Technical Proposal

“MODUL” SPACE FRAME

“KEDING” SKOPJE

Company for Production, Reconstruction and Engineering “KEDING” Skopje, st. Kliment Ohridski 43 a

tel. +389 2 3238 008: +389 2 3238 377 fax + 389 2 3116 905 email: gabriel@on.net.mk

MODUL SPACE – FRAME

INTRODUCTION

The MODUL space frame is modular three dimensional frame work with bolted connections.

With help from Institute for engineering research in Civil Engineer faculty in Skopje , Keding conducted 2 series of loads tests on full size roof structures to determine the true behaviour of system under gravity and lateral loading conditions.

A number of laboratory tests were also carried out on individual **1.2 m** and **1.5 m module** space frame components.

The safety factor for the whole structure is for more project , higher. In the MODUL space frame , deformation of any one part will not cause total failure. Stresses can seek many pats to the support If members in one particular path reach their ultimate capacity , members in neighbouring paths will co-operate and carry additional loads until finally entire structure is acting to its full capacity .

1. Choice of assembly methods:

a. Ground assembly and lifting into place by one or two cranes
b. Partial assembly and partial assembly in place
c. Total structure assembled on place
d. Other assembly methods

2. Shop drawings

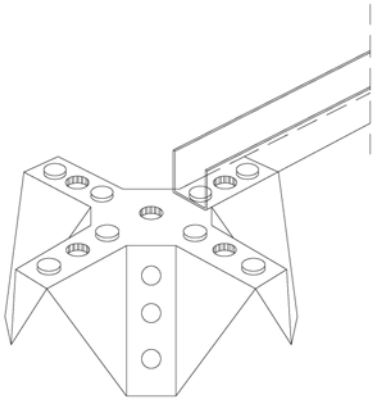
Shop drawings are prepared for each project by Company Keding. This drawing will show the dimensions and configuration of the space frame roof, the reinforcement parts as required , the location of supports , typical section and details, and other pertinent information. The contractor or assembler should follow these drawings exactly with no deviation.

3. “MODUL” space frame parts

A basic understandings of the system and knowledge of design criteria for the various parts will help speed up the work and eliminate some possible errors.

a. Space frame connectors

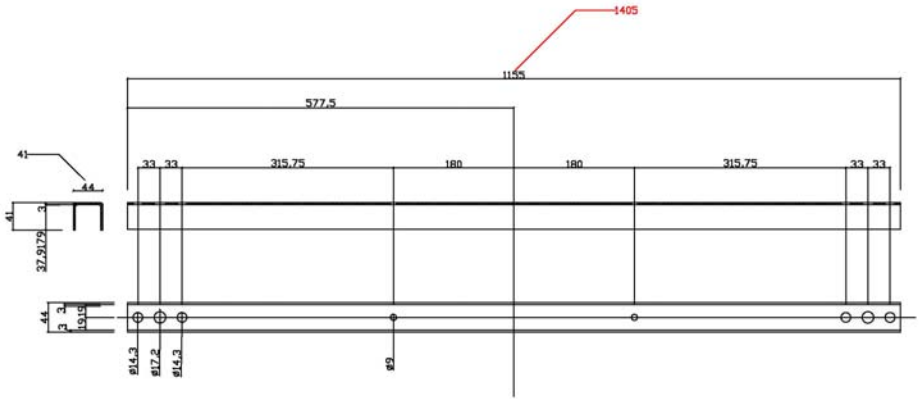
There a two types of connectors used in the space frame roof assembly . The **out-strut** type and **in-strut** type.



The visual distinction between the two types is direction the shear lugs project on the inclined planes of the connector. If the projection is toward the outside of the connectors , it's the out-strut type . If the projection is toward the inside of the connectors it is in-strut type.
These two types are used in the same roof assembly. When one of type is used exclusively on the plane of the space frame , the other type should be used on the opposite plane only. For instance , if out-strut connectors are used for on the bottom or ceiling plane of the roof structure as indicated in the shop drawing, than in-strut connectors will be used on the top of the roof plane of the same structure. Never mix the two connectors in the same plane.

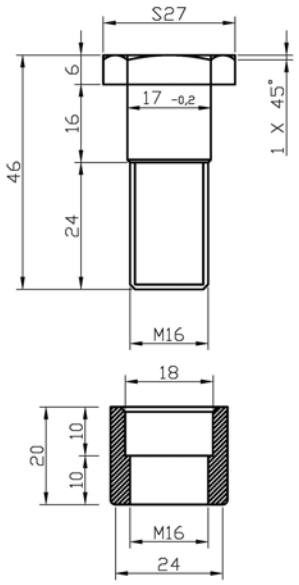
b. Space frame struts

The space frame struts can be different, 1,2 m module and 1,5 m module . The calculation and shop drawings show what kind of profile will be used.



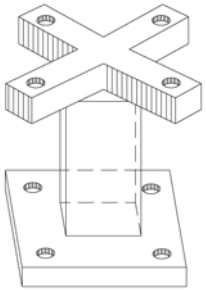
c. Space frame bolts and nuts

There are one type of bolt and one type of nut. They are special made for this kind of space frame. It secure the stability of whole space truss.



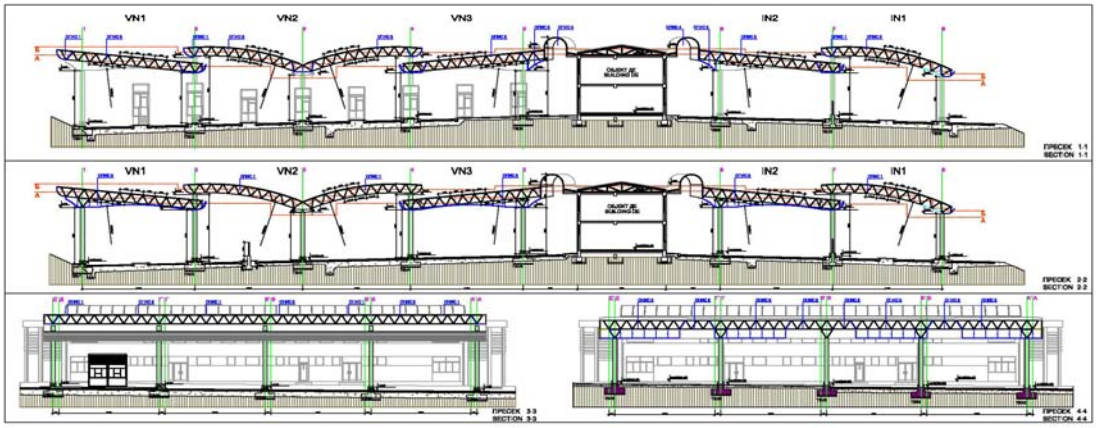
d. The seat fittings

The seat fittings are used to connect the space frame to tops of supporting columns or column arms or sometimes bearing walls as called for on the shop drawing.
One type of seat fittings is made by welding a steam to the space frame connector. The steam could be made from steel tubing or pipe or solid bar as determinate by design. The connectors could either be in-strut type or out-strut type depend upon detailing.



"MODUL"

SPACE FRAME



METRIC PLANNING MODULES

Company for Production, Reconstruction and Engineering “KEDING” Skopje, st. Kliment Ohridski 43 a
tel. +389 2 3238 008: +389 2 3238 377 fax + 389 2 3116 905 email: gabriel@keding.com.mk

1,2 m module load capacities

Tabular values represent the total uniformly distributed load capacity in Kg/m2.

Live-load capacity is determined by deducting from the total uniformly distributed load capacity to the (1) weight of the space-frame, 24 kg/m2, and (2) all other dead loads.

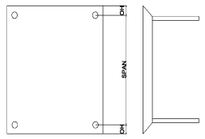
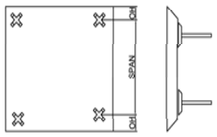
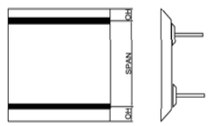
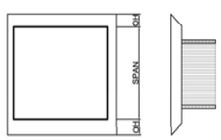
Tabulated values are for 1.2 meter module symmetrically supported MODUSPAN space-frame; structures. These values also serve as a guide in esftimating the load-carrying capacity of morei.e. multiple spans, random supported patterns, irregular shapes and combinations of support types* Exact strength data for such irregular structures require specific engineering analysis.

Loads are based on a safety factor of two (0.5 of ultimate test loads) for individual members and connections. The safety fac-tsr; for the whole structure^, however, is higher. In the " MODUSPAN'space-frame, stresses can seek many paths to the , support. If merrtbers in one particularpath reach meir ultimate capacity,members neighboring -paths will cooperate and carry additional loads.

For lateral or wind loading, the MODUSPAN space-frame acts as a very stiff horizontal beam and requires no additional diagonal bracing within the roof.

The MODUSPAN lspaee-ftarne will deflect either downward or upward depending upon applied load, span and overhang relationships. Precambering cannot be accomplished with standardized component parts
Drainage of roof water can be accomplished by placing roof sumps at low points of the roof as determined by the behavior of the space-frame structure. Sloping the entire space-frame from One side to the other by varying support he! hts is another method of draining the roof. Still another way is to build up a sloping framework—with adjustable screw jacks or posts of varying heights—that will direct the flow of water to predetermined locations.

L= SPAN IN METERS

		OH OVERHANG		8.4	9.6	10.8	12,0	13,2	14,4	15,6	16,8	18,0	19,2	20,4	21,6	22,8	24,0	25,2	26,4	27,6	28,8	30,0	31,2
		meters	modules	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
column suports		3	2 1/2	537	434	358	307	256	221	193	169												
		4.2	31/2	460	374	313	265	288	198	173	153												
		5.4	41/2	313	295	278	237	205	129	157													
		6.6	51/2	194	186	179	173	166	161	155													
columns with x-arm supports		4.2	3 1/2		1462	1209	923	734	564														
		5.4	4 1/2		704	678	655	633	581	424	340												
		6.6	5 1/2				373	362	351	340	293	266	221	185									
		7.8	6 1/2					229	222	216	210	204	199	194	151								
parallel wall supports		0.6	1/2	989	766	593	484	395	334	282	244	212	187	164	147	131							
		1.8	1 1/2	1187	879	659	527	424	354	296	255	220	193	169	151	134							
		3.0	2 1/2	1827	1250	848	642	494	402	330	279	237	206	180	159	141	127						
		4.2	3 1/2	950	950	950	950	659	505	395	325	269	230	197	173	152	135						
		5.4	4 1/2	579	579	579	579	579	579	539	417	330	273	228	196	169	149	131					
		6.6	5 1/2	389	389	389	389	389	389	389	389	389	354	282	235	197	170	148	131				
		7.8	6 1/2	279	279	279	279	279	279	279	279	279	279	279	279	247	206	174	151	131			
		9.0	7 1/2	209	209	209	209	209	209	209	209	209	209	209	209	209	209	209	184	156			
perimetrical wall supports		0.6	1/2	1500	1158	896	731	596	503	425	368	318	281	247	221	193	179	162					
		1.8	1 1/2	2007	1437	1055	833	663	550	457	392	337	295	258	230	205	184	166					
		3.0	2 1/2	1827	1827	1620	1147	849	672	540	451	379	327	283	249	220	197	176	159	138	126		
		4.2	3 1/2	950	950	950	950	950	950	765	585	470	392	330	285	247	219	193	173	156	142	129	
		5.4	4 1/2	579	579	579	579	579	579	579	579	579	533	425	353	297	256	223	197	174	157	141	128
		6.6	5 1/2	354	354	354	354	354	354	354	354	354	354	354	354	354	327	274	236	205	181	160	144
		7.8	6 1/2	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	221	191	169
		9.0	7 1/2	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158

1,5 m module load capacities

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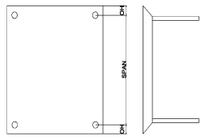
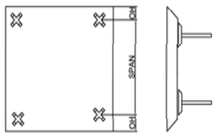
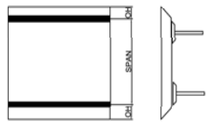
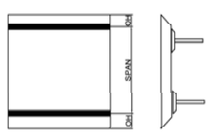
L= SPAN IN METERS

		OH OVERHANG		7,5	9,0	10,5	12,0	13,5	15,0	16,5	18,0	19,5	21,0	22,5	24,0	25,5	27,0	28,5	30,0	31,5	33,0	34,5	36,0
		meters	modules	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
column suports		3.75	2 1/2	572	434	341	275	227	190	162	140												
		5.25	31/2	341	314	292	238	198	168	144													
		6.75	41/2	227	212	198	187	176	150	130													
		8.25	51/2	144	138	132	127	122	118	113													
columns with x-arm supports		5.25	3 1/2				437	767	590	488	384												
		6.75	4 1/2				480	462	447	432	357	289	232										
		8.25	5 1/2						255	247	239	230	222	181	151	126							
		9.75	6 1/2							156	151	147	143	139	136	132							
parallel wall supports		0.75	1/2	1272	898	636	492	381	311	254	215	181	157	136	120								
		2.25	1 1/2	1908	1174	763	563	424	339	272	227	190	164	141	124								
		3.75	2 1/2	1246	1246	1246	803	545	412	318	258	212	179	152	132								
		5.25	3 1/2	648	648	648	648	648	610	424	324	254	209	173	148	127							
		6.75	4 1/2	395	395	395	395	395	395	395	395	341	267	212	175	146	126						
		8.25	5 1/2	265	265	265	265	265	265	265	265	265	265	265	227	181	151	127					
		9.75	6 1/2	190	190	190	190	190	190	190	190	190	190	190	190	190	190	159	132				
		11.25	7 1/2	143	143	143	143	143	143	143	143	143	143	143	143	143	143	143	143	141	118		
perimetrical wall supports		0.75	1/2	1949	1367	964	744	575	469	383	323	273	236	204	180	159	142	127					
		2.25	1 1/2	3983	2114	1290	923	678	535	328	353	293	252	216	189	166	147	131					
		3.75	2 1/2	1245	1245	1245	1245	1041	737	541	432	347	289	243	210	182	160	141	126				
		5.25	3 1/2	644	644	644	644	644	644	644	644	488	375	297	249	209	180	156	136	122			
		6.75	4 1/2	390	390	390	390	390	390	390	390	390	390	390	341	273	224	190	161	141	122		
		8.25	5 1/2	239	239	239	239	239	239	239	239	239	239	239	239	239	239	209	175	151	131		
		9.75	6 1/2	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156	141	

KEDING Skopje

For production and installation of metal space frame (truss) for roofing t

The work includes the following:

1. Engineering design of space frame and accessory parts by Space frame Contractor including structural calculation submittals.

2. Fabrication, packaging and delivery to job site by Space frame Contractor.

3. Erection by the Space frame Contractor or under the direction of a technical advisor of the Space frame Contractor by a specialist installer.

Remark

The top chord of space frame is made of rectangle cross section metal profile , which is giving installation of roof sandwich panel with out secondary frame.

Submittals

Structural Calculations:

1. Prior to fabrication of space frames , submit design calculations prepared in accordance with current design rules of the EN and applicable codes as called for by the project engineer. Include analysis for all pertinent load cases live, dead, wind, thermal, seismic, etc

a. Supply reactions at supports for review by Project Engineer and maximum frame deflections.

b. Supply calculations for support and other details as necessary.

Samples:

1. Fabricator shall submit one (1) sample full size “node” with connecting.

2. Submit one sample of all cladding elements which fall under this section.

3. Submit product data showing compliance with galvanizing of components and other quality and fabrication requirements.

Quality Control of Space frame Components:

1. Quality control of nodes, metal profiles and bolts shall be carried out at the factory, with test loading..

2. Submit certificate of compliance with the above factory test procedure.

3. Preference shall be given to products fabricated domestically.

4. All factory welding shall be by certified welders.

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tel. +389 2 3238 008: +389 2 3238 377 fax + 389 2 3116 905 email: gabriel@on.net.mk

DELIVERY, STORAGE , HANDLING AND INSTALLATION

A. Factory finished components shall be stored, handled and shipped in a manner that will provide unscratched and undamaged units delivered to the site. Time the starting delivery of material to the site to insure uninterrupted progress of work.(20 days after signing the contract)

B. Installation for space frame as drawing will be **100 m^2 per day** and for "MODUL" space frame will be **150 m^2 per day**.

WARRANTY

A. The Space frame Contractor shall furnish the Owner with a written guarantee warranting all work of this section to be free of defects in material, workmanship and corrosion for a period of **one (1) year** from date of completion. Completion shall be defined as the specific work of this section.

MANUFACTURER

A. This is system has been design based on products and solutions offered by the following provider. As such, the approved manufacturer for this work is:

1. Manufacturer for "MODUL" space frame is:

"KEDING" – Skopje, Macedonia Macedonia

ALL INSTALATION WILL BE PERFORM BY "KEDING" – Skopje, Macedonia]

Firm's References

A Small Sample of Relevant experience in the last two years.

<table>
<tr><td colspan="2">Assignment Name:
GD" Granit" Skopje</td><td>Country:
Republic of Macedonia</td></tr>
<tr><td colspan="2">Location within Country:
Border station for trucks and ttransport veicles "Blace"</td><td>Professional Staff Provided
Civil eng
technical</td></tr>
<tr><td colspan="2">Name of Client:
Ministry for transport and comication</td><td>No of Staff:
eleven</td></tr>
<tr><td colspan="2">Address:
str.</td><td>No of Staff-Months;
Duration of Assignment:</td></tr>
<tr><td>Name of Associated Consultants:
MIK Kavadarci</td><td>No of Months Professional Staff Provided by Associated Consultants:6</td><td>Approx value of services:</td></tr>
<tr><td colspan="2">Name of Senior Staff:
Kedioski Dragan, Project Director, Consultant
Drnkovski Ljubomir Technical menager
Kedioski Gabriel, Quality Manager
Anevski Aco Database Manager</td><td>No of Months Professional Staff Provided by Associated Consultants:</td></tr>
<tr><td colspan="3">Description of Project:
Space truss</td></tr>
</table>

Firm's References

Assignment Name: **AD Trudbenik Ohrid**		Country: **Republic of Macedonia**
Location within Country: **Border station Kafasan**		Professional Staff Provided **Civil eng** **technical**
Name of Client: **Ministry for transport and comication**		No of Staff: **ten**
Address: **str.**		No of Staff-Months; Duration of Assignment:
Name of Associated Consultants: **MIK Kavadarci**	No of Months Professional Staff Provided by Associated Consultants:6	Approx value of services:
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Description of Project: **Space truss**		

Firm's References

Assignment Name: **Found for roads in Macedonia**		Country: **Republic of Macedonia**
Location within Country: **Roadtoll in Tetovo and Gostivar**		Professional Staff Provided **Civil eng** **technical**
Name of Client: **Found for roads in Macedonia**		No of Staff: **NINE**
Address: **str.**		No of Staff-Months; Duration of Assignment:
Name of Associated Consultants: **MIK Kavadarci**	No of Months Professional Staff Provided by Associated Consultants:3	Approx value of services:
Name of Senior Staff: **Kedioski Dragan, Project Director, Consultant** **Drnkovski Ljubomir Technical menager** **Kedioski Gabriel, Quality Manager** **Anevski Aco Database Manager**		No of Months Professional Staff Provided by Associated Consultants:
Description of Project: **Space truss**		

Firm's References

Assignment Name: **LUK OIL**		Country: **Russia**
Location within Country: **Ingusetia luk oil petrol stations**		Professional Staff Provided **Civil eng** **technical**
Name of Client: **Luk Oil Moscow**		No of Staff: **NINE**
Address: **str.**		No of Staff-Months; Duration of Assignment:
Name of Associated Consultants: **MIK Kavadarci**	No of Months Professional Staff Provided by Associated Consultants:3	Approx value of services:
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Description of Project: **Space truss for 5 petrol stations**		

Firm's References

Assignment Name: **LUK OIL**		Country: **Uzbekistan**
Location within Country: **Samarkand Uzbekistan luk oil petrol stations**		Professional Staff Provided **Civil eng technical**
Name of Client: **Luk Oil Moscow**		No of Staff: **NINE**
Address: **str.**		No of Staff-Months; Duration of Assignment:
Name of Associated Consultants: **MIK Kavadarci**	No of Months Professional Staff Provided by Associated Consultants:3	Approx value of services:
Name of Senior Staff: **Kedioski Dragan, Project Director, Consultant** **Drnkovski Ljubomir Technical menager** **Kedioski Gabriel, Quality Manager** **Anevski Aco Database Manager**		No of Months Professional Staff Provided by Associated Consultants:
Description of Project: **Space truss for 2 petrol stations**		

Firm's References

Assignment Name: **LUK OIL**		Country: **Kazahstan**
Location within Country: **Aktjubinsk Kazahstan luk oil petrol station**		Professional Staff Provided **Civil eng** **technical**
Name of Client: **Luk Oil Moscow**		No of Staff: **NINE**
Address: **str.**		No of Staff-Months; Duration of Assignment:
Name of Associated Consultants: **MIK Kavadarci**	No of Months Professional Staff Provided by Associated Consultants:3	Approx value of services:
Name of Senior Staff: **Kedioski Dragan, Project Director, Consultant** **Drnkovski Ljubomir Technical menager** **Kedioski Gabriel, Quality Manager** **Anevski Aco Database Manager**		No of Months Professional Staff Provided by Associated Consultants:
Description of Project: **Space truss for 1 petrol stations**		

Firm's References

Assignment Name: **Raketa turs Uzice**		Country: **Serbia and Montenegro**
Location within Country: **Bus station in the town Uzice Serbia and Montenegro**		Professional Staff Provided **Civil eng** **technical**
Name of Client: **Raketa Turs Uzice Serbia and montenegro**		No of Staff: **NINE**
Address: **str.**		No of Staff-Months; Duration of Assignment:
Name of Associated Consultants: **MIK Kavadarci**	No of Months Professional Staff Provided by Associated Consultants:3	Approx value of services:
Name of Senior Staff: **Kedioski Dragan, Project Director, Consultant** **Drnkovski Ljubomir Technical menager** **Kedioski Gabriel, Quality Manager** **Anevski Aco Database Manager**		No of Months Professional Staff Provided by Associated Consultants:
Description of Project: **Space truss for hole main bus station**		

Firm's References

Other relevant experience can also be supplied for the following spaces trusses:

- Petrol station Bunar Petrol Gostivar
- Petrol station Petrol Ohrid
- Petrol station Bama Petrol Skopje
- Petrol station Mak Oil Skopje, Kocani
- Petrol station Tajmiste Kicevo
- Petrol station Goding Petrol Gostivar
- Petrol station Blagoevgrad Bulgaria
- Petrol station Mimi Petrol Lesok Tetovo
- Post office at the border station Bogoodica

Technical equpment for producing and instalation of space truss

By the producing of elements for canopy-space truss are accepted all condition from the design, all valid standards and rules for this kind of works in Republic of Macedonia.

Producing elements who are accepted , mainly are adopt with open cross section U in accordiance with statics dimensioning and knot(conector) who is used for space conecting of profiles by special construct bolt and nut.

1. Profile (chord) with it's dimensions is produced in accordiance with static solution given in this case with suitable details. Sheet for this profile is 3mm and processing is by cold treatment.
2. Conector who has spacial form is made from sheet with thickness 6mm. The processing the form of conector is made by hot treatment.

Protection from the corrodion is made by galvanizing, paint with special primer coat for galvanized stell sheet. And at least to paint with colour like investor wish.

3. Bolt and nut are with special dimensions are made with quality in accordiance with all technical regulation .We galvanized bolts and nuts for protection from the corrodion.
4. Other details who are in our space truss are same protectet like all others.
5. Instaling the space truss is made on the ground level and than we lift with autocrane. In our expiriance we lifted the bigest space truss with 970m^2 in once.
6. With good preparation of area we can instal and lift 100m^2 per one day with premature instalation of columns.

For other questions and details we are ready to answer any time.

Company for Production, Reconstruction and Engineering "KEDING" Skopje, st. Kliment Ohridski 43 a

tel. +389 2 3238 008: +389 2 3238 377 fax + 389 2 3116 905 email: gabriel@on.net.mk

KEDING Skopje

For production and installation of metal space frame (truss) for roofing t

The work includes the following:

1. Engineering design of space frame and accessory parts by Space frame Contractor including structural calculation submittals.

2. Fabrication, packaging and delivery to job site by Space frame Contractor.

3. Erection by the Space frame Contractor or under the direction of a technical advisor of the Space frame Contractor by a specialist installer.

Remark

The top chord of space frame is made of rectangle cross section metal profile , which is giving installation of roof sandwich panel with out secondary frame.

Submittals

Structural Calculations:

1. Prior to fabrication of space frames , submit design calculations prepared in accordance with current design rules of the EN and applicable codes as called for by the project engineer. Include analysis for all pertinent load cases live, dead, wind, thermal, seismic, etc

a. Supply reactions at supports for review by Project Engineer and maximum frame deflections.

b. Supply calculations for support and other details as necessary.

Samples:

1. Fabricator shall submit one (1) sample full size “node” with connecting.

2. Submit one sample of all cladding elements which fall under this section.

3. Submit product data showing compliance with galvanizing of components and other quality and fabrication requirements.

Quality Control of Space frame Components:

1. Quality control of nodes, metal profiles and bolts shall be carried out at the factory, with test loading..

2. Submit certificate of compliance with the above factory test procedure.

3. Preference shall be given to products fabricated domestically.

4. All factory welding shall be by certified welders.

Company for Production, Reconstruction and Engineering “KEDING” Skopje, st. Kliment Ohridski 43 a

tel. +389 2 3238 008: +389 2 3238 377 fax + 389 2 3116 905 email: gabriel@on.net.mk

DELIVERY, STORAGE , HANDLING AND INSTALLATION

A. Factory finished components shall be stored, handled and shipped in a manner that will provide unscratched and undamaged units delivered to the site. Time the starting delivery of material to the site to insure uninterrupted progress of work.(20 days after signing the contract)

B. Installation for space frame as drawing will be **100 m^2 per day** and for "MODUL" space frame will be **150 m^2 per day**.

WARRANTY

A. The Space frame Contractor shall furnish the Owner with a written guarantee warranting all work of this section to be free of defects in material, workmanship and corrosion for a period of **one (1) year** from date of completion. Completion shall be defined as the specific work of this section.

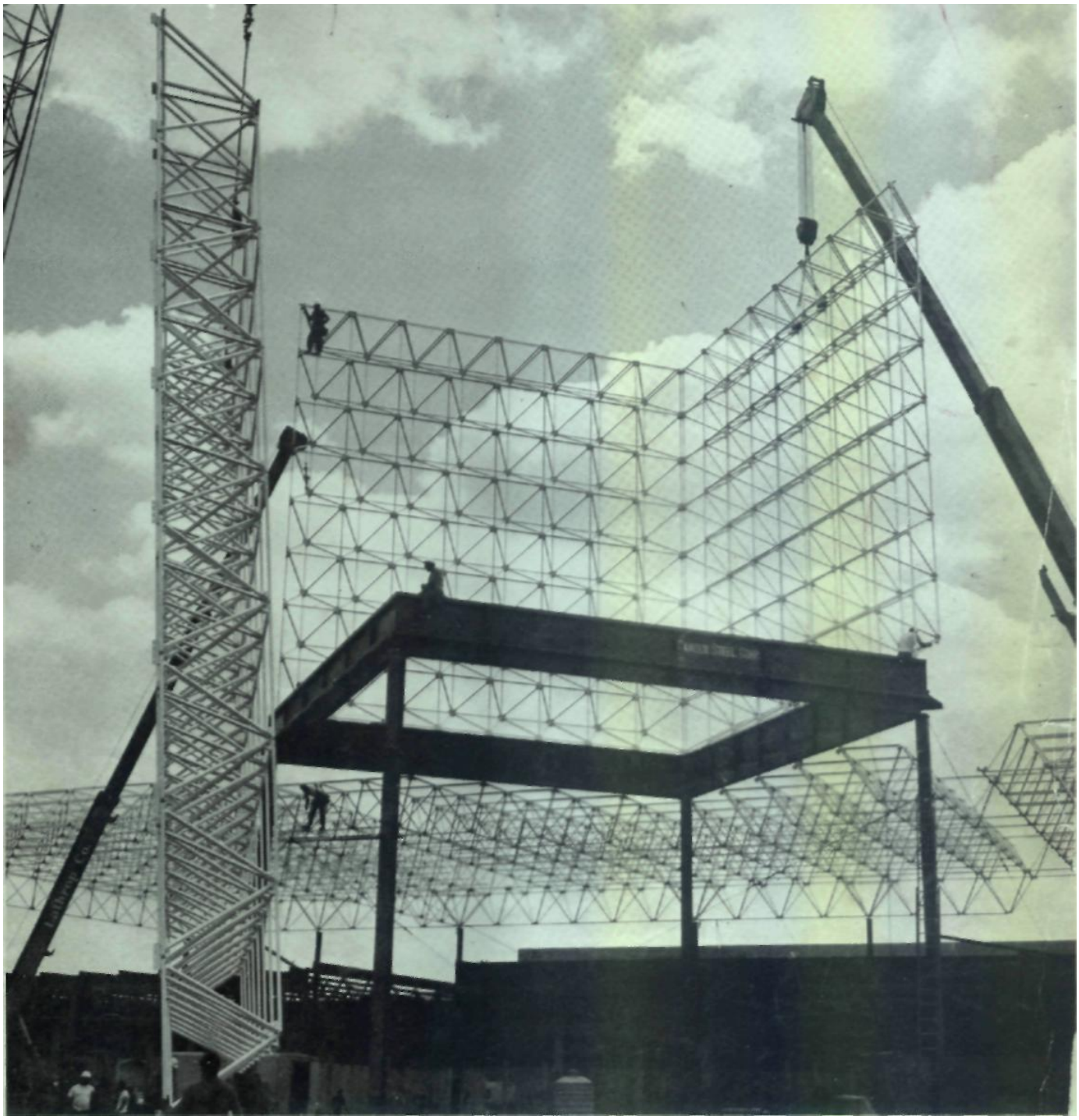
MANUFACTURER

A. This is system has been design based on products and solutions offered by the following provider. As such, the approved manufacturer for this work is:

1. Manufacturer for "MODUL" space frame is:

"KEDING" – Skopje, Macedonia Macedonia

ALL INSTALATION WILL BE PERFORM BY "KEDING" – Skopje, Macedonia]



Modul

SPACE-FRAME
and
construction procedures

Table of Contents

1. CHOICE OF ASSEMBLY METHODS

Depending on site conditions, size of roof structure and the availability of construction equipment, the KEDING space-frame may be assembled in any one of the following methods.

A Ground Assembly and Lifting into Place by One or Two Cranes

This method is applicable to most small structures where their size and shape and their total weight can be handled quite easily by one or two cranes. The advantages of this method are the ease of material handling and fast assembly of parts when it is done on the ground. For an average project, the estimated direct labor time to assembly MODUL space-frame on the ground is one-half man-hour per one 4 ft. square module or 16 square feet and five-eighths man-hour per one 5 ft. square module or 25 square feet. Size of the crew may consist of 4 or 5 workmen each equipped with an impact wrench to do the assembly work.

B. Ground Assembly and Lifting with Equipment Attached to the Columns

This method is applicable to medium and large size structures where lifting equipment is available to the contractor and where the column design permits the attachment of this equipment. The advantages here are savings in labor and time. It may be possible to install the roof deck and some electrical and mechanical apparatus at the ground level before lifting operations. The estimated direct labor time to assemble MODUL space-frame on the ground is also one-half man-hour per 4 ft. square module and five-eighths man-hour per one 5 ft. square module. Size of the crew will vary depending on the size of the project.

C. Partial Ground Assembly and Partial Assembly in Place

This method is also applicable to space-frame structures medium and large in size. Subassemblies, in the form of strips, are assembled on the ground and then lifted onto the column supports. The resulting voids are filled with the assembly of parts in place to unite the strips. Space-frame strips should be sized appropriately to the structure, the support pattern and the size of crane available. They may be assembled at the site or be assembled elsewhere and brought to the site.

Direct ground assembly time for the MODUL space-frame strips is still the one-half man-hour per 4 ft. square module and five-eighths man-hour per one 5 ft. square module mentioned earlier. For those areas assembled in place the direct labor time may increase to about one-third more than the ground assembly time.

D. Total Structure Assembled in Place

When lifting equipment is not available the MODUL space-frame may be assembled in place. Assembly starts at one support and is expanded in the form of a strip toward another support. Scaffolds and temporary supports are used until the space-frame strip is self-supporting. When two or more of these strips are built then the infillings are assembled to unite all the strips into one base structure. From this base structure the remaining roof can be built as an extension from it. Estimated direct labor time to assemble MODUL space-frame in place for a normal one story high roof, is about two-thirds man-hour per one 4 ft. square module and seven-eights man-hour per one 5 ft. square module. Besides those workmen using impact wrenches in assembly work, a full time material handling man may be needed to supply parts to the work scaffolds.

E. Other Assembly Methods

There are other methods for assembling the space-frame in addition to those mentioned above. Job and site conditions will dictate the best method for each project. For instance, when the space-frame is used as a skylight structure over a large roof opening, the space-frame may be assembled either in strips, each being slid into place on rollers, or the entire assembled structure may be mounted on rollers and pulled to the final location.

2. COMMENTS ON THE MAN-HOUR FIGURES

The man-hour figures mentioned for the various methods of assembling the MODUL space-frame are based on past experiences which indicate they do not vary a great deal from job to job or from one area to another. They can be used to estimate a project with reasonable accuracy. A crew that is inexperienced before the job starts will become experienced quickly with a few hours of doing the work following instructions.

On very small projects consideration should be given to start-up time which may increase overall direct labor time.

Heavily reinforced space-frame assemblies may take a little longer than the moderately reinforced structures. For the former one may add 5 to 10% more hours to the mentioned figures, and similar reductions can be made for the simplest non-reinforced structures.

The above mentioned man-hour figures are for average projects. Any unusual roof height, or difficult site which may adversely affect material handling and scaffold building or crane movement will increase the man-hours accordingly.

3. SHOP DRAWINGS

Shop drawings are prepared for each project by Unistrut Corporation. These drawings will show the dimensions and configurations of the space-frame roof, the reinforcement parts as required, the location of supports, typical sections and details, and other pertinent information. The contractor or assembler must follow these drawings exactly with no deviation unless authorized by a Keding Representative.

4. FAMILIARIZATION WITH THE PARTS

Before assembly work begins, the foreman and his men should be instructed to identify the parts and understand how they are put together. A basic understanding of the system and knowledge of design criteria for the various parts will help speed up the work and eliminate some possible errors later. The pride of the workers, once they become masters of the system, can explain the enthusiasm one finds in many of the projects completed. The time required for the instruction can be as short as one-half to one hour just prior to the actual work.

Part numbers are stamped on space-frame connectors and most fittings. Space-frame struts, seat-fittings and bolts and nuts will not have part numbers on them. Refer to shop drawings and part drawings to identify them.

Space-frame connectors, stacking connectors, connector reinforcing parts, seat-fittings, bolts and nuts are used interchangeably for 1.2 m. or 1.5 m. module assembly.

A. Space-Frame Connectors

There are two types of connectors used in the space-frame roof assembly; the outstrut type or P-8150 series and the instrut type or P-8151 series.

The visual distinction between the two types is the direction the shear lugs project on the inclined planes of the connector. If the projection is toward the outside of the connector, it is the outstrut type. If the projection is toward the inside of the connector, it is the instrut type.

These two types are used in the same roof assembly. When one type is used exclusively on one plane of the space-frame, the other type should be used on the opposite plane only. For instance, if P-8150 or outstrut connectors are used on the bottom or ceiling plane of the roof structure as indicated on a shop drawing, then P-8151 or instrut connectors will be used on the top or roof plane of the same structure. Never mix the two connector types in the same plane. If a mix occurs, one can tell by inspecting the web assemblies, since the lugs on the inclined planes of the connectors will not be utilized by the web members as required.

B. Stacking Connectors

There are two types of stacking connectors used in the space-frame stacked assembly; the outstrut type or P-8140 series and the instrut type or P-8141 series.

The visual distinction between the two series is the same as for the P-8150 and P-8151 series described before. In addition all the stacking connectors are punched with holes in place of the lugs on the flat plane so that the holes fit over the lugs on the regular connectors when stacked back to back. Bolting is done with space-frame bolt and nut as will be shown on the shop drawings.

C. Space-Frame Struts for the 4 ft. Module Assembly

There are five different space-frame struts used singly or in various combinations in the 4 ft. module MODUL space-frame.

The most commonly used strut is P-8800. It measures 1%" x 1%" x 46%" long and is made from 12-gage steel, cold-rolled into a channel with three holes punched in the back at each end for the purpose of joining to the connector. At approximately the third points of the strut, there are two prelocated knockouts which can be punched out for tying purposes in the double-strut assembly. P-8800 is used for chords, both top and bottom, and for webs.

P-8801 is the same strut mentioned above except with one mitered end. It is used for webs only, with the mitered end pointing at those places where P-8800 would not fit. For example, when P-8151 connectors are used at the top plane, the mitered end would be at the top plane seat-fittings, top plane reinforcing cross fittings, P-8155 and top plane %" thick reinforcing chords, P-8802. It replaces the P-8800 web wherever shown on the shop drawings.

P-8802 is a !4" thick reinforcing strut. It has one hole and two lugs at each end. The lugs fit the indentations on the space-frame connector. Two holes at approximately the third points are used for the ties. This strut is used to reinforce chords as well as webs as shown on the shop drawings.

P-8803 is a 12-gage thick reinforcing strut. It has one hole at each end and both ends are mitered. It is used to reinforce chords and webs wherever shown on the shop drawings. The two holes at the approximate third points are used for the ties.

P-8804 is a %" thick strut similar in appearance to P-8802 except it has three holes at each end. It replaces the P-8800 strut wherever called for on the shop drawings.

D. Space-Frame Struts for the 5 ft. Module Assembly

There are ten different space-frame struts used singly or in various combinations in the 5 ft. module MODUL space-frame.

The most commonly used struts are P-8600 chord strut, P-8601 web strut and P-8605 top chord strut.

P-8600 measures $1^{5}/_{8}$" x $1^{5}/_{8}$" x 58%" long and is made from 12-gage steel, cold-rolled into a channel with three holes punched in the back at each end for the purpose of joining to the connector. At approximately the quarter points there are two pre-located knockouts on the back of the strut which can be punched out for tying purposes in the double-strut assembly. P-8600 is used only as a chord member and most commonly at the bottom plane.

P-8601 is identical to P-8600 except the length is $59^{15}/32^{r}$. It is used only as a web member.

P-8602 is the same strut as P-8601 except with one mitered end. It is used only for webs, with the mitered end pointing at those places where P-8601 would not fit. For example, when the P-8151 connectors are used at the top plane, the mitered end would be at the top plane seat-fittings, top plane reinforcing cross fittings, P-8158 and top plane %" thick reinforcing chords P-8607. It replaces the P-8601 web wherever shown on the shop drawings.

P-8603 is a 12-gage thick reinforcing chord strut. It has one hole at each end and both ends are mitered. It is used to reinforce chords wherever shown on the shop drawings. The two holes at the back of strut are used for the ties.

P-8604 is a 12-gage thick reinforcing web strut. It is similar to P-8603 except the length is 1^{7}/3z" longer than P-8603.

P-8605 measures 1^{5}/в"x 2^{7}/i6"x 58%" long and is made from 12-gage steel, cold-rolled into a channel with three holes punched in the back at each end similar to P-8600 strut. It is used only as chord member and most commonly at the top plane.

P-8606 is a %" thick chord strut 58%" long. It has three holes punched in the back at each end for the purpose of joining to the connector. It replaces the P-8600 or P-8605 strut wherever called for on the shop drawings.

P-8607 is a %" thick reinforcing chord strut with the same length as P-8606. It has one hole and two lugs at each end. The lugs fit the indentations on the space-frame connector.

P-8608 is a %" thick web strut 59^{15}/32" long. It is similar in appearance as P-8606 except for the length.

P-8609 is a %" thick reinforcing web strut with the same dimension as P-8608. It has one hole and two lugs at each end. The lugs fit the indentations on the space-frame connector.

E. The Connector Reinforcing Parts

There are two space-frame connector reinforcing parts, the P-8157 reinforcing bar and the P-8158 cross. Both are used to reinforce connectors wherever called for on the shop drawings. The reinforcing bar must be bolted to the connector with three P-8122 bolts and P-8120 nuts, while the reinforcing cross uses five of the same bolts and nuts.

F. The Strut Reinforcing Plates

The strut reinforcing plates are made from %" thick by 3" wide steel, placed between the %" thick double-strut assemblies to give additional stiffness for compressive load-carrying members. They are bolted to the assembly at the third points with $^{3}/_{8}$" x 1 %" hex bolts and %" hex nuts.

P-8160 reinforcing plate is measured %" x 3" x 51^{3}/i6" and is used for web assemblies in the 5 ft. module system.

P-8161 reinforcing plate is measured %" x 3" x 49%" and is used for chord assemblies in the 5 ft. module system.

P-8162 reinforcing plate is measured %" x 3" x 37^{13}/i6" and is used for both web and chord assemblies in the 4 ft. module system.

G. Space-Frame Bolts and Nuts*

There are two standard space-frame bolts and one nut.

P-8121 bolt is 1^{s}/s" long and used practically everywhere except as noted below. The *V_B"* diameter shoulder of the bolt acts as a shear pin.

P-8122 bolt is 2%/' long and used only at the seat-fittings, the reinforcing bar, P-8157, the reinforcing cross, P-8158 and at the double-strut assembly made from two %" thick struts, P-8802 and P-8804.

The P-8120 nut has a counterbored hole which should face the bolt head when assembled. This counterbore allows the same nut and bolt to clamp varying thicknesses of material found in the single-strut assembly and the various double-strut assemblies.

-P-8120, P-8121 and P-8122 are not available in hot dipped galvanized finish. So when projects call for hot dipped galvanized finish bolts and nuts, regular %" high tensile bolts will be used to replace the P-8121 and P-8122 bolts and *V_B"* nuts will replace the P-8120 nuts.

H. The Seat-Fittings

The seat-fittings are used to connect the space-frame to tops of supporting columns or column-arms or sometimes bearing walls as called for on the shop drawings.

One type of seat-fittings is made by welding a stem to the space-frame connector. The stem could be made from steel tubing or pipe or solid bar as determined by design. The connector could either be instrut type or outstrut type depending upon detailing.

Another type of seat-fittings is made by welding a steel cross bar to the stem. The cross is %" thick and with prelocated holes for bolting to the space-frame connector with four P-8122 bolts and P-8120 nuts. The stem, made from a 3" x 3" solid steel bar with predetermined height, is welded to the cross. Both types of seat-fittings may include base plates, with predetermined sizes and holes that are welded to the bottom of the stems. These would be bolted to the column or column-arm as shown on the architectural and the shop drawings. When base plates are eliminated, stems of the seat-fittings are welded to the top plates of the columns on the job site.

5. GENERAL NOTES ON THE ASSEMBLY OF SPACE-FRAME PARTS

In general, single-strut assemblies can be made first and reinforcing struts added later. One must be sure that the proper struts and bolts are used. As the assemblers become more experienced it is possible and sometime necessary to make the total double-strut assemblies in one operation, therefore saving time.

Tightening of the nut should be done first by hand and then by impact wrench. When using the impact wrench, use fast on-off trigger action first and check if all lugs engage correctly with the holes. If not, loosen the nut slightly and make the correction. When all lugs align perfectly then torque up the assembly fully. Minimum nut torque requirement is 75 foot-pounds.

The head of the bolt should always be inside the basic strut, such as P-8800, P-8801, P-8804 for the 4 ft. module or P-8600, P-8601, P-8602, P-8605, P-8606, P-8608 for the 5 ft. module space-frame. The nut should be on the connector side or in the reinforcing struts. This orientation permits the parts to be drawn together easier and will permit the adding of refnforcing parts later without taking the whole assembly apart. On occasions when this rule is not followed due to design or detailing considerations, it will be noted on the shop drawings. All double-strut assemblies require two ties per strut. This is done by knocking out the two prelocated knockout holes on the back of the 12-gage strut with a drift pin and hammer. Then, with the *V»"* thick spacer P-1063 between the two struts, they are bolted together with hex bolts and hex nuts.

6. INSPECTION OF THE WORK

A. Check Engagement of Connector Lugs to Strut Holes

B. Check Torque of the Nuts

C. Check Location and Type of Reinforcements with Shop Drawings

D. Check Ties at Third Points of all Double-Strut Assemblies

7. TOOL INFORMATION FOR MODUSPAN€) SPACE-FRAME ASSEMBLY

The following list of tools are those which have been used successfully for assembly of the space-frame parts. Other manufacturer's tools of equal performance may also be used.

Portable Electric Alternator or Generator

1500 watts, 115 volt, 13 amp., 60 cycle

Electric Impact Wrench

'square drive	Standard	Heavy Duty
Black and Decker	2211	2220
Ingersoll-Rand ...	Ws 550	5U-HD
Milwaukee		9051
Rockwell		425

Sockets

For single-strut assembly
Snap-on Tool No. SP-280
VB" socket, heavy duty, bolt clearance type, for *V2"* square drive

For double-strut assembly
Snap-on Tool No. S-281
Va" socket, **deep** hexagon type, for Y_2" square drive

For intermediate ties in double-strut assembly
Snap-on Tool No. S-181
^{9}/i6" socket, **deep** hexagon type, for *Vz"* square drive

In general, it is a good practice to have a complete set of sockets available from *y2"* to 1%" with ratchet, universal and breaker bar to take care of variations in bolt and nut sizes, that occur at seat fitting, bearing plates and other special connections in the space-frame.

Miscellaneous

Drift-Pins
%" stock, 12 to 15" long taper to approximately
%" tip

Hammer

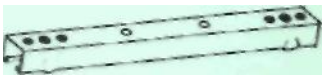
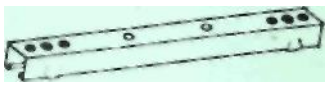
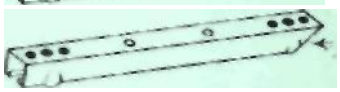
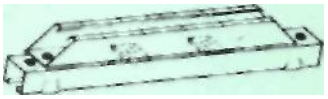
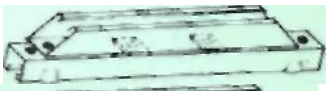
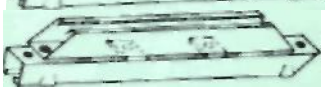
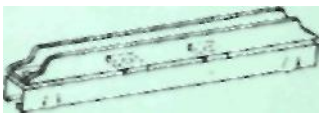
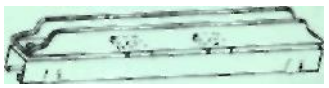
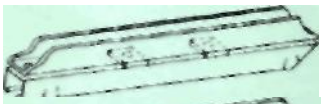
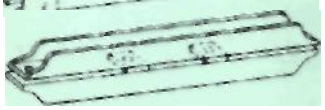
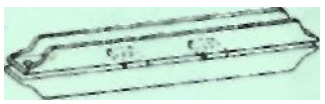
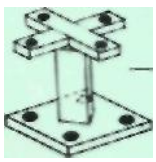
Combination hammer with one steel and one rubber end

Extension Chords

100 feet heavy duty 3-wire (one ground)

8. COMPONENT ASSEMBLIES

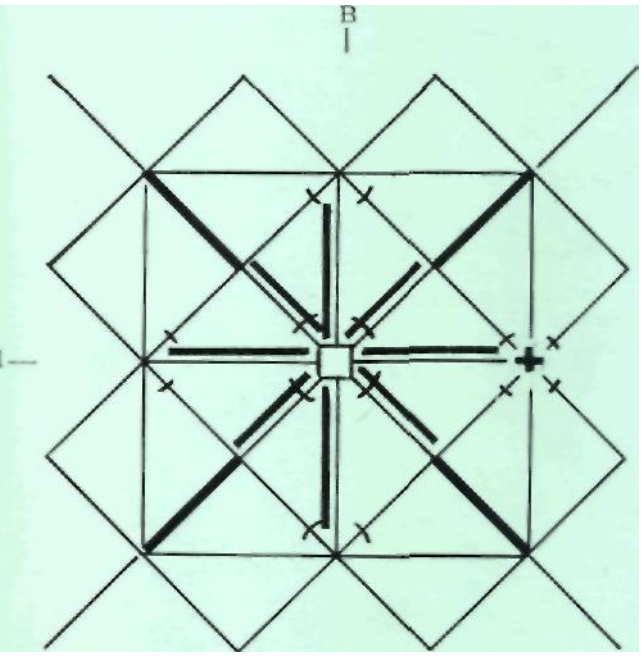
The chart below shows the various component assemblies used in the 4 ft. or 5 ft. module MODUSPAN space-frame. Symbols for the various assemblies are similar to those shown on the shop drawings.

SYMBOL	PART NUMBER 4 Ft. Mod.	PART NUMBER 5 Ft. Mod.	DESCRIPTION"
	P-8800	P-8600 orP-8605	12 Gage Single-Strut Chord Assembly
	P-8800	P-8601	12 Gage Single-Strut Web Assembly
	P-8801	P-8602	12 Gage Single Web with One End Mitered
	P-8800 & P-8803	P-8600 & P-8603 orP-8605& P-8603	12 Gage Double-Strut Chord Assembly
	P-8800 & P-8803	P-8601 & P-8604	12 Gage Double-Strut Web Assembly
	P-8801 & P-8803	P-8602 & P-8604	12 Gage Double-Strut Web Assembly
	P-8804	P-8606	Vi" Single-Strut. Used mostly at Bottom Chord Seat Fitting. Use P-8122 Bolt & P-8120 Nut
	P-8800 & P-8802		12 Gage & Vi" Double-Strut Chord Assembly
		P-8600 & P-8607 brP-8605 & P-8607	
	P-8800 & P-8802	P-8601 & P-8609	12 Gage & Vi" Double-Strut Web Assembly
	P-8801 & P-8802	P-8602 & P-8609	12 Gage & Vi" Double-Strut Web Assembly
	P-8802 & P-8804	P-8606 & P-8607	Vi" Double-Strut Chord Assembly. Use P-8122 Bolt and P-8120 Nut
	P-8802 & P-8804	P-8608 & P-8609	Vi" Double-Strut Web Assembly, Use P-8122 Bolt and P-8120 Nut
	P-8157		%" Reinforcing-Bar, Use 3 P-8122 Bolts & P-8120 Nuts
	P-8158		%" Reinforcing Cross, Use 5 P-8122 Bolts & P-8120 Nuts
			Seat-Fitting, Use P-8122 Bolt and P-8120 Nut

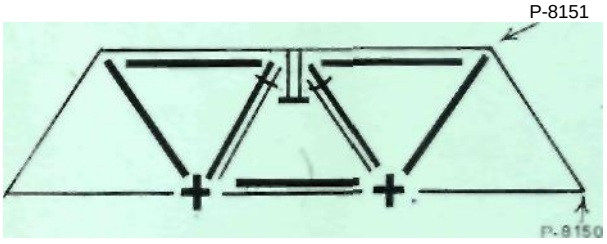
'Unless otherwise noted, use P-8121 bolts and P-8120 nuts on all component assemblies. For all double-strut assemblies, ties must be made at the quarter or third poi

10. ASSEMBLY INSTRUCTIONS-EXAMPLE—4 FT. MODULE CASE STUDY

The method proposed here is taken from a case study for illustration purposes only. The instructions are for a 3 module square space-frame at a certain column point identified as B-1. They are the only detailed assembly instructions given for a whole roof on how parts are put together. Once the assembler knows the principles of how the system works he can generally proceed to build the entire roof without further detailed explanation.



Top Chords and Webs Plan



Elevation

Bottom
Chords
Plan

MATERIALS NEEDED FOR THIS ASSEMBLY		
PART No.	QUAN.	DESCRIPTION -Qfi^
P-8150	16	Outstrut Connector, Bottom
P-8151	9	Instrut Connector, Top-
P-8800	58	12 Ga. Strut
P-8801	14	12 Ga. Strut, Mitered 1 End
P-8802	12	Strut
P-8803	4	12 Ga. Strut, Mitered 2 Ends
P-8158	3	Reinforcing Cross
P-8120	147	Nut
P-8121	129	Bolt $1^{5}/_{8}$" Long
P-8122	18	Bolt 2V&* Long
P-1063	32:	Spacer, *'he"* Dia. Hole
—	32	$^{3}/_{8}$" x 1%" Hex Bolt
—	32	*Vs"* Hex Nut
P-1964	6	Spacer, "/is" Dia. Hole
—	1	Seat-Fitting >*osre*