www.ruukki.com

RUUKKI FORMA™

DESIGN INSTRUCTION

ruukki
Building your tomorrow.

1. General

Ruukki Forma™ is a complete façade system in which Ruukki energy panels form an energy efficient base structure and Ruukki cladding products finalize the visual looks for the building façade.

Ruukki energy panels are steel faced insulated sandwich panels with excellent air tightness for high energy efficiency. With Ruukki energy panels the building can be quickly covered from weather. Panels are available with different technical properties and insulation materials for various needs. Detailed and up to date energy panel properties are available from www.ruukki.com.

Ruukki cladding products offer a wide range of shapes, materials and colours for the visual design of the façade. Ruukki cladding product portfolio includes:

- Liberta cassettes
- Cladding lamellas
- Design profiles.

Detailed and up to date information about Ruukki cladding products is available from www.ruukki.com.

Ruukki Forma™ includes all needed accessories such as fixings, sealants, studs and flashings.

Ruukki Forma™ comes with full design support as well as Ruukki® energy simulation service for optimized energy efficiency.

2. Design principles

Designing of Ruukki Forma™ can be divided into 2 main phases:
1. Design of base structure (Ruukki® energy panel system)
2. Design of cladding & cladding support system

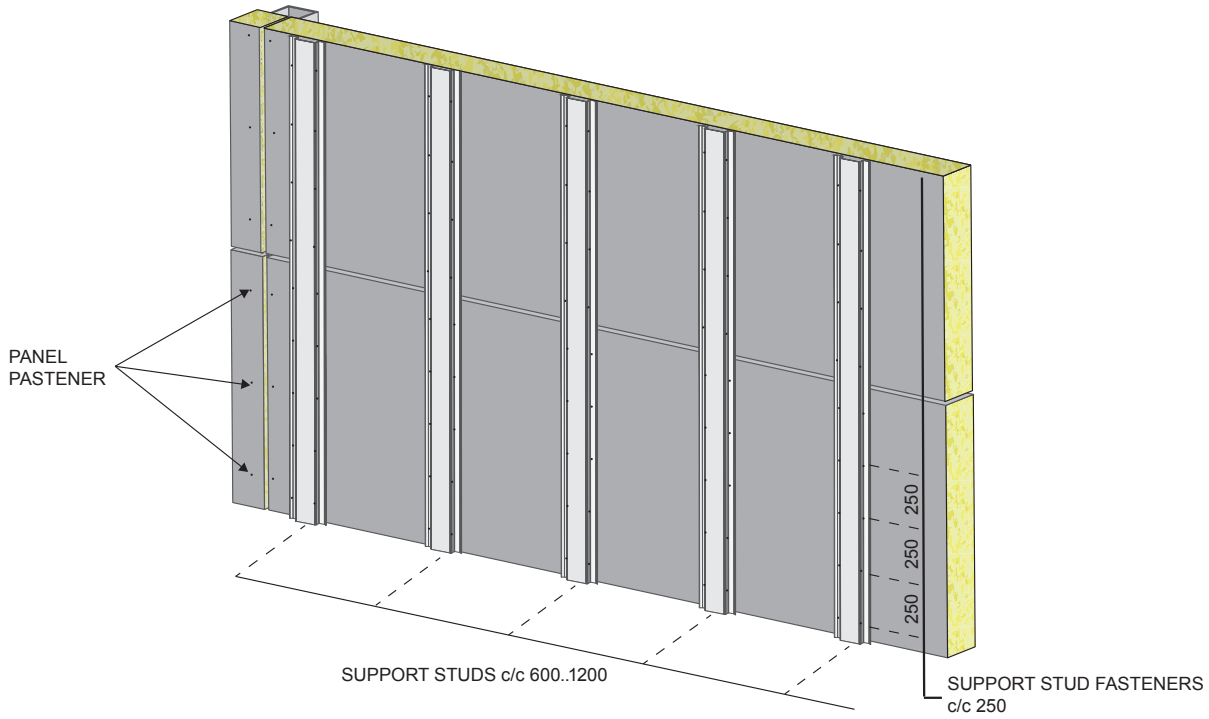
- **Design of base structure (Ruukki® energy panel system)**
  Base structure is designed using special Ruukki Forma™ construction details. Panels can be installed either horizontally or vertically. Main phases for base structure design are:

  a. Selecting suitable panel type based on required technical properties (U-value, fire etc.).
  b. Checking panel strength against given loads and spans by using Ruukki's load/span tables or dimensionin program TrayPan.
  c. Utilizing Ruukki Forma™ principle details in designing of project specific details. Details are available from Ruukki's technical support.
  d. Calculating the needed amount of panel fasteners (see paragraph 3).

- **Design of cladding & cladding support system**
  Cladding products are always fixed to base structure via Ruukki's support studs. More detailed instructions for cladding system design are given in paragraphs 4-6.

  NOTE: If support studs are running perpendicular to panels (e.g. panels installed horizontally between columns and support studs vertically), the utilization rate for bending moment against wind pressure has to be limited to 85%. This can be checked with Ruukki's dimensioning program (TrayPan).

- **Fire design**
  Reaction to fire classification for Ruukki Forma™ with steel based external face is the same as for it's base structure (Ruukki energy panel system). The fire resistance classification for Ruukki Forma™ against the fire from inside the building is the same as for it's base structure (Ruukki energy panel system). In case of fire resistance requirements against the fire from outside the building, please contact Ruukki's technical support.



3. Designing fastenings

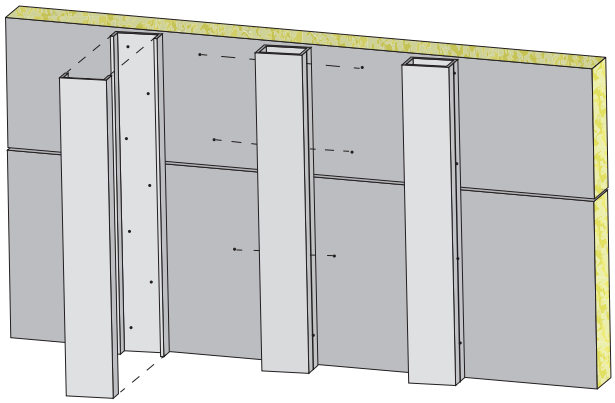
The fastenings of Ruukki Forma™ have been pre-designed to make design work easier. It is important that only fasteners supplied by Ruukki are used to ensure that the fastening solution works as planned.

- **Fastening support studs to base structure (Ruukki® energy panels)**
  Support studs are fixed to outer skin of the panel by using overlap screws (Ruukki code 'Screw S1H48023L02A4') at 250 mm centers from both flanges. The edge distance (distance from screw to panel edge) has to be ≥ 100 mm.

  If support studs are running perpendicular to panels (e.g. panels are installed horizontally and support studs vertically), support studs are located at 600...1200 mm centres depending on the cladding system. Full length (≥ panel module width x 2) support studs must be used to distribute the loads between adjacent panels.

  If support studs are running to same direction as panels (e.g. both panels and support studs are installed vertically), the maximum stud center is 600 mm. Support studs must reach the panel ends.

  If base structure is not flat, i.e. panels are not forming an even surface (e.g. due to tolerances in load bearing frames) to cladding material, adjustable Ruukki studs have to be used. Adjustable Ruukki studs can accommodate up to 30 mm tolerances.



Following values have been used for calculating the above mentioned stud and fixing centers:

- Maximum cladding system weight:
  - Mineral wool panels: 50 kg/m²
  - PIR panels: 30 kg/m²
- Maximum stud centres:
  - Cladding system weight ≤ 30 kg/m²: c/c 1200 mm
  - Cladding system weight ≤ 50 kg/m²: c/c 600 mm
- Stud fastener resistances:
  - Allowed tensile resistance: 0.3 kN/fastener
  - Allowed shear resistance: 0.3 kN/fastener
- Minimum outer facing thicknesses in panels:
  - Mineral wool panels: 0.6 mm
  - PIR panels: 0.5 mm
- Maximum wind loads (un-factored):
  - Mineralwool panels
    - Wind pressure: 1.5 kN/m²
    - Wind suction: 1.9 kN/m²
  - PIR panels:
    - Wind pressure: 1.5 kN/m²
    - Wind suction: 1.7 kN/m²
- Load combinations:
  a) Wind loads (pressure and suction)
  b) Cladding weight
  c) Wind loads + cladding weight (interaction)
- Safety factors:
  - Wind loads: 1.5
  - Own weight: 1.35
  - Material: 1.33

- **Fastening base structure (Ruukki® energy panels) to load bearing frames**

Panels are fixed to load bearing frames using penetrating panel fasteners. Fastener type is selected based on load bearing frame material (steel, wood or concrete) and panel thickness. Please contact Ruukki for recommended fastening type. The edge distance for the fastening (distance from fastening to panel edge) has to be ≥ 30 mm. When calculating the needed amount of panel fasteners, following loads need to be considered:

Wind suction load (pull-through strength):

The needed amount of fasteners can be easily calculated by using Ruukki's dimensionin program TrayPan. Alternatively, fasteners can be calculated manually by using tensile strength values as given in table 1 below.

Self weight (shear strength):

The needed amount of fasteners can be calculated manually by using shear strength values as given in table 1 below and the Ruukki Forma™ weight. The system weight consist of:

- Base structure weight: Check the weight of chosen Ruukki® energy panel type.
- Cladding & cladding support material weight: Check the weight of chosen cladding system.

Whichever calculation from the above (wind suction and self weight) results bigger amount of screws, is then finally the needed amount of screws.

Table 1. Characteristic resistances for panel fasteners.

Panel fastener	Edge distance (mm)	Allowed pull-through resistances (kN/fastener)		Allowed shear resistances (kN/fastener)	
		Mineral wool panels*	PIR panels*	Mineral wool panels*	PIR panels*
19 mm washer	≥30 mm	1.25	1.1	0.89	0.67
	≥100 mm	1.5	1.25		
29 mm washer	≥30 mm	1.6	1.1		
	≥100 mm	1.95	1.25		

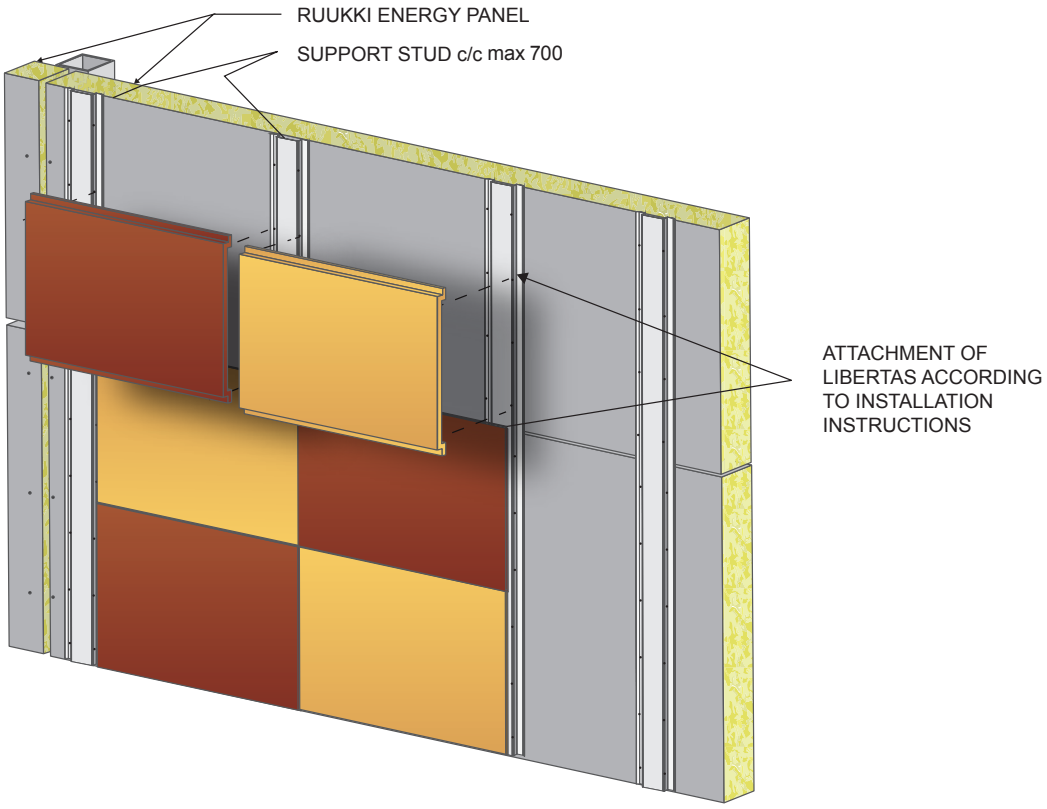
* Panel facing thicknesses in mineral wool panels 0.6mm/0.5mm and PIR panels 0.5mm/0.4mm (external/internal).

Note: Allowed fastener resistances include following safety factors:

- Safety factors for pull-through resistance: Material 1.33; wind loads 1.5
- Safety factors for shear resistance: Material 1.33; own weight 1.35

4. Ruukki Forma™ with Liberta cassettes

The wall structure in Ruukki Forma™ with Liberta cassettes is as follows:
1. Base structure: Ruukki® energy panel system fixed to load bearing frames
2. Support studs fixed to outer skin of base structure
3. Libertas fixed to support studs



- **Design of base structure (Ruukki® energy panel system)**
  See paragraph 2 above. Moreover, to ensure flat visual appearance for the Liberta, the energy panel deflections should be limited as follows:
  - Liberta length 0...1 m: L/100
  - Liberta length 1...2 m: L/200
  - Liberta length 2...3 m: L/300

- **Design of cladding & cladding support system**
  Before ordering Libertas project-specific plans should be made, considering the background structures, Liberta frame structures, Liberta installation direction, joint width, ventilation, thermal expansion and gaps as well as flashings and fastenings. The plans should be made by a structural design company familiar with facade planning or the structure planner of the building project.

  Liberta installation drawings are made based on the facade drawings. The Libertas are identified with unique ID numbers. Liberta dimensions must match the architect`s plan, which is complemented by detailed dimensions of the horizontal and vertical Liberta joints as well as details of any corner, window and door connections. Based on these plans the installer can report the Liberta dimensions as the work progresses. At the same time the location and number of the Liberta substructure (support studs) should be specified. These are determined based on Liberta dimensions.

- **Dimensioning**
  The width and height of the Libertas (A- and B-dimensions) are measured from the center of the joint to the center of the joint. The depth (C) is measured from the top of the support stud to the outer surface of the Liberta and the joint widths (Dh and Dv) as the widths of the visible joints. The minimum and recommended maximum Liberta sizes are specified in separate Liberta size charts.

- **Liberta joints**
  The outward turned flanges form the base of the vertical joint between the cassettes Liberta original 102 and original 102Grande. In cassette Liberta elegant 500 and elegant 500Grande, the support stud is used as the joint base. In all Libertas the base of the horizontal joint between the Libertas consists of the turned Liberta flanges.

- **Fastening holes**
  The fastening holes are punched during Liberta manufacturing. The holes are round, with diameter 7 mm in Liberta Liberta original 102, or oval, 5 x 10 mm in size in casssettes Liberta original 102Grande, elegant 500 and elegant 500Grande. Standard fastening holes are made at the corners of the Liberta, 15 mm from the Liberta end. Additional holes are made automatically or according to customer specifications. If the customer does not specify the positions of the additional holes, the holes are always made automatically as described below. The positions of the required additional holes depend on the dimensions of the Liberta. The positions of the holes are expressed in the following format:A-dimension (B-dimension) / 2; A-dimension (B-dimension) / 3, etc. where A and B are dimensions of the Liberta sides and the divisor is a number indicating the number of equal-size parts the side should be divided into. The fastening holes are punched in B direction only in casssettes Liberta original 102 and original 102Grande.

  Standard fastening holes:
  - A-dimension (B-dimension) ≤ 700 mm; fastening at the Liberta corners.
  - A-dimension (B-dimension) 701 – 1 400 mm / 2; fastening at the Liberta corners and in the middle.
  - A-dimension (B-dimension) 1 401 – 2 100 mm / 3; fastening at the Liberta corners and in the middle with two equally spaced fasteners.
  - A-dimension (B-dimension) 2 101 – 2 800 mm / 4; fastening at the Liberta corners and in the middle with three equally spaced fastener.
  - A-dimension (B-dimension) 2 801 – 3 000 mm / 5; fastening at the Liberta corners and in the middle with four equally spaced fastener (these dimensions apply to cassettes Liberta original 102Grande and elegant 500Grande only).

- **Support studs**
  The Libertas are fastened to support studs by self-drilling screws. When the Libertas are over 700 mm wide, additional center support studs are required. Moreover, if the support studs are fixed parallel to panel length, the maximum c/c for studs is 600 mm and the stud ends have to reach the panel end. Levelness of the substructure for the entire width of a Liberta is extremely important, so that fastening causes no deformation of the Liberta surface. In cassettes Liberta original 102 and original 102Grande, all the studs can be galvanized. In cassettes Liberta elegant 500 and elegant 500Grande, the studs at the vertical joints are visible and should be the colour of the Liberta (the additional center studs by the Libertas can be galvanized).

  NOTE: If support studs are running perpendicular to panels (e.g. panels installed horizontally between columns and support studs vertically), the utilization rate for bending moment against wind pressure has to be limited to 85%. This can be checked with Ruukki's dimensioning program (TrayPan).

  Support studs are fixed to outer skin of the base structure from both flanges with overlap screws ('Screw S1H48023L02A4') c/c 250 mm. Studs with only one flange (e.g. CA1RS1) are fixed c/c 125 mm.

  If base structure flatness can't be ensured, i.e. panels are not forming even surface (e.g. due to tolerances in load bearing frames) to cladding material, adjustable Ruukki studs have to be used. Adjustable Ruukki studs can accommodate up to 30 mm tolerances.

- **Starting fillets**
  In Libertas elegant 500 and elegant 500Grande separate starting fillet is needed (Starting fillet CA1SF2). Length of the starting fillet is determined as follows: Liberta A-dimension – width of one vertical joint between the Libertas (Dv) – 5 mm. The starting fillet is only visible from directly below.

- **Special Libertas**
  Libertas can be used for manufacturing various kinds of special cassettes for a wide range of uses. When using special Libertas, also note the general size recommendations of the Libertas. More detailed dimension regulations and the minimum and maximum dimensions that apply for special Libertas can be found on the dimensional drawings for the Libertas.

  Corner Libertas
  Corner Libertas can be made to extend around the external corner of the building. In addition to normal fastening holes in the Liberta is automatically included additional fastening holes on both sides at a 100 mm distance from the corner unless the customer requires otherwise. A single Liberta for the internal corner of a building cannot be manufactured – two separate Libertas and a flashing must be used.

  Pitched Libertas
  Libertas with a pitched upper edge can be manufactured for the eaves of a building, for example. The lower edge of the Liberta or a vertical edge can also be pitched. Any holes are not made on the pitched edge. It is generally recommended for only one edge of the Liberta to be pitched.

  U-Libertas
  So-called "U-Libertas" (with two external corners) can be manufactured for lining pillars, for example, in building. In addition to normal fastening holes in the Liberta is automatically included additional fastening holes on both sides at a 100 mm distance from the corners unless the customer requires otherwise. The possibility to produce other special Libertas than those mentioned here must be determined case-specifically.

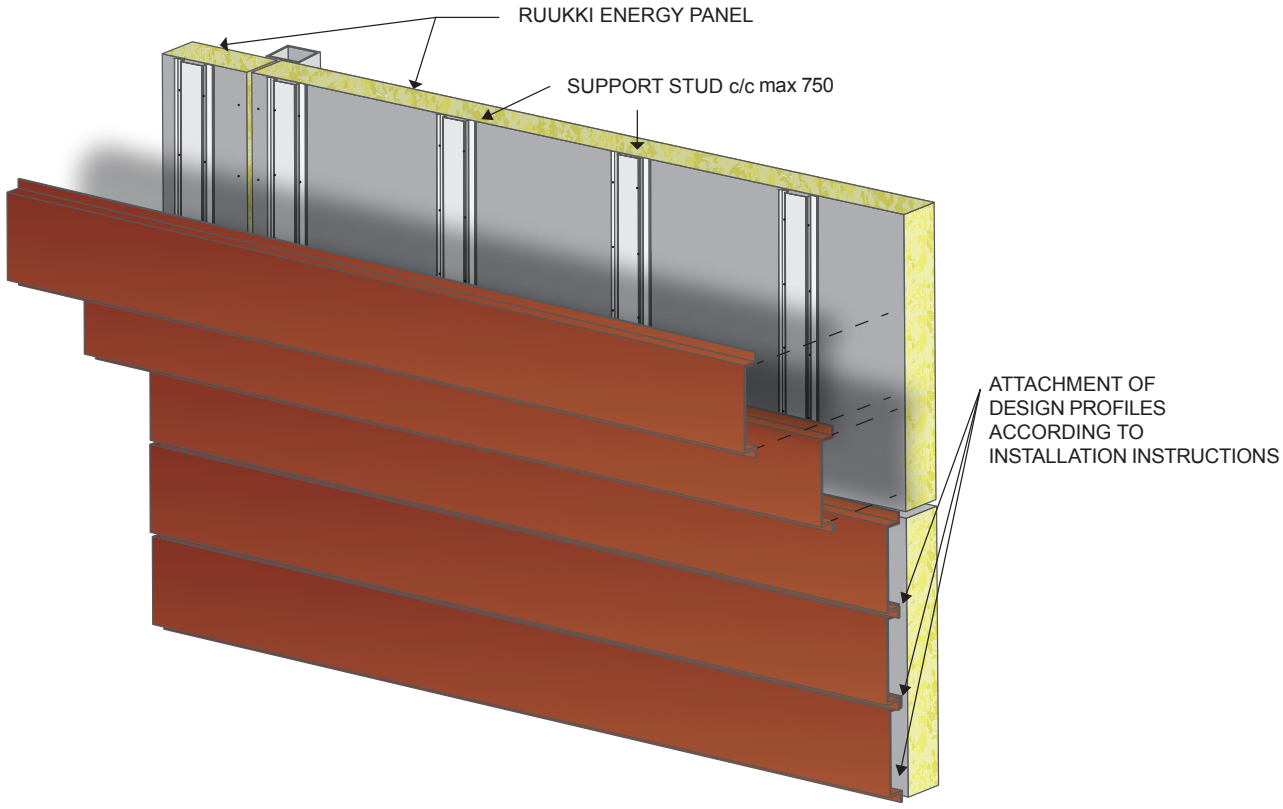
- **Ventilation**
  There must be an adequate ventilation space (min. 20 mm) between the Liberta and the base wall structure, enabling an unobstructed air change. It must also be ensured that there are gaps in the upper and lower edge of the wall structure to ensure free air change. The lower edge of the Libertas has ventilation holes, through which the water that has entered the structure through the joints or is caused by condensation can be removed. The ventilation holes are oval, of 5 x 15 mm in size. The holes are prepared as described in the fastening hole instruction above, independent of the customer-specified fastening hole positions. The outermost holes are placed 60 mm from the Liberta ends.

- **Facade flashings**
  The number of the flashings in a Liberta facade can be decreased significantly through good planning, as the Libertas can be ordered to the exact shape and dimensions. Typical applications include the corners of the building, such as corner Libertas, window frames, etc. Flashings are typically designed to be covered by the Libertas to improve the esthetic quality of the facade. When planning the flashings the mounting method and shape of the basic Liberta must be considered. Note. When the flashings are powder coated, notice that the flashings must be designed and bent before coating. Flashings shall be coated at the same time with the Libertas to avoid variance in colour appearance.

- **Other**
  In case of Libertas made of Cor-Ten®, please contact Ruukki for more detailed instructions.

5. Ruukki Forma™ with Cladding lamellas

The wall structure in Ruukki Forma™ with Cladding lamellas is as follows:
1. Base structure: Ruukki® energy panel system fixed to load bearing frames
2. Support studs fixed to outer skin of base structure
3. Cladding lamellas fixed to support studs



- **Design of base structure (Ruukki® energy panel system)**
  See paragraph 2 above. Moreover, to ensure flat visual appearance for the lamella, the energy panel deflections should be limited as follows:
  - Lamella length 0...1 m: L/100
  - Lamella length 1...2 m: L/200
  - Lamella length 2...3 m: L/300

- **Design of cladding & cladding support system**
  Before ordering lamellas project-specific plans should be made, considering the background structures, lamella frame structures, lamella installation direction, ventilation, thermal expansion and gaps as well as flashings and fastenings. The plans should be made by a structural design company familiar with facade planning or the structure planner of the building project.

  Lamella installation drawings are made based on the facade drawings. The lamellas are identified with unique ID numbers. Lamella dimensions must match the architect's plan, which is complemented by detailed dimensions of the lamella joints as well as details of any corner, window and door connections. Based on these plans the installer can report the lamella dimensions as the work progresses. At the same time the location and number of the support studs should be specified. These are determined based on lamella dimensions.

- **Dimensioning**
  The lamella width is always expressed as the manufacturing width excluding joints, the height as the effective height and the depth as the distance from the support stud surface to the exterior surface of the lamella. The exception to the rule is Lamella vertical 70, where the width is expressed using the manufacturing height and the height using the effective width (this lamella is for vertical installation only).

- **Lamella joints**
  The vertical lamella joints are usually left open and covered with vertical joint flashings. Depending on the lamella type, flashings can be installed either on top of the lamellas or under the lamellas. Vertical joints can also be done using lamella shaped joint pieces, which are installed under the lamella ends (not in Lamellas groove 10, 20 and 30). Note. There must be a gap of 4–5 mm between the lamella ends. Lamella vertical 70 is an exception as it already has a standard vertical joint (5 mm). The horizontal joints are distinct for each lamella type, excluding Lamella vertical 70, where sill flashing is used in horizontal joint.

- **Fastening holes**
  The fastening holes are punched during lamella manufacturing for Lamellas sharp 40 and 45, lap 60, vertical 70 and straight 100. The holes are oval, 5 x 10 mm in size. Standard fastening holes are made at the corners of the lamella, 15 mm from the lamella end. Additional holes are made automatically or according to customer specifications. If the customer does not specify the positions of the additional holes, the holes are always made automatically as described below. The positions of the required additional holes depend on the width of the lamella. The positions of the holes are expressed in the following format: Lamella width / 2; lamella width / 3, etc. where the divisor is a number indicating the number of equal-size parts the width should be divided into.

- **Standard fastening holes:**
  - Lamella width ≤ 750 mm; fastening at the lamella corners.
  - Lamella width 751 – 1 500 mm / 2; fastening at the lamella corners and in the middle.
  - Lamella width 1 501 – 2 250 mm / 3; fastening at the lamella corners and in the middle with two equally spaced fasteners.
  - Lamella width 2 251 – 3 000 mm / 4; fastening at the lamella corners and in the middle with three equally spaced fastener.

- **Support studs**
  The lamellas are fastened to support studs by self-drilling screws. When the lamellas are over 750 mm wide, additional center support studs are required. Moreover, if the support studs are fixed parallel to panel length, the maximum c/c for studs is 600 mm and the stud ends have to reach the panel end. Levelness of the substructure for the entire width of a lamella is extremely important, so that fastening causes no deformation of the lamella surface. All support studs used in lamella systems can be galvanized as they do not remain visible.

  NOTE: If support studs are running perpendicular to panels (e.g. panels installed horizontally between columns and support studs vertically), the utilization rate for bending moment against wind pressure has to be limited to 85%. This can be checked with Ruukki's dimensioning program (TrayPan).

  Support studs are fixed to outer skin of the base structure from both flanges with overlap screws ('Screw S1H48023L02A4') c/c 250 mm. Studs with only one flange (e.g. CA1RS1) are fixed c/c 125 mm.

  If base structure flatness can't be ensured, i.e. panels are not forming even surface (e.g. due to tolerances in load bearing frames) to cladding material, adjustable Ruukki studs have to be used. Adjustable Ruukki studs can accommodate up to 30 mm tolerances.

- **Starting fillets**
  In Lamellas groove 10 and 20, sharp 45, lap 60, and straight 100 a separate starting fillet is needed. Length (width) of the starting fillet is same than the width of the lamella. The starting fillet is visible in Lamellas groove 10 and 20. In Lamellas sharp 45, lap 60 and straight 100 the starting fillet is only visible from directly below.

- **Special lamellas**

  Corner lamellas

  Two separate lamellas slanted at a 45 degree angle can be combined to make a corner lamella, which can be used for the external and internal corners of the building. These external and internal turns can be done with Lamellas groove 10, 20 and 30, sharp 40 and 45, lap 60 and straight 100. The maximum width for the corner lamellas is 3 000 mm. The corners are measured from the outermost point on the lamella. Corner lamellas are used with flashings designed for that purpose.

  The possibility to produce other special lamellas than those mentioned here must be determined case-specifically.

- **Ventilation**

  There must be an adequate ventilation space (min. 20 mm) between the lamella and the base wall structure, enabling an unobstructed air change. It must also be ensured that there are gaps in the upper and lower edge of the wall structure to ensure free air change. The lower edge of the lamellas has ventilation holes (not in Lamellas groove 10, 20 and 30 and vertical 70), through which the water that has entered the structure through the joints or is caused by condensation can be removed. The ventilation holes are oval, 5 x 15 mm in size. The holes are prepared as described in the fastening hole instruction above, independent of the customer-specified fastening hole positions. The outermost holes are placed 60 mm from the lamella ends.

- **Facade flashings**

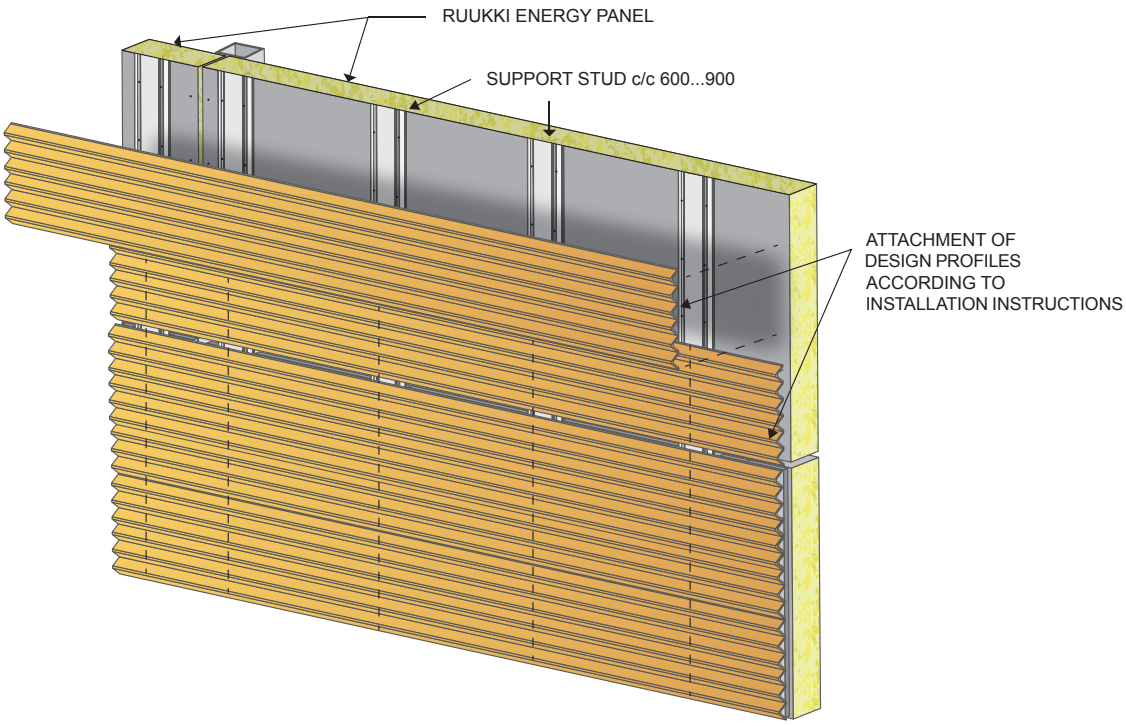
  The number of the flashings in a lamella facade can be decreased significantly through good planning. Typical applications include the corners of the building, window frames, etc. Flashings are typically designed to be covered by the lamellas to improve the esthetic quality of the facade. When planning the flashings the mounting method and shape of the basic lamella must be considered. Note. When the flashings are powder coated, notice that the flashings must be designed and bent before coating. Flashings shall be coated at the same time with the lamellas to avoid variance in colour appearance.

- **Other**

  In case of lamellas made of Cor-Ten®, please contact Ruukki for more detailed instructions.

6. Ruukki Forma™ with Design profiles

The wall structure in Ruukki Forma™ with Design profiles is as follows:
1. Base structure: Ruukki® energy panel system fixed to load bearing frames
2. Support studs fixed to outer skin of base structure
3. Design profiles fixed to support studs



Design of base structure (Ruukki® energy panel system)

See paragraph 2 above. The energy panel deflection has to be limited to L/100.

Design of cladding & cladding support system

Before ordering Design profiles project-specific plans should be made, considering the background structures, Design profile frame structures, Design profile installation direction, ventilation, thermal expansion and gaps as well as flashings and fastenings. The plans should be made by a structural design company familiar with facade planning or the structure planner of the building project.

Design profile installation drawings are made based on the facade drawings. The Design profiles are identified with unique ID numbers. Design profile dimensions must match the architect's plan, which is complemented by detailed dimensions of the Design profile joints as well as details of any corner, window and door connections. Based on these plans the installer can report the Design profile dimensions as the work progresses. At the same time the location and number of support studs should be specified. These are determined based on Design profile dimensions.

- **Dimensioning**
  The Design profile width is always expressed as the manufacturing width excluding joints, the height as the effective height and the depth as the distance from the support stud surface to the exterior surface of the Design profile.

- **Design profile joints**
  The vertical Design profile joints are usually left open and covered with vertical joint flashings. Depending on the Design profile type, flashings can be installed either on top of the Design profiles or under the Design profiles.

- **Support studs**
  The lamellas are fastened to support studs by self-drilling screws. When the Design profiles are over 900 mm wide, additional center support studs are required. Moreover, if the support studs are fixed parallel to panel length, the maximum c/c for studs is 600 mm and the stud ends have to reach the panel end. Levelness of the substructure for the entire width of a Design profile is extremely important, so that fastening causes no deformation of the Design profile surface. All support studs used in Design profile systems can be galvanized as they do not remain visible.

  NOTE: If support studs are running perpendicular to panels (e.g. panels installed horizontally between columns and support studs vertically), the utilization rate for bending moment against wind pressure has to be limited to 85%. This can be checked with Ruukki's dimensioning program (TrayPan).

  Support studs are fixed to outer skin of the base structure from both flanges with overlap screws ('Screw S1H48023L02A4') c/c 250 mm. Studs with only one flange (e.g. CA1RS1) are fixed c/c 125 mm.

  If base structure flatness can't be ensured, i.e. panels are not forming even surface (e.g. due to tolerances in load bearing frames) to cladding material, adjustable Ruukki studs have to be used. Adjustable Ruukki studs can accommodate up to 30 mm tolerances.

- **Ventilation**
  There must be an adequate ventilation space (min. 20 mm) between the Design profile and the base wall structure enabling an unobstructed air change. It must also be ensured that there are gaps in the upper and lower edge of the wall structure to ensure free air change.

- **Facade flashings**
  The number of the flashings in a Design profile facade can be decreased significantly through good planning. Typical applications include the corners of the building, window frames, etc. Flashings are typically designed to be covered by the Design profiles to improve the esthetic quality of the facade. When planning the flashings the mounting method and shape of the basic Design profile must be considered. Note. When the flashings are powder coated, notice that the flashings must be designed and bent before coating. Flashings shall be coated at the same time with the Design profiles to avoid variance in colour appearance.

- **Other**
  In case of Design profiles made of Cor-Ten®, please contact Ruukki for more detailed instructions.

7. Ruukki Forma™ with other cladding systems

The wall structure in Ruukki Forma™ with other cladding systems is as follows:
1. Base structure: Ruukki® energy panel system fixed to load bearing frames
2. Support studs fixed to outer skin of base structure
3. Cladding system fixed to support studs

Design of base structure (Ruukki® energy panel system)

See paragraph 2 above. The energy panel deflection has to be limited to L/100, but please check requirements also from cladding system supplier.

Design of cladding & cladding support system

Design the cladding system according to system supplier's instructions. Please ensure that the weight of the cladding system doesn't exceed the limits given in page 4.

- **Support studs**

  Cladding system is fastened to support studs according to system supplier's recommendations. Stud centres are designed according to system supplier's recommendations, but can't exceed c/c 1200 mm. Moreover, if the support studs are fixed parallel to panel length, the maximum c/c for studs is 600 mm and the stud ends have to reach the panel end.

  NOTE: If support studs are running perpendicular to panels (e.g. panels installed horizontally between columns and support studs vertically), the utilization rate for bending moment against wind pressure has to be limited to 85%. This can be checked with Ruukki's dimensioning program (TrayPan).

  Support studs are fixed to outer skin of the base structure from both flanges with overlap screws ('Screw S1H48023L02A4') c/c 250 mm. Studs with only one flange (e.g. CA1RS1) are fixed c/c 125 mm.

  If base structure flatness can't be ensured, i.e. panels are not forming even surface (e.g. due to tolerances in load bearing frames) to cladding material, adjustable Ruukki studs have to be used. Adjustable Ruukki studs can accommodate up to 30 mm tolerances.

- **Ventilation**

  There must be an adequate ventilation space (min. 20 mm) between the cladding system and base wall structure, enabling an unobstructed air change. It must also be ensured that there are gaps in the upper and lower edge of the wall structure to ensure free air change.

8. Calculation example

Ruukki Forma™ with Design profile 'Design Tokyo S18'
Orientation: Horizontal
Building column centers: 6000 mm
U-value requirement: 0.17W/m²K
Fire resistance: EI60
Reaction to fire: A2-s1, d0

- **Design of base structure (Ruukki® energy panel system)**
  Based on the U-value and fire resistance requirements, 'SPA230E ENERGY' is chosen as a base structure. This is a 230 mm thick MW (mineral wool) core panel and it will be installed horizontally, i.e. spanning between columns at 6000 mm centers. Wind loads (un-factored) as given by the structural engineer are as follows:

  - Mid areas: ±0.6kN/m²
  - Corner areas: +0.6kN/m² (wind pressure) / -0.9kN/m² (wind suction)
  - Width of corner area: 6000 mm

  According to Ruukki's panel dimensioning program TrayPan, the 'SPA230E ENERGY' can easily withstand the above given wind loads.

- **Design of cladding & cladding support system**
  'Design Tokyo S18' is fixed to base structure via Ruukki's support studs. As the 'Design Tokyo S18' will be installed horizontally (just like the base structure), support studs must be installed vertically. Therefore, according to rules, bending strength utilization rate against wind pressure must be limited to 85%. According to TrayPan, the utilization rate in this case is only appr. 37%, so the strength of the base structure is OK.

- **Design of fastenings**
  The fastening system for Ruukki Forma™ has been pre-designed. Screws supplied by Ruukki are used to ensure that the fastening solution works as planned.

- **Fastening support studs to base structure (Ruukki® energy panels)**
  According to instructions in paragraph 3, support studs are fixed to external face of the panel by using overlap screws (Ruukki code 'Screw S1H48023L02A4) at 250 mm centers from both flanges. The edge distance (distance from screw to panel edge) is designed to be minimum of 100 mm. Support studs are designed to 900 mm centers in accordance with the rules in paragraph 6.

- **Fastening base structure (Ruukki® energy panels) to load bearing frames**
  Panels are fixed to load bearing frames using penetrating panel fasteners. Fastener type 'SCREW S3H55275D14S9B 100' is selected according to instructions from Ruukki. This screw type is self-drilling stainless steel screw for steel frame with thickness 4-14 mm.

  Wind suction load (pull-through strength):
  According to TrayPan, the needed amount of screws in corner area is 3no per panel end. In mid areas 2no per panel end is enough. Manual calculation: (wind suction load x panel module width x span/2) /allowed tensile strength of fastener.
  - Mid area: (-0.6 kN/m² x 1.2 m x 6 m / 2) / 1,25 = 2no → 2 fasteners / panel end
  - Corner area: (-0.9 kN/m² x 1.2 m x 6 m / 2) / 1,25 = 3no → 3 fasteners / panel end

  Self weight (shear strength):
  The needed amount of screws is calculated manually based on system weight:
  - Base structure weight: The weight of 'SPA230E ENERGY' is 30.4kg/m² (www.ruukki.com/energypanels)
  - Cladding + support stud weight: 20kg/m²
  - Total wall weight: 50.4kg/m²

Against the wind suction loads minimum of 2^{no} of fixings per panel end (mid areas) are needed. This equals 4 fixings per 7.2 m^2 are of wall. According to table 1, the allowed shear resistance value for one fastener is 0,89 → 4^{no} of screws → 3.6 kN = 360 kg. The total weight of 7.2 m^2 wall area is 360 kg. In this case 4^{no} of screws is enough.

Finally, wind suction load results higher amount of needed screws:

- Corner areas: 3^{no} per panel end.
- Mid areas: 2^{no} per panel end.

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