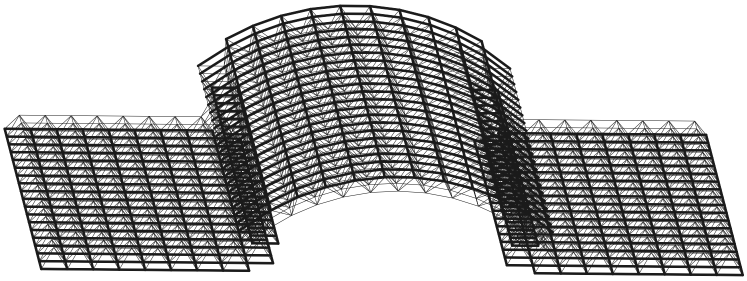
NILKA
system



SPACEFRAMES NILKA

1. GENERAL

The NILKA system space frames are 3-D bearing structures with many advantages. The main advantages are shown below:

a. Excellent aesthetic, availability of several colours, assuring compositions which can completely satisfy any architectural requirements.
b. Unlimited possibilities in the construction's geometry, no restriction in creating any structural shape.
c. Space frames have the smallest possible structural dead load, consequently lower transportation cost.
d. Easy assembly, therefore the possibility of utilization of unskilled labour exists.
e. Inhered rigidity, making the space frame ideal bearing structures for large free spans without intermediate supports.
f. Excellent relation between dead load - live loads.

The advantages mentioned above, enable space frames to cover a wide range of applications.

Our company fabricates space frames for:

a. Swimming pools, where large free spans are required.
b. Shopping centres, which demand natural lighting during the day and superior aesthetics.
c. For traditional fair/exhibition stands, which demand easy and quick installation and dismantling.
d. Stores, where excellent aesthetics is required for an attractive presentation of the product.

2. GEOMETRY

A space frame, from a geometrical viewpoint, consists of two plane grids, parallel to each other, which form the upper and lower layers of the space frame. These two plane frames (grids) are connected to each other with the use of diagonal bars. The external loads are distributed amongst the two parallel layers and the diagonal bars which connect them.

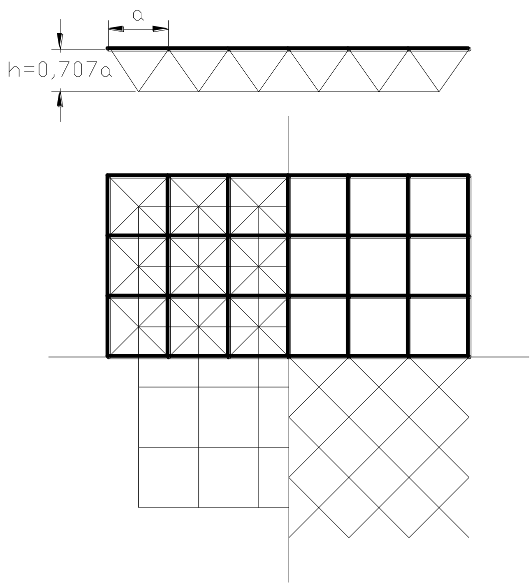
The distance between the two plane grids is called the structural height of the space frame. The structural height depends on the type of space frame constructed.

NILKA system space frames are constructed according to one of three types that are described below:

2.1 Types of the spaceframes

2.1.1 Square "A" - 1/2 O+T

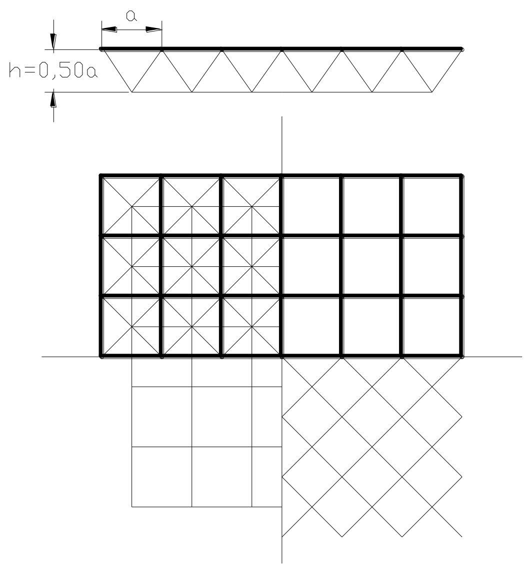
The two plane grids (upper and lower layer) are formed through a repetition of the basic square with side “α” - module - and are connected with diagonal bars. The members of the plane grids and the diagonals, shape equivalent triangles and in this way they create semi-octahedras and tetrahedras. In this case, the structural depth of the space frame - h - is h=0.707α and the bars have the same length “α”. The angle between the diagonal bar and bar of the upper or lower layers is 60 °.



This type of space frame is used in the majority of our constructions, because it is more economical.

2.1.2 Square "B" - 1/2 O+T

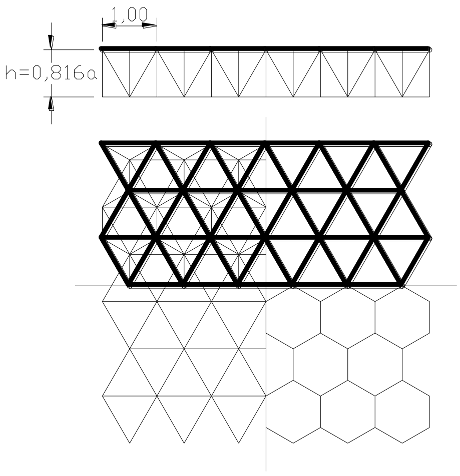
This type of space frame, is formed in the same way as the space frame of the type - *Square “A”*- differing only in the structural depth which in this case is smaller than the depth of the space frame type - *Square "A"* - h=0.50α, where “α” is the space frame’s module.



This type of space frame is used in constructions that have a small free span or the required structural height is small.

2.1.3 __Triangle - O+2T__

The two planes, parallel grids (upper and lower layer), are formed through a repetition of the basic equilateral triangle with side “α”. These are connected between them with diagonal bars which shape equivalent triangles. Hence these shape octahedrals with each two tetrahedras as closely three-dimensional interlocking modules. Octahedras and tetrahedras as modules are kinetically stable and therefore such a three-dimensional frame is rigid.



The bars have the same length “α” and the structural height of the space frame is h=0.816α.

A ccomparison between type - *Square "A"* - and - *Triangle* - reveals a greater density of members and a greater structural depth -h-.

This type of space frame is suitable for constructions with a large free span and for trihexagonal plan configurations.

3. DESIGN OF A NILKA system SPACE FRAME

The design of NILKA system space frames mainly depends on the architectural requirements, specified loads, supportt conditions and the desired structural depth of the space frame.

All the above data is shown in the attached sheet " DESIGN REQUIREMENTS OF SPACE FRAME ".

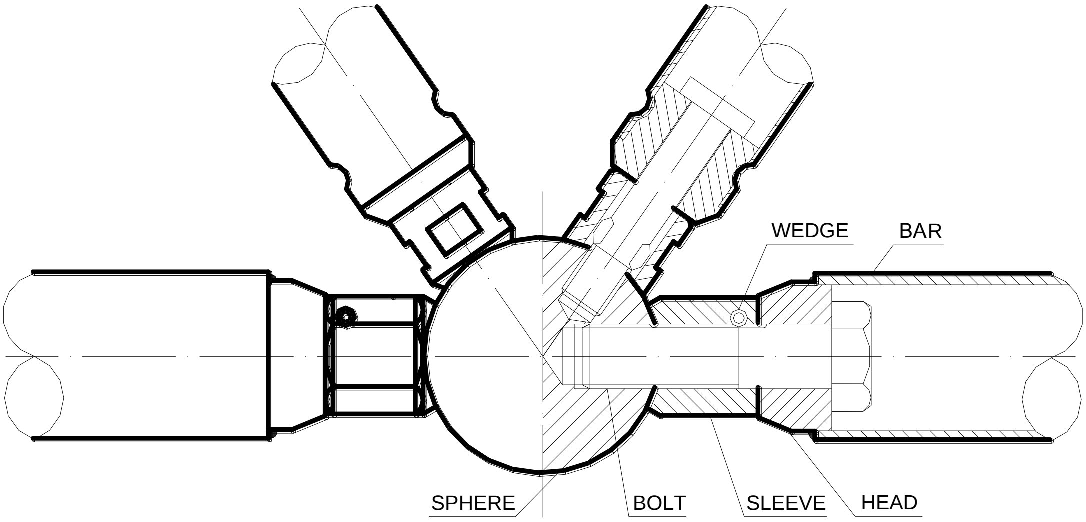
The requirements should be combined with certain basic rules so that the optimum economic and technical results are achieved.
These basic rules are:

a. The structural depth of a space frame depends on the frame span and must be equal to 1 /15 - 1 /12 of the span.
b. The cost of the space frame is reduced by increasing the size of the grid module.

Taking into consideration the above data, the space frame’s geometrical shape and the most suitable grid module is selected, and is then drawn and processed with a static analysis program. With the aid of analysis results the size of the components are determined as well as an estimation of the cost. The above process is repeated until the optimum technical and economical solution is achieved.
After finalizing the design, the space frame’s drawings are prepared, showing the ground plan of structure, as well as details for support and the cladding. This way we have an overall view of the space frame and its behaviour under specific conditions of support, loading, and cladding. Moreover with treatment of results of static analysis, the quantities of the elements required are determined, including all main elements and accessories (purlins, gutter, etc.). Finally the exact delivery time can be estimated. Taking into consideration the local conditions, the most appropriate methods of assembly and installation of the space frame are selected.

4. COMPONENTS OF A NILKA system SPACE FRAME

The basic components of a NILKA system space frame are the SPHERES (nodes), BARS, HEADS, BOLTS and SLEEVES.



4.1 Sphere

The sphere (node) of the space frame NILKA system is the component to which the bars are attached and undertakes the external loads. The forces, which act radically on the spheres, have different magnitudes and sometimes opposing directions, these forces are distributed through the bars, into the space frame.

The connection between the sphere and the bars is achieved using threading holes which are drilled into the sphere. The angles between the holes depend on the construction's geometrical aspect and the diameter depends on the maximum tension force.

The spheres are made of solid hot forged steel or through a mechanical process in accordance with DIN 17100 CK45.

The size of the sphere depends on the parameters shown below:

a. The magnitudes of the forces to be transmitted.
b. The size of the bolts, to avoid contact amongst them within the sphere.
c. The size of the neighboring sleeves.

The spheres used in NILKA system space frames have a diameter of 60 mm, 80 mm, 110 mm 150mm and 200 mm. Spheres with a larger diameter can be fabricated if needed.
Holes are drilled in the spheres with certain angles between them, in accordance to the direction of the bars. A maximum of 18 holes can be drilled in each sphere.

The diameters of the holes, which are drilled in each sphere, depend on the maximum transmitted tension force.

In table 1 the interaction between diameter of the node-diameter of the bolts and bearing capacity.

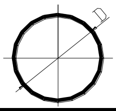
	M12	M16	M20	M24	M30	M36	M42	M56	NOMINAL THREAD DIAM.
	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	BOLT QUALITY
D (mm)	**60**	**110**	**175**	**250**	**400**	**580**	**800**	**1500**	PERMISSIBLE FORCE (kN)
60									
80									
110									
150									
200									

TABLE 1: INDERPEDENCE OF THE NODE DIAMETER – NOMINAL THREAD DIAMETER – BEARING CAPACITY OF THE NODE

4.2 Bars

The bars of NILKA system space frames have a hollow circular cross-section (cylinders), their diameter and thickness depending on the maximum developed force.

The bars are made of seamed circular hollow sections in accordance with DIN 2458 or without seam in accordance with DIN 2448, of steel quality St 37-2 in accordance with DIN 17100.

The ends of the tubes are tapered with two heads, provided with a central hole to pass the bolts through for the connection of the bar with the sphere.

4.3 Heads

The heads are fixed on to the ends of the circular hollow section shaft either mechanically or by welding and are made of steel DIN 17100, St37-2. The welding procedure is in accordance with EN 287 and EN288 and is part of the Quality System of the company.

4.4 Bolts

The bolts connect the bars with the nodes and also transmit tension forces from the bars to the spheres.

They are made of high strength steel, in accordance with DIN 267, quality 8,8 and 10.9 with metric threading.

4.5 Sleeves

The sleeve is the component, which transmits the compression forces between the bars and spheres.
The sleeve is made of hexagonal steel cross sections, in accordance with DIN 17100, St37-2.
The sleeve's size depends on the bar's size.

5. <u>SURFACE PROTECTION OF THE COMPONENTS IN NILKA system SPACE FRAMES</u>

Metals are subject to corrosion, as a result of the chemical reactions with oxygen. To avoid these reactions, their surface is covered either by a more resistant metal, or by polyester powder or by a combination of these materials. Generally, the period of protection increases with the layer of thickness of the coating. The component's surface protection is made through a combination of these materials.

The surface's coating with other metals is achieved in two ways :

a. Electrolytic galvanizing
b. Hot - dip galvanizing

5.1.1 <u>Electrolytic galvanizing</u>

The spheres (nodes) of the space frame NILKA system are galvanized with an electrolytic alloy in weak acidic galvanic baths in accordance with DIN 50961. This way, they are provided with a zinc coating, approximately, 25μm thick.

5.1.2 <u>Hot - dip galvanizing</u>

The bars of a NILKA system space frame are hot dip galvanized in accordance with DIN 50976. The hot - dip galvanizing process is performed by dipping the steel bars into baths of molten zinc in 450°C temperature. This way the zinc diffuses upon the steel surface. Additionally when removed from the baths, the steel bars are coated with a layer of pure zinc with a minimum thickness of approximately 55μm.

5.2 <u>Electrostatic powder coating</u>

The surface protection of the spheres, bars and sleeves of the NILKA system space frame is completed with high quality powder coating.

During the coating procedure, the polyester powder is sprayed on to the steel components in an electrostatic field, and then is hardened in a run-through furnace at, approximately, 200° C. This way, a dry film layer of thickness 80μm is achieved.

The colour of the powder is chosen from a wide range of colours RAL, from the sample collection.

Compared, to traditional painting, the electrostatic powder coating method offers the advantage of a much longer protection period due to its maximum toughness and resistance to impacts. In addition, it offers resistance to temperatures from -40°C to +240°C and the coating is UV lightproof.

6. ASSEMBLY - ERECTION OF THE SPACE FRAME NILKA system

Generally, a space frame is assembled by combining and repeating the triangular pyramid units.

There are four basic methods for the installation of a space frame:

a. Assembly - erection method.
b. Lift-up method.
c. Assembly - sliding method.
d. Block method.

The choice of one from the above methods for the installation depends on the area's condition and the requirements of design.

6.1 Assembly - erection method

The area of the structure is covered by scaffolding and the assembly and installation of the space frame is done concurrently.

There are two types of scaffoldings. The first is fixed, covering the entire area; the second is a moveable scaffold, in the form of a tower, changing positions according to the progress of the job.

The choice of the appropriate scaffolding depends on the local conditions.

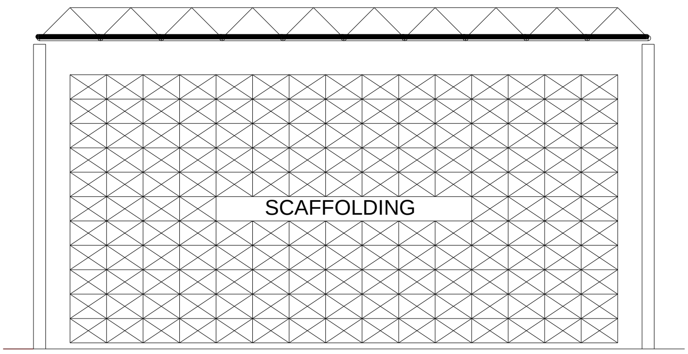


fig. 6.1. Assembly - erection method

6.2 Lift-up method

The space frame is assembled on the ground near the final site and is then erected to the final positions with the use of cranes.

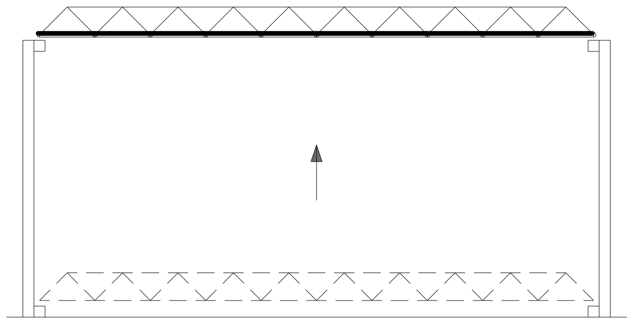


fig. 6.2. Lift - up method

6.3 Assembly - sliding method

Scaffolding is installed with the aid of which a part of the space frame is assembled, and then this part of the space frame is pushed on rails to its final position. Afterwards, a second part is assembled and is slid on rails to the final position in the same way. The two parts are joined together. This process is repeated until the space frame is completely assembled and in position.

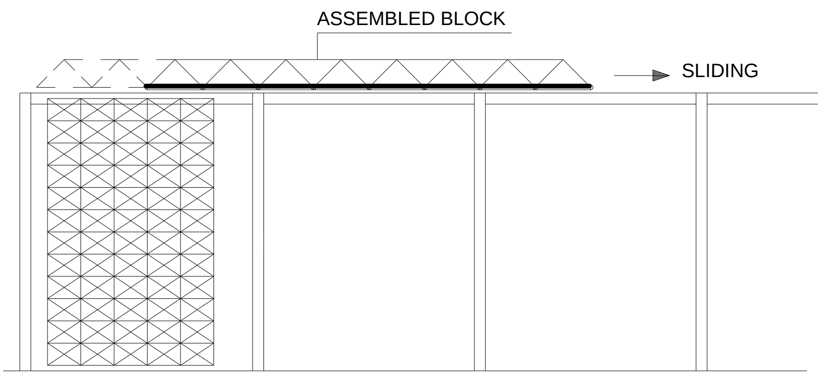


fig. 6.3. Assembly - sliding method

6.4 Block method

A section of the space frame is assembled on the ground, which afterwards is lifted up by a crane and installed in position. Then another section is assembled on the ground, lifted up near the first one and the two blocks are attached by construction workers working on suitable scaffoldings. The process is carried on this way until the entire space frame is assembled and in position.

The lifting capacity of the crane to be used depends on the maximum weight of the blocks.

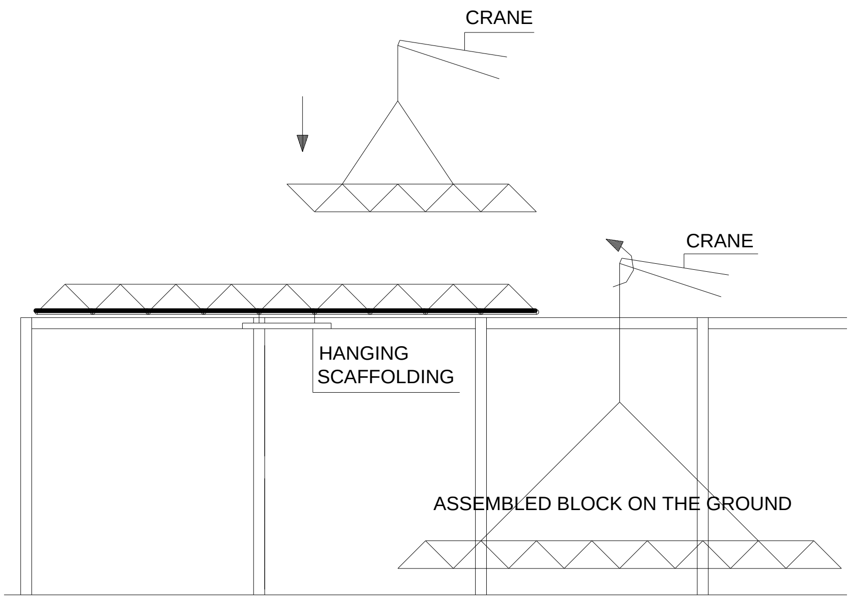


fig. 6.4. Block method

7. <u>SUPPORT OF NILKA system SPACE FRAME</u>

The positioning of the supports of the space frame is selected in accordance with the requirements of the area. Support restraints are generally fixed vertically, and with one, two or no degrees of freedom in the two main horizontal directions, depending on the structural design assumptions.

In figure 01 the support on reinforced girder with one degree of freedom is shown.

In figure 02 the support on cantilever with one degree of freedom is shown.

8. <u>CLADDING OF NILKA system SPACE FRAME</u>

The materials used for the cladding of the NILKA system space frame are selected by the client in accordance with aesthetic requirements and other criteria.

In this case, short stanchions are fixed on the nodes of the upper layer grid to support a system of purlins, whose dimensions and sections are determined by the structural design. The cladding sheets are fixed on the purlins.

By using stanchions with variable height, a desirable slope can be given to the cladding permitting the safe evacuation of rain water.

In figure 03 is shown the support of the cladding on the spaceframe’s node.

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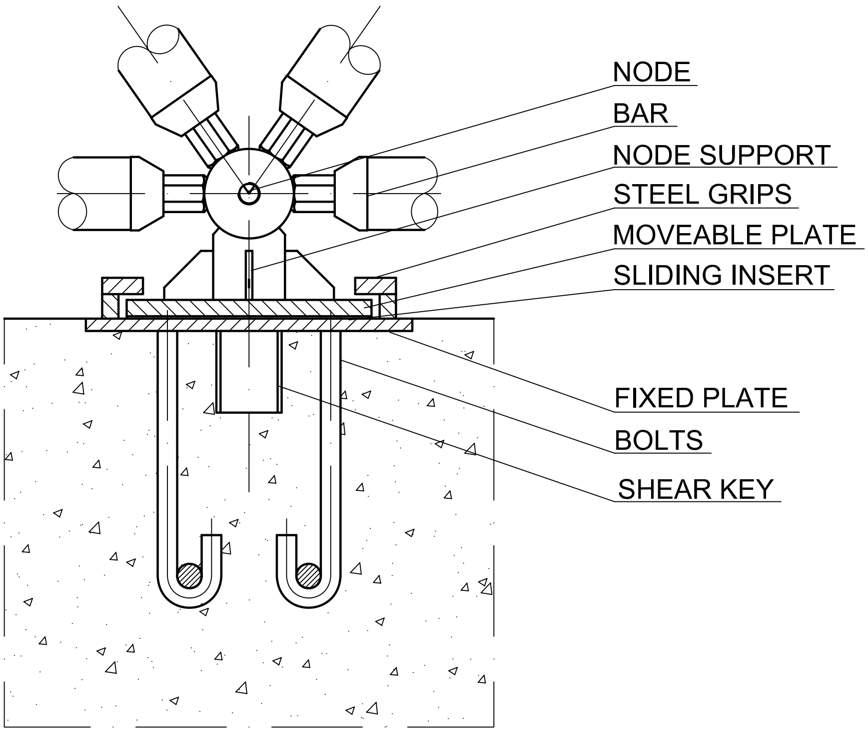

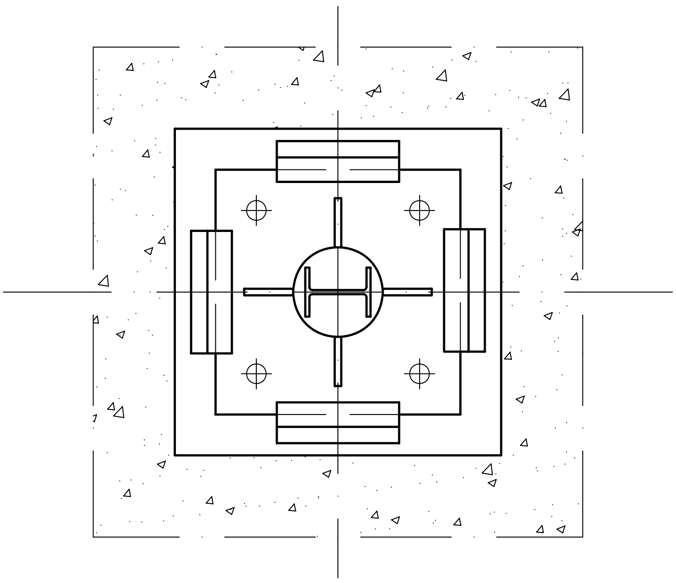

Spaceframe's support on reinforced girder
with one degree of freedom

Design	Checked	Approved - Date	File	Date	Scale
Stathouraki Maria	Kalokerinos Elias		D-01-00	01/06/2003	

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SPACEFRAME'S SUPPORT

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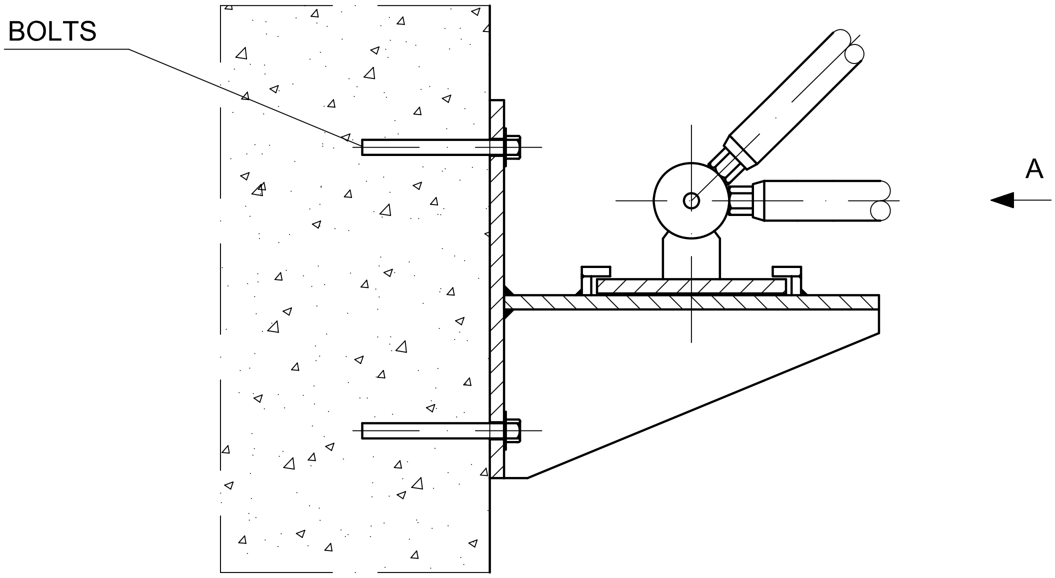

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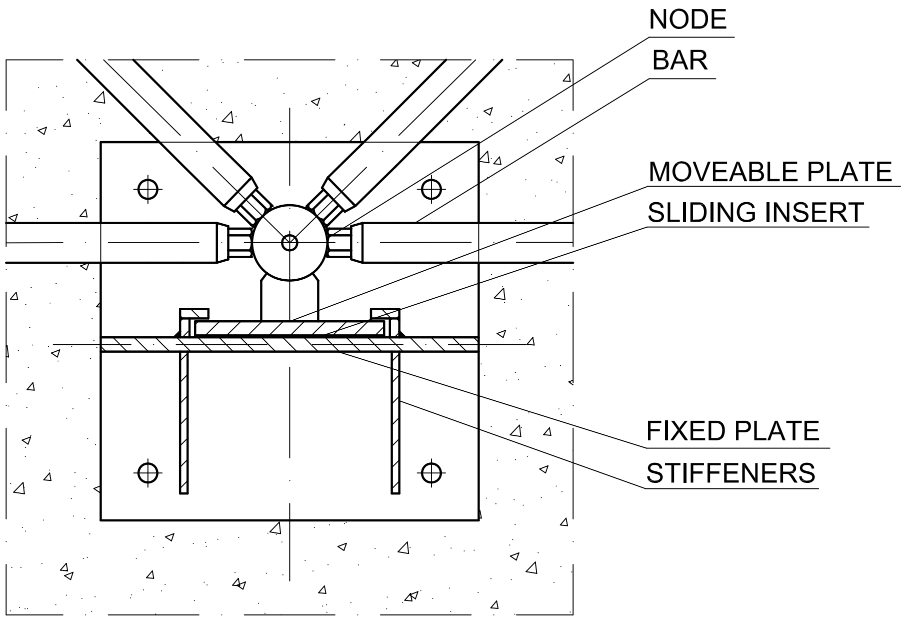

Spaceframe's support on cantilever with one degree of freedom

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SPACEFRAME'S SUPPORT

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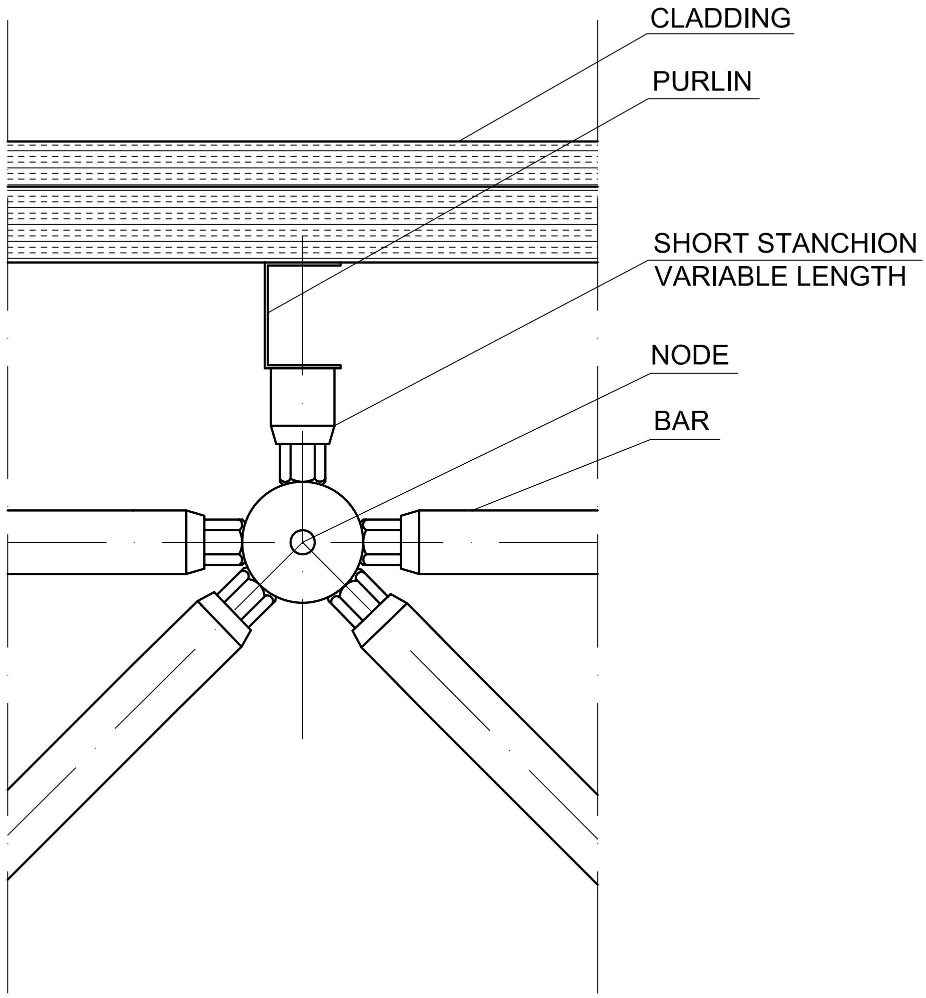

Detail of gladding on spaceframe's node

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SPACEFRAME'S GLADDING

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