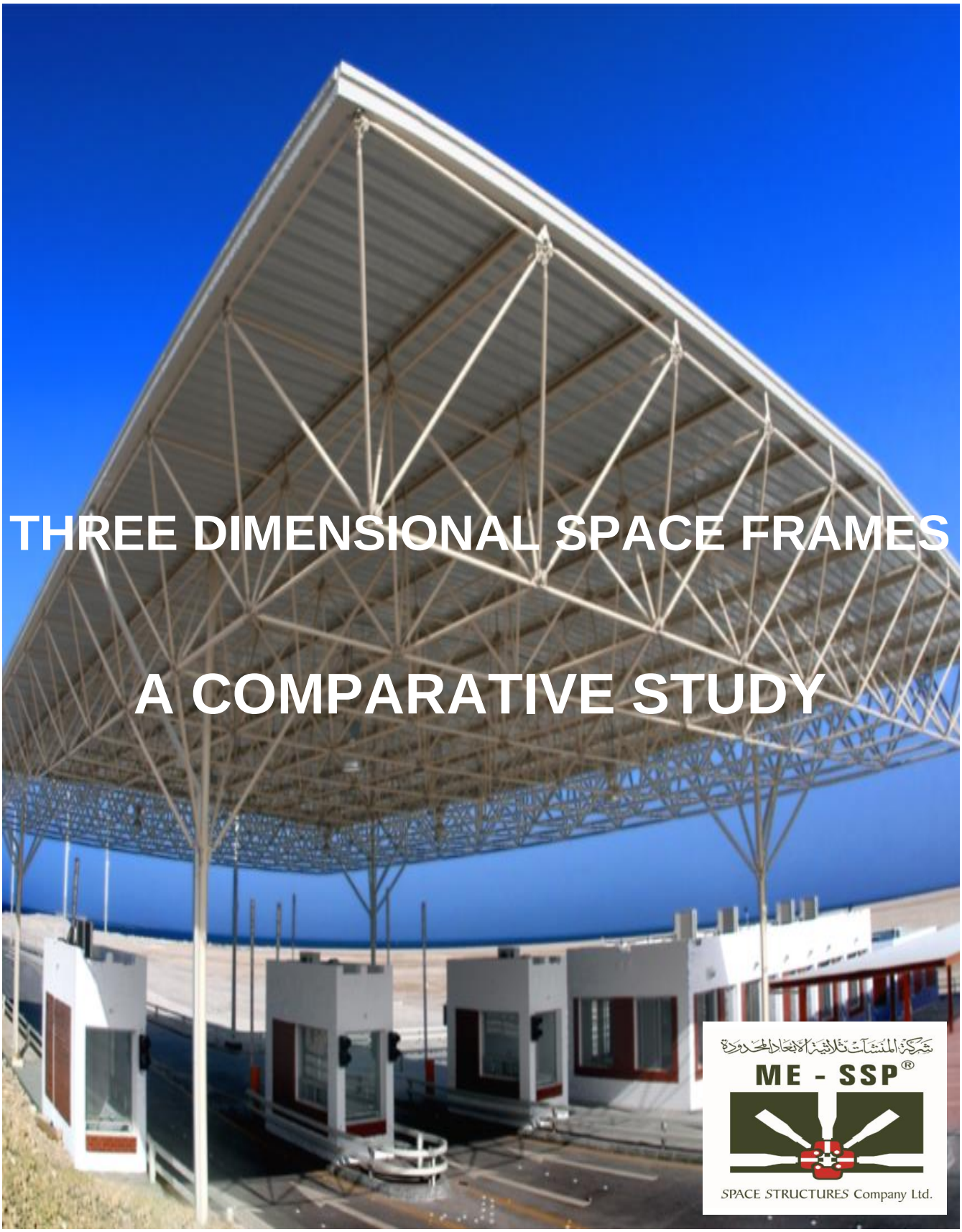

THREE DIMENSIONAL SPACE FRAMES

A COMPARATIVE STUDY

شركة المنشآت ثلاثية الأبعاد المحدودة

ME - SSP®

SPACE STRUCTURES Company Ltd.

THREE DIMENSIONAL SPACE FRAMES

A COMPARATIVE STUDY

Introduction:

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Space frames are a form of three dimensional structures that are characterized by their ability to span large areas with no or with few intermediate supports; they have great ability to transfer forces between members and across their joints to the nearest supporting medium.

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DOUBLE LAYER GRID SYSTEM

One popular form of three dimensional space frames is the "Double Layer Grid System", where members are positioned in the space along three different layers; These are called "Top Chord Layer', the "Bottom Chord Layer" and the "Diagonals Layer" connecting both. Thus creating a structural system that is efficient in transmitting forces, light in weight and can span large areas with no or with few intermediate supports. The "Square on Square Double Layer Grid System" is the most popular type of these kind of 3D space Structures.

Space structures commonly use tubular pipes for their members, as the hollow circular pipes are light in weight and have a uniform moment of inertia about their cross section. Hence, they are ideal for resisting the predominantly tension or compression uniaxial forces as stipulated by the space frame structural analysis.

The tubular members comprising the space frame need to transfer their uniaxial member forces across the connecting joints. It is these connecting joints of the tubular members that qualifies the space frame system and distinguish between various space frame systems. Space frames are usually classified in accordance to the joining technique between their members.

TYPICAL ME-SSP JOINT

In order to qualify a joining system as "viable" system, the joints must deliver the following important qualifying parameters, namely:

A. Ability to transfer forces with efficiency and with reserve capacity.

B. Ease of fabrication at factory and ease of installation at the job site.

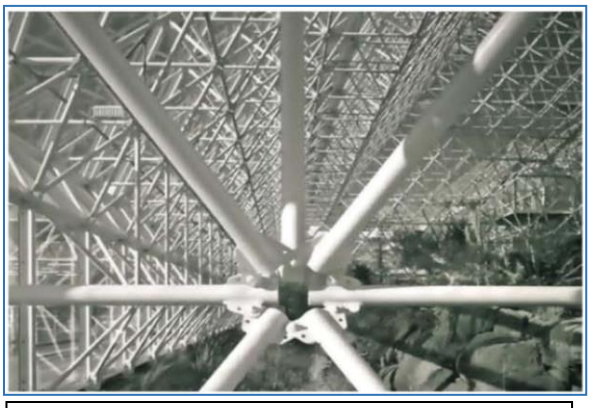
C. Aesthetics and cost effectiveness.

To date, there exist about a dozen of commercially active space frame joining systems around the world, to name only a few as shown below:

1) MERO (Germany)
2) Uni Strut (USA)
3) Space Deck (UK)
4) Pearce International (USA)
5) Triodetic (Holland)
6) Harley System (Australia)
7) Nodus System (UK)
8) Kepa System (Japan)
9) S. du Chateau (France)
10) ME-SSP (Saudi Arabia)

Among the most widely used popular system in the construction industry, is the imitation and cloning of the MERO system, as popularized by Turkish and Chinese suppliers.

Another popular method for classifying the various commercially viable space frame systems, is by distinguishing if the connection between members is done in a direct way, or by utilization of an external connector (sometimes called Hub). Directly connected members (such as Pearce, Harley and ME-SSP System) are considered more favorable then those which require an external connector (such as Mero, Triodetic and Kepa Systems). As it is rather difficult to provide a complete and convincing structural design for the external connector.



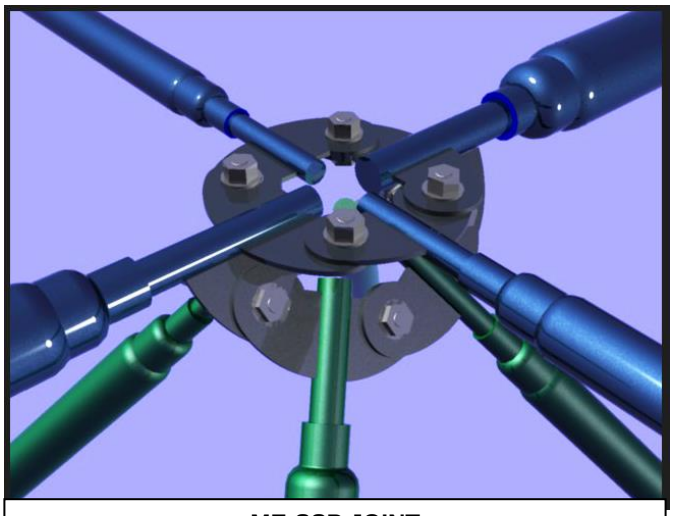
PEARCE DIRECT CONNECTION

VS

MERO EXTERNAL CONNECTOR

The ME-SSP System:-

The ME-SSP space frame system was developed in the mid 1990's by Dr. Mustafa Al-Mandil and Dr. Yasin Ziraba of Al-Mandil Engineering office (ME) in collaboration with the Saudi Steel Pipe Co. (SSP), hence this novel space frame system was called the (ME-SSP) ® System. This system is based on the world famous "Pearce System"; where the members are connected directly to each other via a "Multi-Hinge" ™ connector concept; thus eliminating the need for an external connector. In order to transfer forces at the joint across the diameter of the connecting members, the member ends were "swagged" by hydraulic devices, and a solid steel rod was inserted at the end of each member. Flanges (sometimes called hinges) are directly connected to these solid steel rods at member's ends. Hence the transfer of forces is guaranteed to pass efficiently both along the members as well as across the joints via the solid steel rods.



ME-SSP JOINT

ME-SSP FLANGE 6

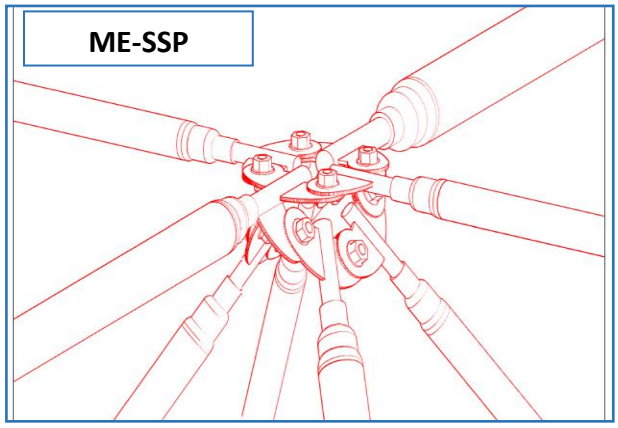
The ME-SSP system development continued over the past three decades by improving on the hydraulic swagging techniques and by improving the size and shape of the connecting flanges. Flange 6 with its three available thicknesses (4mm, 6mm & 8mm) proved to be the ultimate members connectors component.

Utilizing the four available flanges at each members end, insured a "multi-path" force transmission mechanism between the members, unlike the "single bolt" force transmission mechanism by the MERO System.

In the following section, a direct and candid comparison of the various features of the ME-SSP system in comparison to other space frame systems, and in particular to the popular MERO system.

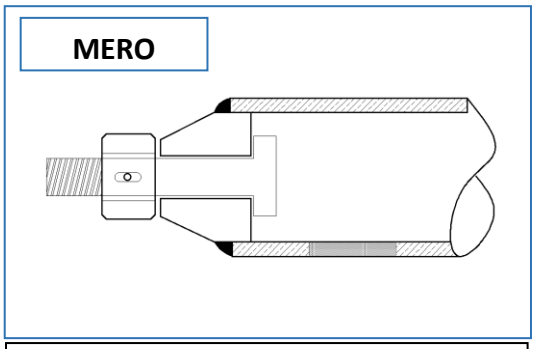
Salient features of the ME-SSP System:

1. Multi Path Stress Transmission:



MULTI-PATH

All the top chord and bottom chord stress sweep members are equipped with four flanges at each end of the member allowing a four-way multi path of stress transfer between adjoining members. This feature is by far superior to the single stress path afforded by the MERO system. Stress distribution in multi path connection is favorable in the steel construction. AISC code stipulates that multi bolt joint connection is more favorable than a single bolt connection. This practice holds truth whether the connected parts are in tension or in shear connections.

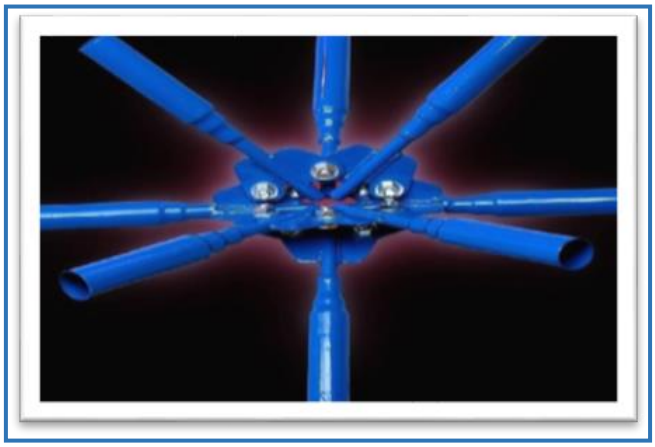


SINGLE-PATH

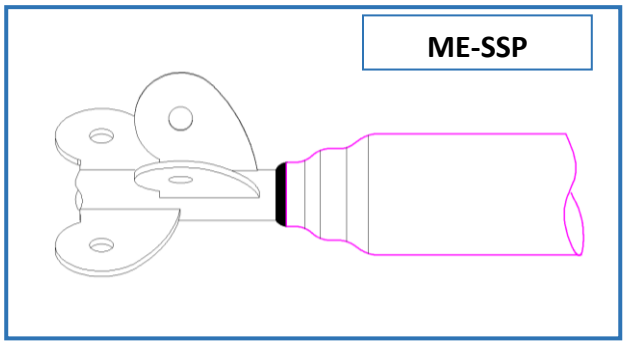
In fact the ASD version of the AISC code requires joints connected by single bolt to assume the bolt size requirement be increased in order to compensate for the single bolt deficiency.

2. Shear Connection Vs. Tensile Connection:

The ME-SSP system transfers forces between members via connecting the “pairing” flanges by four bolts, each bolt in a single force transmission. While the MERO system is obliged to transfer member forces by a single bolt tensile connection. It is well known that shear connections are more favorable in extreme loading conditions, as they allow ample time and allow adequate movement of the connecting parts prior to failure. Unlike the tensile connection which does not allow any movement of connected parts prior to the bolt failure in tension, and hence failure of the whole member in sudden and without adequate warning.



In this regard, the performance of the ME-SSP system advantage is consistent with that of conventional structural steel connection that are used for members carrying heavy loads and loads accompanied by moments.



It is worth mentioning also that all the four components of the ME-SSP system namely (pipe, rods, flanges and bolts) comply to the ASTM standard materials as these are no forged components and other non standard elements as with the MERO system.

3. Handling of Support Design:

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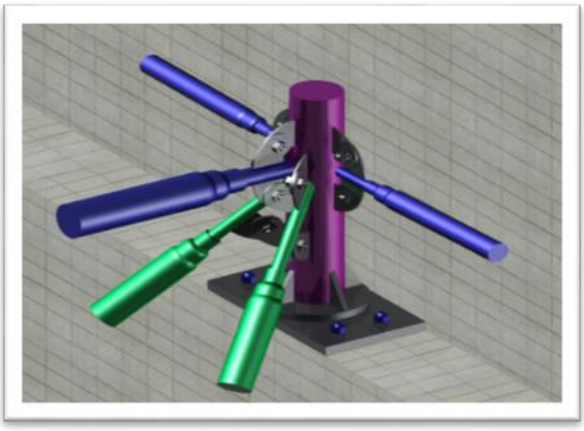
As the MERO commercial software design package are mostly based on the SAP 80 3D Truss design packages, they cannot incorporate the support columns into the space frame 3D truss design. So they opt to get the reactions of the space frame structure and manually design the support columns independently from the truss analysis. We at ME-SSP have incorporated the columns (and all other support members) into the same design package (STAAD Pro). This insures an efficient and sleek design of columns as an integral part of the space frame. The STAAD Pro allows the handling of columns as combined axial and flexure members in parallel to the space frame uniaxial stress truss members.



ME-SSP support modeling, analysis, design, fabrication, and installation is seamlessly achieved in a manner no longer different from that of other ME-SSP members. This implies the ME-SSP system achieving an efficient superstructure-substructure design consideration.

4. Long Term Durability: The ME-SSP Advantage:

ME-SSP space frame system is a robust and versatile space frame product engineered for durability and performance excellence. The service performance of the ME-SSP system in this regard has positioned it to be one of the most favorite products in the engineered space frame market.

The greatest achievement of the ME-SSP space frame system lies in its extended durability performance, made possible by the ability of its members to be fully hot-dipped galvanized (HDG), a process which provides ultimate protection against the elements of nature. The ME-SSP system is thus uniquely engineered for structural and durability performances that are well beyond the reach of many other peer space frame systems in the market.

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In comparison to this ME-SSP great advantage in durability aspects due to HDG, other commercial SF systems (such as MERO, Nodus & Kepa) can only use readily galvanized pipes along with “zinc electroplated” accessories, as the HDG process can damage the threaded bolts and nodes. Electroplating of metals cannot provide the protection afforded by the HDG process.