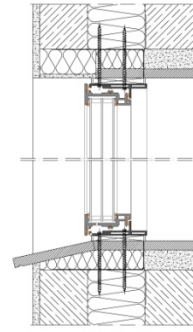
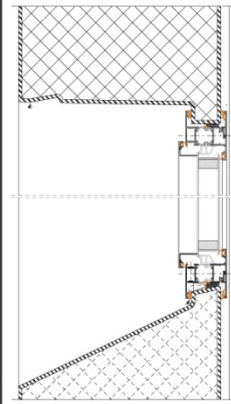
COMMON TYPES OF WINDOW FRAMES _MATERIALS AND COMPONENTS

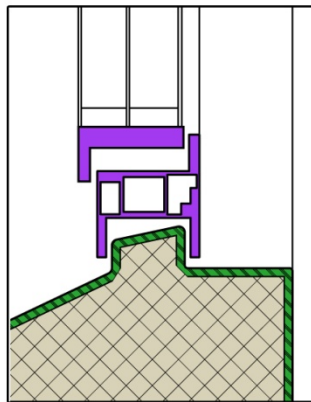
COMPONENTS OF A WINDOW FRAME		ALUMINUM I	ALUMINUM II	STEEL	TIMBER I	TIMBER II	TIMBER/ALUMINUM	u-PVC I	u-PVC II	GRP/ALUMINUM	GRP
	OUTER - FIXED FRAME										
	VENT PROFILE										
	GLAZING LAYERS										
	GLAZING BEAD										
	WEATHERSTRIP GASKETS										
	DESCRIPTION	ALUMINUM DOUBLE INSULATED WINDOW FRAME BY SCHUCO - AWS 50 SYSTEM PROFILES INWARD OPENING VENT	ALUMINUM TRIPLE INSULATED WINDOW FRAME BY SCHUCO - AWS 105 CC.HI SYSTEM PROFILES INWARD OPENING VENT	STEEL DOUBLE INSULATED WINDOW FRAME BY SCHUCO - JANSOL SYSTEM PROFILES INWARD OPENING VENT	TIMBER DOUBLE INSULATED WINDOW PROFILE OLD CONSTRUCTION SCANDINAVIAN TIMBER SYSTEM PROFILES OUTWARD OPENING VENT	TIMBER TRIPLE INSULATED WINDOW PROFILE NEW CONSTRUCTION BY JOSKO - ROBIN 90 SYSTEM PROFILES INWARD OPENING VENT	TIMBER/ALUMINUM TRIPLE INSULATED WINDOW PROFILE NEW CONSTRUCTION BY JOSKO - PLATIV PASSIV SYSTEM PROFILES INWARD OPENING VENT	u-PVC DOUBLE INSULATED WINDOW PROFILE BY INOUTIC - PRESTIGE KLASSISCH SYSTEM PROFILES INWARD OPENING VENT	u-PVC TRIPLE INSULATED WINDOW PROFILE BY SCHUCO - THERMOPLUS SYSTEM PROFILES INWARD OPENING VENT	GRP/ALUMINUM TRIPLE INSULATED WINDOW PROFILE BY JOSKO - SAFIR SYSTEM PROFILES INWARD OPENING VENT	GRP TRIPLE INSULATED WINDOW PROFILE BY ECLIPICA - 3-LAYER GLASS SYSTEM PROFILES OUTWARD OPENING VENT

COMMON TYPES OF WINDOW FRAMES _FUNCTIONS OF FRAME PARTS

DIFFERENT FUNCTIONS OF A WINDOW FRAME		ALUMINUM I	ALUMINUM II	STEEL	TIMBER I	TIMBER II	TIMBER/ALUMINUM	u-PVC I	u-PVC II	GRP/ALUMINUM	GRP
	THERMAL INSULATION										
	DRAINAGE										
	STIFFNESS										
	SOUND INSULATION										
	ADJUSTABLE GLAZ. WIDTH										
	DESCRIPTION	ALUMINUM DOUBLE INSULATED WINDOW FRAME BY SCHUCO - AWS 50 SYSTEM PROFILES INWARD OPENING VENT	ALUMINUM TRIPLE INSULATED WINDOW FRAME BY SCHUCO - AWS 105 c+CC. HI SYSTEM PROFILES INWARD OPENING VENT	STEEL DOUBLE INSULATED WINDOW FRAME BY SCHUCO - JANSOL SYSTEM PROFILES INWARD OPENING VENT	TIMBER DOUBLE INSULATED WINDOW PROFILE OLD CONSTRUCTION SCANDINAVIAN TIMBER SYSTEM PROFILES OUTWARD OPENING VENT	TIMBER TRIPLE INSULATED WINDOW PROFILE NEW CONSTRUCTION BY JOSKO - ROBIN 90 SYSTEM PROFILES INWARD OPENING VENT	TIMBER/ALUMINUM TRIPLE INSULATED WINDOW PROFILE NEW CONSTRUCTION BY JOSKO - PLATIV PASSIV SYSTEM PROFILES INWARD OPENING VENT	u-PVC DOUBLE INSULATED WINDOW PROFILE BY INOUTIC - PRESTIGE KLASSISCH SYSTEM PROFILES INWARD OPENING VENT	u-PVC TRIPLE INSULATED WINDOW PROFILE BY SCHUCO - THERMOPLUS SYSTEM PROFILES INWARD OPENING VENT	GRP/ALUMINUM TRIPLE INSULATED WINDOW PROFILE BY JOSKO - SAFIR SYSTEM PROFILES INWARD OPENING VENT	GRP TRIPLE INSULATED WINDOW PROFILE BY ECLIPTICA - SLAYER GLASS SYSTEM PROFILES OUTWARD OPENING VENT

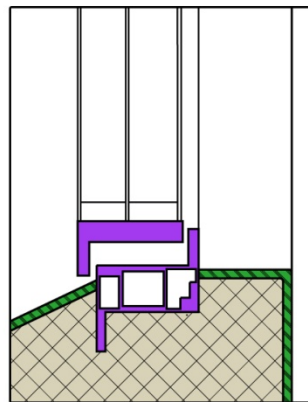
COMMON TYPES OF WINDOW FRAMES _ TYPES OF WALL-TO-FRAME CONNECTIONS

		ALUMINUM	STEEL	TIMBER	TIMBER/ALUMINUM	u-PVC	GRP/ALUMINUM	GRP
WAYS OF CONSTRUCTING A SOLID WALL STRUCTURE	TRADITIONAL CONSTRUCTION METHOD							
	COMPOSITE STRUCTURE (GRP SANDWICH PANEL)		—	—	—	—	—	?



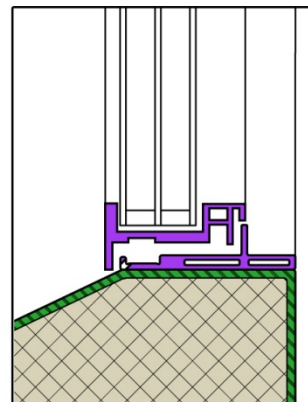
STEP1

CURRENT
CONSTRUCTION SYSTEM
ALUMINUM
FRAME/COMPOSITE
ELEMENT



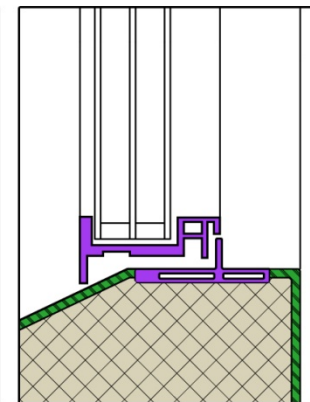
STEP2

ALUMINUM
FRAME
INTEGRATED
INTO
COMPOSITE
ELEMENT



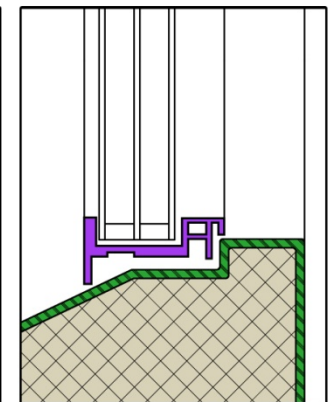
STEP 3

GRPFRAME/COM
POSITE ELEMENT



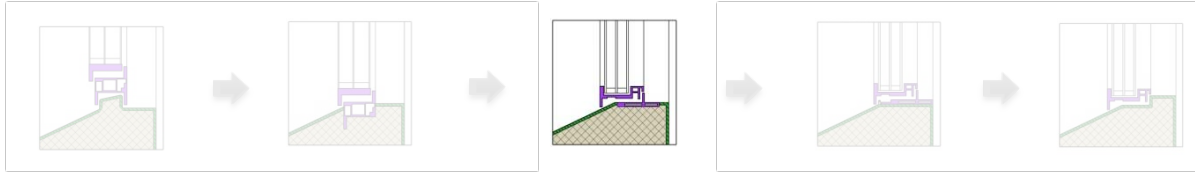
STEP4

GRP OUTER
FRAME
INTEGRATED
INTO COMPOSITE
ELEMENT

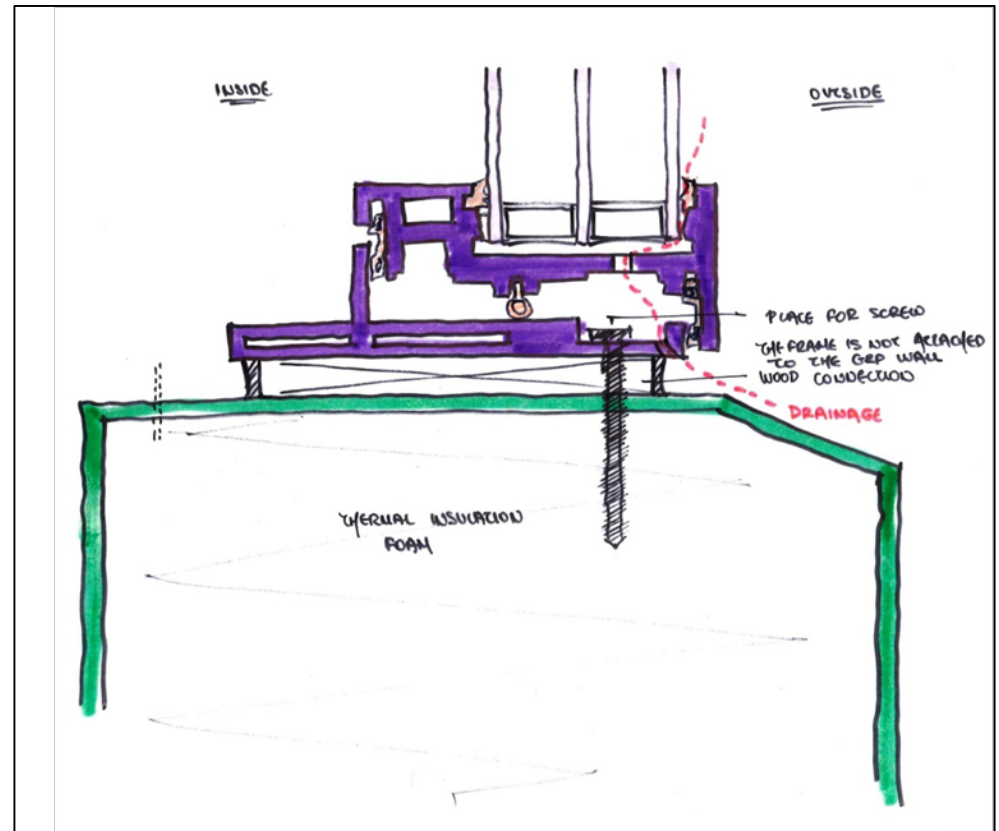
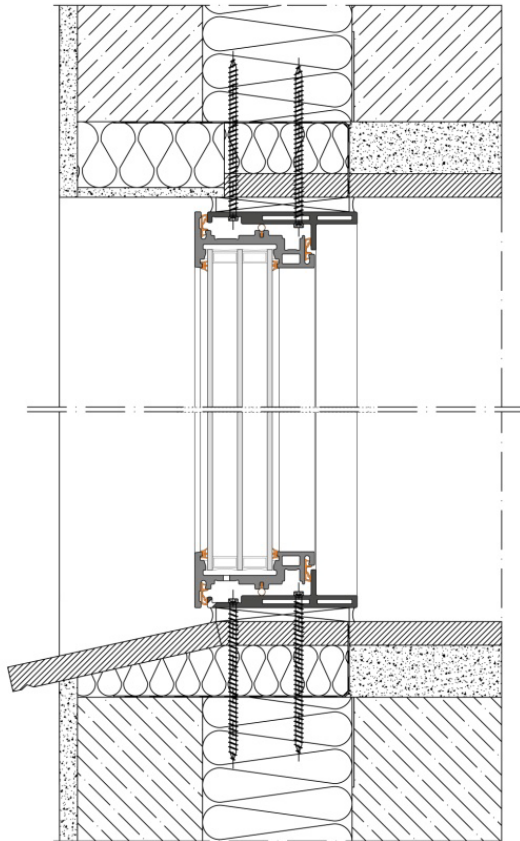


STEP 5

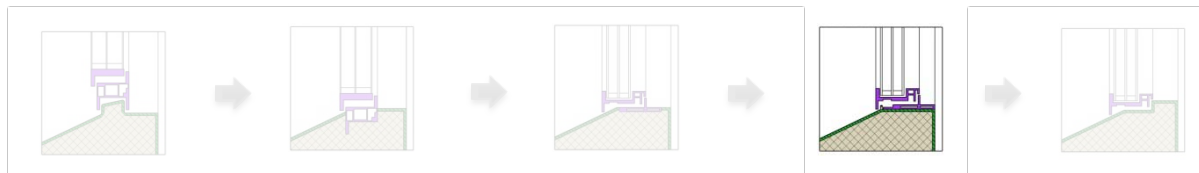
FULLY
INTEGRATED GRP
FACADE



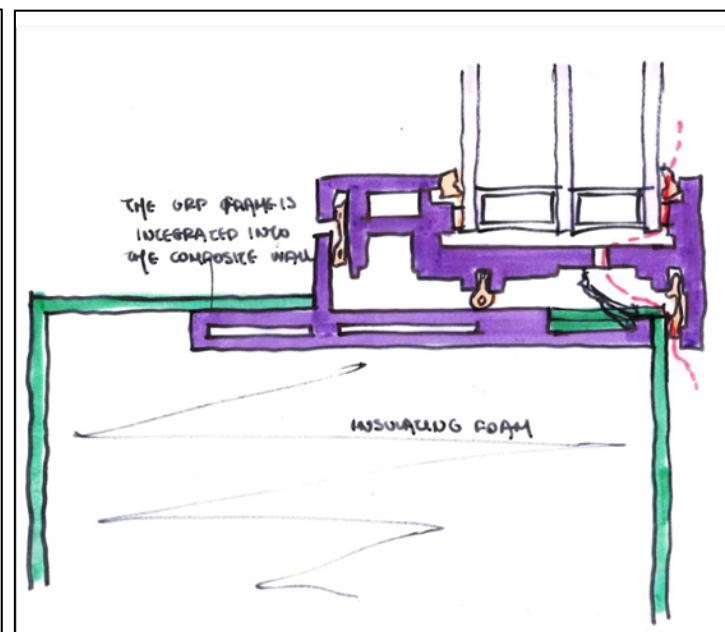
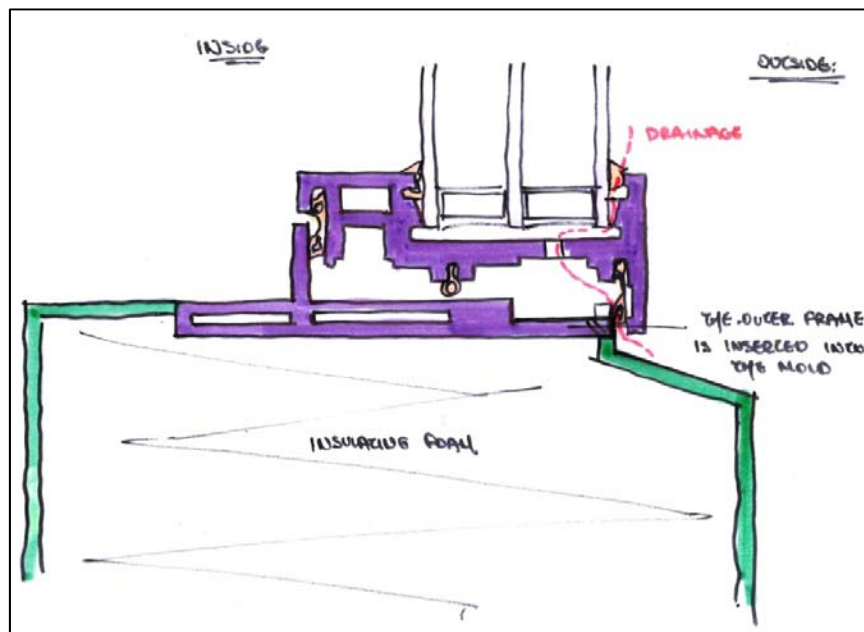
NON-INTEGRATED OUTER FRAME

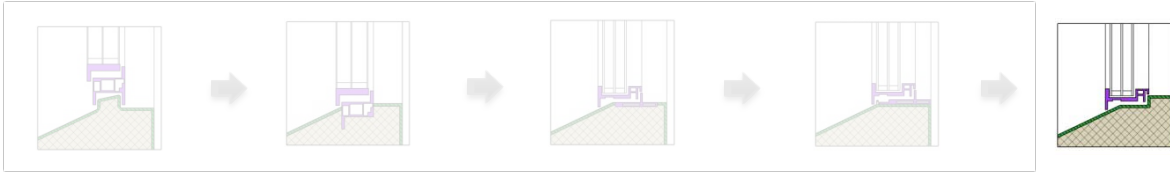


4 NEW DESIGN_ STEPS OF NEW DESIGN APPROACH

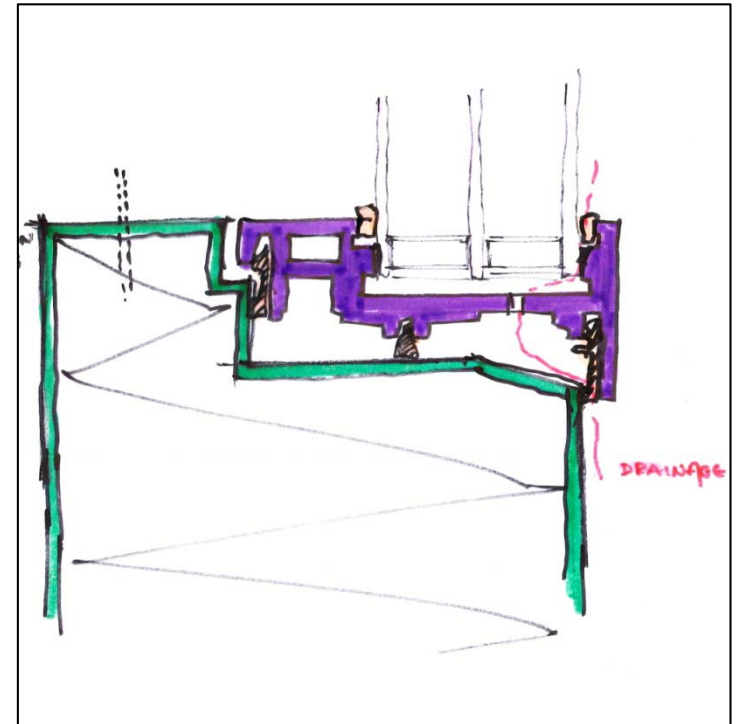
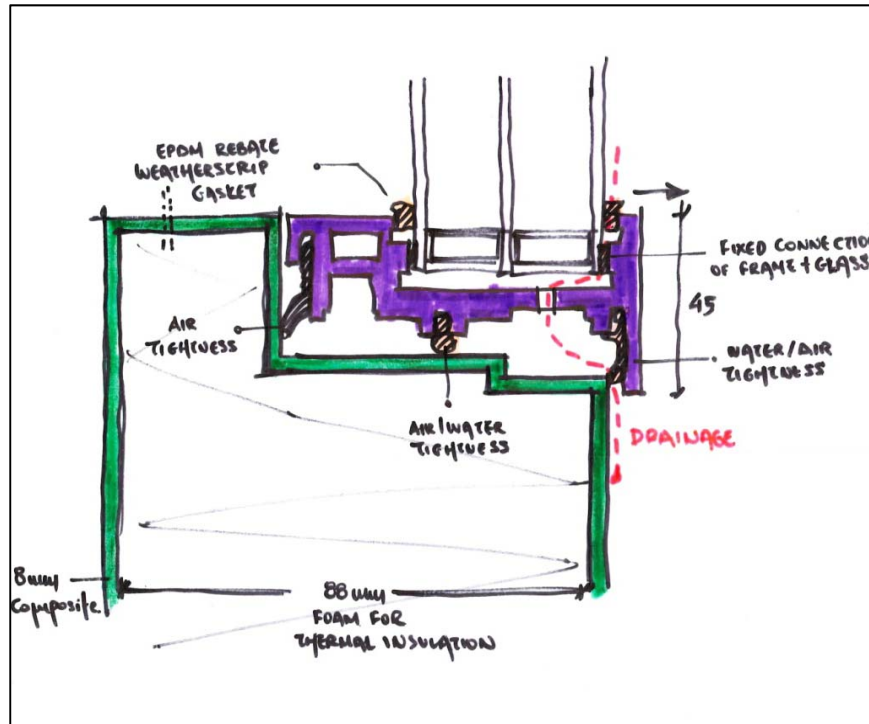


INTEGRATED OUTER FRAME

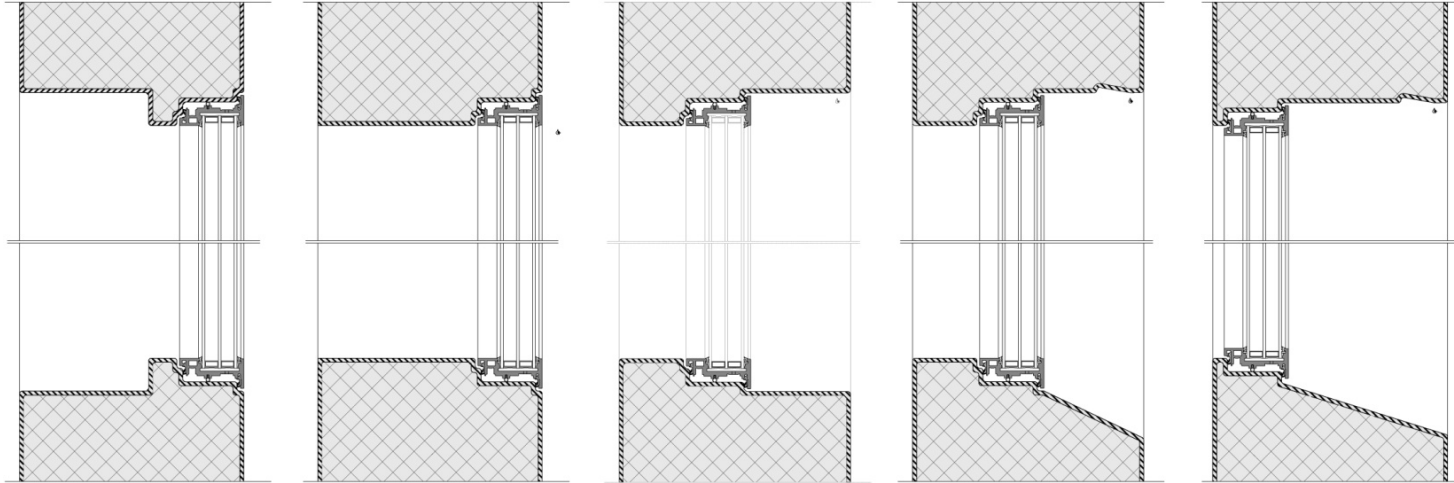




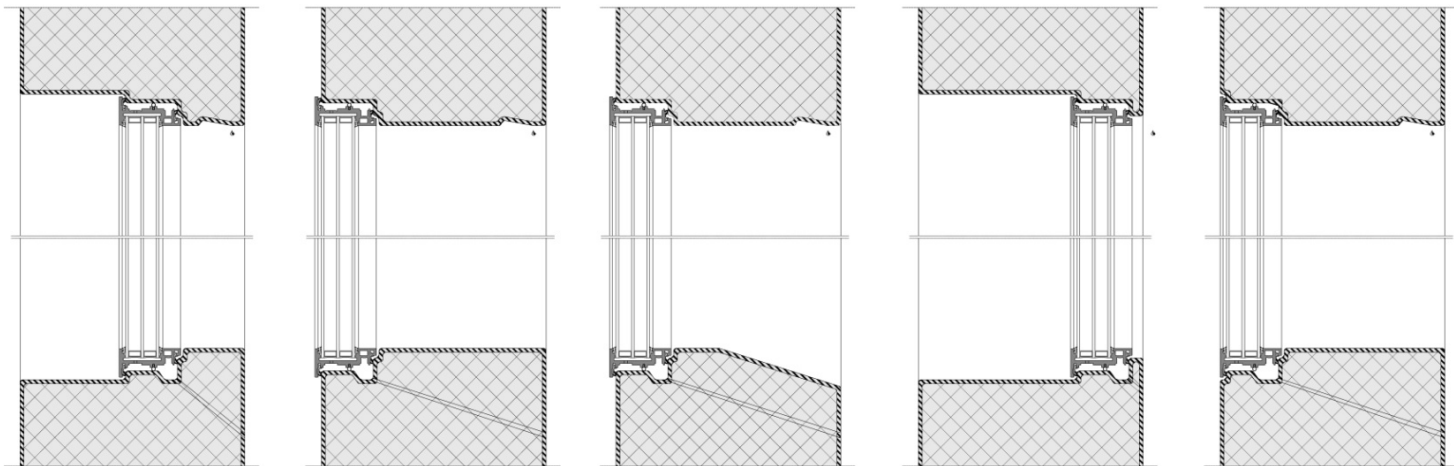
FULLY INTEGRATED GRP FACADE



4 NEW DESIGN_ NEW DESIGN CONCEPTS



OUTWARDS
OPENING
WINDOWS



INWARDS
OPENING
WINDOWS

4 NEW DESIGN_ EVALUATION OF DESIGNS

EVALUATION TOOLS

OBSERVATION

CALCULATION

COMPARISON

THERMAL INSULATION

SOUND
INSULATION

STIFFNESS

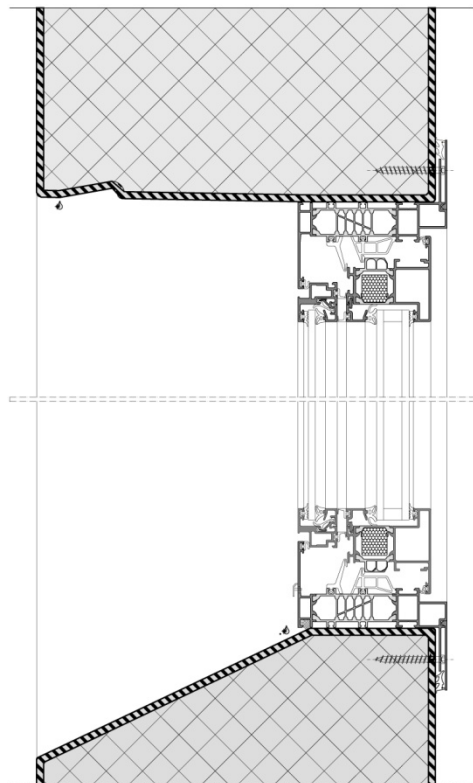
WEIGHT

MANUFACTURING
METHOD

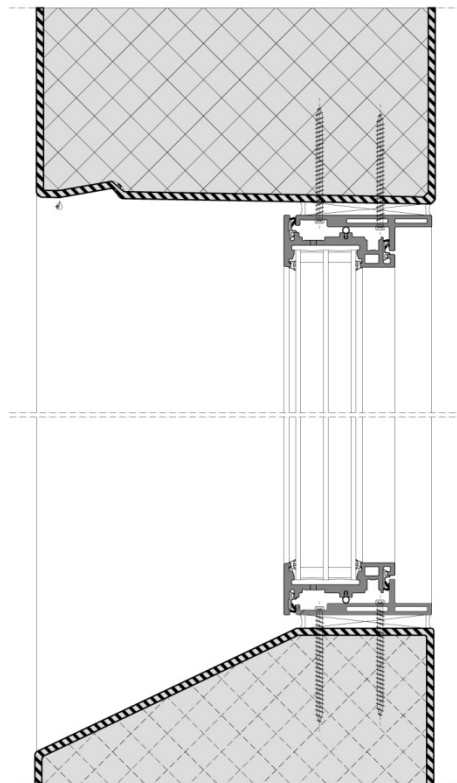
MANUFACTURING AND
INSTALLATION TIME

PRODUCTION COST

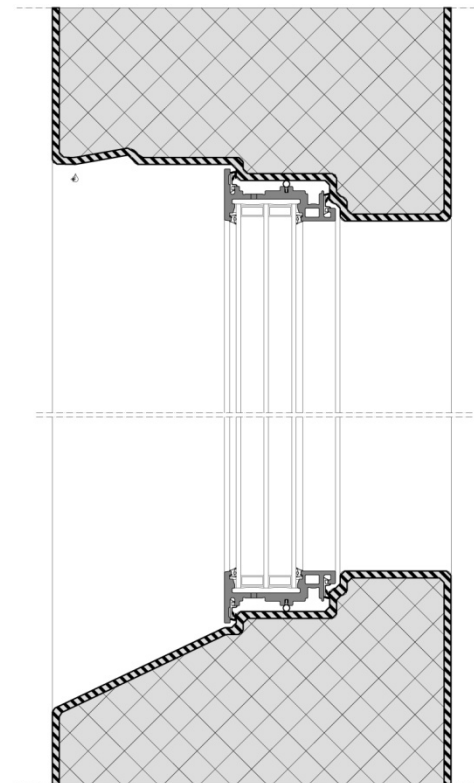
WHICH ARE THE BENEFITS OF AN INTEGRATED GRP FAÇADE OVER A CONVENTIONAL GRP/ALUMINUM FAÇADE SYSTEM?



ALUMINUM FRAME
(SCHUCO AWS 150CC.HI)

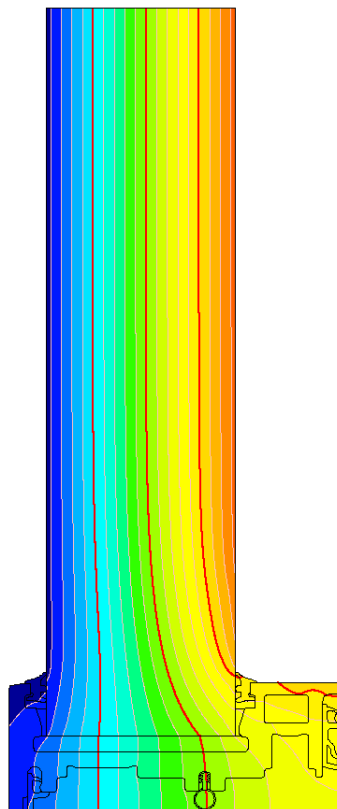


GRP FRAME (ECLIPTICA)

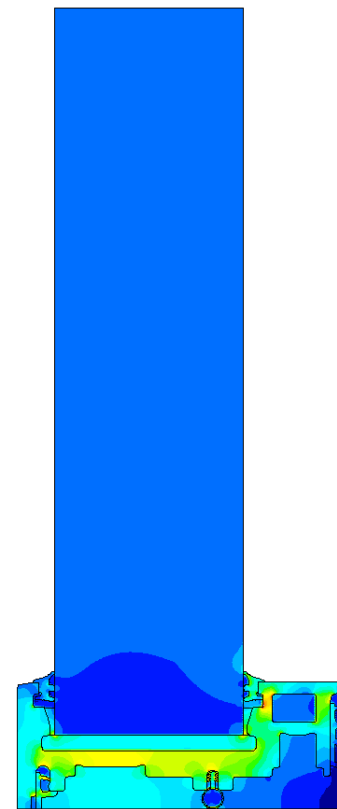
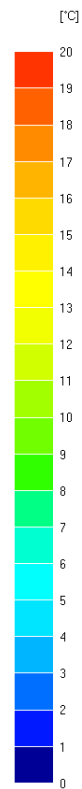


GRP FRAME (BASED ON
EXISTING PRODUCTS)

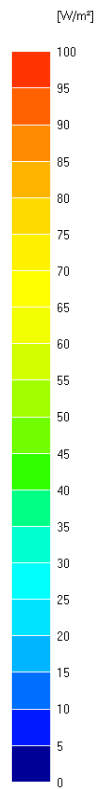
GRP FRAME CALCULATION



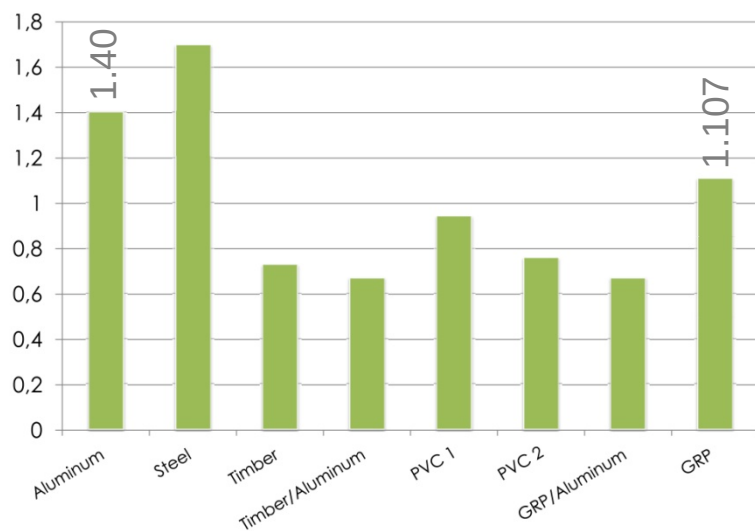
FILL TEMPERATURES DIAGRAM



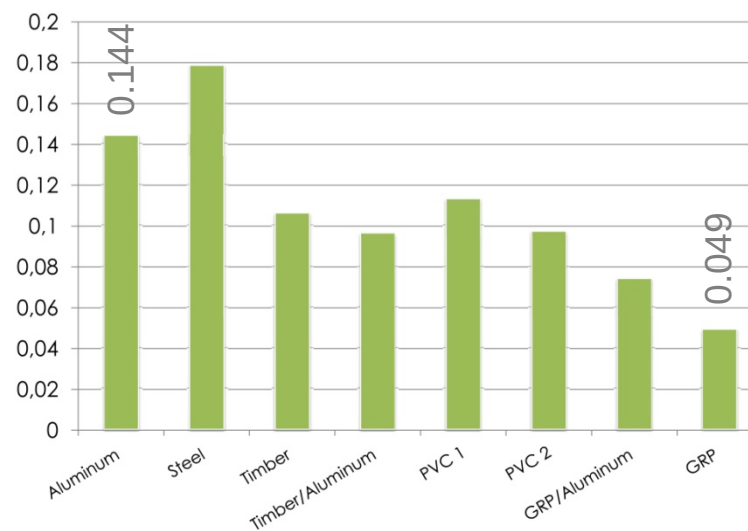
FILL FLUXES DIAGRAM



U-VALUE



THERMAL CONDUCTIVITY



6 EVALUATION_ ACOUSTICAL PERFORMANCE

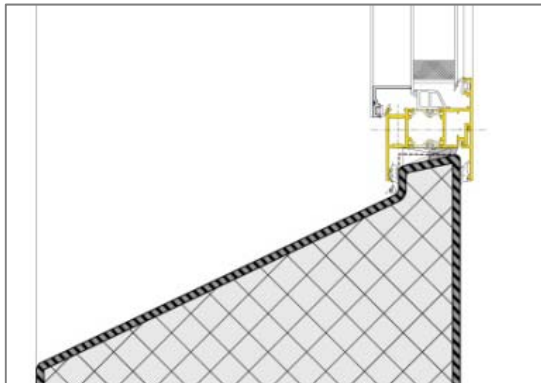
WINDOW FRAME'S WIDTH



SOUND INSULATION TABLES

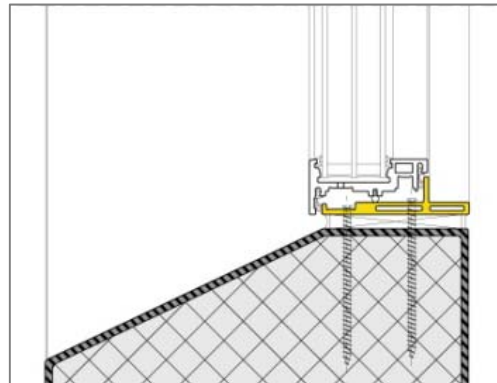
WINDOW FRAMES / WIDTH 50-70mm					
Hertz	125	250	500	1000	2000
Ri	26	28	34	36	40
Rw	33,4 dB				

WINDOW FRAMES / WIDTH 80-120mm					
Hertz	125	250	500	1000	2000
Ri	99	31	34	39	44
Rw	36,6 dB				



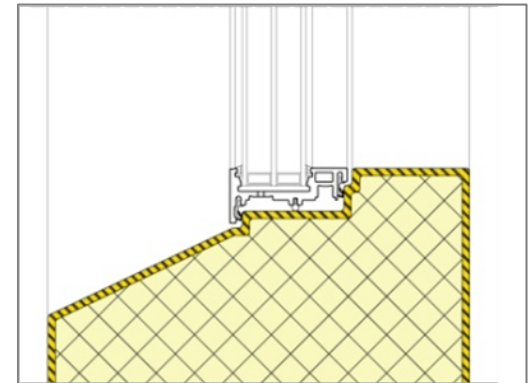
ALUMINUM FRAME
(SCHUCO AWS 150CC.HI)

MATERIAL USE 0.0018m²



GRP FRAME (ECLIPTICA)

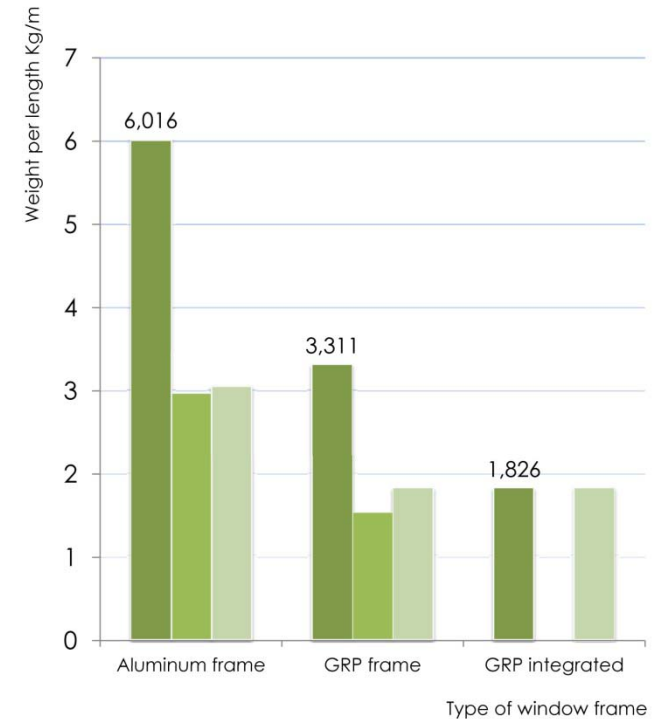
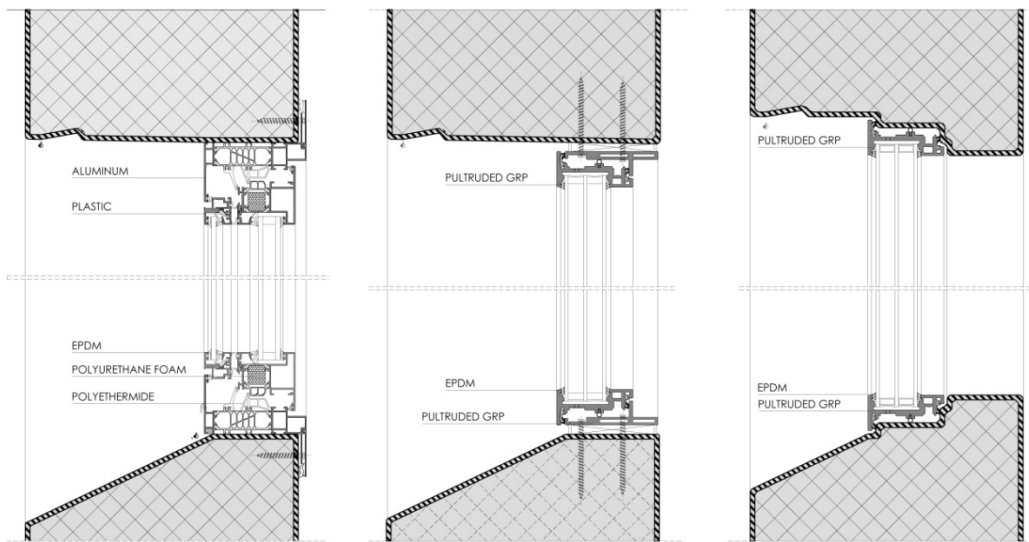
MATERIAL USE 0.0021m²



INTEGRATED GRP FRAME
(NEW DESIGN)

MATERIAL USE 0.0011m²

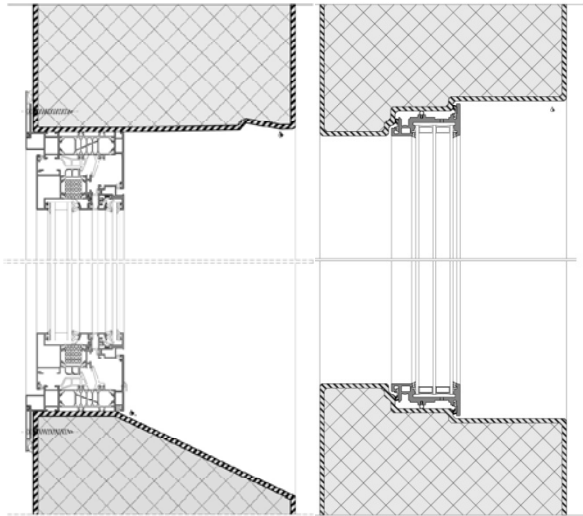
6 EVALUATION_ WEIGHT



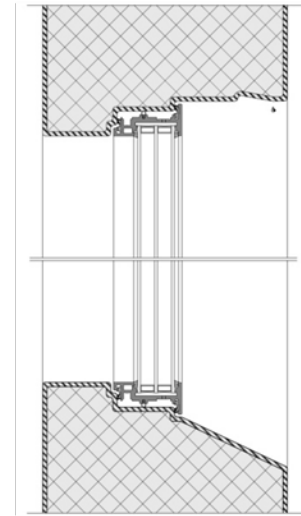
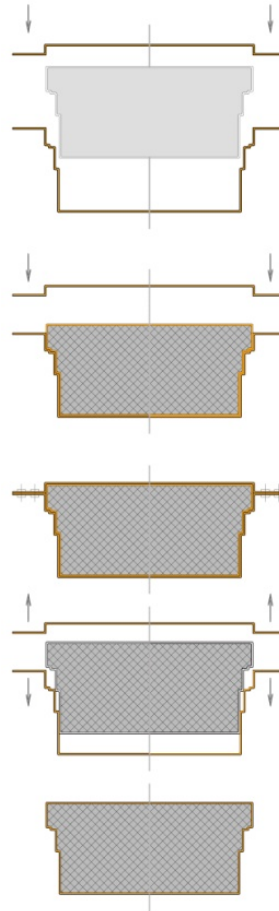
- TOTAL WEIGHT /m
- OUTER FRAME's WEIGHT /m
- VENT PROFILE's WEIGHT /m

6 EVALUATION

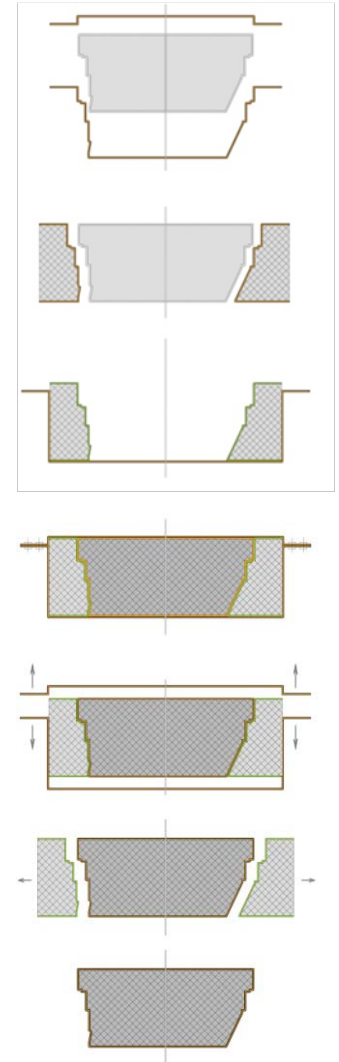
MANUFACTURING METHOD



ALUMINUM FRAMES OR GRP
FRAMES INTEGRATED IN
SIMPLE SHAPED PANELS

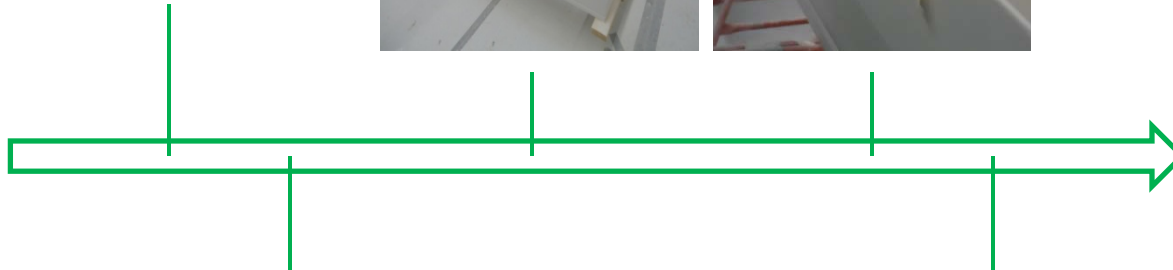


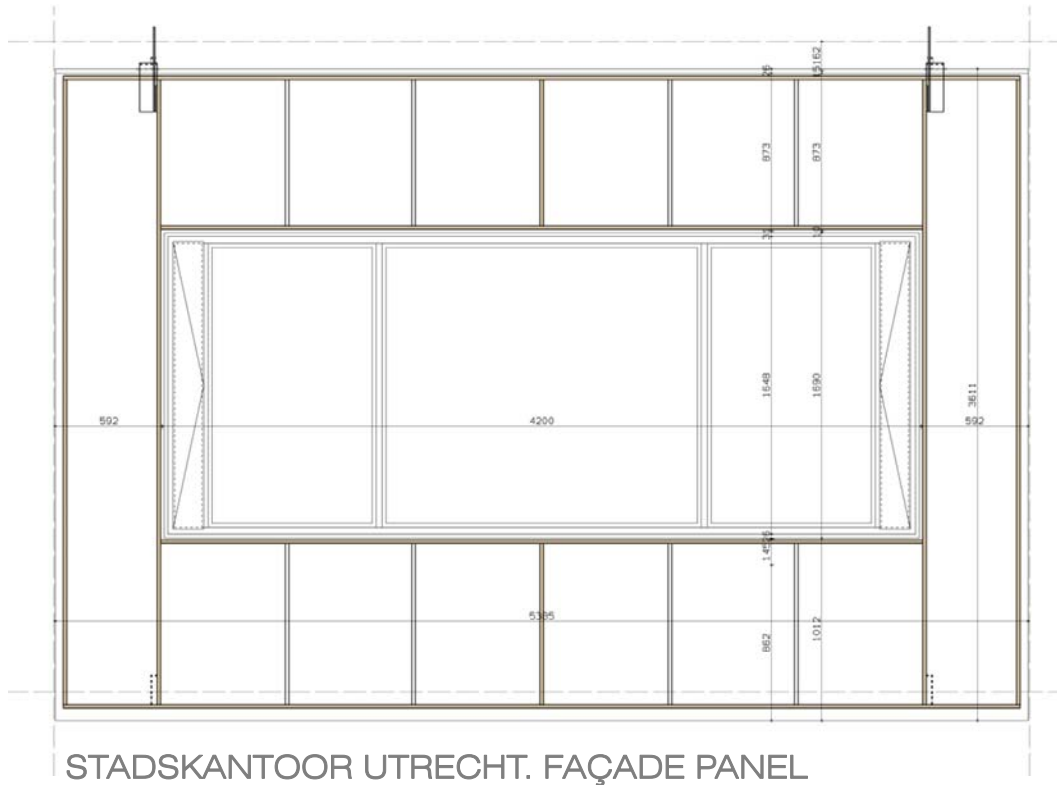
GRP FRAMES
INTEGRATED IN
COMPLEX
SHAPED PANELS



6

EVALUATION_ MANUFACTURING / INSTALLATION TIME





MATERIAL COST

- GRP SANDWICH PANEL 650 €/m²
- ALUMINUM WINDOW 350 €/m²
- GRP WINDOW 650 €/m²

FAÇADE PANEL'S COST

- ALUM. FRAMES **10.512 €**
- NON INTEGR. GRP FRAME 12.640€
- INTEGR. GRP FRAME **12.130 €**

PRICE OF MOLD **60.000 €**

POSITIVE

✓ THERMAL
INSULATION

✓ STIFFNESS

✓ WEIGHT

✓ MANUFACTURING
AND INSTALLATION
TIME

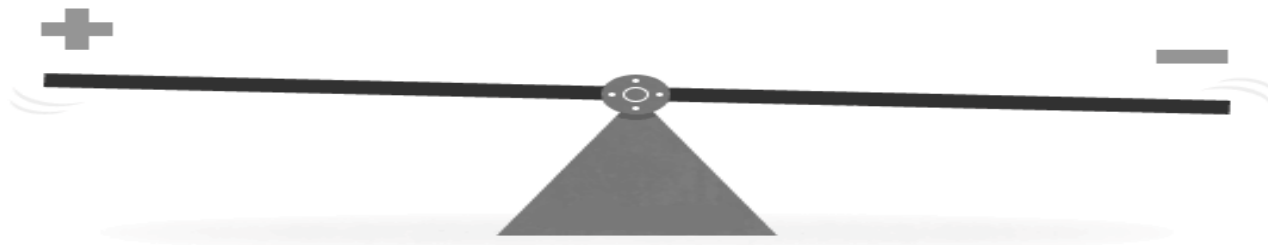
NEUTRAL

- SOUND INSULATION

NEGATIVE

× MANUFACTURING
METHOD

× PRODUCTION COST



FINAL DESIGN



INSULATIVE FOAM 338MM THICK

FIBERGLASS 6MM THICK

TRIPLE GLAZING 4/20/4/20/4MM

GRP OUTWARDS OPENING VENT PROFILE

THIRD AIR-WATER TIGHTNESS LAYER EPDM GASKET

CENTRAL EPDM GASKET

FIRST AIR-WATER TIGHTNESS LAYER EPDM GASKET

345.00

14.00

50.57

7.0

R4.00

14.00

51.80

18.5

14.0

89

89

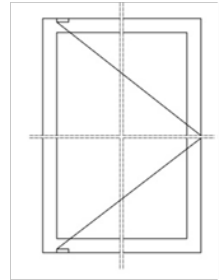
108.46

R4.00

100.00

159.13

101.46



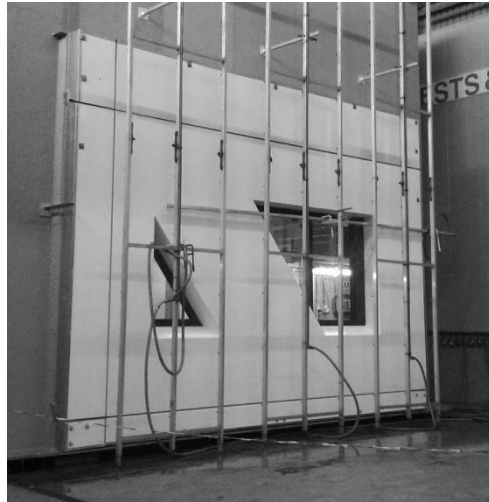
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FINAL DESIGN





BUILDING



TESTING



RECYCLING



THANK YOU
EF/CHA/RI/ST'O